Innovation Consolidation Nexus: Evidence from India's Manufacturing Sector

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Abstract: Often regulatory authorities approve consolidation strategies such as mergers and acquisitions based on the likely impact of it on innovation, which in turn leads to better welfare outcomes. The relationship between consolidation strategies and technological performance was hardly a concern during the initial years of merger activity globally as well as in India. The focus of research during those days was concentrated on the impact of consolidation strategies on production efficiency and market concentration and their trade off. However during the era of globalization the firms realized the potential of consolidation strategies to overcome the challenges posed by the fast moving technological revolution and to take benefit out of it. As a result there has been an unprecedented surge in the number and value of technology related mergers, acquisitions and alliances during this era with a view to minimize cost of production and to eliminate market competition. The present study is an inquiry into the innovation efforts through consolidation strategies in the context of the recent competition regime implemented in India by replacing the three decade old MRTP regime.

Key words: Market structure and innovation, Mergers and acquisitions, Anti-trust Issues, Government Policy and Regulations, Monopolisation Strategies, Innovation
JEL classification: G34, G38, L44, L12, O32

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During the initial merger waves the relationship between consolidation strategies and technological advancement was hardly a concern. That time much of the research on the topic was concentrating on the impact of consolidation strategies on efficiency and market concentration and their trade off. However during the era of globalization the firms realized the potential of consolidation strategies to overcome the challenges posed by the fast moving technological revolution and to take benefit out of it. As a result there has been an unprecedented surge in the number and value of technology related mergers, acquisitions and alliances during this era. Given this backdrop, the present study is an attempt to analyse the impact of consolidation strategies on innovation enhancement in the Indian manufacturing sector with focus on the foreign acquisitions in India. This would be a preliminary attempt in the Indian context to capture the implications on innovation efforts.

The study consists of six sections. First section deals with the nexus between consolidation and innovation, followed by the changes in regulations in the second section, Data and methodology in the third section, observations based on statistical analysis of the nexus between mergers and technological performance in the fourth section, results of the econometric analysis of the impact of consolidation on technological performance in the fifth section and the sixth section concludes with policy implications.

I. Innovation Via /Led Consolidation: Some Insights

Rationally speaking, when two or more firms decide to consolidate their operation through mergers and acquisitions, it is expected to increase the productivity and efficiency of the combined firm. This increased productivity may be the outcome of the elimination of the multiple expenses such as on Research and Development[1], which both the firms were incurring during the pre-consolidation period. Moreover, *ceteris paribus*, the time needed for innovation may come down compared to the pre-merger period since the combined entity can work together for a new product or process and the resultant complementarities in knowledge speed up the innovation process. In other words, the combined entity will benefit through deriving synergies in knowledge compared to their own independent past. This became more important

[1] Other such expenses are marketing, advertising, distribution etc.

for firms involving in more riskier or uncertain inventions such as pharmaceutical and biotech, where the probability of success may be very much unpredictable. Generally this type of inventions cost huge amounts of money which most of the developing country firms hesitant or incapable of undertaking due to the paucity of funds. Added to this, the level of uncertainty further aggravates, if the next best firm succeeds to bring out the new product/ process more quickly to the market, which will mark the wastage of that much money, time and effort for the former firm. Even if a firm succeeds to bring out a new product, it became obsolete when its competitor invents a new product or process to the market. It can lead to a situation in which the former firm might not be even able to recoup the expenses it incurred for inventing that particular product, which may create inertia among firms for entering into inventions and thus hinder the innovation incentives of firms. Here comes the importance of consolidation strategies such as mergers and acquisitions to share the risk related to competition for innovation. Entry into mergers and acquisitions are thus expected to enhance the innovative effort of the firms, which is the core of economic growth and development.

Recently, the firms are undergoing a paradigm shift in their operations from 'national' to 'internationalisation', which means they are forced to produce for the international market rather than the narrowly defined national markets. With the effective implementation of globalization in many countries such as India, national firms are now competing with international products even within the domestic boundaries, due to the relaxation of foreign controls[2]. As a result, firms are now not only relocating their resources but also re-equipping their R&D facilities in order to face the new challenges arising out of increased competition. However, as Guellec and Potterie (2001) rightly mentions, "*….it is not enough to read technical journals to keep pace with advancing technology. It is also to be part of researcher's networks, which means to be active in research in the areas of interest*…." (Guellec and Potterie, 2001). In this context, cross-border consolidation activities provide golden opportunities for the firms to internationalise their R&D operations.

It will enable the firms to locate R&D centers at different international locations to tap the comparative advantage in different R&D locations. It will especially help those firms, which are

[2] We recognize the fact that it can vary according to the sectors.

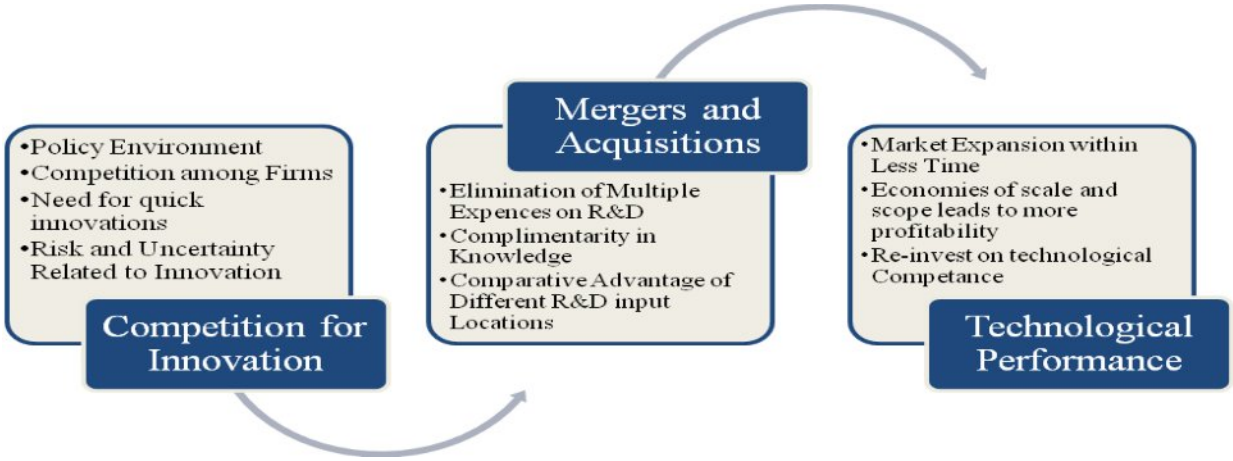
at different stages of patenting their innovations. Horizontal mergers and acquisitions will make the step-by step innovations easier through the systematic matching of competencies of both the firms. However, the success of it depends on the proper post merger co-ordination of both the firms situated from different cultures. Even though the integration risk exists for domestic deals too, it is not as vulnerable as cross-border deals[3]. Local firms will be able to benefit from this through the knowledge spillovers from the foreign ones. Albeit, there is another view suggesting that even though technology is more globalised, most of the foreign firms establish their research facilities abroad mainly to cater their products to the needs of local market conditions rather than to tap foreign technology (Guellec and Potterie, 2001), which essentially means foreign firms gain from their partnership with local ones. In this context, it is worth noting that the degree to which both firms benefit from spillovers depends to a great extent on the absorption capacity[4] of firms (Narulla, 2003), which is considered to be higher for foreign firms compared to the domestic firms.

So far we were discussing how the fast changing innovation scenario is leading to mergers and acquisitions. Some researchers have rightly pointed out that any study on this topic should also consider the counter effect that is how mergers and acquisitions change the innovation efforts of the surviving parties as well as the rest of the firms in the industry (Schulz, 2007). Our effort is in this direction. When firms go for mergers and acquisitions, the resultant enlarged firm size enable the combined entity to undertake more R&D investment, which was impossible previously due to the need for huge amount of capital. Moreover the combined entity is expected to generate more profit due to the operation of economies of scale and scope, which can be reinvested for making strong R&D base for the future operations of the combined entity. It becomes particularly important for mega deals and horizontal mergers and acquisitions. We have summarized the above discussed innovation-consolidation nexus-that is the competition for innovation scenario leads to mergers and acquisitions, which in turn leads to better technological performance-with the help of a figure (see the Figure 1).

3 However, we believe it can vary according to the individual events, which are going for international mergers and acquisitions.

4 This means that a minimum level of knowledge is inevitable to acquire or adapt technology of foreign firms. Domestic firms are considered to be having less absorption capacity since they may be using very outdated techniques or at very initial stages of innovation.

Figure 1 The Innovation Consolidation Nexus



Source: Author's Compilation

As we discussed earlier, there were only few attempts to study the theoretical relationship between mergers and acquisitions and innovation efforts. A review of literature on the relationship between mergers and acquisitions and innovation made by Schulz has also mentioned this fact (Schulz, 2007). Earlier, much of the attention was given to the impact of consolidation on market structure and various performance indicators since the economic environment before the 1980s was very much different from the present market oriented or neo-liberal regime, where the product life cycles are too short due to the competition for innovation among all the firms. The changed global scenario led to the occurrence of more and more technology related mergers and acquisitions during the present scenario. In this context, we shall discuss here a few studies, which are directly linked to this topic.

