Concentration and Other Determinants of Innovative Efforts in Indian Manufacturing Sector: A Dynamic Panel Data Analysis

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Abstract

The relationship between market concentration and innovative efforts by firms has attracted a lot of attention by researchers. However, a consensus is yet to emerge on the conceptual underpinnings and empirical manifestations of this relationship. While Schumpeter (1942) argued that existence of large firms in imperfectly competitive markets provides the most conducive condition for technical progress, Arrow (1962) pointed out that a pre-innovation monopolist has weaker incentive to innovate than a firm operating in a competitive market. However, even a monopolist faced with contestable markets may be forced to undertake innovative activities to meet 'potential competition'. Further, R&D efforts by a firm are likely to depend on a variety of risks in the market and an increase in such risks may discourage firms to spend on in-house R&D. This is particularly so as expenditure on R&D by a firm is an endogenous sunk cost (Sutton, 1991) and significant innovative efforts by a firm do not always yield success in the market (Scherer, 2000). Given the difficulty in predicting the demand patterns of the consumers and R&D strategies of the rivals with information asymmetries, there is a large stochastic component in R&D spending and economic returns. In addition, possibility of disclosure of the outcomes of publicly funded R&D projects also poses threat on the rate of returns and, therefore, may reduce firms' own R&D expenditure. Given such importance of risks, it is potential/expected market structure and not actual concentration that is likely to influence innovative efforts by the firms. Although the existing studies have attempted to explore different aspects of R&D efforts in Indian manufacturing (e.g., Kumar and Agarwal, 2000), examining the role of potential market concentration in determining R&D efforts is largely ignored. The present paper attempts to fill in this gap. The basic objective of the present paper is to understand the role of expected market concentration in determining inter-industry variations in R&D efforts in Indian manufacturing sector, controlling for various other aspects of market structure, firms' conduct (other than R&D), their performance, and policy related aspects. The paper is based on the proposition of Kamien and Schwartz (1982) that market power interacts with a firm's decision to make innovative efforts via anticipated market power. It is assumed that higher the anticipated market power associated with the post-innovation industry, the innovators have greater incentive to innovate. This is so because larger anticipated market power promises higher profits in future and hence can compensate for current R&D investment. We use Arellano-Bond dynamic panel estimation technique

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and a panel dataset of 34 manufacturing industries over the period from 2001-02 to 2008-09. The paper finds that firms in industries with greater R&D efforts in the past, larger participation of the MNCs, higher capital intensity, and greater penetration in the international market through exports spend more on innovation. On the other hand, in-house R&D efforts are less in the industries with larger incidence of mergers and acquisitions and greater competition from imports. However, the degree of sellers' concentration in a market, size of the market, efforts by the firms towards creation of product differentiation and image advantage, purchase of technology, and the level and variations in their profitability do not make any significant difference in in-house R&D intensity across the industries. The findings of the present paper raise some important policy concerns relating to investment, trade and competition. Should restrictions on entry of MNCs be relaxed further and exports encouraged for promoting in-house R&D? Should M&As be restricted as they hinder in-house R&D efforts? How to encourage the MNCs to enter through Greenfield investment, instead of M&As? Answering these questions requires detailed understanding of technology strategies at the firm level and, therefore, leaves interesting areas for further research.

Keywords: Innovation, Concentration, Risks, India

JEL Classification: L1, L2, L5, O3

Concentration and Other Determinants of -Innovation in the Indian Manufacturing Sector: A Dynamic Panel Data Analysis

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Introduction:

The relationship between market concentration and innovative efforts by the firms has attracted a lot of attention by researchers. However, a consensus is yet to emerge on the conceptual underpinnings and empirical manifestations of this relationship. According to Schumpeter (1942), existence of large firms in imperfectly competitive markets is conducive for technical progress. In other words, concentrated industries are more favourable for innovation as the firms in such industries operate in a way that more closely approximates imperfectly competitive markets. This enables the firms to possess market power and thereby achieve more appropriation from innovation. In other words, in concentrated markets the firms have an incentive to raise their control through innovation. Besides, the firms with market power usually have more resources and hence are more likely to afford in-house R&D. Thus, the Schumpeterian hypothesis challenges conventional economic thinking that competitive market conditions are necessary for optimal allocation of resource. A number of empirical studies (e.g., Fellner, 1951; Williamson, 1965; Scherer, 1967; Levin 1981; Mukhopadhyay, 1985; Jefferson et al., 2006) have found a positive relationship between market concentration and R&D activities that support the Schumpeterian proposition.

