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Does declining patenting activity in technological companies direct them towards corporate acquisitions or boost their internal R&D spending?

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Statement of Originality

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Abstract

Using a large and comprehensive M&A-patent dataset over the period 1975-2010 involving technological firms in the United States of America, I show that technological firms use acquisitions as a medium to compensate for their declining innovation. Lesser research intensive firms show a greater tendency to engage in acquisitions in the event of declining patenting activity. I further show that technological firms are able to significantly improve their innovation performance reflected by increased internal R&D intensity and increased innovation output measured by cumulative patent citation count in the post-acquisition period. I conclude that acquiring firms realize the synergistic effects of acquisitions to improve their innovation capabilities.

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I. Introduction

It is well known that technological companies lay a vast stress upon innovation and keep inventing new and unique products to survive and succeed amidst the fierce competition in the global markets. In the continuously evolving world, technological companies need to keep revolutionizing their products by radical innovations to emerge as market leaders in their respective industries. This explains the reason why some companies like Microsoft and Google could attain so much success whereas some which couldn't match the innovative moves of their competitors had to finally shut down their operations. Apple Inc. was one of the first movers in its industry when it launched its industry defining innovative products iTunes and iPod which branded it as an innovation leader. History shows the need for technological companies to keep innovating to achieve a sustainable growth. In a famous instance, Boeing launched its highly successful 777 in 1994 which made it the market leader in jet manufacturing industry but it didn't revolutionize its technology with time and hence, had to face threat to its dominance from its rival Airbus which proves that relying on a single innovation doesn't guarantee sustainable success to any company. The best reliable way to be successful and dominate over its competitors in the long run for any company is by continuously innovating.

The first question that needs to be answered is how is innovation defined? Innovation can be defined as a novel product or a process of bringing better unique solutions which can meet the existing market requirements (Maranville S, 1992). Innovation promotes economic growth and introduces revolutionary developments in the society (Brookings Institution: Metropolitan Policy Program Report, 2008). Innovation in technological arena, i.e. Technological Innovation is the process of developing new technological products or processes after carrying out intense research, demonstration and deployment (Sagar, Ambuj and Bob van der Zwaan, 2006).

A. Measuring Technological Innovation

The subject of innovation and metrics for quantifying innovation has recently attracted much attention from the academicians worldwide with a lot of theories being proposed. In a relatively older research studies performed, Schroeder et al (1989) developed a framework comprising of 4 categories to measure innovation for a manufacturing firm – A) The percentages of new products developed by new processes, B) New products developed by old processes, C) Old products produced by new processes and D) Old products produced by old processes. So, a manufacturing firm cannot be considered innovative if all its products fall in category D with other categories implying different levels of innovativeness.

Archibugi (1988) talks about technological indicators to quantify innovation in technological companies. R&D expenditures is the first indicator included to measure innovation but it adds a major limitation to using this indicator that due to high uncertainty prevailing in technological and scientific research, R&D expenditures as input do not share any linear relation with innovative activity as output. Another indicator highlighted is Technology balance of payments which measures the amount of technology transfer transactions between entities of different countries but this indicator completely excludes the technology flows within the country and the technological activities which were not the object of commercial transactions but were intended to be used by the producing firm only. But the most reliable and precise technological indicator mentioned in the article incorporates the use of patent statistics to measure the quantity and quality of innovation. Acs et al (2001) investigates using the patent data developed by United States Patent and Trademark Office and innovation output indicator developed by the US Small Business Administration, the validity of patent count as an effective indicator of innovation and finds that patent count is a fairly reliable measure of innovative activity.

To summarize, it is clear that there is no standard measure for quantifying innovation till now. A lot of theories have been proposed by researchers worldwide to measure the quantity and quality of innovation and among them, one incorporating the use of patent based metrics has been considered the most reliable one.

B. Institutional background

Since my research is based on the use of patents as a proxy for technological innovation, I provide some background information about patents.

World Intellectual Property Organization (WIPO) defines a patent as a "document describing an invention, creating a legal situation in which the patented invention can be exploited (manufactured, used, sold, and imported) with the authorization of the owner of the patent". A patent is granted to the applicant in the specific countries the applicant applies, for a limited period of time (generally 20 years). A patent gives the owner the statutory right to prevent others from commercially exploiting his invention without his permission in return for the disclosure of details about the invention, thus rewarding him for his intellectual effort. For an invention to be patentable, it must meet certain criteria. It must consist of patentable subject matter, must be industrially applicable, novel and non-obvious. After the expiry of the patent, the invention enters the public domain and everybody is free to commercially exploit the invention without seeking the permission of patent owner.

In United States, USPTO (United States Patent and Trademark Office) grants the patents effective within United States, U.S. territories and U.S. possessions and administers all the laws and regulations concerning patents. USPTO classifies patents into 3 categories: a) Utility patents, b) Design patents, and c) Plant patents. Utility patents are granted for inventions related to new and useful processes, machines, articles of manufacture. Design patents are granted for inventions related to new ornamental designs. Plant patents are granted for inventions related to new distinct varieties of plants. In United States, for applications filed on or after June 8, 1995, the term of a patent (other than a design patent) begins from the issuing date and is valid for 20 years from the filing date in the United States. All patents (other than design patents) that were in force on June 8, 1995, or that issued on an application that was filed before June 8, 1995, are valid for 20 years or 17 years from the grant date. *(Source: http://www.uspto.gov)*

C. Measuring Patent Value

Not all innovations can be considered as equally important. Some inventions build upon the existing inventions and are not considered possessing very high value. These are categorized as incremental innovations. Whereas some inventions which are completely novel and may hold very high technological importance, have been categorized as radical innovations in the existing literature. Hence, not all innovations can be considered as breakthrough innovations, which makes it important to judge the quality of a patent. There have been various indicators proposed for measuring the value of a patent.

One of the determinants of the quality of a patent proposed is the effective life of the patent. A patent is generally valid for a term ranging from 14 to 20 years (exact life term may vary across countries). To keep the patent valid for that duration, the patent owner has to keep paying the annual fees to the regional patent office. However, not all patents are protected for the entire life term. The effective life of the patent generally depends on the trade-off between the annual renewal fees of patent and profitability by patented invention. The more profitable the invention is, more is the effective life of the patent. Another indicator for patent value considered is the number of countries in which the patent is filed. Foreign patents can be regarded as having higher value than domestic patents since patenting abroad incurs additional costs and hence, only inventions with greater profit generating expectations will be protected in multiple countries (Basberg, 1987).

This study uses “patent citation count” as the patent value indicator, the idea which has been tested a lot by researchers worldwide in the past few years and hence, considered as one of the most reliable ways to measure the economic value of a patent. Trajtenberg (1990) was the first research article to present the idea of using patent citation count as patent value indicator. He investigates the relation between patent counts weighted by citations and a measure indicating social value of innovation (Trajtenberg, 1989) for Computed Tomography scanners using the related patent dataset for the period 1972 – 1982 and finds that patent counts weighted by citations are positively correlated with the value of innovation. A similar study to test the validity of patent value indicators is performed by Harhoff et al (2003) who conduct a survey of German patent holders in 1996 (considering all patents granted in 1977 and renewed to full term) and measure the value of a patent as the price at which the inventor would be willing to sell the patent rights. Its results also indicate a similar result that the number of citations a patent receives is positively related to its value. Even a significant positive correlation is found between patents renewed to full term and patent citations as documented in Harhoff et al (1999). The similar results on the validity of patent citation count as a reliable indicator for economic value have been concluded by Hall et al (2000) who investigate the contribution of citation weighted patents to measure of Tobin’s Q for 4800 U.S. Manufacturing firms over a period of 30 years spanning from 1970 – 1999, and find a very high correlation between citation weighted patents and market value of firms.

Thus, greater number of patents citing a previous patent signifies that the cited patents hold a greater economic value which forms the basis of using patent citation count as the value indicator for patents.

Hence, it has been established very clearly till now that innovation plays a key role in the survival of a technological company and determines its future strategy. As explained earlier, innovation can be measured reliably by patent statistics. But it is a well-established fact that to convert R&D as input to patent as an output, firms have to incur very huge research expenditures including time costs and employing large number of research personnel along with facing high risks of research project failure due to legal issues or not being a first mover in the competitive markets. Hence we can infer that innovation although necessary, has several disadvantages also which need to be taken into consideration when determining the future strategy of a business. So, it is worthwhile investigating the alternatives of innovating for a technological company and how these companies have designed their strategies in the past.

One of the alternatives in front of a technological company in place of incurring huge research expenditures is engaging in acquisitions of other innovative companies. So, do these companies choose the acquisitions strategy instead of innovating by themselves? If they start emphasizing on acquiring other innovative companies, when do they start strategizing that? These questions lead us to ponder over if it is the declining innovation, i.e., declining patenting activity that prompts these companies to engage in acquisitions? Or at that time do they think of boosting their internal R&D spending to recreate more innovative products? So, my research study aims to answer the following research question:

"Does declining patenting activity in technological companies direct them towards corporate acquisitions or boost their internal R&D spending?"

The research question holds importance for the target firms in Mergers & Acquisitions deals. It helps to answer if the companies, especially the younger firms and start-ups, wishing to be acquired by the larger companies in order to survive in the long run and benefitting from acquisition deals through a higher acquisition premium, should produce valuable innovative products relevant for the technological companies whose patenting activity is declining over time. It is also important for the rival firms to anticipate the strategic behavior of its close competitors and perform better than them by redefining their strategies accordingly.

The rest of the thesis is arranged as follows: Section II briefly describes the relevant work done in the past by various researchers and how the present study aims to contribute to the existing literature. Section III develops the hypothesis building on the past literature and concluding from them intuitively. Section IV describes the methodology to be used for testing the hypothesis and provides information on the variables to be included in the regression analysis. Section V presents an overview of the sample used for performing regression analysis and the process to construct the sample. In this section, I include the summary statistics for all the variables to be used in the analysis. Section VI lists the empirical findings obtained from performing the regression analysis. Section VII includes the experiments performed to validate the robustness of the results obtained in Section VI. Section VIII concludes the research work listing key findings, limitations, implications for technological firms and suggestions for further research.

II. Literature Review

Mol (2005) investigates the effect of R&D intensity on the level of outsourcing using a sample of 52 manufacturing industries in Netherlands for the period 1993-1998. This study empirically tests the general perception in the early 1990s that a high R&D intensity leads to lower levels of outsourcing and finds that R&D intensity (total R&D expenditures divided by total sales) of an industry in 1993 is negatively correlated with the outsourcing levels in 1994 but positively correlated with the changes in the level of outsourcing during the period 1994 - 1998. The study is performed using three-digit industry level (European NACE system) census data of Statistics Netherlands (Centraal Bureau voor de Statistiek). The results suggest that R&D intensity no longer negatively affects the outsourcing levels. Due to interdependence of various sectors within a technological organization, it is considered more appropriate by R&D intensive firms to engage in outsourcing activities with external suppliers specialized in a particular area, thus using buyer-supplier relation as a means to compensate for the loss of technological innovation.

Hoberg and Phillips (2010) conclude that mergers and acquisitions are more likely to happen between firms which have complementary product markets thus generating synergies. The study employs text-based analysis of 10-K product descriptions obtained from the Securities Exchange Commission (SEC) Edgar website over the period 1997 - 2006 to establish a product similarity measure superior to SIC- or NAICS-based measures. They find that the merger probability is greater for firms possessing asset complementarities and lower for firms more similar to rival firms. Higher product market competition creates incentives to merge with the firms possessing related products, thus leading to generation of differentiated unique products and higher cash flows whereas higher competition decreases the likelihood of being acquired due to existence of multiple substitute target firms. A firm having “patents, copyrights or trademark” words in its product description is more likely to be acquired than other firms in the market since these words reflect the innovativeness and uniqueness of its products which are highly desired by the acquiring firms. More profitable firms tend to be the acquirers whereas less profitable ones tend to be the targets. The acquiring firm is able to achieve higher profitability, higher sales growth and greater product differentiation when it is operating in the highly competitive market and the target firm is operating in the lesser competitive market.

Zhao (2009) examines the effect of technological innovation on a firm’s propensity to engage in acquisition activities and the effect of acquisition on subsequent innovation. This study uses a sample of acquisitions over the period 1984 – 1997 along with National Bureau of Economic Research (NBER) patent data set created by Hall et al. (2001). Zhao (2009) finds that bidding firms possess comparable number of patents as that of non-bidders, however have inferior patent quality indicated by lesser patent citation count and have lower citation growth in the three years prior to bid, which implies that when bidding firms are not able to generate valuable patents, they try to acquire innovation through acquisitions. Bidders with less citation count before the transaction are more likely to complete the deal, after which they are found to perform better than the failed bidders. Less innovative firms before the deal display greater innovation quality after the deal, thus generating synergies in the form of higher patent counts, citation counts, and cumulative stock returns than those of non-bidding firms which shows that less innovative firms use acquisitions as a strategy to gain a competitive edge over other firms.