A Look at the Relevant Literature

Hagedoorn and Duysters (2000) studied the effects of mergers and acquisitions on the technological performance in a high tech sector namely computer industry for the period 1986-1992. The study reached the conclusion that mergers and acquisitions do have its impact on technological performance, which varies according to the degree of relationship between the

combined entities. In other words, it varies according to the type of integration such as horizontal, vertical or conglomerate deals that occurred. Guellec and Potterie (2001) studied the internationalization of technology using the patent data applied to European patent office over the period 1985-86 and 1993-1995. The study found that small nations and the nations with low R&D intensity go for internationalization of R&D than the big ones. Dessyllas and Alan Hughes (2005) analysed the propensity to acquire firms in the high technology industry during the period January 1984 to June 2001 using R&D and patent data. The major finding of the study is that firms are using acquisitions as a means of sourcing information externally as a substitute to in-house R&D.

Ravenscraft and Scherer (1987) studied the impact of mergers and acquisitions on R&D performance for US firms that went for mergers during 1950-1977 and compared the R&D of the acquirers to that of the industry average using R&D intensity as the measure. The study found a negative relationship. Kleer (2006) studied the impact of mergers on the incentive of firms to invest on cost reducing innovations and found that merger enhances the innovation effort of the surviving firms. But the rivals of the combined entity change the innovation efforts according to the strength of the combination. When the organizational problems are included into the analysis, even a clear picture of increased incentives of the surviving parties is disappeared (as in Schulz, 2007).

Thus the studies were dealing with different aspects of technological performance through mergers. From their conclusion, it becomes clear that the consolidation strategies are having its impact on technological performance, even though the direction is not clear. In the Indian context, there has not been any specific attempt to study the technological performance of the firms entering into consolidation. However, there are certain studies, which passively dealt with the R&D intensity during the post merger period (Beena, PL, 2004; 2008). Here, the point made by studies on the effect of FDI on innovation creation in India also becomes important. One major argument made by these studies have been that consolidation has not resulted much in in-house R&D creation, rather the payments for import of technology increased. Many scholars including Rao and Dhar (2015) observed that foreign subsidiaries in India are spending a substantial amount for import of technology rather than in-house R&D creation. Coming to the consolidation scenario in India, many foreign firms are entering to the Indian market through

consolidation strategy and there has been an apprehension that the disappearance of national firms will adversely affect domestic consumers in future through various ways.

II. Intellectual Property Rights (IPR) vs. Competition Law (CL)

Recently the competition authorities across the world are concerned about the creation of innovation through mergers and acquisitions. The policy makers are facing a dilemma whether to allow the big firms to merge and permit them to undertake costly innovations, or to restrict them on the ground that it can lead to concentration of market power in the hands of a few big firms. If they allow, it can be argued that mergers and acquisitions will enhance consumer welfare in future with the introduction of better quality products at cheaper prices through engaging in innovation facilitated by consolidation. On the other hand it can also lead to the monopolization of innovation and the consequent rise in prices, which will adversely affect the welfare of consumers.

It is widely accepted that competition and open market provides better incentives for innovation. On the one hand competition among the firms enhances the innovation creation, which is evident through the emergence of new products and process. On the other side, if there is effective competition between the firms producing similar line of products, it enhances the quality of products or it results in reducing the cost of production. Thus it can be argued that innovation helps to escape competition. However, it is also possible that due to the fear of acute competition through imitation of innovation firms may prefer not to invest on innovation or remain less innovative. This will adversely affect the economic development itself. Here comes the role of Intellectual Property Rights (IPR). IPR allows the right holder to exclusively exploit the protected subject matter that is the possibility to exclude competition by imitation. IPR systems encourage new and improved products which means, it enhances competition by substitution[5] and contribute to the dynamic competition that is to promote innovation. However, a right balance between the innovation promotion and maintaining effective competitive environment that forces firms to innovate is very important. In this context, the IPR may be abused like any other rights. Therefore, the concerns of Competition Law come up to restrict the right holders move to hinder competition in any manner. Thus CL puts limit on

[5] Substitution by new products.

what IPR holders may do with its rights (Gallego, 2010). In modern times, the central feature of innovation scenario is *Schumpeterian Rivalry*. That is, in the case of some markets competition for innovation may result in the creation of *Temporary Monopolists* who displaces one another through innovation and as a result, there is little or no head-to-head price competition. However, there will be high competition for innovation over time (Katz and Shelanski, 2004). Thus the central task with the competition authorities is to consider all these facts and to ensure maximum consumer surplus without harming that of producers'.

III. Data and Methodology

We have observed that similar to the global scenario, there is a gradual shift from the organic ways of foreign investment to inorganic means of brownfield investment in India as well (see Beena, S 2010). This must have led to the improvement in technology. We have noticed that industrialized countries such as UK, USA and Germany are the most common dealmakers in India. Adding to this, most of the top valued mergers and acquisitions are occurring in technology intensive sectors such as drugs and pharmaceutical, telecom, petroleum, power generation etc and there is high instance of horizontal and vertical deals. In the case of horizontal and vertical deals, there is high possibility of cutting down of multiple expenses as well as synergy creation. It follows that the growing cross-border mergers and acquisitions are expected to improve technological performance of the companies since they are in similar line of business activity. We will therefore be examining the technological performance of firms involved in cross-border mergers and acquisitions (that is, brownfield investment) vis-à-vis the domestic deals.

We have started the analysis with the conventional methodology of pre and post deal[6] performance. We have taken four years before the deal and, four and six years after the deal as the pre merger and post merger period respectively. We have prepared a database on mergers and acquisitions occurred in India from different secondary sources of information such as Monthly Review of Indian Economy, Mergers & Acquisition Database by PROWESS, SEBI Website etc. We have applied this list of mergers and acquisitions to the PROWESS database of CMIE, which provides data on the financial performance of the firms. We have undertaken pre

[6] By 'deal' we mean the mergers and acquisitions in the analysis.

and post four and six year analysis. PROWESS data covers the period from 1988-1989[7] to the recent period[8]n only. This restricted our analysis to the mergers and acquisitions occurred between 1993-2004 for the pre and post four-year analysis and 1993-2002 for the pre and post six year analysis. Post sixth year performance was calculated mainly to allow more years for post deal integration. As we have already mentioned we will be examining each industry separately to account for sector-wise variations in performance[9]. With this methodology we have tried to overcome the problems associated with some of the previous studies on mergers and acquisitions in the Indian context[10] (eg. Beena, 2008; Mantravadi and Reddy, 2007 etc). We may not be able to capture the effect of each event separately; instead we will be focusing on each surviving firm. We have taken the year of first merger or acquisition as the cut off point to treat a firm as 'surviving' firm. When we considered all these criteria, the number of firms in our sample got reduced considerably.

Our database covers 1631 mergers and acquisitions[11] in the *manufacturing sector*, of which we have information on 1060 deals from PROWESS database that means 65 percent of the cases, the corresponding surviving firms can be identified from PROWESS database. In the case of cross-border deals, we have information on 61 percent of the deals (383 deals out of 631). Sector-wise coverage can be seen from the Table 1. In this context, it is very important to note that many of the firms went for multiple mergers and acquisitions, which reduced the number of surviving firms further. The total number of surviving firms available is 484; out of this, 278 firms involved only in domestic deals and 206 are involved in cross-border deals. Intensity of multiple deals that is the average frequency of a surviving firm to undertake mergers and acquisitions shows that, it is two for overall and in some sectors such as pharmaceutical industry it is high at 4 deals per firm.

[7] Now PROWESS gives information from 1987-88, but the coverage for the firms is very low for the initial period.
8 However, from 2009 onwards PROWESS restricted the data from 1995 onwards to the recent years. Hence we will not get the valuable pre-merger information for many companies. Hence, we restricted the analysis based on old version till 2009.
[9] However, we will be concentrating on major industrial categories due to the data limitation and less occurrence of deals in certain sectors.
[10] These studies were mainly concentrating on the financial performance of surviving firms. Beena, PL (2004, 2008) studies is based on an assumed pre and post merger period. It is not taking into account the year of merger of each firm separately. Even though Mantravadi and Vidyadhar Reddy (2007) make such a distinction, it is very short period (3 years) to realize the effect of mergers and acquisitions.
[11] Excluding primary sector and service sector.

Table 1 Matching of Data for Analysis: Our Database and PROWESS

Sector	Our data (1)	Available Deals (No.) All Deals (2)	Available Deals (No.) Cross-border (3)	Coverage (%) (2)/(1)	Surviving (5)	Deal/firm (2)/(5)
Chemicals	264	165	45	63	91	2
Drugs and Pharmaceutical	266	140	60	53	40	4
Food and Beverages	118	118	30	100	36	3
Machinery	314	227	116	72	102	2
Metals and Metal Products	126	77	13	61	42	2
Non-metallic Mineral Products	101	61	23	60	30	2
Textiles and Leather	48	48	13	100	48	1
Transport Equipments	131	50	30	38	35	1
Manufacturing	1631	1060	383	65	484	2

Source: Data described in text and PROWESS, CMIE

We have defined technological performance of firms, in terms of two major input measures of technological performance such as R&D intensity and payments made for royalties and technical know-how. While the first two involve embodied technology, the latter represents disembodied technology[12]. Having selected the sample and variables for analysis, the next question emerges would be the extent of 'improvement' in technological performance after getting into mergers and acquisitions? Or more specifically, whether an increased R&D intensity shows better performance as under normal conditions? Our answer coincides with that of Cassiman and Colombo, (2008), who treats decreased R&D intensity during the post merger period as an indicator of successful mergers. The logic behind this is that, when firms go for consolidation it will reduce the multiple wasteful expenses on R&D along with such other expenses, which will help the firms to utilize the R&D investment more efficiently. However, an increased R&D intensity can be seen as a measure of improved performance after mergers since it is also possible when the firm expands its scale of operation. However, a better utilization of R&D inputs is envisaged under both conditions. Our hypothesis would be that, the intensity of technological performance changes according to the type and characteristics of mergers and acquisition[13]. As we have mentioned earlier, it is expected to be higher in the case of cross-border deals compared to the domestic deals for, the new entities (through mergers and acquisitions) have better opportunity to learn from the firms from highly industrialised

[12] Patents would have been another good indicator, however in the Indian context, only few firms are able to make such innovation. Adding to this, the number of patents is not an appropriate indicator of the qualitative value of a particular innovation. Moreover, linking the patent to a particular merger or acquisition is also a difficult task.

[13] Even though we will be doing a firm level analysis one of the major limitations of our study would be that we will not be capturing the performance based on the underlying motive of each firm's merger decisions due to the lack of adequate data.

countries. However, the intensity of it depends on the absorption capacity of the domestic firms too, which is considered to be less than that of the foreign firms. The effect of mergers can vary from industry to industry, firm to firm and time to time. Within cross-border and domestic deals, the intensity of it can vary according to the type of integration such as horizontal, vertical or conglomerate deals. It is expected to be higher under the first two types. Thus we will be giving due importance to the aspects of 'strategic fit'[14]. Now we shall discuss the major observations based on our analysis.

IV. Major Observations

4.1 Based on the Conventional Analysis

Our analysis shows that there has been a reduction in the post merger R&D intensity for the manufacturing sector as a whole (see Figure 2). The pre merger period average R&D intensity was 1.4, which declined to 0.9 during the post merger period. However, some sectors such as drugs and pharmaceutical industry and transport equipments show a spectacular increase in R&D intensity compared to pre-merger period (see Table 2). It is interesting to note that the R&D intensity of the machinery sector declined considerably during the latter period.

We have further explored the R&D behaviour of the cross-border and domestic firms separately in order to understand both set of firms thoroughly. Interestingly for the manufacturing sector as a whole, the cross-border deals' R&D intensity increased during the post merger period whereas that of domestic deals declined during this time (see Table 2). However, our sector-wise break up of mergers and acquisitions show that there is considerable variation across different sectors in technological performance. In the case of drugs and pharmaceutical industry, non-metallic minerals, food and beverages and textiles, both the domestic as well as cross-border deals registered an increased R&D intensity during the post merger period. It is noticeable that the cross-border firms in the chemicals and transport equipments decreased their spending on R&D irrespective of the increased spending of the domestic firms in these industries. When we allowed a longer time period of six years, there was a reduction in the R&D spending in some sectors, compared to the post four years. Food and beverages (both cross-border and domestic deals), domestic deals in the drugs and pharmaceutical industry and transport equipments; and the cross-border deals in metals and minerals, food and beverages

[14] Organisational fit will not be analysed in the study.

have shown such a tendency. Another point to be mentioned in this context is that the magnitude of R&D intensity was higher for the domestic deals than that of cross-border deals for manufacturing as a whole. Drugs and pharmaceutical, machinery, non-metallic minerals followed this trend while food sector and textiles were showing the opposite. Cross-border firms in the chemicals and transport equipments were having high R&D intensity compared to the domestic firms during the pre merger period, which changed during the post merger period.

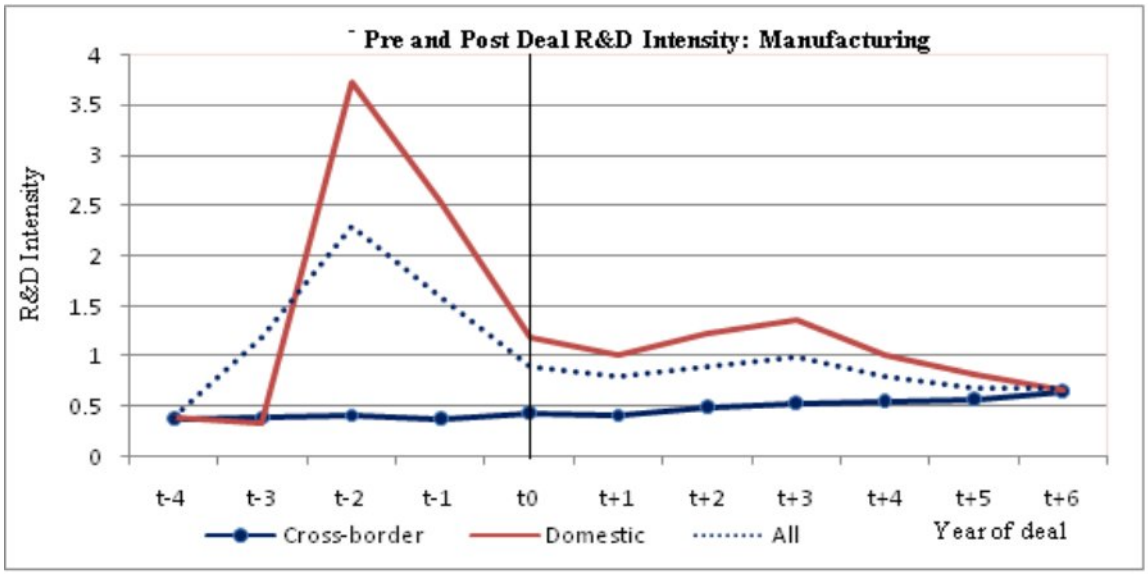
Table 2 R&D Intensity: Domestic vs. Cross-border Deals

		t-4	t-3	t-2	t-1	t0	t+1	t+2	t+3	t+4	t+5	t+6	Pre merger	Post four	Post six
	Cross-border	0.38	0.39	0.41	0.38	0.44	0.41	0.50	0.54	0.56	0.57	0.65	0.39	0.50	0.54
	Domestic	0.39	0.34	3.73	2.55	1.19	1.01	1.24	1.36	1.01	0.83	0.66	1.75	1.16	1.02
Manufacturing	All	0.4	1.2	2.3	1.6	0.9	0.8	0.9	1	0.8	0.7	0.7	1.4	0.88	0.82
	Cross-border	0.31	10.88	0.27	0.42	0.40	0.48	0.54	0.59	0.58	0.57	0.27	2.97	0.55	0.50
	Domestic	0.24	0.58	0.55	0.99	0.56	0.74	0.89	1.42	1.03	1.31	1.20	0.59	1.02	1.10
Chemicals	All	0.2	4.3	0.4	0.7	0.5	0.6	0.7	1.1	0.8	1	0.8	1.4	0.80	0.83
	Cross-border	0.28	0.41	0.73	0.86	1.57	1.06	1.26	1.41	1.69	1.79	2.42	0.57	1.36	1.61
Drugs and	Domestic	1.03	1.28	1.53	1.42	3.29	1.63	4.24	2.15	1.83	2.30	1.72	1.32	2.46	2.31
Pharmaceutical	All	0.7	0.9	1.1	1.1	2.6	1.4	3.2	1.8	1.7	2.1	1.9	1.0	2.03	2.02
	Cross-border	0.28	0.34	0.46	0.35	0.34	0.15	0.32	0.23	0.49	0.43	0.53	0.35	0.30	0.36
	Domestic	0.25	0.30	17.36	8.51	2.73	2.28	1.72	0.90	0.54	0.54	0.53	6.61	1.36	1.08
Machinery	All	0.3	0.4	9.6	4.7	1.7	1.3	1.1	0.6	0.5	0.6	0.7	3.8	0.88	0.80
	Cross-border	0.32	0.59	0.17	0.26	0.58	0.74	0.38	0.27	0.30	0.21	0.31	0.34	0.42	0.37
Metals and	Domestic	0.18	0.17	0.17	3.64	0.41	0.27	0.42	0.26	0.25	0.29	0.30	1.04	0.30	0.30
Minerals	All	0.2	0.3	0.2	2.8	0.4	0.4	0.4	0.3	0.2	0.3	0.3	0.9	0.33	0.32
	Cross-border	0.09	0.11	0.12	0.16	0.12	0.15	0.06	0.30	0.12	0.20	0.12	0.12	0.16	0.16
Non-metallic	Domestic	0.12	0.12	0.11	0.22	0.12	0.16	0.66	0.13	0.16	0.16	0.29	0.14	0.28	0.26
Minerals	All	0.1	0.1	0.1	0.2	0.1	0.1	0.4	0.2	0.1	0.2	0.2	0.1	0.20	0.20
	Cross-border	0.01	0.10	0.10	0.08	0.05	0.26	0.57	0.86	0.28	0.15	0.24	0.07	0.49	0.39
Food and	Domestic	0.03	0.04	0.01	0.03	0.06	0.25	0.23	0.28	0.14	0.17	0.11	0.03	0.23	0.20
Beverages	All	0	0.1	0	0	0.2	0.3	0.5	0.6	0.3	0.2	0.2	0.0	0.43	0.35
	Cross-border	0.21	0.26	0.32	0.16	0.11	0.34	0.18	0.27	0.22	0.25	0.21	0.24	0.25	0.25
	Domestic	0.04	0.05	0.06	0.14	0.18	0.16	0.11	0.24	0.24	0.20	0.35	0.07	0.19	0.21
Textiles	All	0.1	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.25	0.25
	Cross-border	0.10	0.99	1.00	0.71	0.64	0.68	0.69	0.64	0.71	0.57	0.81	0.70	0.68	0.68
Transport	Domestic	0.95	0.58	0.33	0.22	1.97	3.29	3.14	1.46	1.41	0.41	1.54	0.52	2.33	1.88
Equipment	All	0.3	0.5	0.4	0.3	0.9	1.3	1.1	0.9	1	0.5	0.9	0.4	1.08	0.95

Source: Calculated from PROWESS, CMIE

Note: 'to' denote the year of merger, t+1 is one year post merger, t-1 one year pre merger and so on.