In a more recent study performed, Bena and Li (2014), using patent data from Patent Statistical Database and M&A dataset over the period 1984 – 2006 investigate the differences in innovation characteristics of acquirers and targets in M&A deals and effect of technological overlap between two firms on deciding the probability of their merger pair formation. The study concludes that firms with higher innovation output as patent index and citation weighted patents but lesser R&D intensity tend to be acquirers and firms with greater R&D expenses but having lesser growth in innovation output tend to be target firms. Firms which base their innovations on their past innovation output are less likely to engage in acquisitions. Size, sales growth, operating performance, lower B/M ratios and past stock returns are positively correlated with probability to engage in M&As as acquirers. However the study doesn't find any significant correlation between innovation output and likelihood of a firm to be a target firm. But better operating performance and lower past stock returns increase the probability of a firm to get acquired. To analyze technological overlap between two firms, Bena and Li (2014) construct a technological overlap measure based on relatedness of patents and mutual patent citations, and find this measure to be positively correlated with probability of merger pair formation and post-merger innovation output. However, overlap in product markets reduces the positive effect of technological overlap on merger pair formation which supports the finding by Hoberg and Phillips (2010) that firms are less likely to merge with their close rivals in terms of product markets.

Phillips and Zhdanov (2012) examine the effect of mergers and acquisitions market on firms' motivation to innovate constructing a sample including 12,941 firms operating in 181 different industries classified by three digit SIC codes over the period 1984 – 2006. They find that an active acquisition market positively affects smaller firms in an industry to increase their R&D intensity unlike larger firms which prefer to outsource their innovation activities over conducting in-house research and development and later acquire successful innovative smaller firms. The study finds that size of a firm is negatively correlated with the R&D intensity of a firm in active acquisition markets which indicates that smaller firms use their increased innovation output to enable them get acquired by larger firms and generate potential gains whereas larger firms use acquisitions as a source to acquire innovation assets.

In one of the earliest studies conducted on impact of acquisitions on innovation, Hitt et al. (1991) concludes that acquisitions negatively affect innovation. The study uses 191 acquisitions completed between 1970 and 1986 spanning 29 separate industries to examine the effect of acquisitions on R&D intensity (R&D divided by firm sales) and patent intensity (number of patents divided by firm sales). After analyzing data on acquiring and target firms for 3 years prior to the merger and for 3 years after the merger, Hitt et al. (1991) find that R&D intensity of the acquiring and target firms is comparable to the industry average R&D intensity three years prior to the acquisition, however, it keeps decreasing relative to industry average in subsequent years. Furthermore, innovation output in the form of patent intensity undergoes a huge drop before and after acquisition. However, the major limitation of this study is that for measuring innovation, patent intensity has been used as number of patents but we know that all patents are not equally valuable. So, the quality of patents is not being accounted for while analyzing the impact of acquisitions on innovation.

Higgins and Rodriguez (2006) investigate the validity of declining R&D intensity as a determinant for acquisitions in the biopharmaceutical industry and analyze correlation between pre-acquisition information regarding target firm and post-acquisition performance. The study uses biopharmaceutical industry acquisitions data over the period 1994 – 2001 constructing a unique measure as "Desperation Index" to estimate the propensity of firms to engage in acquisitions. Desperation Index, categorized into four different levels, is created from two components measuring products in the pipeline and sales-weighted exclusivity horizon which are both negatively correlated with firm's propensity to engage in acquisitions. Thus, the firms with increasing pipeline products and higher sales growth are less likely to outsource their R&D activities through acquisitions and vice-versa. They find that pre-merger alliance with the target firm and greater access to information regarding its activities (product pipeline) are positively correlated with post-acquisition success for the acquiring firms mitigating the problem of winner's curse and leading to higher post-acquisition cumulative abnormal returns. The acquirer is able to improve its product pipeline and product sales post acquisition. The study also finds that pre-acquisition information gathering activities related to target firm like prior sales of patented products and research experience within the similar drug category have a positive influence on post-acquisition abnormal returns while desperation index is negatively correlated with CAR. Interestingly, even CAR for the most desperate firms also remains positive with more pre-merger information about target.

In a recent study performed on R&D and acquisitions focusing solely on IT firms over the period 2004 - 2006, Banker et al. (2014) examine the effect of firm diversification on R&D and acquisitions as a strategy to combat the threat of new innovative entrants in the Information Technology (IT) industry. The study finds that firm diversification (indicating different product segments) is positively correlated with investments in acquisitions and negatively correlated with investments in R&D as a means to acquire innovation. In addition, the study views diversification in two ways – related and unrelated diversification and concludes that it is the unrelated diversification which is positively associated with the firm's propensity to acquire whereas related diversification has no significant effect on acquisitions. Investments in R&D and investments in acquisitions are found to be complementary towards each other. Due to rapidly evolving technologies and low entry barriers, IT firms find it suitable to engage in acquisitions than internal innovations to face intense competition. However, the limitation of the study is that it involves aggregate investment in acquisitions and does not focus solely on controlling acquisitions.

Wagner (2007) analyzes the determinants of acquisition behavior of large firms in three high tech industries, namely semiconductor manufacturing, biotechnology and electronic design automation (EDA) in Europe and Asia using the largest firms in these industries over the period 1981 – 2004. The study finds that in EDA industry, sales and R&D intensity are positively correlated with the value of acquisitions. For acquisition of private firms, sales growth is found to positively affect the number of acquisitions whereas financial leverage is negatively associated with acquisition. For biotech industry, both sales and financial leverage are positively correlated with number of acquisitions. For semiconductor manufacturing industry also, sales is found to positively affect the number of acquisitions. However, the patenting intensity and R&D intensity are not found to have any significant association with the firm's acquisition activities.

Ransbotham and Mitra (2010) examine the effect of timing of acquisitions in high technology environment. Using an event study methodology for telecommunications industry over the period 1995 – 2001, the study finds that acquiring firms can benefit from early acquisitions of young targets in case of uncertainty in valuing the target, adding more value to the acquirer which implies that target age is negatively correlated with abnormal returns for the acquirer. The negative effect gets amplified for targets without recent patents and public targets. However, the negative effect of target age gets reduced for targets possessing valuable patents or for privately owned targets. The probability to get acquired is greater for targets with more valuable patents reflected by patent citation count and vice versa since possessing more valuable patents reduces valuation uncertainty and increases the acquisition premium to the target. In addition, the probability to get acquired is negatively correlated with venture capital funding since firms possess adequate capital to run their operations smoothly. The study also finds that traditional finance parameters are not significantly related to acquisition likelihood.

It is generally believed that strategic mergers or acquisitions between firms generate abnormal returns. To shed more light on this relatedness belief, Barney (1988) analyzes different situations to find when strategic mergers or acquisitions are able to generate abnormal returns and when they are not. The study finds that strategic mergers or acquisitions between related firms are not always able to generate abnormal returns. For the perfectly competitive markets, the economic value generated from acquisitions is passed on to the shareholders of target firms. However, if the markets are imperfectly competitive, acquiring firms may be able to generate abnormal returns. If the target firm holds a greater economic value to a particular bidder and no other bidder and the target itself are aware of this additional value, that particular bidder will be able to acquire this target at the market perceived value, thus generating synergistic gains for the acquirer. In another situation, if the other bidders are not able to replicate the combined cash flows of acquirer-target pair, the markets will be imperfectly competitive and the acquiring firm will be able to generate abnormal returns.

In a study focused on investigating the economic role of mergers and internal corporate investments at the industry and firm level, Andrade and Stafford (2004) classify forces driving mergers into two categories – expansionary (addition of capital stock) and contractionary (reduction of asset base). Most of the mergers in 1970s and 1980s happened due to fundamental shocks such as deregulation, increased foreign competition, financial innovations and oil price shocks. During that period, excess capacity within the industries is found to cause mergers whereas capacity utilization is found to be positively associated with non-merger investments. However in 1990s, industries with near capacity, high Tobin's Q having strong growth prospects, increased profitability experience merger activities.

Carow et al. (2004) investigate the incentives for an early mover in the industry acquisition process and compares its post-acquisition performance with the transactions occurring later in the industry acquisition wave. The study categorizes early movers in the wave of transactions as either strategic pioneers or happenstance early movers. Since the early movers may possess superior information about the pool of target firms which may enable them to identify best undervalued targets, they may generate higher stock returns as compared to their industry peers.

However, they find that post-acquisition returns for early movers (including both strategic and happenstance acquirers) are not significantly higher than late movers in the industry acquisition wave who generally experience negative returns after transaction announcements. They also conclude that managers of the strategic acquirers possessing superior information about the target finance the transactions with cash rather than equity so that all the gains accrue to the existing shareholders whereas acquisitions where the target value is uncertain, happenstance acquirers prefer to issue equity to secure required funding for transaction. Strategic acquirers are able to generate higher announcement returns than happenstance or other acquirers. Late movers in the acquisition industry wave are found to imitate the acquisition strategies of early movers without possessing significant information about the target and hence, are not able to generate competitive announcement returns.

Using an EU dataset collected from 62 high and medium tech firms involved in 31 M&A deals, Cassiman et al. (2005) analyze the effects of M&A by different categories of technological relatedness on post transaction R&D levels and find that M&A has a positive impact on R&D levels for the firms which are technologically complementary whereas a negative impact for the firms which are technologically substitutive. R&D efficiency is found to increase more prominently for technologically complementary firms than substitutive firms. Amongst technologically substitutive firms, those which are rivals in the product markets before M&A exhibit greater decline in R&D levels and lesser increase in R&D efficiency as compared to non-rival firms.

Until now, there has been very little evidence on whether declining patenting activity as measured by the decreasing number of patents (weighted by patent citation count) influences the strategy of the technological companies to boost their internal R&D spending or direct it towards corporate acquisitions to gain more innovative products. Higgins and Rodriguez (2005) examine the performance of 160 pharmaceutical companies from 1994 to 2001 and conclude using a unique desperation index that firms which are more desperate (nearing the expiration of patents) are more likely to engage in acquisitions to regenerate their innovation assets.

The present study attempts to investigate the propensity of firms to engage in acquisitions as opposed to increasing internal R&D intensity in the event of declining patenting activity (when the valuable patents are about to expire) performing analyses on firms in the United States over the period 1975 - 2010. This study is different from Higgins and Rodriguez (2005) since it focused only on pharmaceutical companies from 1994 to 2001 only taking into account the pre and post-acquisition period and not using patent citation weighted metric to measure innovation. The effect of declining innovation may not be the same across other industries also. Hence, it is important to observe the impact of innovation on acquisitions behavior across a range of industries in order to verify it as a general phenomenon. Moreover, Higgins and Rodriguez (2005) use R&D intensity as a measure of innovation which actually reflects innovation input and not innovation output. This study contributes to the existing literature as it examines the strategy of firms to either acquire or increase R&D intensity over a period of 1975 – 2010 covering a vast set of industries, thus estimating the causal effect of declining patenting activity on the firm's propensity to engage in acquisitions and validating it as a possible determinant for corporate acquisitions.

III. Hypothesis Development

When the technological firms see a continuous drop in their amount of innovation assets, they need to think of a strategy to restore that amount in order to remain in competition. At that time, the companies can increase their internal research expenditures to regenerate their innovation assets since more research expenditures have been found to lead to generation of greater number of patents (Gurmu and Perez-Sebastian, 2008). Andrade and Stafford (2004) categorize investments into merger and non-merger investments or internal corporate investments. They observe that the decision of a firm to use anyone of these depends on capacity and growth prospects but the trend has been observed to vary across time. The targets with more valuable patents are able to generate higher acquisitions premium, implying that acquiring firms engage in corporate acquisitions to acquire innovation assets which may indicate that using target's innovation assets, acquirers look to compensate for their declining innovation. Banker et al. (2014) find that IT firms engage in acquisitions due to rapidly evolving technologies in IT industry which leaves little time to develop them internally and hence, they adopt corporate acquisitions strategy to acquire latest technologies. In active M&A markets, larger firms prefer to outsource their innovation activities over conducting internal R&D and later acquire successful innovative smaller firms (Phillips and Zhdanov, 2012). Evidence provided by Mol (2005) also suggests that firms increase their levels of outsourcing during continuous evolutionary technological environment. So, the firms with lesser research productivity are more prone to engage in acquisition activities, considering acquisitions as effective substitutes for internal R&D (Zhao, 2009).

Hence, from the above arguments, a hypothesis can be derived that in case of declining patenting activity when the breakthrough patents are about to expire, technological firms tend to rely on acquisitions.

Hypothesis 1: In case of declining patenting activity when the breakthrough patents are about to expire, technological firms tend to rely on acquisitions.

Mergers and acquisitions are more likely to happen between firms having complementary product markets in order to generate synergies (Hoberg and Phillips, 2010). Bena and Li (2014) also find that acquiring firms prefer the target firms sharing technological overlap with them. Given the complementarity between acquirer and target, the primary motive of acquiring firms remains the same which is to increase their returns post acquisition using the unique characteristics of the target. Pre-merger alliance with the target firm or superior information regarding its innovation activities leads to higher post-acquisition cumulative abnormal returns and improvement in innovation assets for the acquiring firm post acquisition (Higgins and Rodriguez, 2006). Furthermore, M&A has a positive impact on R&D levels for the firms which are technologically complementary whereas negative impact for the firms which are technologically substitutive (Cassiman et al., 2005). Using these findings, I conclude that since acquiring firms prefer to acquire innovative target firms sharing product complementarity with them, they find it more advantageous to combine the knowledge and technological resources of both acquirer and target to develop unique differentiated products. Thus, acquiring firms feel more motivated to increase their R&D intensity post acquisition in order to secure a leading position in their industry. Hence, I derive the second hypothesis that acquisitions positively affect firm’s internal R&D intensity.