Figure 2



Source: Calculated from PROWESS, CMIE

When we take the case of payments made for royalties and technical know-how, there has been a gradual increase in it after getting into consolidation[15]. In the case of all the sectors except textiles, this trend can be seen (see Table 3). For the manufacturing sector as a whole, it was 1.1 during the pre-merger period, which increased to 2 and 2.2 during the post four and six years respectively. This trend is applicable for cross-border and domestic classification. Interestingly, in terms of magnitude, cross-border firms were much more import intensive than that of domestic firms (see Table 3 for details).

Thus our analysis using three major input measures of technological performance lead us to the conclusion that there has been a decline in the post merger R&D intensity, whereas the payment made for royalties and technical know-how increased during this time period. Our close examination of the cross-border and domestic deals shows that both set of firms increased their spending on royalties during the longer time period. Interestingly, the R&D intensity of the domestic firms declined during this period. This is an indication towards the usage of Indian market as a marketing hub rather than leading to the technological improvements to the firms in India.

[15] It is taken as percent of sales value.

Table 3 Payment for Royalties and Technical Know-how: Domestic vs. Cross-border Deals

Sector		t-4	t-3	t-2	t-1	t0	t+1	t+2	t+3	t+4	t+5	t+6	Pre merger	Post four	Post six
	D	0.31	0.33	0.26	0.38	0.52	0.45	0.3	0.35	0.35	0.41	0.46	0.32	0.36	0.39
	C	0.35	0.31	0.51	0.71	0.97	0.79	1.11	2.47	3.27	1.16	1.48	0.47	1.91	1.71
Chemicals	A	0.32	0.32	0.35	0.51	0.69	0.58	0.59	1.14	1.51	0.72	0.84	0.4	1.0	0.9
	D	0	0	0	0.03	0	0	0	0.01	0.02	0.13	0.19	0.01	0.01	0.06
Drugs and	C	0.3	0.56	0.54	0.34	0.26	0.77	0.76	0.85	0.86	0.22	0.19	0.44	0.81	0.61
Pharmaceutical	A	0.13	0.25	0.23	0.16	0.11	0.31	0.35	0.38	0.39	0.17	0.19	0.2	0.4	0.3
	D	0.06	0.06	0.1	0.1	0.04	0.03	0.78	0.81	1.27	2.19	3.19	0.08	0.72	1.38
Food and	C	1.3	1.56	2.21	4.14	6.51	7.95	7.93	6.03	7.96	9.92	13.03	2.30	7.47	8.80
beverages	A	0.53	0.62	0.92	1.69	2.2	3	4.06	2.97	3.75	4.88	7.21	0.9	3.4	4.3
	D	0.59	0.62	0.7	0.65	0.85	1.08	1.3	0.74	1.28	1.53	1.79	0.64	1.10	1.29
	C	1.04	1.76	1.82	2.17	3.5	4.75	3.46	3.83	3.5	2.24	3.16	1.70	3.89	3.49
Machinery	A	0.78	1.14	1.22	1.36	2.08	2.88	2.3	2.21	2.35	1.87	2.41	1.1	2.4	2.3
	D	1.46	1.2	1.07	1.35	1.29	1.74	1.74	1.87	2.26	2.95	3.4	1.27	1.90	2.33
Metals and	C	8.93	11	9.05	10.4	10.9	11.1	13.2	15.2	18.5	21.8	23.3	9.83	14.49	17.17
Metal Products	A	4.11	4.26	3.66	4.18	4.07	4.51	5.14	5.84	6.89	8.65	9.62	4.1	5.6	6.8
	D	1.52	1.6	2.66	2.63	3.29	3.89	3.53	3.96	4.04	4.42	5.47	2.10	3.86	4.22
Non-metallic	C	4.69	4.29	5.39	5.31	5.27	5.43	7.26	10.4	10.6	11.1	8.86	4.92	8.42	8.93
mineral prod.	A	2.64	2.54	3.53	3.48	4.01	4.54	5.02	6.31	6.31	6.91	6.74	3.0	5.5	6.0
	D	0.05	0.12	0.02	0.03	0	0	0.01	0.03	0.04	0.05	0.12	0.06	0.02	0.04
Textiles and	C	0.1	0.22	0.21	0.25	0.33	0.07	0.08	0.12	0.13	0	0	0.20	0.10	0.07
leather	A	0.07	0.15	0.06	0.08	0.07	0.01	0.02	0.04	0.06	0.04	0.1	0.1	0.0	0.0
	D	0.4	0.52	0.83	0.92	1.07	0.82	0.69	1.02	1.43	2.09	2.27	0.67	0.99	1.39
Transport	C	1.12	1.48	1.67	2.44	1.59	2.56	2.96	1.59	1.93	3.88	5.15	1.68	2.26	3.01
Equipments	A	0.76	0.98	1.29	1.72	1.34	1.83	1.92	1.32	1.7	3.15	3.85	1.2	1.7	2.3
	D	0.47	0.47	0.55	0.58	0.66	0.77	0.82	0.78	0.98	1.3	1.6	0.52	0.84	1.04
	C	1.49	1.78	1.93	2.21	2.64	3.23	3.37	3.86	4.13	3.89	4.67	1.85	3.65	3.86
Manufacturing	A	0.89	1.00	1.11	1.25	1.46	1.79	1.87	2.04	2.28	2.36	2.85	1.1	2.0	2.2

Source: Calculated from PROWESS, CMIE

Note: D denotes domestic and C denotes cross-border deals

4.2 Based on the Own Firm Pre Merger Performance

One major limitation with the above analysis is that the 'to' (that is the year of merger) can take any year from 1993 to 2004 and the corresponding t-1, t-2 etc and t+1, t+2 etc can also vary (see Figure 2). Simply speaking, within each industry, each surviving firm's year of merger will vary. Therefore, at the micro level we will be obtaining the pre/post merger performance of each firm, which may not cover the macro economic scenario prevailing in each time period, since each deals, to, t+1 etc changes. Compared to the existing studies on mergers and acquisitions, even though we have used a much-refined methodology for calculating post merger performance, we feel that it is too inadequate to deal with this issue. In order to overcome this, we may have to compare the performance of each firm separately, that is, what happened to the performance of a particular firm after getting into merger. For this purpose, we have analysed each surviving firm before and after involving in mergers and acquisitions and

compared the performance of each firm with its own pre merger performance[16] using the same variables as we discussed earlier. The results are the following.

Table 4 Domestic vs. Cross-border Firms' R&D Intensity (Post Four Year)

Sector	Category	Increased		Decreased		No Change		Total Available	
		No.	Percent	No.	Percent	No.	Percent	No	Percent
	Domestic	21	43	11	22	17	35	49	100
	Cross-border	12	40	11	37	7	23	30	100
Chemicals	All	33	42	22	28	24	30	79	100
	Domestic	15	75	5	25	0	0	20	100
Drugs and	Cross-border	8	50	7	44	1	6	16	100
Pharmaceutical	All	23	64	12	33	1	3	36	100
	Domestic	25	49	13	25	13	25	51	100
	Cross-border	18	40	15	33	12	27	45	100
Machinery	All	43	45	28	29	25	26	96	100
	Domestic	1	5	8	36	13	59	22	100
	Cross-border	2	18	2	18	7	64	11	100
Metals & Minerals	All	3	9	10	30	20	61	33	100
	Domestic	4	25	2	13	10	63	16	100
Non-Metallic	Cross-border	2	29	3	43	2	29	7	100
Minerals	All	6	26	5	22	12	52	23	100
	Domestic	4	36	4	36	3	27	11	100
	Cross-border	4	50	3	38	1	13	8	100
Transport	All	8	42	7	37	4	21	19	100
	Domestic	9	28	5	16	18	56	32	100
	Cross-border	4	57	0	0	3	43	7	100
Textiles	All	13	33	5	13	21	54	39	100
	Domestic	9	56	1	6	6	38	16	100
Food and	Cross-border	4	40	0	0	6	60	10	100
Beverages	All	13	50	1	4	12	46	26	100
	Domestic	90	39	51	22	88	38	229	100
	Cross-border	54	36	45	30	50	34	149	100
Manufacturing	All	148	39	96	25	138	36	382	100

Source: Calculated from PROWESS, CMIE

In the case of R&D intensity, as it can be seen from Table 4, most of the firms either increased their spending towards R&D after getting into mergers or remained the same without change in their spending. For manufacturing sector as a whole, 39 percent of the firms increased their spending after getting into merger and another 36 percent remained the same after merger. A good proportion of firms from pharmaceutical industry (64%), food and beverages (50%) and machinery (45%) increased their R&D intensity (see Table 4). Overall, post six year performance also shows a trend in favour of increased spending on R&D (44% of firms; decreased 25% and no change 36%; see appendix Table 1). One striking point to be mentioned here is that there has been a rise in the percentage of firms whose R&D intensity increased during the post six year period. From the tables (Table 4 and appendix Table 1) it can be seen that this increase was

[16] Here also we have taken four years pre and four and six years post to compare.

mainly contributed by the shift in the spending of 'No change' category firms during post four year, towards 'increased' spending category in the post six year. This may indicate the fact that immediately after merger, firms may try to integrate and utilize their existing resources properly and therefore the R&D intensity may remain more or less constant. But when the time needed for proper integration exceeds, they start to spend more on R&D as the firm is now in a better position to undertake innovation. How much time each firm requires to reach this stage will be subjected to different aspects relating to each merger. In our sample, all the sectors except transport equipments show this trend[18].

Further, our domestic and cross-border classification of the firms shows almost similar results, that is either increase or no change. As it can be seen from the Table 4, the notable rise in R&D intensity occurred among the domestic deals in pharmaceutical (75%), food and beverages (56%), machinery (49%) and the cross-border deals in the textiles sector (57%). Earlier, we have found that the above mentioned first three are the major sectors that experienced increase in the overall R&D spending (see Table 4), now it becomes clear that this increase was mainly contributed by the domestic deals in these sectors than cross-border deals (see Table 4). If we compare the R&D spending of the domestic and cross-border deals, it is interesting to note that in the case of majority of the merger and technology intensive sectors, the domestic firms' increase was above that of cross-border firms. We have compared again the post four year results with that of post six year and found that there has been a clear increase in the percentage of 'increased R&D firms' after six years, which confirms our earlier findings regarding this.

Next, we have analysed the payments made for royalties and technical know-how. Here, majority of the firms were not showing any change in their spending during the post merger period compared to the pre-merger period. Almost all the sectors were showing the same trends with machinery and transport equipments showing some smaller variations in this trend (see Table 5). Domestic and cross-border behavior is in line with the overall result. However, another interesting trend can be observed is in the magnitude of increase in the number of firms. If we compare it for domestic and cross-border deals, the latter's spending remained higher than that of the former in all the sectors, which is essentially showing that the cross-

18 Non-metallic minerals remained the same.

border firms are depending more on the import of technology after getting into mergers (see Table 5).

Table 5 Domestic vs. Cross-border: Royalties and Technical Know-how Fees paid (Post Four Year)

		Increased		Decreased		No change		Total Available	
Sector	Type	No.	Percent	No.	Percent	No.	Percent	No.	Percent
	Domestic	7	15	5	11	34	74	46	100
	Cross-border	13	46	5	18	10	36	28	100
Chemicals	All	20	27	10	14	44	59	74	100
	Domestic	1	4	2	9	20	87	23	100
	Cross-border	5	31	1	6	10	63	16	100
Drugs and Pharmaceutical	All	6	15	3	8	30	77	39	100
	Domestic	19	37	14	27	18	35	51	100
	Cross-border	21	47	9	20	15	33	45	100
Machinery	All	42	44	21	22	33	34	96	100
	Domestic	4	15	4	15	18	69	26	100
	Cross-border	3	27	2	18	6	55	11	100
Metals and Metal Products	All	7	19	6	16	24	65	37	100
	Domestic	4	27	4	27	7	47	15	100
	Cross-border	4	57	1	14	2	29	7	100
Non-metallic mineral products	All	8	36	5	23	9	41	22	100
	Domestic	4	36	2	18	5	45	11	100
	Cross-border	6	60	1	10	3	30	10	100
Transport Equipments	All	10	48	3	14	8	38	21	100
	Domestic	2	6	5	16	25	78	32	100
	Cross-border	1	13	2	25	5	63	8	100
Textiles and leather	All	3	8	7	18	30	75	40	100
	Domestic	3	18	3	18	11	65	17	100
	Cross-border	4	40	2	20	4	40	10	100
Food and beverages	All	7	26	5	19	15	56	27	100
	Domestic	44	19	39	16	154	65	237	100
	Cross-border	61	40	23	15	69	46	151	100
Manufacturing*	All	107	27	62	16	222	57	392	100

Source: Calculated from PROWESS, CMIE
Note: * Including misc. manufacturing

However, when we allow a long period (six years post merger), there is slight change in the behaviour of firms in two sectors- textiles and transport equipment (see appendix Table 2). Here it should be remembered that in these sectors, cross-border deals increased their R&D spending compared to the domestic firms during the post merger period. These firms may be investing more on their in-house R&D creation, which help them to reduce their dependence on foreign technology purchase in the long run. This may be to face the domestic competition powerfully. However when we compare these results with the analysis based on the conventional methodology, there is a clear difference from the earlier analysis. To illustrate, while the transport equipments becoming more import intensive technology oriented, the textiles

depended more on the in-house R&D creation. Both the cases, cross-border firms' spending on import of technology remained higher than that of domestic deals (see Table 2 and Table 3).

Next we will be examining whether the effect of mergers and acquisitions on technological performance changes according to the nature and structure of deals. First we have examined the horizontal deals (see Table 6). For 39 percent of the firms, there was no change in the R&D intensity after getting into mergers, 35 percent of the firms increased and for the rest of the firms it decreased during the post four-year period. A slightly reverse trend is noticed for the post six year. Here majority of the firms increased (38%) while 36% of firms did not show any change in it. Notably, Drugs and Pharmaceutical sector is the only sector where more than 60 percent of the firms increased their R&D intensity after getting into mergers and this trend again increased when we allowed more time period. Similarly, 'no change' was noticed in Metals and Minerals (69%) and Non-metallic minerals (63%). Thus it seems that one major reason why the pharmaceutical firms are going for mergers is to ensure technological advantage. As we have discussed earlier, this is one of the major sectors in which policy changes drastically occurred, which necessitated the fast restructuring and re-strengthening of the previously dominant firms to face the challenges from the changed global environment, which necessitated the unavoidable investment on innovation.

Table 6 R&D Intensity after Mergers and Acquisitions: Horizontal Deals

Sector	Four Year							Six Year						
	Number			Percent			TA	Number			Percent			TA
	I	D	N	I	D	N	No	I	D	N	I	D	N	No
Chemicals	17	16	10	40	37	23	43	15	14	7	42	39	19	36
Drugs and Pharmaceutical	18	10	1	62	34	3	29	17	9	0	65	35	0	26
Machinery	23	15	17	42	27	31	55	19	13	16	40	27	33	48
Metals and Minerals	2	3	11	13	19	69	16	1	3	10	7	21	71	14
Non-Metallic Minerals	1	5	10	6	31	63	16	1	5	10	6	31	63	16
Transport	4	5	4	31	38	31	13	4	5	2	36	45	18	11
Textiles	8	4	13	32	16	52	25	10	2	11	43	9	48	23
Food and Beverages	5	1	8	36	7	57	14	6	1	5	50	8	42	12
Manufacturing	81	61	91	35	26	39	233	76	53	71	38	27	36	200

Source: Calculated from PROWESS, CMIE

Note: I denotes Increased; D for Decreased, N is for No change; TA is total available

Interestingly, horizontal deals within the cross-border firms were showing more decreasing trend, while the same for domestic deals were remaining constant. Cross-border firms were shifting towards increased R&D intensity during the six-year period compared to the four year (see Table 7, appendix Tables 3). For payments for royalties and technical know-how, the post

merger period for the horizontal and vertical deals are associated with increased spending for majority of the firms. However, for the conglomerate deals (only less number of deals), it shows a mixed result of increase and decrease.

Table 7 R&D Intensity and Structure of Mergers

Deal	Type	Four years post (No. of Firms)						Six years post (No. of firms)					
		Increase		Decrease		No change		Increase		Decrease		No change	
		No	%	No	%	No	%	No	%	No	%	No	%
Cross-border	Horizontal	38	33	41	36	35	31	35	41	26	31	24	28
	Vertical	3	20	7	47	5	33	3	20	7	47	5	33
	Conglomerate	1	50	0	0	1	50	1	50	0	0	1	50
Domestic	Horizontal	43	33	30	23	56	43	41	36	27	23	47	41
	Vertical	21	43	9	18	19	39	21	49	7	16	15	35
	Conglomerate	3	33	1	11	5	56	3	33	1	11	5	56

Source: Calculated from PROWESS, CMIE

The new methodology we have used yields two major departures from our earlier analysis based on the conventional methodology. First one is that most of the firms' (75%), R&D intensity increased or remained the same during the post merger period, which is against the earlier finding that pre merger R&D intensity was higher than the post merger. The second point to mention here is that when we considered the payment made for royalties and technical know-how in our earlier analysis, we have found that it is increasing during the post merger period. But, our inter-firm analysis showed that for majority of the firms it remained constant. However, this analysis also confirms that cross-border cases were more technology import intensive than that of domestic firms. ons.