Hypothesis 2: Acquisitions positively affect firm’s internal R&D intensity

Building on the second hypothesis that acquisitions positively affect firm's internal R&D intensity which is a measure of innovation input, I try to derive the impact of acquisitions on firm's innovation output. Zhao (2009) finds that lesser innovative firms before M&A deal display greater innovation output in the form of higher patent count and patent citations count as compared to non-bidding firms after the deal. Furthermore, since greater research expenditures are found to be positively associated with number of patents, I conjecture the third hypothesis that acquisitions positively affect firm's innovation output.

Hypothesis 3: Acquisitions positively affect firm's innovation output

IV. Methodology

A. Testing Hypothesis 1: In case of declining patenting activity when the breakthrough patents are about to expire, technological firms tend to rely on acquisitions

To test the first hypothesis, I estimate the causal effect of percent change in cumulative patent value held by the firm (total innovation output) on number of acquisitions pursued. Using firm-year panel data, I run a firm fixed effects regression represented by the below equation:

$$Acquisition_{it} = \alpha_0 + f_i + \beta_1\, Change\ in\ Patents_{it+2} + \beta_2\, R\&D_{it-1} + \beta_3\, Size_{it-1} + \beta_4\, Cash_{it-1} + \beta_5\, Sales_{it-1} + \beta_6\, M/B_{it-1} + \beta_7\, ROA_{it-1} + \beta_8\, Leverage_{it-1} + c \qquad (1)$$

The dependent variable $Acquisition_{it}$ is taken as the number of acquisitions pursued by a firm 'i' in a year 't'. This variable measures the extent to which technological firms engage in acquisition activities over time. The key independent variable $Change\ in\ Patents_{it+2}$ is measured as the percentage change in the cumulative patent value of a firm in the next 2 years assuming that no acquisition takes place in between those 2 years so as not to include the patent value of the acquired firms while calculating the 2 year ahead value of patents. All the regressions in this study are run using robust standard errors. The value of a patent is determined by the number of citations a patent receives. In a specific year, the cumulative value of all patents possessed by a firm is thus calculated as the summation of values of all valid patents in that year. Since I hypothesize that technological firms use acquisitions as a substitute to internal innovation in the event of declining patenting activity, I expect this independent variable to be negatively correlated with the number of acquisitions which will imply that technological firms do resort to acquisition activities to compensate for declining innovation.

Since all the patents considered in the analysis belong to the category of utility patents, the life-term of a patent is considered to be 20 years if it was filed after June 8, 1995 (Section 532(a)(1) of the Uruguay Round Agreement Act). However, before that period, the life-term of a patent is taken as greater of 20 year term from filing and 17 years from grant.

Within the technological firms also, all are not equally R&D intensive (Wagner, 2007). Some of the industries are considered more R&D intensive as compared to others. Information Technology and Pharmaceutical industries are examples of such industries in which innovation plays a more dominant role in their operations. Hence, I analyze the causal effect of *Change in Patents* on *Number of Acquisitions* adding an interaction term *Change in Patents * Hitech* to Equation (1). I categorize the firms in my dataset into Hi-tech and Non Hi-tech based on classification of SIC codes as High Technology documented by Kile and Phillips (2009). Hence, to isolate the causal effect of $Change\ in\ Patents_{it+2}$ in Non Hi-tech industries from Hi-tech industries, I run the below stated fixed effects regression using firm-year panel data.

$$Acquisition_{it} = \alpha_0 + f_i + \beta_1\, Change\ in\ Patents_{it+2} + \beta_2\, R\&D_{it-1} + \beta_3\, Size_{it-1} + \beta_4\, Cash_{it-1} + \beta_5\, Sales_{it-1} + \beta_6\, M/B_{it-1} + \beta_7\, ROA_{it-1} + \beta_8\, Leverage_{it-1} + \beta_9\, Change\ in\ Patents_{it+2} * Hitech + c \qquad (2)$$

Along with *Number of Acquisitions* which indicates the number of acquisitions pursued by the firm, I use another measure of acquisition intensity as *Value of Acquisitions* to highlight the desperation level of a technological firm in case of declining innovation and strengthen my findings obtained from Equations (1) and (2). I construct *Value of Acquisitions* variable taking the natural logarithm of raw value of acquisitions. I run both the equations replacing *Number of Acquisitions* with *Value of Acquisitions* to test my hypothesis.

In addition to investigating the effect of declining innovation on tendency of technological firms to acquire target firms, I estimate the causal effect of *Change in Patents* variable on *R&D Intensity* of a technological firm. The traditional way to regain lost innovation is through greater investment in R&D activities so that new unique innovative products can be developed. Hence, I evaluate the motivation of technological firms to increase their internal R&D expenditures in order to compensate for the declining patenting activity. Using firm-year panel data, I run the below stated regression model:

$$R\&D_{it} = \alpha_0 + f_i + \beta_1 \, Change\ in\ Patents_{it+2} + \beta_2 \, Size_{it-1} + \beta_3 \, Cash_{it-1} + \beta_4 \, Sales_{it-1} + \beta_5 \, M/B_{it-1} + \beta_6 \, ROA_{it-1} + \beta_7 \, Leverage_{it-1} + c \quad (3)$$

I expect internal *R&D intensity* to be negatively correlated with *Change in Patents* since a technological firm will focus more on internal R&D activities when its innovation assets are declining. I analyze the effect of innovation intensity on internal R&D intensity for all technological firms included in the sample and later on, dividing the sample into two sub-samples – one of Hi-tech firms and another including Non-Hitech firms since I may find a different behavior implying difference in motivation to focus on internal R&D activities.

B. Testing Hypothesis 2: Acquisitions positively affect firm's internal R&D intensity

To test the second hypothesis, I estimate the causal effect of one year lagged acquisition intensity (at time 't-1') on R&D intensity at time 't'. Using firm-year panel data, I run a firm fixed effects regression:

$$R\&D_{it} = \alpha_0 + f_i + \beta_1 \, Acquisition_{it-1} + \beta_2 \, Size_{it-1} + \beta_3 \, Cash_{it-1} + \beta_4 \, Sales_{it-1} + \beta_5 \, M/B_{it-1} + \beta_6 \, ROA_{it-1} + \beta_7 \, Leverage_{it-1} + c \quad (4)$$

While analyzing effect of acquisition activities on firm's internal R&D intensity, I use both measures of acquisitions intensity, namely *Number of Acquisitions* and *Value of Acquisitions*. I expect firms to be more motivated towards focusing on firm's internal innovation due to synergistic gains from target firm post-acquisition and hence, foreseeing generation of innovative differentiated products using knowledge base of both acquirer and target firms. If acquisitions intensity is found to be positively correlated with R&D intensity, I conclude that acquisitions positively affect firm's internal R&D intensity.

C. Testing Hypothesis 3: Acquisitions positively affect firm's innovation output

To test the third hypothesis, I estimate the causal effect of acquisition intensity at 1-year, 2-years and 3-years lagged time intervals on acquirer's cumulative patent value. Using firm-year panel data, I run the below stated firm fixed effects regression:

$$Acquirer\text{-}Patent_{it} = \alpha_0 + f_i + \beta_1 \, Acquisition_{it-n} + \beta_2 \, Size_{it-1} + \beta_3 \, Cash_{it-1} + \beta_4 \, Sales_{it-1} + \beta_5 \, M/B_{it-1} + \beta_6 \, ROA_{it-1} + \beta_7 \, Leverage_{it-1} + c \quad (5)$$

In hypothesis 2, I investigate the effect of acquisition intensity on firm's internal R&D intensity which is a measure of innovation input. In hypothesis 3, I investigate its effect on innovation output. Innovation output can also be measured by two different patent metrics – number of patents and patent citation count. Since patent value is extremely skewed with a few patents being highly valuable (Griliches et al. 1987), I use patent citations as the appropriate measure of patent intensity. I expect acquiring firms to increase their innovation output after acquisitions. Hence, if acquisitions intensity is found to be significantly positively correlated with acquirer's patent value in all the regressions, I conclude that acquisitions positively affect firm's innovation output.

D. Control Variables:

In all the regressions performed, I control for certain firm characteristics which can affect a technological firm's likelihood to engage in acquisitions or alter its internal R&D intensity. I consider one year lagged values of all the control variables mentioned below:

R&D intensity: R&D intensity for a firm in a specific year is measured by dividing its R&D expenditures by its total assets in that year. Previous literature shows that corporate acquisitions serve as a substitute for innovation (Hitt et al. 1991). Hence, I expect that R&D intensity should be negatively correlated with a firm's propensity to engage in acquisitions.

Size: Size for a firm is calculated by taking natural logarithm of its assets in a particular year so as to limit the large variance exhibited by different firm's assets and make the regression model run successfully. Size of a firm should be positively correlated with the firm's propensity to engage in acquisitions and negatively associated with internal R&D intensity as shown previously in the literature also (Philips and Zhdanov, 2012).

Cash: Cash for a firm in a specific year is measured by dividing its total cash by its total assets in that year. I expect cash to be positively associated with a firm's propensity to engage in acquisitions as well as increasing internal R&D intensity.

Sales: Sales for a firm in a specific year is measured by dividing its total sales by its total assets in that year. Previous literature has found sales to be positively correlated with the probability of acquiring firms to engage in acquisitions (Bena and Li (2014), Wagner (2007)).

M/B: M/B variable is constructed by dividing Market Value of Assets by Total Value of Assets. This ratio signifies a firm's overvaluation or undervaluation in relation to its actual assets (Shleifer and Vishny, 2003). Bena and Li (2014) find this ratio to be positively correlated with a firm's propensity to engage in acquisitions.

ROA: ROA is calculated by dividing EBITDA by total assets of the firm. This variable shows the productivity of a firm to generate asset returns. I expect it to be positively associated with the likelihood of engaging in acquisitions as well as with increasing internal R&D intensity.

Leverage: Leverage is calculated by dividing the sum of current and long term liabilities by the market value of assets. This variable reflects the financial condition of a firm. I expect it to be negatively correlated with both the firm's propensity to engage in acquisitions and internal R&D intensity since high leverage denotes high risk due to excessive debt and hence, limited capacity to engage in any non-operational significant investments.

V. Data and Descriptive Statistics

In this empirical study, I investigate the relation between innovation and corporate acquisitions pursued by the technological firms. Hence, I need to extract data pertaining to these two behavioral characteristics of a technological firm. The literature has been arguing on finding the most precise system of measurement to quantify innovation, however, the research is still going on. In this study, I use patent metrics as an indicator of innovation quantity and quality. Hence, to conduct my empirical research, I need relevant information related to patents and corporate acquisitions. To isolate the inter-relation between these two variables, I need firms' other financial variables to be used as control variables during the regression analysis. I start with extracting all this information to construct the data sample.

A. Sample Construction

To extract data on U.S. patents and patent citations, I retrieve the required information about 4,130,385 patents from the Harvard Patent Database which is a publicly accessible database and provides information about the patent number, patent citation date, citing patents and number of patent citations along with several other patent characteristics. It is one of the most comprehensive datasets on patents and provides the concerned information for the period 1975-2010. Since this database does not provide any information about the patent owner which is one of the key variables for my research work, I search for another patent database filling that void in the data collection. The respective information is obtained from Patent Data Series compiled by Kogan, Papanikolaou, Seru and Stoffman (KPSS database) which provides information about patent owner in the form of stock identifier 'permno' along with other useful information such as patent filing date and grant date for 1,927,579 patents for the period 1920 – 2010. To obtain a comprehensive patent dataset including information on both patent citations and patent owner, I merge both these datasets on 'patent number' variable. As a result, I get an integrated patent dataset encompassing required information on 1,408,851 patents for the period 1975 – 2010.

To collect the data related to M&A deals, I extract the same from Mergers and Acquisitions database of Thomson One database. I filter the database including all completed Mergers and Acquisitions deals with the acquirer nation as 'United States of America' for the period 1971-2014 which presents me with 230,632 M&A deals. I drop the duplicates from the M&A data extracted and include only the deals where acquirer owned less than 50% stake in the target firm before transaction and increased its ownership stake to more than 50% after transaction. This dataset includes the key identifier as '6-digit CUSIP' for both the acquiring and target firms. Since CUSIP codes may change over time due to merger events taking place and may get reassigned to a different firm, 6-digit CUSIP cannot be considered as a permanent identifier for a firm. So, I extract 'NCUSIP' codes corresponding to 6-digit CUSIPs from the Center for Research in Security Prices (CRSP) and match them to 6 digit CUSIP and acquisition date in the acquisitions dataset. The same issue exists in the integrated patent dataset which contains 'permno' as the key identifier for the firms and to resolve the issue; 'NCUSIP' is matched with 'permno' and respective patent filing date. The observations corresponding to M&A deals after 2010 are dropped from the acquisitions dataset. I estimate the patent value of all the firms in the patent dataset by summing up the number of citations of all the valid patents in a given year. Hence, the total patent value is obtained for a given firm-year in the patent dataset.

Both the acquisitions and integrated patent dataset are merged together on 'NCUSIP' key variable keeping all the unmatched observations in the combined dataset. The intention behind doing this is to include those technological firms also in the sample which never engaged in M&A deals and at the same time ensuring randomization in the sample construction process. Since in my research work, I evaluate the quality of technological innovation on the basis of patent metrics only, the acquiring firms which never owned any patent are considered as non-technological firms and hence, are dropped from the dataset. Since many of the acquiring firms also get subsequently acquired by some other firm, I also account for these acquisitions by adding the respective patent values (including the patent values of their targets) of the targets which were once the acquirers in the sample to the patent value of the acquiring firm.