Overall, the present analysis shows that when we take the aggregate industry level performance, we may not be able to capture the micro level realities, which are relevant for the issue in our hand. However, in this context, we understand the need for an econometric methodology to control for the effect of other factors affecting the overall technological performance. In other words, in the real world situation, change in the technological performance may be attributed to factors, other than mergers and acquisitions. In order to see the impact of mergers on technological performance, we have applied an econometric framework, which we shall discuss in the following section.

V. Econometric Estimation

5.1 Variables Selection

Based on the literature, along with mergers and its nature and structure, size and market power of the firm, trade components may affect the technological performance of the firms. The relationship between size and technology activity has been one of the long debated issues in the literature, especially by the neo-Schumpeterian literature. According to the neo-Schumpeterian literature, firm size favours the innovation activity (see Kumar and Siddharthan, 1997, chapter 4 for a detailed review). It is argued that if the size of the firm is large enough, it can spend more amounts on technology. It becomes possible due to the ability to mobilize more resource from the capital market. Moreover, the size allows the firms to undertake costly innovations, which is unable to be done by the small sized firms, which will also help to derive greater economies of scale. In that case, we expect a positive impact of this variable on technological performance. It is conventional to use *sales* data to measure the size of the firm. We have used the natural log of sales (denoted as *logsales*) to obtain this. There are different studies such as Katrak (1997), Basant (1997) which have used sales figures to capture the size of the firms. Another major factor affecting the innovation efforts of firms is the market power of the firm. Like the size of the firm, this has also been one of the major debates in the economics of innovation literature. Schumpeter was among the first to relate market structure and innovative activity, who argues that perfectly competitive markets are not conducive to innovation, because it does not generate resources for investment in such ventures due to the absence of extra normal profit. And favoured the concentrated markets to promote innovation (see Kumar and Siddharthan, 1997 chapter 5 for a detailed review). However, Schumpeter favoured the short term nature of monopoly profit to enhance the innovation and not for the legal institutionalized monopoly power. In the medium and long run, there is threat of new entry and hence the need for continuous innovative activity emerges (Kumar and Siddharthan, 1997). Even though we have used a size variable (that is *logsales*) to capture the size effect, it will not represent the market power of the firm, which in turn depends on other factors such as number of firms in the respective industry and its size distribution. Empirical studies on the developing country context show that as the market power increases, there is a possibility to reduce the spending on innovation through using the monopoly elements, unless there is a threat of new entry. If so, we expect this variable to exert a negative pressure on technology. Measurement of market

concentration has been an ever discussed topic in the industrial organization. Here, as an initial attempt, we have used Price Cost Margin (PCM) or Lerner's Index (L), which is a theoretical measure to capture the effect of market concentration considering the sample of firm level information we have. For a single firm, Lerner's Index (L) is defined as[19],

$$L \quad (P - MC)/P$$

For more than one firm in a particular industry, it is defined as, $L \quad \sum_{i\ 1}^{n} Si(Pi - MC)/Pi$,

that is the weighted average of PCM. If MC is constant, then,

$$L \quad \sum_{i\ 1}^{n} Si(Pi - Ci)/Pi$$

$$L \quad \sum_{i\ 1}^{n} Si(Piqi - Ciqi)/Piqi$$

$$L \quad \sum_{i\ 1}^{n} Si(\prod i)/Ri$$

Where, P is the price, MC is Marginal Cost, $\prod i$ denotes the profit of i^{th} firm *S* is the market share and *Ri* is the revenue of firm i. We have applied this formula for all sectors and got the respective Lerner's Index, which shows the weighted average profit of a firm in the industry[20]. We have used the log form of PCM, denoted as *logpcm* for the analysis. It is conventional to believe that trade induces technological improvements, which is essential to compete in the market especially under the present global scenario. Moreover, the firms from the developing countries had been supporting them to improve their innovation effort to compete in the international market. Thus we expect that the extent of export will enhance the technological performance of the firms. However, it can be the other way, if trade induces the firms to go for import of technology than in-house R&D investment. We have used log of export (denoted as *logexport)* to capture this effect. When the firms go for more imports, it will also expected to strengthen the technological capability of the firm, especially because the import mainly consists of the spending on capital goods and finished goods, raw materials, royalties and technical know-how. This has also link with the in-house R&D investment. There are arguments

[19] However, the theoretical validity of PCM has been criticized by many studies on the ground that there are instances in which high competition leads to higher margines (See Boone, 2008 for details). It is also criticized that measurement of Marginal Cost (MC) is an approximation.

[20] We used Profit after Tax (PAT) and Revenue of the firm for calculating this. Market share is calculated as the share of sales of a firm in the respective industry's aggregate sales.

which suggest that the foreign purchase of technology is a substitute for the in-house investment. Therefore import of technology would be inimical to the building up of local technological capabilities (Pillai, M 1979). However, another view emerged is that the import of technology is complementary to the local capabilities due to the need to adapt it to the local needs, which requires a certain level of in-house investment (for a review of detailed discussion, please see Kumar and Siddharthan, 1997, chapter 9). In this context, Subrahmanian (1991) observed that under liberal economic environment, firms will depend on continuous import of technology to build technological capacity rather than own creation. However, under protection, it will be of complementary nature. We have captured the import effect through the log of import (denoted as *logimport)*. However, we have not separated the import of technology variables in the analysis since our prime aim is to capture the merger variables. Next is the variables related to mergers and acquisitions. As we have discussed earlier, mergers are expected to increase the spending on technology due to the coming together of different firms and the resultant expansion in the availability of capital. However, it can also lead to a reduction in the multiple expenditures. Thus this variable's direction of influence depends on each event. We have used both the number of mergers and acquisitions (denoted as $manos_{t-n}$) as well as the value of deals[21] (denoted as $mavalue_{t-n}$) for understanding this in separate models. However, this effect will operate with a lag, since the proper post merger integration will take some time. Exact period of time depends on each event. In our analysis, we have selected lag based on the Akaike Information Criterion (AIC). From the above discussion, we hypothesis that, the effect of merger on technological performance will vary according to the type and structure of merger. Horizontal and vertical deals may be having positive and significant impact on the performance compared to conglomerate, if it could adequately capture the synergies. We have used a (0, 1) dummy variable to capture this. The variable will take the value '1' if it is horizontal or vertical deal and '0' if it is conglomerate deal (denoted *horiver*). Further, we have used another such dummy variable to separate cross-border and domestic deals (denoted *domcb*). Here domestic deals take the value '0' and cross-border deals' '1'. From the earlier discussion, it follows that cross-border deals are having more impact on the technological performance compared to the domestic deals.

[21] Available for acquisitions only.

In order to measure technological performance, we have used two major input measures of technology, namely, R&D intensity (denoted *rdintensity)* and the payments made for royalties and technical know-how (denoted as *royalties*). Amongst this, the former will capture the in-house investment on R&D, whereas the latter will capture the effect of import of technology. We have constructed two models based on R&D intensity, one taking the number of mergers and acquisitions and the second based on the value of mergers and acquisitions (Equations, (1) and (2)). Similarly, we have two models based on the import of technology, by taking number and value of mergers in separate models (Equations (3) and (4)).We are limiting the analysis to the input measures alone. Patent would have been a good indicator of output measure, but in the Indian context in majority of the sectors, patenting is still at a nascent stage. Even if it is available, we cannot clearly demarcate it is 'due to merger' since it involves long years of innovation effort. Adding to this, the patent measure suffers from the limitation that the number of patents cannot fully capture the innovation content, as the value differ widely. One major problem with the spending on R&D and payments for royalties and technical know-how figures provided by PROWESS database is the presence of large number of 'zero' values, which will lead to the loss of information for a substantial part of the sample. Thus this is a case of limited dependent variable.