I extract information on the firm characteristics such as financial leverage, assets etc. to be included as control variables in the regression analysis from CRSP CompuStat for all U.S. stocks over the period 1975-2010 and merge this information with the merged acquisitions-patent dataset constructed earlier. The final panel dataset thus obtained contains information on 5410 technological firms belonging to 915 industries classified by primary SIC code for the period 1975 – 2010.

B. Sample Overview

The final sample obtained is a panel dataset over the period 1975 – 2010 consisting of technological firms which protect their inventions in the form of patents and engage in corporate acquisitions over time. Some of the technological firms included in the dataset are those firms which never engage in acquisitions. The sample is filtered to obtain a sub sample consisting of only those technological firms which engaged in acquisitions atleast once throughout the whole sample.

From Table 1, we can clearly see that the corporate acquisitions before 1981 are not documented properly in the available resources. Hence, the data on acquisitions prior to 1980 could not be obtained properly. It is clearly visible that the technological firms increased their reliability on mergers and acquisitions from 1993 to 2000 with 2001 experiencing a significant dip in M&A deals. However, it again gained momentum from 2003 onwards till 2007, after which the period of global recession again brought the downfall of this economic activity. We can clearly notice a continuous climb in both the number of patents and number of citation weighted patents issued to the firms over time, clearly proving the acceptance of this intellectual property asset among technological firms to protect their inventions.

[TABLE 1]

C. Summary Statistics

Table 2 presents the summary statistics for the whole sample constructed using patent metrics, M&A and accounting information for 5410 technological firms classified over 915 industries over the period 1975 – 2010.

[TABLE 2]

Panel A of Table 2 reports the mean, standard deviation and median values of all the variables used in the analysis for the complete dataset constructed. As can be seen from the table, the median value of the number of patents a technological firm obtains in a year is 1 whereas the standard deviation of this variable is 123.831 which implies that the distribution of the number of patents a technological firm is granted in an year is highly skewed. Hence, I conclude that the sample contains technological firms with varying degrees of innovativeness which is evident from the fact that all industries are not equally research intensive and therefore, show different patenting intensity. This skewed distribution is even more clearly reflected in the number of patent citations a firm receives in a year. The median value of patent citations is 5 whereas its standard deviation is 1855.677. Thus, both innovation quantity and quality may vary from industry to industry as well as from year to year. The median value of number of acquisitions pursued by a firm is 0 whereas the mean value is 0.283 along with a high standard deviation. The same pattern is observed in value of acquisitions whose median is 0 however mean is 0.444 and standard deviation is 1.437. Most of the firms in the sample spend 4.3% of their total assets on R&D activities every year however this parameter also exhibits a large standard deviation of 15.7% which again confirms the varying R&D levels across different firms. There isn't much variation found in the size of the firms. Most of the firms in the sample keep 4.8% of their assets as liquid assets in the form of cash whereas this behavior also varies a lot inside the sample as depicted by standard deviation of 14%. The median value of Return on Assets is found to be 12.6% which exhibits a high variation with a standard deviation of 24.6%.

The complete sample includes technological firms which engage in acquisitions over time and also those which never engaged in acquisitions even once in their whole life term. Hence, I investigate the difference in characteristics of these two kinds of technological firms. Panel B of Table 2 presents the summary statistics for those technological firms which engaged in acquisitions atleast once whereas Panel C of Table 2 includes the same for those technological firms which never engaged in acquisition even once in their whole life term. From the summary statistics, I don't find much difference in characteristics of these two kinds of firms. The firms which never engaged in acquisitions are found to possess a little higher innovation quantity and quality than firms which engaged in acquisitions as evident from the median value of number of patents, patent citations and growth in innovation output of both these kinds of firms in a year. However, the non-acquiring firms are found to be little smaller in size and relatively undervalued. The non-acquiring firms generate lesser returns on their assets and are more leveraged than the acquiring firms.

Since there is so much variation observed in the innovation characteristics of different technological firms as observed in Panel A of Table 2, following Kile and Phillips(2007) I try to categorize the sample into two broad categories – Hitech and Non-Hitech. Kile and Phillips (2007) classify industries based on SIC codes as high technology due to their relatively very high research intensive nature. Hence, I investigate the difference in characteristics of firms falling in Hitech and Non-Hitech industries in Panels D and E of Table 2. The median value of number of patents produced in a year by a Hitech firm is found to be 2 whereas this value is 1 for Non-Hitech firms. The median value of patent citations a Hitech firm receives in a year is 19 whereas it is 10 for a Non-Hitech firm. Similarly, the growth in innovation output exhibited by a Hitech firm is twice as that of a Non-Hitech firm. All these parameters completely justify the classification of technological firms into Hitech and Non-Hitech due to differences in innovation behavior of these two kinds of firms. The number of acquisitions a Hitech firm pursues in a year on average is also higher than a Non-Hitech firm but the difference is not relatively that large as observed for innovation characteristics. A large difference can be observed in the R&D intensity of Hitech firms as compared to Non-Hitech ones. R&D intensity for Hitech firms is found to be almost 5 times the value for Non-Hitech firms. Moreover, Hitech firms keep 12% of their assets as cash which is 4 times the value for Non-Hitech firms. This suggests that Hitech firms prefer to look for interesting profitable investment opportunities keeping more liquid assets so that they can fully exploit them whenever they encounter them. Hitech firms are also found to be a little overvalued in comparison to their Non-Hitech counterparts. Non-Hitech firms, on the other hand, are generally larger in size, generating more returns on their assets and almost 4 times more leveraged in comparison to the Hitech firms.

VI. Results

A. Declining Innovation and Propensity to engage in Acquisitions

I first study the relation between innovation output and a technological firm's decision to engage in acquisitions which is reflected in *Number of Acquisitions* pursued by the firm as the dependent variable. I present the results obtained from running a firm fixed effects Poisson regression on a large panel dataset over the period 1975 – 2010 in Table 3. As described earlier, I measure innovation output by count of patent citations rather than number of patents due to its superior predictive power about innovation quality. The key explanatory variable here is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years.

[TABLE 3]

Results in Table 3 show that *Change in Patents* exerts a negative causal effect on *Number of Acquisitions*. As can be seen in Table 3, the standard error of this variable is relatively large, still this negative relation is found to be statistically significant at 10% levels of significance which shows that technological firms are more likely to engage in acquisition activities when their innovation output is declining. The marginal effect of the *Change in Patents* variable suggests that one unit standard deviation percent decrease in firm's patent value in next two years leads to an increase of 2.79 percentage points in number of acquisitions pursued. If the number of acquisitions had previously been at its sample mean value (0.283), the number of acquisitions would have increased by 10%. Hence, I conclude that the relation between innovation output and acquisition intensity of a technological firm is economically significant. The results justify the first hypothesis that technological firms tend to rely on acquisitions in case of declining patenting activity.

The results in Table 3 also show that *R&D* intensity of a technological firm is positively correlated with its acquisition intensity, the relation being statistically significant at 5% levels of significance. Hence, I conclude that due to interdependence of various sectors in a technological field, firms supplement their increasing R&D intensities with acquisition activities to overcome the fierce competition and compensate for the declining innovation output. *Size* of a firm is positively associated with its acquisition intensity which is consistent with the results found by Philips and Zhdanov (2012). *Cash* reserves of a firm are positively related to the likelihood of a firm acquiring a target firm which shows that firms use their liquid resources to take advantage of useful investment opportunities. *Market to Book Ratio* is found to be positively related to number of acquisitions pursued by a firm. This result is consistent with the findings by Bena and Li (2014). *Return on Assets* is positively correlated with the acquisition intensity of a firm which suggests that greater operational efficiency of a firm positively affects its tendency to engage in acquisitions as acquirers. Higher financial *leverage* is found to be negatively correlated with the acquisition intensity of a firm. Firms with high debt on their balance sheets are considered to be more risky and hence, possess limited financial resources to invest in the interesting acquisition opportunities.

B. Comparing Acquisition Intensity of Hitech with Non-Hitech firms

Zhao (2009) investigates the innovative behavior of 48 different Fama French industries and shows that all technological industries are not equally research intensive in terms of number of patents, count of patent citations and R&D intensity and exhibit a large amount of variation. The study reveals that technological innovation is not restricted to high-tech industries only and is a major concern for several industries including food, retail, transportation etc. which are not considered highly R&D intensive. Based on these findings, I anticipate a significant variation in the impact of declining innovation intensity on the acquisition behavior of firms in different industries. Using the classification of different industries as High Technology Industries done by Kile and Phillips (2009), I classify a set of industries in my sample as Hitech whereas rest of the industries are classified as non-Hitech. To isolate the acquisition behavior of Non-Hitech from Hitech industries due to declining innovation, I introduce an interaction term *Change in Patents * Hitech* in the regression model, where *Hitech* is a dummy variable equaling 1 for Hitech industries and 0 for Non-Hitech industries. Rest of the regression equation remains the same with the same control variables.

Table 4 reports the results obtained from running the firm fixed effects Poisson regression with *Number of Acquisitions* as the dependent variable and *Change in Patents* as the independent variable. Table 4 includes several exhibits from the same regression model in order to investigate the similarities or differences in acquisition behavior of Hitech and Non-Hitech industries. As can be seen from Table 4, results from all the exhibits indicate that *Change in Patents* variable is negatively related to acquisition intensity of Non-Hitech firms. The results are found to be statistically significant at 1% level of significance this time whereas the similar negative causal effect of declining innovation on acquisition intensity was found to be statistically significant at 10% levels of significance in Table 3. Thus, after adding for the interaction term, the negative causality of declining innovation on acquisition intensity becomes more prominent which leads to a conclusion that Non-Hitech firms display a greater tendency to rely upon acquisitions in the event of declining internal innovation.

[TABLE 4]

To observe the causal effect of declining innovation on number of acquisitions for Hitech firms, I divide my whole dataset sample into two sub-samples consisting of firms from Hitech and Non-Hitech industries. Thus, I run Equation 1 for both the sub-samples separately and document the results obtained in Table 5. Results shown in Table 5 obtained from running the fixed effects Poisson regression using *Change in Patents* as key independent variable and *Number of Acquisitions* as dependent variable show that *Change in Patents* variable is negatively correlated with acquisition intensity for both Hitech and Non-Hitech firms, however, the coefficient is found to be statistically insignificant for Hitech firms as opposed to statistically significant at 5% levels of significance for Non-Hitech firms. Moreover, the magnitude of the negative coefficient for Hitech firms is found to be quite smaller than that for Non-Hitech firms. Thus, the effect of declining innovation on the likelihood to engage in acquisitions is found to be comparatively less intense for Hitech firms in comparison with Non-Hitech firms.

[TABLE 5]

I verify first hypothesis using *Value of Acquisitions* as a measure of acquisition intensity keeping all the independent variables as same as in above analysis. Table 6 reports the results obtained from running a fixed effects OLS regression to estimate the causal effect of *Change in Patents* on *Value of Acquisitions* as the dependent variable. As can be seen from Table 6, *Change in Patents* is negatively correlated with *Value of Acquisitions* when the regression is run without including the interaction term *Change in Patents * Hitech.* However, the coefficient is found to be statistically insignificant, hence no specific conclusion can be derived regarding the investment in corporate acquisitions as a response to declining innovation. The similar results are obtained when the regression model is run after including the interaction term. Hence, Hypothesis 1 could be verified using Number of acquisitions as a measure of acquisition intensity but not using investment in acquisitions.

[TABLE 6]

C. Declining Innovation and Internal R&D Intensity

Above I have investigated the effect of declining innovation on tendency of technological firms to acquire target firms. However the traditional way to generate innovation assets is through greater investment in R&D activities so that new unique innovative products can be developed. In this section, I evaluate the motivation of technological firms to increase their internal R&D expenditures in order to compensate for the declining patenting activity. I estimate the causal effect of *Change in Patents* variable on *R&D Intensity* of a technological firm. Table 7 reports the results obtained from running a firm fixed effects OLS regression for all technological firms in the sample including both Hitech as well as Non-Hitech firms. As can be seen clearly from Table 7, *Change in Patents* is negatively correlated with Internal *R&D intensity* of the firm, however, the coefficient is found to be statistically insignificant. Hence, no specific conclusion can be derived from the results regarding whether declining innovation output motivates the technological firms to focus on internal research and development activities. However, a significant negative relation was found between innovation intensity and acquisitions intensity in the analysis performed earlier which indicates that corporate acquisitions may be the preferred method over innovating internally for regaining lost innovation assets.

[TABLE 7]

The results also show that *size* of a firm is negatively correlated with internal *R&D* intensity. Hence, a firm at a younger age remains more motivated to innovate internally than acquiring it from external sources which works quite differently for firms having attained maturity, which prefer to acquire innovation through external sources. This finding is consistent with that of Phillips and Zhdanov (2012) who conclude that smaller firms use their internal innovation output to enable them get acquired by the larger firms and gain a higher acquisition premium. *Sales* is found to have a positive causal effect on internal *R&D* intensity of a firm. Internal *R&D* intensity is found to be negatively correlated with *Market to Book Ratio*, *Return on Assets* and *Leverage* of a firm. This implies that firms on being undervalued relative to their assets focus on internal R&D activities so that they can produce innovative products using which they can subsequently increase their market value. Firms not being able to generate enough returns on their assets also increase their internal R&D intensities. Firms with high leverage face high risk and have limited financial capacity to invest in their R&D activities and hence are not able to focus on internal R&D activities. This finding is consistent with that of Kazuo Ogawa (2007) who investigates the effect of outstanding debt on firms' R&D activities in research intensive industries based on a panel dataset of manufacturing firms in Japan during 1990s and finds that outstanding debt has a significantly negative effect on R&D investments.

I further divide the whole sample into two sub-samples containing firms in Hitech and Non-Hitech industries separately. In the analysis performed earlier to investigate the effect of declining innovation on acquisition intensity of firms, Non-Hitech firms were found to be involved more prominently in acquiring target firms to compensate for their declining innovation whereas a significant correlation was not found for Hitech firms. Hence, I may observe a different behavior regarding focusing on Internal R&D intensity to complement the declining innovation. I estimate the causal effect of *Change in Patents* on Internal *R&D Intensity* running a fixed effects OLS regression separately for both the sub-samples and list the results obtained in Table 8.

Results reported in Table 8 show that *Change in Patents* is negatively related to Internal *R&D Intensity* for Hitech firms. This negative causal effect is statistically significant at 10% levels of significance. The magnitude of the coefficient suggests that one unit standard deviation percent decrease in firm's patent value leads to an increase of 0.324 percentage points in internal R&D

intensity of the Hitech firm. If the internal R&D intensity of a Hitech firm would previously have been at its mean value (0.139), the internal R&D intensity would have increased by 2.33%. However, no specific conclusion can be drawn regarding the causal effect of *Change in Patents* on *R&D Intensity* for Non-Hitech firms since the coefficient obtained is statistically insignificant.

[TABLE 8]

D. Post-Acquisition Innovation Performance

I have already established one of the primary sources of motivation behind engaging in corporate acquisitions by technological firms which is acquiring innovation from target firms to compensate for the declining internal innovation. But it is unclear what happens to innovation performance of the acquiring firm in the subsequent years after the acquisition is successfully completed. An acquisition may prove very beneficial for the acquiring firm and can help it beat its rivals in the intensely competitive markets with its unique innovative products. However, there may arise a situation when the acquisition goes terribly wrong if the target firm doesn't get successfully integrated into the acquirer in which case it may negatively affect the post-acquisition performance of the acquiring firm. Therefore, I investigate the post-acquisition innovation performance of the acquiring firms using the same firm-year panel dataset used for previous analysis over the period 1975 – 2010. I measure post-acquisition innovation performance with two parameters – Post-acquisition Internal R&D Intensity and Post-acquisition Acquirer's Cumulative Patent Value as a proxy for Internal Innovation Output.

To test my second hypothesis that acquisitions positively affect firm's internal R&D intensity, I run a fixed effects OLS regression to estimate the causal effect of One-year lagged *Number of Acquisitions* along with control variables on *Internal R&D Intensity* as the dependent variable. Table 9 reports the coefficient estimates obtained from running the regression model. As can be seen from Table 9, *Number of acquisitions* has a positive causal effect on Post-Acquisition Internal *R&D Intensity*. The coefficient estimate obtained is statistically significant as evident from six out of seven different exhibits of the regression model. Hence, I conclude that firms experience increase in internal R&D intensity due to synergistic effects of acquisitions.

[TABLE 9]

I strengthen my claim running another regression model with *Value of Acquisitions* in place of *Number of Acquisitions* as the key independent variable while keeping all other variables as the same. Table 10 reports the coefficient estimates obtained from running this regression. It can be seen clearly from Table 10 that *Value of Acquisitions* is also significantly positively related to Internal *R&D Intensity* of the firm which proves that acquisitions have a positive effect on acquiring firm's motivation to innovate.

[TABLE 10]

The results obtained are consistent with the findings of Hoberg and Phillips (2010) that technological firms acquire the target firms which share asset complementarities with their internally generated products. Thus, these kinds of acquisitions enable the acquiring firms to develop differentiated unique products using the innovation and knowledge base of target firms. As concluded earlier that firms tend to rely upon acquisitions to regenerate innovation assets, they see the combined innovation of both acquirer and target as an opportunity to build upon the existing knowledge and gain an upper hand by focusing more on internal innovation so as to create highly unique innovative products. Thus, I validate my second hypothesis that acquisitions positively affect firm's internal R&D intensity.

Having established the positive impact of acquisitions on the acquiring firm's innovation input in the post-acquisition period, I investigate the relation between acquisitions and firm's internal innovation output in the post-acquisition period to empirically test my third hypothesis that acquisitions positively affect firm's innovation output. I measure firm's innovation output by its patent citation count since it is a better indicator of innovation quality. I run a firm fixed effects OLS regression model with *Innovation Output* after 1 year of acquisition as the dependent variable and *Number of Acquisitions* as the independent variable and present the results in Table 11. As can be seen from Table 11, results obtained show that *Number of Acquisitions* is significantly positively associated with post-acquisition *Innovation Output* (measured by patent citation count) in all the exhibits of the regression model. Following the same strategy opted for validating second hypothesis; I again run another regression model with *Value of Acquisitions* in place of *Number of Acquisitions* as the key independent variable while keeping all other variables as the same. Table 12 reports the coefficient estimates obtained from running this regression. It can be seen clearly from Table 12 that *Value of Acquisitions* is significantly positively related to *Innovation Output* of the firm which proves that acquisitions have a positive effect on Post-acquisition Innovation output of the acquiring firm. Thus, I conclude that after acquisitions, firms are able to significantly improve their innovation output.

[TABLE 11, TABLE 12]

VII. Robustness Checks

In my original sample, I had included technological firms which were innovative as reflected by their patent productivity but didn't acquire any target firm over the whole period 1975 – 2010. A possible concern regarding the results obtained would be whether those were biased due to inclusion of the technological firms which never engaged in acquisitions over their whole life term. So, I examine the possibility of any sample selection bias impacting the regression results obtained earlier by including only those firms in the sample which had acquired atleast once in their life term. I present the results obtained from running the respective regression models to validate hypothesis 1, 2 and 3 in Tables 13, 14 and 15. As can be seen from the tables, I obtain similar results as obtained earlier, hence validating the robustness of all the results obtained so far. I conclude that the sample constructed for the analysis does not suffer from any selection bias and achieves proper randomization which is a necessary condition for the sample to be true representative of the entire population. Hence, I validate the conclusions I earlier drew from the analysis that technological firms tend to rely upon acquisitions to compensate for their declining innovation and acquisitions positively affect the acquiring firm's innovation performance reflected in the improved internal R&D intensity and innovation output in the post-acquisition period.

[TABLE 13, TABLE 14, TABLE 15]

In my previous analysis, I found the relation of acquisitions intensity with declining innovation of an acquiring firm using fixed effects Poisson regression model with *Number of acquisitions* as the dependent variable and *Change in Patents* as the independent variable. Now I evaluate the robustness of the results estimated using Poisson regression model with Conditional Logit regression model. I introduce two dummy variables into my dataset – ‘Acquisition’ and ‘Declining Patent’. ‘Acquisition’ takes the value of 1 if the firm engages in any number of acquisitions in that year; otherwise it takes on the value of zero. ‘Declining Patent’ takes on the value of 1 if the cumulative patent value of the firm decreases or remains the same from time ‘t’ to time ‘t+2’ years, otherwise this variable is valued as 0. I run the firm-fixed effects logit model bootstrapping all the groups signifying different acquiring firms. Thus, I attempt to verify robustness of the results across different kinds of regression models also to eliminate the possibility of regression results being specific to any particular type of regression model. Table 16 reports the coefficient estimates obtained from running the conditional firm fixed effects logit regression model. Results obtained verify the robustness of the result that declining patenting activity has a significant positive effect on propensity of technological firms to engage in acquisitions.

[TABLE 16]

Next, I run a firm fixed effects OLS regression model used to test the second hypothesis that acquisitions positively affect firm’s internal R&D intensity, using Post acquisition Internal R&D intensity as the dependent variable and Number of acquisitions as the independent variable. I earlier tested the hypothesis analyzing the effect of acquisitions on internal R&D intensity one year after acquisition. Here I test the robustness of the causal effect of acquisition event on acquiring firm’s motivation to innovate after 2 years of acquisition (at time ‘t+2’). I report the coefficient estimates obtained from running the regression in Table 17. The results prove that acquisitions have a significant positive impact on post-acquisition internal R&D intensity of the acquiring firm even after 2 years of the event, hence validating the robustness of this causal effect.

[TABLE 17]

Similarly, I check the robustness of the causal effect of acquisition event on post-acquisition innovation output of the acquiring firm as analyzed earlier while testing third hypothesis. Earlier I had analyzed the effect of acquisition on innovation output of the acquiring firm just one year after the acquisition and had found a significant positive effect on innovation output. However, the impact of the acquisition should be more long-lasting than just one year since acquiring firms would want to draw maximum possible benefit from the acquired target firm even though the effect of acquisition on acquiring firm's internal R&D intensity may be not that much long-lasting. So, I here run a fixed effects OLS regression model using acquiring firm's *Innovation Output* (cumulative patent value measured by patent citation count) as the dependent variable and 2-year lagged *Number of acquisitions* as the key independent variable. Next, I perform the same analysis using 3-year lagged *Number of acquisitions* as the key independent variable to verify the long-lasting impact of the acquisition on innovation output and present the results in Table 18. Analogous to the methodology adopted, I verify the post-acquisition innovation output of the acquiring firm using both 2-years and 3-years lagged values of acquisitions as key independent variables and report the results in Table 19.

As can be seen from both the tables 18 and 19, both *Number of acquisitions* and *Value of acquisitions* are significantly positively related to post-acquisition *Innovation Output* of the acquiring firm. Hence, results obtained validate the robustness of the positive causal effect of acquisition activity on innovation output of the acquiring firm, thus proving that acquisitions positively impact the innovation output of the acquiring firms.

[TABLE 18, TABLE 19]

VIII. Conclusion

In this empirical study, I investigate the relation between technological innovation, corporate acquisitions and internal R&D intensity in technological firms. The past literature has proven how important role innovation plays in the technological firms. Infact innovation is the backbone of these R&D intensive firms. Companies those are unable to innovate lag behind their competitors and operate inefficiently. Innovation is the key factor that separates market leaders from their rivals.

Most of the technological firms try to prevent their innovations in the form of patents. The researchers have proposed many metrics for quantifying innovation; however the most acceptable till now has been one incorporating the use of patent metrics. Many researchers in the past quantified innovation by number of patents; however, since number of patents does not tell anything about the quality of the patent, a better measure is needed. Trajtenberg (1990) proposes the idea of measuring the value of a patent based on its citation count. This idea is later validated by Harhoff et al. (1999) and Hall et al. (2000); and has now become a well-accepted metric for measuring innovation. Hence, I also use patent citation count for measuring the value of a patent. In order to develop a unique novel product, a firm has to incur huge research expenditures facing high risks which constitutes the biggest disadvantage of carrying out R&D activities and thus requires careful consideration.

To gain innovative products, an alternative for the firms besides increasing internal R&D investments is to acquire other firms possessing unique innovation assets. Both the options seem equally likely but this matter becomes more eminent when the firm is nearing the expiration of its breakthrough patents. Hence, to explore the strategic behavior of technological firms, I investigate the causal effect of declining patenting activity on their propensity to engage in acquisitions and increasing their internal R&D intensity.

I extract patents related data from Harvard Patent database and Kogan, Papanikolaou, Seru and Stoffman (KPSS database) for 1,408,851 patents over the period 1975 – 2010. After merging this information with 230,632 M&A deals over the period 1971 – 2014 with acquirer nation as ‘United States of America’ and firm characteristics such as financial leverage, assets etc. to be used as control variables in the regression analysis, I construct a panel dataset containing information on 5410 technological firms belonging to 915 industries over the period 1975 – 2010. By running a firm-fixed effects regression of percent change in patent value of the firm along with control variables on number of acquisitions pursued by the firm, I show that change in patent value has a statistically significant negative causal effect on tendency of technological firms to engage in acquisitions, leading to the conclusion that technological firms tend to rely on acquisitions in case of declining patenting activity. I find that acquiring firms with an increased R&D intensity but lesser innovation output are more inclined towards acquisition activities. Size, cash reserves, market to book ratio and return on assets of a firm are found to be positively correlated with its likelihood to engage in acquisitions whereas greater financial leverage inhibits the tendency to engage in acquisitions.

All the technological industries are not equally research intensive as indicated by number of patents, patent citation count and R&D intensity (Zhao, 2009). The value attributed to innovation is different for firms belonging to different industries indicating different acquisitions behavior in response to declining innovation. Hence, to account for these differences, I analyze the causal effect of percent change in patent value on acquisitions intensity separately for Hitech and Non-Hitech firms, categorization done using Kile and Phillips (2009) and find that Non-Hitech firms show a more prominent tendency to rely on acquisitions to compensate for their declining innovation. The result is found to be statistically significant at 5% levels of significance for Non-Hitech firms whereas it is statistically insignificant for Hitech firms.