5.2 The Tobit Regression/ Latent Variable Analysis

According to Verbeek, "*In certain situations, the dependent variable is continuous, but its range may be constrained. Most commonly this occurs when the dependent variable is zero for a substantial part of the population, but positive (with many different outcomes) for the rest of the population.....Tobit models are particularly suited to model this type of variables*" Verbeek, Marno (2000). Conventional regression models fail to account for the qualitative differences between zero observations and continuous observations (Greene, 2003). The Tobit model is suggested by James Tobin (1958) to handle this type of situations. Since we are also facing this type of limited dependent variables, we have applied Tobit regression framework. The Tobit model assumes that there is a latent or unobserved variable Y^*. The observable variable Y is equal to Y* if $Y^* > 0$ and Y=0 when $Y^* \leq 0$. That is,

$$Y \quad \begin{cases} Y^* \, if Y^* > 0 \\ \\ 0 if Y^* \leq 0 \end{cases}$$

Y has continuous distribution over strictly positive values. The general solutions for the model

$$rd\,\text{int}\,ensity^{*} \quad \beta_0 + \beta_1 \log sales_{it} + \beta_2 \log pcm_{it} + \beta_3 \log \exp ort_{it} + \beta_4 \log import_{it} + \beta_5 manos_{i(t-n)} + \beta_6 horiver_{it} + \beta_7 domcb_{it} + U_{it} \ldots\ldots\ldots\ldots(1)$$

are,

$$rd\,\text{int}\,ensity^{*} \quad \beta_0 + \beta_1 \log sales_{it} + \beta_2 \log pcm_{it} + \beta_3 \log \exp ort_{it} + \beta_4 \log import_{it} + \beta_5 mavalue_{i(t-n)} + \beta_6 horiver_{it} + \beta_7 domcb_{it} + U_{it} \ldots\ldots\ldots(2)$$

$$royalties^{*} \quad \beta_0 + \beta_1 rd\,\text{int}\,ensity_{it} + \beta_2 \log sales_{it} + \beta_3 \log pcm_{it} + \beta_4 \log \exp ort_{it} + \beta_5 manos_{i(t-n)} + \beta_6 horiver + \beta_7 domcb_{it} + U_{it} \ldots\ldots\ldots\ldots(3)$$

$$royalties^{*} \quad \beta_0 + \beta_1 rd\,\text{int}\,ensity_{it} + \beta_2 \log sales_{it} + \beta_3 \log pcm_{it} + \beta_4 \log \exp ort_{it} + \beta_5 mavalue_{i(t-n)} + \beta_6 horiver_{it} + \beta_7 domcb_{it} + U_{it} \ldots\ldots\ldots(4)$$

Where *i* is the i^{th} firm and *t* denotes time, *t*= 1, 2, 3,….20 and $U_i \mid X_i \sim$ Normal (0, σ^2). That is, the latent variable Y^* (here, *rdintensity* and royalty**) satisfies the assumptions of the classical linear model, in particular it has a normal, homoscedastic distribution with linear conditional mean[22]. We have used random effects tobit model[23], because fixed effects panel Tobit is affected by the *incidental parameters problem* (Lancaster, 2000; as in Henningsen[24]) that is, the estimated coefficients are inconsistent unless the number of time periods approaches infinity[25]. Before entering into the results, we have checked multicollinearity of the variables—which is important to check since we are dealing with the independent variables, which are having close relationship—and we have found none of the independent variables are significantly correlated with other variables (see Appendix Table 5).

[22] The log likelihood function for each variable i is,

$$l_i(\beta,\sigma) \quad 1(Y_i \quad 0)\log[1-\phi(X_i\beta \mid \sigma)] + 1(Y_i > 0)\log\{(1/\sigma)\phi[(Y_i - X_i\beta)/\sigma]\}$$

Where, σ is the SD of U. Maximum Likelihood estimates of β and σ are obtained by maximizing log likelihood (Wooldridge, 2000).

[23] If the individual specific effects are independent of the regressors, the parameters can be consistently estimated with random effects model (Henningsen, "Estimating Censored Regression Models in R using the censReg Package", University of Copenhagen, available at http://cran.r-project.org/web/packages/censReg/vignettes/censReg.pdf, accessed on 8/5/2012).

[24] Henningsen, "Estimating Censored Regression Models in R using the censReg Package", University of Copenhagen, available at http://cran.r-project.org/web/packages/censReg/vignettes/censReg.pdf, accessed on 8/5/2012).

25 However, Greene (2004) showed the slope parameters can be estimated consistently, but not the variance, even if the number of time periods is small.

Table 8 Estimated Coefficients of Tobit Regression: R&D Intensity

Model: 1 Number based			Model: 2 Value based		
rdintensity	Coefficient	p-value	rdintensity	Coefficient	p-value
logsales	1.31**	0.00	logsales	1.53**	0.00
logexport	-0.29*	0.04	logexport	-0.27	0.06
logimport	-0.13	0.50	logimport	-0.11	0.58
logpcm	0.17	0.22	logpcm	0.12	0.39
manos2	0.19*	0.01	mavalue2	0.00	0.15
horver	0.28	0.80	horver	0.34	0.77
domcb	-0.17	0.78	domcb	-0.22	0.72
constant	-9.57	0.00	constant	-10.98	0.00
sigma_u	9.6	0.00	sigma_u	9.54	0.00
sigma_e	3.867063	0.00	sigma_e	3.88	0.00
rho	0.860304		rho	0.86	
LLF	-4156.8129		LLF	-4158.8973	
LR Test	1612.22**		LR Test	1562.06**	
No. of observations	2065		No. of observations	2065	
Wald chi2(7) = 48.79 Prob > chi2= 0.0000			Wald chi2(7) =44.82 Prob > chi2 = 0.0000		

Source: Calculated from PROWESS, CMIE

Note: ** significant at 1% level; * significant at 5% level; For LR test, chi square values are reported

Now we shall discuss the major findings of the analysis. First, we shall take the case of R&D intensity. The results are shown in Table 8. As we mentioned earlier, we have used AIC to select the number of lags for merger variable. For both of these models, we got two lag as the best-fitted model[26]. Both the model is significant as shown by the significant Wald statistic as well as the Likelihood Ratio (LR) test[27]. When we used the number of mergers, three major factors are significantly affecting R&D intensity, they are, export, sales and mergers and acquisitions. The resultant coefficients show that size of the firm measured by sales is having the largest and positive impact on in-house R&D creation. Interestingly, among the trade variables, only export have significant impact and that too negative, which is against our expectation. In fact, these two results are common for both the models. Coming to the merger variables, number of mergers is having a positive and significant impact on R&D intensity. However, here none of the variables explaining the type of merger (*domcb* and *horver)* is having any significant impact on this. When we took the value of mergers, as the merger variable, it is insignificant, which may be due to the less coverage of value of merger in our data.

[26] AIC with the lowest value is selected, which shows the best fitted model.

[27] Likelihood Ratio Test (LR) is based on the same concept of F-Test in the linear regression model. The major difference between Wald statistic and LR is that the former will not estimate the constraint model, but evaluate its fit based on the difference between the estimates and its constrained value. When the restricted model and unrestricted models are calculated, LR is attractive. Also, unlike the linear models, Tobit maximizes log likelihood rather than R-square (Wooldridge, 2000).

The Table 9 shows the impact of mergers on the payments made for royalties and technical know-how based on number and value of merger respectively. Here, based on the AIC criteria, we have selected three lags for value based model and four lags for number based model. In addition to the significant sales and export variables, all the merger variables- number/value of mergers, dummy variables for cross-border and domestic deals as well as the merger structure are significantly affecting payments made for royalties and technical know-how. Number/value of mergers is positively affecting the import of technology. Moreover, the cross-border firms are having significant impact on the payments made for royalties and technical know-how, which is an indication that, these firms are becoming more technology import intensive rather than focusing only on the in-house R&D creation. This is again validating our statistical analysis. Another point to mention here is that the role of horizontal and vertical deals in the overall result, it is having a positive and significant effect in the payments made for royalties and technical know-how, compared to the conglomerate deals. Thus altogether, a trend in favour of cross-border deals with horizontal or vertical mergers can be seen to have greater say in the technology purchase.

Table 9 Estimated Coefficients of Tobit Regression: Royalties and Technical Know-how

Model: 3 Number based			Model: 4 Value based		
Variable	Coefficient	p-value	Variable	Coefficient	p-value
rdintensity	0.0314487	0.679	rdintensity	0.0314487	0.679
logsales	7.734827**	0.00	logsales	7.734827**	0.000
logexport	-1.524871**	0.00	logexport	-1.524871**	0.000
logpcm	0.5976767	0.185	logpcm	0.5976767	0.185
manos4	0.6544711*	0.024	Mavalue3	0.6544711*	0.024
horver	23.27919**	0.00	horver	23.27919**	0.000
domcb	12.26791**	0.00	domcb	12.26791**	0.000
constant	-82.30375	0.00	constant	-82.30375	0.000
sigma_u	22.86916	0.00	sigma_u	22.86916	0.000
sigma_e	9.933843	0.00	sigma_e	9.933843	0.000
rho	0.8412668		rho	0.8412668	
LLF	-3220.3769		LLF	-3220.3769	
LR test	1484.92 **		LR test	1484.92**	
No. of observations	2070		No. of observations	2070	
Wald chi2(7) =232.15 Prob > chi2= 0.0000			Wald chi2(7)=230.16 Prob > chi2=0.0000		

Source: Calculated from PROWESS, CMIE

Note: ** significant at 1% level; * significant at 5% level; For LR test, chi square values are reported