Further, I analyze the effect of declining innovation on the tendency of technological firms to increase their R&D expenditures which is the traditional way to generate innovative products. I find that *Change in Patents* has a negative causal effect on Internal *R&D* intensity of the firm, however, it is found to be statistically insignificant. In order to observe the research intensive behavior of Hitech and Non-Hitech firms separately in response to declining innovation, I evaluate the causal effect of change in patent value on internal R&D intensity for both Hitech and Non-Hitech firms separately and conclude that Hitech firms are more likely to increase their R&D expenditures to compensate for their declining innovation whereas as previously found, Non-Hitech firms are more likely to use acquisitions as a substitute to internal R&D to acquire innovation. The results also show that younger firms are more motivated to innovate internally whereas mature firms prefer to acquire innovation through external sources. *Sales* of a firm is found to be positively correlated with its internal R&D intensity whereas *Market to Book Ratio*, *Return on Assets* and *Leverage* are found to be negatively associated with R&D intensity.

Using the same firm-year panel dataset over the period 1975 – 2010 as used earlier, I further investigate the innovation performance of the acquiring firms, measured by both Internal R&D intensity and Internal Innovation Output (Cumulative Patent Value) of the acquirers after one year of acquisition. The study reveals that acquisitions positively affect a firm’s internal R&D intensity as the acquiring firms experience a significant increase in internal R&D intensity in post-acquisition period. Acquiring firms prefer to acquire target firms sharing product market complementarities and technological overlap to benefit from synergistic effects of acquisitions (Hoberg and Phillips (2010), Bena and Li (2014)). R&D intensity is an indicator of innovation input. So, I analyze the innovation output for acquiring firms in post-acquisition period by cumulative patent citation count and conclude that acquisitions positively influence innovation output of the acquiring firms as firms experience a significant improvement in their innovation output post acquisition.

A. Limitations

The major limitation of this research work is that technological innovation has been measured using patent metrics solely; however, technological firms may choose to secure their inventions using other intellectual property rights such as trade secrets instead of patenting them. I here consider those firms as technological firms which use patents as a tool to protect their inventions, without considering any other alternative of protecting the inventions. Even though the patent metrics are a well-accepted measure of innovation and patent citations provide a realistic measure of quality of patents, they pose another serious challenge. Future patent citations cannot be determined at the time of patent issuance and hence cannot provide information regarding the economic value of a patent. However, a superior measure to value a patent based on stock market reaction around the day of patent grant has been proposed by Kogan et al. (2012) who validate this measure with patent citations and find that stock market reaction is an efficient predictor of the number of citations a patent receives in future.

B. Implications for technological companies

The findings in this research work are especially important for the young entrepreneurial technological start-up firms wishing to get acquired by large firms and benefitting from high acquisition premium. These young start-ups can focus their research on producing unique innovative products and protect their inventions in the form of patents. In an active M&A market, they can serve as efficient sources for large technological firms sharing product market complementarity with them and nearing the expiration of their valuable patents to acquire innovation in a very less time. More competition among acquiring firms can help the target firms gain higher acquisition premiums. Additionally, the research findings suggest that by acquiring technologically overlapping target firms, acquiring firms can generate synergistic effects by significantly improving their internal R&D intensities and innovation output in the post-acquisition period.

C. Suggestions for further research

In this work, I conclude that technological firms tend to rely upon acquisitions in the case of declining patenting activity. Future research can be aimed at understanding whether acquiring firms prefer to acquire target firms possessing patents which can replace the acquirer's patents nearing expiration. In this work, I investigate the effect of acquisitions on innovation performance of the acquiring firms post-acquisition. Future research can investigate the effect on financial performance like stock returns etc. of acquisitions involving target firms possessing patents which can replace the acquirer's patents nearing expiration.

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Table 1

Corporate Acquisitions and Patents issued over 1975 – 2010

This table presents a sample overview of completed corporate acquisitions by the year of the announcement and patents issued every year indicating time trends over the period January 1, 1975 – December 31, 2010. Only those acquisitions are included where the acquirer nation is coded as 'United States of America', acquirer owned less than 50% stake in the target before acquisition and increased its ownership stake to more than 50% after acquisition. The number of patents along with citation weighted patents issued to all the acquiring firms in the sample are shown by their year of issuance over time.

Year	Number of acquiring companies (1)	Number of acquisitions (2)	Number of patents issued to acquirers (3)	Citation Weighted patents issued (4)
1975	0	0	9547	46476
1976	1	1	10000	49913
1977	0	0	9476	49051
1978	7	7	9662	50806
1979	4	4	6854	38485
1980	15	15	8554	53049
1981	129	151	9216	61294
1982	160	206	8347	58170
1983	224	307	8384	59448
1984	287	421	9714	71543
1985	137	205	10290	78841
1986	185	295	9909	76906
1987	217	343	11379	93142
1988	214	309	10021	86796
1989	276	429	12165	111429
1990	300	452	11110	102046
1991	286	441	12329	113025
1992	331	515	13028	122382
1993	358	587	13633	137091
1994	441	754	14861	159555
1995	467	861	15194	175206
1996	528	1015	17117	202458
1997	586	1183	17339	217944
1998	619	1272	23925	273992
1999	603	1352	25761	302363
2000	616	1289	26505	331011
2001	491	884	27418	372349
2002	453	798	29086	418170
2003	478	822	30633	471930
2004	532	957	30543	485254
2005	520	995	29875	639128
2006	504	1013	36018	879334
2007	497	1048	32055	851151
2008	462	898	32554	924464
2009	352	609	34437	1088299
2010	382	720	35630	1209843

Table 2

Summary Statistics

This table reports the summary statistics of all the variables included in the study. I analyze the firm characteristics for the whole sample over the period 1975 – 2010. The sample also includes the technological firms which never engaged in acquisitions even once in their life term. I analyze the sample based on both these categories – firms which engaged in acquisitions and those which never acquired even once to observe the differences in their characteristics if any. All technological firms are not equally research intensive. Hence, I divide the sample into Hitech and Non-Hitech firms based on classification done by Kile and Phillips (2009) using SIC codes and analyze them separately to observe the distinct characteristics of these two classifications. I measure innovation output using citation weighted patents which depict innovation quality along with quantity whereas number of patents alone show innovation quantity only. *Change in Patents* is measured as the percentage change in cumulative patent value of a firm in the next two years. *Value of Acquisitions* is measured as natural logarithm of raw value of acquisitions. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash, R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively.

	Mean	Standard deviation	Median	Observations
	Panel A: All firms in the sample			
Number of patents	21.725	123.831	1	51462
Citation Weighted patents	247.5611	1855.677	5	51462
Change in Patents	53.312	70.997	24.234	51462
Number of Acquisitions	0.283	0.869	0	51462
Value of Acquisitions	0.444	1.437	0	51462
R&D Intensity	0.086	0.157	0.043	51462
Size	5.676	2.304	5.467	51462
Cash	0.105	0.14	0.048	51462
Sales	1.137	0.649	1.082	51462
M/B	1.947	2.248	1.365	51462
ROA	0.082	0.246	0.126	51462
Leverage	0.163	0.157	0.125	51462

	Mean	Standard deviation	Median	Observations
	Panel B: Firms which engaged in acquisitions atleast once			
Number of patents	21.925	120.872	2	27295
Citation Weighted patents	258.5398	1957.707	6	27295
Change in Patents	48.676	68.202	22.365	27295
Number of Acquisitions	0.523	1.136	0	27295
Value of Acquisitions	0.837	1.887	0	27295
R&D Intensity	0.077	0.135	0.043	27295
Size	5.977	2.049	5.83	27295
Cash	0.1	0.127	0.05	27295
Sales	1.141	0.624	1.079	27295
M/B	1.93	2.019	1.424	27295
ROA	0.107	0.2	0.133	27295
Leverage	0.152	0.147	0.116	27295

Continued

	Mean	Standard deviation	Median	Observations
	Panel C: Firms which never engaged in acquisitions			
Number of patents	21.500	127.091	1	24167
Citation Weighted patents	256.342	1743.436	10	24167
Change in Patents	58.484	73.647	26.937	24167
R&D Intensity	0.096	0.178	0.042	24167
Size	5.335	2.519	4.932	24167
Cash	0.110	0.154	0.045	24167
Sales	1.132	0.676	1.086	24167
M/B	1.967	2.484	1.285	24167
ROA	0.054	0.286	0.116	24167
Leverage	0.175	0.166	0.138	24167

	Mean	Standard deviation	Median	Observations
	Panel D: Hitech Technological firms			
Number of patents	27.968	160.815	2	18640
Citation Weighted patents	438.482	2906.037	19	18640
Change in Patents	68.347	77.104	37.500	18640
Number of Acquisitions	0.320	0.981	0	18640
Value of Acquisitions	0.513	1.514	0	18640
R&D	0.139	0.200	0.089	18640
Size	5.146	2.202	4.876	18640
Cash	0.171	0.175	0.117	18640
Sales	0.915	0.545	0.873	18640
M/B	2.564	2.764	1.765	18640
ROA	0.015	0.333	0.100	18640
Leverage	0.101	0.132	0.047	18640

	Mean	Standard deviation	Median	Observations
	Panel E: Non-Hitech Technological firms			
Number of patents	18.180	96.547	1	32822
Citation Weighted patents	127.921	1371.927	10	32822
Change in Patents	45.032	65.951	18.182	32822
Number of Acquisitions	0.262	0.797	0	32822
Value of Acquisitions	0.405	1.389	0	32822
R&D	0.042	0.087	0.022	32822
Size	5.977	2.306	5.823	32822
Cash	0.065	0.094	0.030	32822
Sales	1.263	0.668	1.205	32822
M/B	1.596	1.801	1.233	32822
ROA	0.120	0.166	0.136	32822
Leverage	0.197	0.159	0.170	32822

Table 3

Effect of Patenting Activity on Number of Acquisitions

Table 3 reports the coefficient estimates obtained from running a firm fixed effects Poisson regression model represented by Equation (1) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *Number of Acquisitions*. *R&D*, *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash*, *R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Number of Acquisitions	
	Unstandardized coefficients	Standardized coefficients
Change in Patents	-0.0006*	-0.0321*
	(0.0003)	
R&D(t-1)	0.9586**	0.0959**
	(0.3933)	
Size(t-1)	0.4858***	0.8081***
	(0.0364)	
Cash(t-1)	0.9545***	0.1062***
	(0.2295)	
Sales(t-1)	-0.0964	-0.0428
	(0.0951)	
M/B(t-1)	0.0317***	0.0648***
	(0.0101)	
ROA(t-1)	0.6490**	0.1187**
	(0.3098)	
Leverage(t-1)	-3.2091***	-0.3642***
	(0.2768)	
Firm Fixed effects	Yes	
Number of observations	51462	
Wald chi2	509.97	
p-value	0.0000	

Table 4

Patenting Activity and Acquisitions considering High Technology effect

Table 4 reports the coefficient estimates obtained from running a firm fixed effects Poisson regression model represented by Equation (2) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *Number of Acquisitions*. I include an interaction term *Change in Patents* * *Hitech* in this regression model to isolate the effect of declining innovation on acquisition intensity in Non-Hitech firms from Hitech firms. Several exhibits of the regression are included in the analysis to establish the effect of innovation on acquisition behavior of technological firms. *R&D*, *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash, R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Number of Acquisitions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Change in Patents	-0.0016***	-0.0010***	-0.0033***	-0.0018***	-0.0016***	-0.0016***	-0.0015***	-0.0019***
	(0.0005)	(0.0004)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
R&D(t-1)	0.9305**		0.2707	0.8894**	0.8109**	1.0897***	0.3353	1.2207***
	(0.3844)		(0.4634)	(0.3933)	(0.3718)	(0.4021)	(0.2817)	(0.3811)
Size(t-1)	0.4823***	0.4678***		0.4988***	0.4940***	0.4711***	0.4854***	0.4879***
	(0.0366)	(0.0300)		(0.0369)	(0.0304)	(0.0373)	(0.0361)	(0.0361)
Cash(t-1)	0.9462***	0.9376***	0.7812***		0.9617***	1.0034***	0.9326***	1.3444***
	(0.2284)	(0.2111)	(0.2365)		(0.2255)	(0.2240)	(0.2293)	(0.2267)
Sales(t-1)	-0.0888	-0.0572	-0.8806***	-0.1381		-0.1122	0.0138	0.0379
	(0.0951)	(0.0740)	(0.0965)	(0.0959)		(0.0974)	(0.0830)	(0.0923)
M/B(t-1)	0.0310***	0.0325***	0.0223**	0.0323***	0.0312***		0.0323***	0.0361***
	(0.0099)	(0.0103)	(0.0105)	(0.0100)	(0.0099)		(0.0102)	(0.0117)
ROA(t-1)	0.6380**	0.5113*	0.8270**	0.6497**	0.5419**	0.7950**		1.1971***
	(0.3081)	(0.2822)	(0.3239)	(0.3091)	(0.2661)	(0.3455)		(0.3326)
Leverage(t-1)	-3.1837***	-3.4008***	-3.2492***	-3.3386***	-3.1597***	-3.2903***	-3.3212***	
	(0.2776)	(0.2174)	(0.3037)	(0.2675)	(0.2760)	(0.2776)	(0.2759)	
Change in Patents * Hi-tech	0.0017***	0.0014**	0.0023***	0.0019***	0.0017***	0.0019***	0.0018***	0.0021***
	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0007)
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	51462	51462	51462	51462	51462	51462	51462	51462
Wald chi2	520.06	667.59	292.56	560.99	485.97	492.70	461.54	386.78
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 5