Thus from the analysis, it is becoming clear that compared to the in-house R&D creation, mergers, especially the cross-border deals, affect the import of technology. However, we believe that each deal is a separate event and its success or failure depends on so many factors, which

may be more event specific. Therefore, we have also tried to understand the effect of mergers on technological performance in a more disaggregated level and we have found that even though the result at the sectoral level are almost similar to that of the macro incidence, it varies for different sub-sectors[28] when we applied the same models for each industry[29]. It is interesting to note that in majority of the sectors, mergers and acquisitions do have its impact on technological performance, whether negative or positive. In the case of R&D intensity, Drugs and Pharmaceutical industry (measured by number of mergers and acquisitions) and metals and minerals (in terms of value of deals) have positive impact, while the chemical sector is negatively affected in terms of both number and value. In textiles, the horizontal and vertical deals are resulting in reduced spending on R&D, which may be due to the efficient utilization of the existing resources and the synergy creation. However, more investigation is necessary to establish this. The consolidation strategies not much affected the R&D spending of machinery, non-metallic minerals and transport sectors. In the case of the payments made for royalties and technical know-how, chemicals, metals and minerals and transports have positive impact of mergers—which means spending increases with the merger— on it in terms of the value of the deals and non-metallic minerals, textiles and transport sectors are positively related in terms of the number of deals. Only for the machinery sector, a negative and significant association—which means the spending declined after getting into merger— is noted. In terms of R&D intensity also machinery sector was not showing any change after merger. This may be due to the efficient utilization of the unutilized capacity after getting into mergers and acquisitions in this sector, which reduces the need for import of technology. Interestingly, as we have seen earlier, the cross-border deals are having a strong positive relation with the import of technology as compared to the domestic deals in majority of the sectors such as Drugs and pharmaceutical, machinery, metals and minerals, non-metallic minerals, transport equipments, which is true for both number and value of deals. Even though the machinery sector as a whole was showing reduced spending on import of technology, in the case of cross-border deals, it is showing increasing trend, which may be due to the more than proportionate increase in the spending on in-house R&D by the domestic deals in this sector. In general, the regression

[28] We have used only broad industry classification. For some sectors, there are so many mergers and for others, its incidence is less. So we limited our analysis to nine broad industries.
[29] We realize the fact that sector-specific, there may be differences.

results support the involvement of mergers in increased spending on innovation activity, especially for the import of technology.

VI. Concluding Observations and Policy Implications

In the context of increasing number and value of cross-border consolidation strategies, we tried to analyse whether this has actually led to the expected increase in technological performance during the post merger period and whether it changes according to the nature and structure of deals. Using two major input measures of technology our initial analysis based on the conventional methodology reached the conclusion that R&D intensity declined after mergers, even though there are sectoral variations. Interestingly, the payments for royalties marked a substantial increase during the second period. However, this result is not completely reflecting on the reality since the pre and post merger period for each firms differ and when we aggregate the effect for pre and post merger, the time element get diluted with different years and therefore it cannot capture the actual macro economic situation prevailed at a particular point of time.

In order to take into account the inter-firm variations in performance, we have analysed each firm separately in our second step of analysis, which pointed out that R&D intensity of majority of the firms increased or remained the same during the post merger period. Payments for royalties remained constant for majority of the firms. Major observation from the cross-border and domestic classification is that R&D intensity of domestic firms is higher than the cross-border cases in more technology and merger intensive sectors. Whereas, cross-border firms are more technology import intensive than engaging in in-house R&D. Our investigation on the impact of the structure of mergers is not showing much impact on the technological performance excluding the cross-border deals, in which case R&D intensity declined for a good proportion of firms during the post four years, which again increased during the post six years. It may be showing that firms uses the existing resources immediately after getting into mergers and when they become properly integrated, they try to invest more as they are in a relatively better position to do so in the long run.

In order to take into account the 'other factors' affecting technological performance, we have undertaken a Tobit Regression analysis, which indicated that mergers and acquisitions play a

very important role in changing the technological performance measured in terms of two input measures, such as R&D intensity and the payments made for royalties and technical know-how. The cross-border firms seems to be spending more for royalties and technical know-how, which is similar to the findings of the statistical analysis. Added to this, mergers in similar line of business activities, that is horizontal deals found to be making more payments for royalties and technical know-how. We have also analysed the impact in a more disaggregated level, which validates the overall results, but also shows that the incidence and impact of merger varies for different sectors according to the sector specific characteristics. One of the major findings from our study is the dependence of the cross-border merger firms on the import of technology rather than inbound R&D creation.

Though we realize the fact that in India, consolidation strategies are of recent origin unlike the US or UK experience, our results shows that the cross-border firms are becoming more and more technology import intensive than investing in domestic R&D, which is similar to the findings of studies on FDI in India, which found that the foreign firms in India are paying royalties than strengthening the inbound R&D locations. Our findings send a strong message to the competition authorities in developing countries to be more vigilant in approving transactions which are having impact on technological development.

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Appendix

Table 1 Post Merger R&D Intensity of Surviving Firms (Six Year)

	Increased		Decreased		No Change		Total Available	
Sector	No.	Percent	No.	Percent	No.	Percent	No	Percent
Chemicals	29	43	19	28	20	29	68	100
Drugs and Pharmaceutical	20	65	11	35	0	0	31	100
Machinery	41	46	26	29	22	25	89	100
Metals and Minerals	13	32.5	8	20	19	47.5	40	100
Non-Metallic Minerals	6	26	5	22	12	52	23	100
Transport	7	39	7	39	4	22	18	100
Textiles	15	41	3	8	19	51	37	100
Food and Beverages	15	63	1	4	8	33	24	100
Manufacturing	142	41	85	25	116	34	343	100

Source: Calculated using PROWESS, CMIE

Table 2 Post Merger Royalties and Technical Know-how fees paid (Six years)

Sector	Increased		Decreased		No Change		Total Available
	No.	Percent	No.	Percent	No.	Percent	No
Chemicals	17	27	9	14	38	59	64
Drugs and Pharmaceutical	5	16	3	9	24	75	32
Machinery	41	46	17	19	31	35	89
Metals and Minerals	6	18	5	15	23	68	34
Non-Metallic Minerals	8	36	5	23	9	41	22
Transport	11	61	2	11	5	28	18
Textiles	3	8	6	16	29	76	38
Food and Beverages	8	32	4	16	13	52	25
Manufacturing	103	29	53	15	194	55	350

Source: Calculated using PROWESS, CMIE

Table 3 Payments for Royalties and Technical Know-how: According to the Type of Deal

Deal	Type	Four years post (No. of Firms)			Six years post (No. of firms)		
		Increase	Decrease	No change	Increase	Decrease	No change
	Horizontal	20	15	56	25	11	60
	Vertical	2	3	8	1	3	5
Cross-border	Conglomerate	1	0	2	1	0	2
	Horizontal	23	26	108	28	21	98
	Vertical	7	6	21	10	5	14
Domestic	Conglomerate	2	0	2	2	0	1

Source: Calculated using PROWESS, CMIE

Table 4 Trends in R&D Behavour

Indicator	Domestic > Cross-border	Cross-border > Domestic
R&D Intensity	Chemicals	Metals and Minerals
	Drugs and Pharmaceutical	Non-metallic Minerals
	Machinery	Transport Equipments
	Food and Beverages	Textiles
Payments on Royalties and Technical Know-how		Chemicals
		Drugs and Pharmaceutical
		Machinery
		Metals and Minerals
		Non-metallic Minerals
		Transport Equipments
		Textiles
		Food and Beverages

Source: Calculated using PROWESS, CMIE

Note: Domestic> Cross-border refers to the percentage number of increase is higher for domestic deals compared to cross-border deals.

Table 5 Check for Multicollinearity: Variance Component Estimation (VCE) Correlation Matrix

Model 1	logsales	logexport	logimport	logpcm	manos2	horver	domcb
logsales	1						
logexport	-0.3366	1					
logimport	-0.4975	-0.2307	1				
logpcm	-0.3162	0.0407	-0.0847	1			
manos2	-0.3092	-0.0553	-0.0457	0.1491	1		
horver	-0.0014	-0.0178	-0.0194	0.0121	-0.0343	1	
domcb	0.013	0.0155	-0.0342	0.0132	0.0315	-0.0248	1
Model 2	logsales	logexport	logimport	logpcm	mavalue2	horver	domcb
logsales	1						
logexport	-0.3706	1					
logimport	-0.5364	-0.2337	1				
logpcm	-0.2849	0.0492	-0.0789	1			
mavalue2	-0.1178	0.0034	0.0128	-0.0027	1		
horver	-0.0112	-0.0185	-0.0208	0.0176	-0.027	1	
domcb	0.0233	0.0178	-0.0332	0.0089	-0.0042	-0.0228	1
Model 3	rdintensity	logsales	logexport	logpcm	manos4	horver	domcb
rdintensity	1						
logsales	-0.0486	1					
logexport	0.066	-0.5161	1				
logpcm	-0.0245	-0.4612	0.0448	1			
manos4	0.0077	-0.415	0.0172	0.1243	1		
horver	-0.0008	0.0019	-0.0238	0.0045	-0.0336	1	
domcb	0.0222	0.04	-0.0254	-0.0036	-0.1006	-0.027	1
Model 4	rdintensity	logsales	logexport	logpcm	mavalue4	horver	domcb
rdintensity	1						
logsales	-0.0405	1					
logexport	0.0629	-0.561	1				
logpcm	-0.0269	-0.445	0.0437	1			
mavalue3	-0.0276	-0.1928	0.0578	0.013	1		
horver	0.002	-0.0096	-0.0222	0.0063	-0.0142	1	
domcb	0.026	0.0085	-0.0272	0.0078	-0.0319	-0.0283	1

Source: Calculated using PROWESS, CMIE