Declining Innovation and Acquisitions by Hitech and Non-Hitech firms

Table 5 reports the coefficient estimates obtained from running a firm fixed effects Poisson regression model represented by Equation (1) for Hitech as well as Non-Hitech firms separately over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *Number of Acquisitions*. *R&D*, *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash*, *R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Number of Acquisitions			
	Hitech firms		Non-Hitech firms	
	Unstandardized coefficients	Standardized coefficients	Unstandardized coefficients	Standardized coefficients
Change in Patents	-0.0001	-0.0056	-0.0010**	-0.0582**
	(0.0004)		(0.0005)	
R&D(t-1)	0.6391	0.0751	0.3937	0.0192
	(0.4222)		(1.1007)	
Size(t-1)	0.4232***	0.6326***	0.5511***	0.9461***
	(0.0455)		(0.0576)	
Cash(t-1)	0.8880***	0.1072***	0.8630**	0.0657**
	(0.2762)		(0.4295)	
Sales(t-1)	0.0532	0.0206	-0.1810	-0.0818
	(0.1437)		(0.1287)	
M/B(t-1)	0.0274***	0.0657***	0.0921***	0.1182***
	(0.0093)		(0.0198)	
ROA(t-1)	0.4877	0.1056	0.5991	0.0693
	(0.3516)		(0.5218)	
Leverage(t-1)	-2.5222***	-0.2266***	-3.5793***	-0.4432***
	(0.4388)		(0.3619)	
Firm Fixed effects	Yes		Yes	
Number of observations	18640		32822	
Wald chi2	221.79		358.58	
p-value	0.0000		0.0000	

Table 6

Declining Innovation and Investment in Acquisitions

Table 6 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *Value of Acquisitions*. *R&D*, *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash*, *R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Value of Acquisitions	
	(1)	(2)
Change in Patents	-0.0002	-0.0002
	(0.0001)	(0.0002)
R&D(t-1)	0.1737*	0.1737*
	(0.0994)	(0.0995)
Size(t-1)	0.2657***	0.2657***
	(0.0219)	(0.0219)
Cash(t-1)	0.3195***	0.3195***
	(0.0809)	(0.0809)
Sales(t-1)	-0.0318	-0.0318
	(0.0407)	(0.0407)
M/B(t-1)	0.0358***	0.0358***
	(0.0056)	(0.0056)
ROA(t-1)	0.0711	0.0711
	(0.0624)	(0.0626)
Leverage(t-1)	-1.0171***	-1.0169***
	(0.0915)	(0.0915)
Change in Patents * Hi-tech		0.0000
		(0.0003)
Firm Fixed effects	Yes	Yes
Number of observations	51462	51462
Adjusted R-squared	0.032	0.032

Table 7

Declining Innovation and Internal R&D Intensity

Table 7 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (3) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *R&D Intensity* which is measured by dividing R&D expenditures by total assets. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: R&D Intensity	
	Unstandardized coefficients	Standardized coefficients
Change in Patents	-0.00001	-0.0066
	(0.00001)	
Size(t-1)	-0.0070***	-0.0975***
	(0.0018)	
Cash(t-1)	0.0350	0.0322
	(0.0230)	
Sales(t-1)	0.0123**	0.0433**
	(0.0050)	
M/B(t-1)	-0.0034***	-0.0555***
	(0.0013)	
ROA(t-1)	-0.0892***	-0.1471***
	(0.0210)	
Leverage(t-1)	-0.0387***	-0.0356***
	(0.0072)	
Firm Fixed effects	Yes	
Number of observations	51462	
p-value	0.0000	
Adjusted R-squared	0.024	

Table 8

Declining Innovation and R&D Intensity by Hitech and Non-Hitech firms

Table 8 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (3) for Hitech as well as Non-Hitech firms separately over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *R&D Intensity* which is calculated by dividing R&D expenditures over total assets. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: R&D Intensity			
	Hitech firms		Non-Hitech firms	
	Unstandardized coefficients	Standardized coefficients	Unstandardized coefficients	Standardized coefficients
Change in Patents	-0.00004*	-0.0162*	0.00001	0.0105
	(0.00003)		(0.0000)	
Size(t-1)	-0.0117***	-0.1203***	-0.0022	-0.0584
	(0.0032)		(0.0018)	
Cash(t-1)	0.0540*	0.0462*	-0.0206	-0.0232
	(0.0301)		(0.0205)	
Sales(t-1)	0.0137	0.0357	0.0065**	0.0404**
	(0.0097)		(0.0032)	
M/B(t-1)	-0.0055***	-0.0828***	0.0013	0.0305
	(0.0015)		(0.0023)	
ROA(t-1)	-0.1034***	-0.1642***	-0.0357	-0.0767
	(0.0284)		(0.0235)	
Leverage(t-1)	-0.0535***	-0.0330***	-0.0170**	-0.0299**
	(0.0132)		(0.0084)	
Firm Fixed effects	Yes		Yes	
Number of observations	18640		32822	
p-value	0.0000		0.0000	
Adjusted R-squared	0.032		0.011	

Table 9

Post-Acquisition Internal R&D Intensity

Table 9 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (4) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Number of Acquisitions* which shows the number of acquisitions pursued by the firm in the previous year. The dependent variable used in this analysis is post-acquisition internal *R&D Intensity* of the acquiring firm which is calculated by dividing R&D expenditures over total assets. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. Several exhibits of the regression are included in the analysis to establish the effect of acquisitions on internal R&D intensity of technological firms. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA over total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Post-Acquisition Internal R&D Intensity						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Number of acquisitions(t-1)	0.0018***	0.0008	0.0016***	0.0017***	0.0014**	0.0021***	0.0020***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0006)	(0.0006)
Size(t-1)	-0.0060***		-0.0054***	-0.0089***	-0.0052***	-0.0110***	-0.0061***
	(0.0015)		(0.0014)	(0.0014)	(0.0015)	(0.0020)	(0.0015)
Cash(t-1)	0.0426**	0.0413**		0.0381*	0.0363*	0.0393**	0.0478**
	(0.0198)	(0.0198)		(0.0196)	(0.0194)	(0.0197)	(0.0199)
Sales(t-1)	0.0198***	0.0263***	0.0186***		0.0176***	0.0003	0.0210***
	(0.0043)	(0.0040)	(0.0039)		(0.0044)	(0.0041)	(0.0043)
M/B(t-1)	-0.0045***	-0.0043***	-0.0040***	-0.0043***		-0.0026**	-0.0041***
	(0.0014)	(0.0014)	(0.0013)	(0.0014)		(0.0011)	(0.0013)
ROA(t-1)	-0.1231***	-0.1281***	-0.1206***	-0.1143***	-0.1116***		-0.1189***
	(0.0160)	(0.0163)	(0.0155)	(0.0152)	(0.0159)		(0.0158)
Leverage(t-1)	-0.0442***	-0.0445***	-0.0481***	-0.0490***	-0.0268***	-0.0138**	
	(0.0074)	(0.0074)	(0.0079)	(0.0074)	(0.0066)	(0.0068)	
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	51462	51462	51462	51462	51462	51462	51462
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R-squared	0.037	0.036	0.035	0.035	0.031	0.008	0.036

Table 10

Investment in Acquisitions and Post-Acquisition Internal R&D Intensity

Table 10 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (4) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Value of Acquisitions* which is measured as natural logarithm of raw value of acquisitions pursued by the firm in the previous year. The dependent variable used in this analysis is post-acquisition internal *R&D Intensity* of the acquiring firm which is calculated by dividing R&D expenditures by total assets. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. Several exhibits of the regression are included in the analysis to establish the effect of acquisitions on internal R&D intensity of technological firms. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Post-Acquisition Internal R&D Intensity						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Value of acquisitions(t-1)	0.0015**	0.0010	0.0013**	0.0013**	0.0012*	0.0014**	0.0015**
	(0.0007)	(0.0007)	(0.0006)	(0.0007)	(0.0006)	(0.0007)	(0.0007)
Size(t-1)	-0.0060***		-0.0054***	-0.0090***	-0.0053***	-0.0110***	-0.0061***
	(0.0015)		(0.0013)	(0.0014)	(0.0014)	(0.0019)	(0.0015)
Cash(t-1)	0.0430**	0.0416**		0.0384*	0.0366*	0.0396**	0.0481**
	(0.0198)	(0.0198)		(0.0196)	(0.0194)	(0.0197)	(0.0199)
Sales(t-1)	0.0201***	0.0267***	0.0188***		0.0178***	0.0005	0.0214***
	(0.0044)	(0.0041)	(0.0040)		(0.0045)	(0.0041)	(0.0044)
M/B(t-1)	-0.0045***	-0.0044***	-0.0040***	-0.0043***		-0.0026**	-0.0041***
	(0.0014)	(0.0014)	(0.0013)	(0.0014)		(0.0011)	(0.0013)
ROA(t-1)	-0.1233***	-0.1283***	-0.1208***	-0.1143***	-0.1117***		-0.1191***
	(0.0160)	(0.0163)	(0.0155)	(0.0152)	(0.0159)		(0.0158)
Leverage(t-1)	-0.0445***	-0.0447***	-0.0484***	-0.0494***	-0.0270***	-0.0142**	
	(0.0074)	(0.0074)	(0.0080)	(0.0074)	(0.0066)	(0.0068)	
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	51462	51462	51462	51462	51462	51462	51462
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R-squared	0.038	0.036	0.036	0.035	0.031	0.008	0.036

Table 11

Post-Acquisition Innovation Output

Table 11 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (5) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Number of Acquisitions* which shows the number of acquisitions pursued by the firm in the previous year. The dependent variable used in this analysis is post-acquisition *Innovation Output* which is measured as the total citation weighted patents of the acquiring firm. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. Several exhibits of the regression are included in the analysis to establish the effect of acquisitions on post-acquisition innovation output of technological firms. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Post-Acquisition Innovation Output						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Number of acquisitions(t-1)	1,684*	2,210**	1,656*	1,670*	1,680*	1,688*	1,709*
	(1,046)	(1,038)	(995)	(1,044)	(1,045)	(1,046)	(1,041)
Size(t-1)	3,263***		3,201***	3,066***	3,269***	3,128***	3,278***
	(484)		(461)	(468)	(484)	(469)	(484)
Cash(t-1)	3,289**	4,154***		2,944**	3,231**	3,257**	3,144**
	(1,358)	(1,367)		(1,307)	(1,342)	(1,354)	(1,292)
Sales(t-1)	1,284***	-1,721***	1,093**		1,268***	793*	1,287***
	(481)	(562)	(445)		(473)	(415)	(492)
M/B(t-1)	-43	-108**	-18	-33		14	-49
	(50)	(51)	(47)	(48)		(44)	(52)
ROA(t-1)	-4,011***	-1,623**	-3,796***	-3,412***	-3,906***		-4,079***
	(850)	(680)	(814)	(697)	(802)		(892)
Leverage(t-1)	269	576	-175	-128	414	1,204	
	(1,945)	(1,983)	(1,710)	(1,961)	(1,939)	(1,964)	
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	51462	51462	51462	51462	51462	51462	51462
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R-squared	0.054	0.025	0.055	0.053	0.054	0.052	0.055

Table 12

Investment in Acquisitions and Post-Acquisition Innovation Output

Table 12 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (5) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Value of Acquisitions* which is measured as natural logarithm of raw value of acquisitions pursued by the firm in the previous year. The dependent variable used in this analysis is post-acquisition *Innovation Output* which is measured as the total citation weighted patents of the acquiring firm. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. Several exhibits of the regression are included in the analysis to establish the effect of acquisitions on post-acquisition innovation output of technological firms. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Post-Acquisition Innovation Output						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Value of acquisitions(t-1)	359*	638***	350*	346*	358*	356*	360*
	(210)	(228)	(199)	(208)	(210)	(210)	(209)
Size(t-1)	3,527***		3,466***	3,340***	3,530***	3,390***	3,550***
	(501)		(478)	(468)	(502)	(482)	(504)
Cash(t-1)	2,983**	3,924***		2,650**	2,949**	2,947**	2,887**
	(1,231)	(1,284)		(1,193)	(1,228)	(1,227)	(1,199)
Sales(t-1)	1,227***	-2,033***	1,044**		1,218***	723*	1,247***
	(459)	(462)	(431)		(454)	(389)	(478)
M/B(t-1)	-25	-94*	0	-15		34	-25
	(46)	(48)	(45)	(45)		(42)	(47)
ROA(t-1)	-4,103***	-1,535**	-3,883***	-3,531***	-4,042***		-4,118***
	(892)	(644)	(852)	(740)	(859)		(918)
Leverage(t-1)	-248	-60	-625	-625	-164	705	
	(1,857)	(1,902)	(1,648)	(1,889)	(1,836)	(1,865)	
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	51462	51462	51462	51462	51462	51462	51462
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adjusted R-squared	0.045	0.01	0.045	0.044	0.045	0.042	0.045

Table 13

Validating Robustness of Effect of Patenting Activity on Number of Acquisitions

In my original sample, I had also included technological firms which were innovative as reflected by their patent productivity but didn't acquire any target firm over their whole life term. A possible concern regarding the results obtained would be whether those may suffer from sample selection bias due to inclusion of firms which never acquired. I verify the robustness of my results related to first Hypothesis by including only those firms from the sample which had acquired atleast once in their life term. Table 13 reports the coefficient estimates obtained from running a firm fixed effects Poisson regression model on the various sub-samples over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is *Number of Acquisitions*. *R&D*, *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash, R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Number of Acquisitions			
			Hitech firms	Non-Hitech firms
	(1)	(2)	(3)	(4)
Change in Patents	-0.0006*	-0.0016***	-0.0001	-0.0010**
	(0.0003)	(0.0005)	(0.0004)	(0.0005)
R&D(t-1)	0.9586**	0.9305**	0.6391	0.3937
	(0.3933)	(0.3844)	(0.4222)	(1.1007)
Size(t-1)	0.4858***	0.4823***	0.4232***	0.5511***
	(0.0364)	(0.0366)	(0.0455)	(0.0576)
Cash(t-1)	0.9545***	0.9462***	0.8880***	0.8630**
	(0.2295)	(0.2284)	(0.2762)	(0.4295)
Sales(t-1)	-0.0964	-0.0888	0.0532	-0.1810
	(0.0951)	(0.0951)	(0.1437)	(0.1287)
M/B(t-1)	0.0317***	0.0310***	0.0274***	0.0921***
	(0.0101)	(0.0099)	(0.0093)	(0.0198)
ROA(t-1)	0.6490**	0.6380**	0.4877	0.5991
	(0.3098)	(0.3081)	(0.3516)	(0.5218)
Leverage(t-1)	-3.2091***	-3.1837***	-2.5222***	-3.5793***
	(0.2768)	(0.2776)	(0.4388)	(0.3619)
Change in Patents * Hitech		0.0017***		
		(0.0006)		
Firm Fixed effects	Yes	Yes	Yes	Yes
Number of observations	27295	27295	9997	17298
Wald chi2	509.97	520.06	221.79	358.58
p-value	0.0000	0.0000	0.0000	0.0000

Table 14

Validating Robustness of Effect of Innovation on Internal R&D Intensity

To check for the regression results not being robust due to any sample selection bias, I again run the regressions to validate Hypothesis 1 by including only those firms from the sample which had acquired atleast once in their life term since in my original sample, I had also included technological firms which were innovative as reflected by their patent productivity but didn't acquire any target firm over their whole life term. Table 14 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model on the various sub-samples over the period 1975 – 2010. The main independent variable used in this regression is *Change in Patents* which is measured as the percentage change in cumulative patent value of a firm in the next two years. The dependent variable used in this analysis is internal *R&D Intensity* of the acquiring firm which is calculated by dividing R&D expenditures by total assets. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. Several exhibits of the regression are included in the analysis to establish the effect of declining innovation on internal R&D intensity of technological firms. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: R&D Intensity		
		Hitech firms	Non-Hitech firms
	(1)	(2)	(3)
Change in Patents	-0.0000	-0.00004*	0.0000
	(0.0000)	(0.0000)	(0.0000)
Size(t-1)	-0.0057***	-0.0080***	-0.0036*
	(0.0017)	(0.0028)	(0.0019)
Cash(t-1)	0.0347	0.0423	0.0207
	(0.0261)	(0.0349)	(0.0178)
Sales(t-1)	0.0210***	0.0305***	0.0072**
	(0.0041)	(0.0071)	(0.0033)
M/B(t-1)	-0.0044**	-0.0059***	-0.0001
	(0.0018)	(0.0022)	(0.0015)
ROA(t-1)	-0.1171***	-0.1236***	-0.0718**
	(0.0135)	(0.0154)	(0.0339)
Leverage(t-1)	-0.0394***	-0.0463***	-0.0229**
	(0.0088)	(0.0178)	(0.0104)
Firm Fixed effects	Yes	Yes	Yes
Number of observations	27295	9997	17298
p-value	0.0000	0.0000	0.0000
Adjusted R-squared	0.035	0.036	0.038

Table 15

Validating Robustness of Post-acquisition Innovation Performance

To check for the regression results not being robust due to any sample selection bias, I again run the regressions to validate Hypothesis 2 and Hypothesis 3 by including only those firms from the sample which had acquired atleast once in their life term since in my original sample, I had also included technological firms which were innovative as reflected by their patent productivity but didn't acquire any target firm over their whole life term. Table 15 reports the coefficient estimates obtained from running a firm fixed effects OLS regression model on the various sub-samples over the period 1975 – 2010. The main independent variable used in this regression is *Number of Acquisitions*. In Column (1), the dependent variable used in this analysis is post-acquisition internal *R&D Intensity* of the acquiring firm which is calculated by dividing R&D expenditures by total assets. In column (2), the dependent variable used in this analysis is post-acquisition *Innovation Output* measured by citation weighted patents produced by the acquiring firm. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Post-acquisition Innovation Performance	
	R&D Intensity	Innovation Output
Number of acquisitions(t-1)	0.0021***	1,787*
	(0.0006)	(1,058)
Size(t-1)	-0.0070***	2,790***
	(0.0019)	(535)
Cash(t-1)	0.0523**	6,655***
	(0.0211)	(2,338)
Sales(t-1)	0.0190***	1,086
	(0.0057)	(708)
M/B(t-1)	-0.0047**	-98
	(0.0019)	(85)
ROA(t-1)	-0.1251***	-4,697***
	(0.0163)	(1,498)
Leverage(t-1)	-0.0381***	3,378
	(0.0088)	(2,238)
Firm Fixed effects	Yes	Yes
Number of observations	27295	27295
p-value	0.0000	0.0000
Adjusted R-squared	0.038	0.058

Table 16

Validating Robustness of Effect of Declining Innovation on Propensity to engage in acquisitions

Using logistic regression, I verify the robustness of the results obtained for Hypothesis 1 that declining innovation increases the propensity of technological firms to engage in acquisitions. Table 16 reports the coefficient estimates obtained from running a conditional firm fixed effects logit model bootstrapping all the groups signifying different acquiring firms over the period 1975 – 2010. The main independent variable used in this regression is a dummy variable *'Declining Patent'* which takes on the value of 1 if the cumulative patent value of the firm decreases or remains the same from time 't' to time 't+2' years, otherwise this variable is valued as 0. The dependent variable used in this analysis is a dummy variable '*Acquisition*' which takes the value of 1 if the firm engages in any number of acquisitions in that year, otherwise it takes on the value of zero. *R&D*, *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash*, *R&D* and *Sales* are measured by dividing cash, R&D and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

Conditional logistic regression	
	Propensity to engage in acquisitions
Declining Patent	0.2492***
	(0.0641)
R&D(t-1)	0.6768*
	(0.3955)
Size(t-1)	0.6668***
	(0.0403)
Cash(t-1)	1.2618***
	(0.2170)
Sales(t-1)	-0.1417*
	(0.1069)
M/B(t-1)	0.0657***
	(0.0132)
ROA(t-1)	0.4616*
	(0.2658)
Leverage(t-1)	-4.0307***
	(0.2845)
Firm Fixed effects	Yes
Number of observations	51462
Wald chi2	620.89
p-value	0.0000

Table 17

Validating Robustness of Post-Acquisition Internal R&D Intensity

I earlier analyzed the effect of one-year lagged number of acquisitions on firm's internal R&D intensity and validated the second hypothesis that acquisitions positively affect firm's internal R&D intensity. Here I verify the robustness of the results obtained for second hypothesis using two-years lagged number of acquisitions. This table reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (4) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Number of Acquisitions* which shows the number of acquisitions pursued by the firm two years ago. The dependent variable used in this analysis is internal *R&D Intensity* of the acquiring firm after two years of acquisition and is calculated by dividing R&D expenditures over total assets. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Post-Acquisition Internal R&D Intensity
Number of acquisitions(t-2)	0.0007*
	(0.0004)
Size(t-1)	-0.0056***
	(0.0017)
Cash(t-1)	0.0480**
	(0.0194)
Sales(t-1)	0.0183***
	(0.0049)
M/B(t-1)	-0.0045***
	(0.0016)
ROA(t-1)	-0.1149***
	(0.0201)
Leverage(t-1)	-0.0415***
	(0.0085)
Firm Fixed effects	Yes
Number of observations	51462
p-value	0.0000
Adjusted R-squared	0.032

Table 18

Validating Robustness of Post-Acquisition Innovation Output

I earlier analyzed the effect of one-year lagged number of acquisitions on firm's innovation output and validated the third hypothesis that acquisitions positively affect firm's innovation output. Here I verify the robustness of the results obtained for third hypothesis using 2-year and 3-year lagged number of acquisitions. This table reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (4) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Number of Acquisitions* which shows the number of acquisitions pursued by the firm. The dependent variable used in this analysis is post-acquisition innovation output of the acquiring firm and is measured as total patent citation count after acquisition. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Post-Acquisition Innovation Output	
	2-year lagged Acquisitions	3-year lagged Acquisitions
Lagged Number of acquisitions	2,105*	2,289*
	(1,229)	(1,278)
Size(t-1)	3,321***	3,537***
	(543)	(585)
Cash(t-1)	3,253**	2,854*
	(1,517)	(1,553)
Sales(t-1)	1,257***	1,332***
	(472)	(502)
M/B(t-1)	-57	-52
	(61)	(70)
ROA(t-1)	-4,014***	-4,441***
	(871)	(1,069)
Leverage(t-1)	-830	-1,637
	(2,054)	(2,256)
Firm Fixed effects	Yes	Yes
Number of observations	51462	51462
p-value	0.0000	0.0000
Adjusted R-squared	0.059	0.061

Table 19

Validating Robustness of Post-Acquisition Innovation Output

I earlier analyzed the effect of one-year lagged investments in acquisitions on firm's innovation output and validated the third hypothesis that acquisitions positively affect firm's innovation output. Here I verify the robustness of the results obtained for third hypothesis using 2-year and 3-year lagged investments in acquisitions. This table reports the coefficient estimates obtained from running a firm fixed effects OLS regression model represented by Equation (4) on the whole sample over the period 1975 – 2010. The main independent variable used in this regression is *Value of Acquisitions* which shows the total investment in acquisitions undergone by the firm. The dependent variable used in this analysis is post-acquisition innovation output of the acquiring firm and is measured as total patent citation count after acquisition. *Size*, *Cash*, *Sales*, *M/B*, *ROA* and *Leverage* are used as the control variables. One-year lagged values of all the control variables are used. *Size* of a firm is measured as natural logarithm of its total assets. *M/B* (Market to Book Ratio) for a firm is measured as Market Value of Assets divided by Total Value of Assets. *ROA* (Return on Assets) is calculated by dividing EBITDA by total assets. *Leverage* is measured as the sum of current and long term liabilities divided by market value of assets. *Cash* and *Sales* are measured by dividing cash and sales over assets respectively. Robust standard errors are reported in parenthesis. *, ** and *** denote levels of significance at 10%, 5% and 1% respectively.

	Dependent variable: Post-Acquisition Innovation Output	
	2-year lagged Acquisitions	3-year lagged Acquisitions
Lagged Value of acquisitions	363*	499*
	(214)	-285
Size(t-1)	3,744***	3,950***
	(546)	-588
Cash(t-1)	2,842**	2,649*
	(1,378)	-1,515
Sales(t-1)	1,253***	1,356***
	(479)	-519
M/B(t-1)	-43	-52
	(61)	-72
ROA(t-1)	-4,354***	-4,939***
	(982)	-1,197
Leverage(t-1)	-920	-1,415
	(2,042)	-2,247
Firm Fixed effects	Yes	Yes
Number of observations	51462	51462
p-value	0.0000	0.0000
Adjusted R-squared	0.044	0.045

APPENDIX

Key terminologies/variables used during the study are defined below:

Patent Value of Firm in year t	Cumulative Patent Citation Count of all valid patents possessed by the firm in year t
Change in Patents	Percentage change in patent value in the next two years
Innovation Output	Total Citation weighted Patents
R&D(t-1)	R&D/Assets at time t-1
Size(t-1)	ln(Total Assets) at time t-1
Cash(t-1)	Cash/Assets at time t-1
Sales(t-1)	Sales/Assets at time t-1
M/B(t-1)	Market to Book Ratio at time t-1
Market to Book Ratio	Market Value of Assets / Total Value of Assets
Market Value of Assets	Assets - Stockholder's Equity + Market Value of Equity
Market Value of Equity	Annual Closing Price of share * Number of shares outstanding
ROA(t-1)	Return on assets at time t-1, calculated as EBITDA/Total Assets
Leverage(t-1)	(Current Liabilities + Long Term Liabilities) / Market Value of Assets at time t-1
Value of Acquisitions	ln(Value of Acquisitions)
Hitech firms	I follow Kile and Phillips (2009) to sample high technology firms. Here I list the high technology industries considered during the analysis with their 3 digit SIC Codes in parenthesis: Drugs (283), Computer and Office Equipment (357), Communication Equipment (366), Electronic Components and Accessories (367), Laboratory, Optic, Measure, Control Instruments (382), Surgical, Medical, Dental Instruments (384), Telephone Communications (481), Miscellaneous Communication Services (482), Communication Services, NEC (489), Computer Programming, Data Processing, etc. (737), Research, Development, Testing Services (873)
Non-Hitech firms	All firms in the sample not classified as Hitech firms, have been considered Non-Hitech firms