However, lack of active competitive forces in a concentrated market may generate X-inefficiency and thereby make the firms move slowly on the innovation path. Besides, when there is competition to innovate, monopolists innovate at a slower rate than competitive firms (Arrow, 1962). According to Arrow (1962), a pre-innovation monopolist has a weaker incentive to innovate than a firm operating in a competitive market. For a monopolist, innovation simply replaces one profitable investment with another. The monopolist may actually receive a lower net return from introducing a new innovation that displaces activities of the old one. For example, Horowitz (1962), Levin, Cohen and Mowery (1985), and Cohen, Levin and Mowery (1987) Geroski (1990), Blundell, Griffith and Van Reenen (1995) have found that industry concentration has either no effect or a negative impact on innovation[3]. Rather, it is competitive pressure that raises innovation, especially for the new firms (Aghion et al 2002). In this context, degree of contestability may be a more important as it captures the impact on firm behaviour both of existing as well as potential competition. For example, the threat of potential competition may make a monopolist behave like a firm in a competitive market. Further, in contestable markets, potential competition may not cause prices to descend to the competitive level, but may provide restraints on monopolistic pricing (Graham et al., 1983; Moore, 1986; Morrison and Winston, 1987)[4].

Overall, therefore, there is no consensus on the nature of relationship between market concentration and in-house R&D efforts and it remains largely an empirical issue. Further, since the process of economic reforms increases market competition and hence the risks and uncertainties of business, in-house R&D efforts by a firm are likely to depend considerably on the *anticipated risks* and an increase in such risks may discourage firms to spend on in-house R&D. There are a number of studies that show inverse relationship between market uncertainty and investment in in-house R&D. For example, by using panel data on innovative firms in Germany's manufacturing sector, Czarnitzki and Toole (2011) have found that R&D investment by non-patenting firms falls in response to higher levels of market uncertainty as perceived through revenue volatility[5]. On the other hand, Milton and Schrand (1999) have observed that volatility in cash flow results in lower level of R&D investment. Similarly, Goel and Ram (2001) have found that greater fluctuations in inflation rate reduced the share of R&D investment in the GDP of the OECD countries.

This is particularly so as expenditure on R&D by a firm is an *endogenous sunk cost* (Sutton, 1991)[6] and massive innovative efforts do not always yield success in the market (Scherer, 2000). Given information asymmetries and hence the difficulty in predicting the demand patterns of the consumers and R&D strategies of the rivals, there is a large stochastic

[3]A review of the empirical literature up to the late 70's by Kamien and Schwartz (1982) also reveals inconclusiveness on the relationship between market structure and innovative activities.

[4]The issue of market contestability is likely to be crucial in Indian context as economic reforms have resulted in introduction of liberal policies relating to trade and investment, and greater contestability in different markets seems to restrict the scope for monopolistic behaviour of the incumbents.

[5] When patent protection mitigates market uncertainty, R&D investment by patenting firms is expected to be less responsive to revenue volatility as compared to the non-patenting firms. The regression analysis by Czarnitzki and Toole (2011) shows that R&D investment by non-patenting firms falls in response to revenue volatility while firms with patent protection have no significant response. It is found that patent protection confers a 20% increase in R&D investment. Using OECD data, Kanwar and Evenson (2003) have found that intellectual property rights significantly increase R&D investment as a share of gross national product.

[6]Investment in in-house R&D is largely irreversible, as a considerable proportion of R&D investment is used to pay salaries of the research personnel and it cannot be recouped if projects fail.

component in economic returns from R&D investments. Further, greater market uncertainty also raises the value of waiting to invest in irreversible capital (Dixit 1992; Dixit and Pindyck 1994), and the firms can lower R&D investment to avoid large losses by waiting for new information about market conditions. However, patent protection can partially mitigate the influence of demand related uncertainty and stimulate R&D investment (Czarnitzki and Toole, 2011)[7]**.** Besides, in-house R&D can also be undertaken to mitigate risks, especially when it is of adaptive kind and technological /market uncertainty is relatively low.

This means that the relationships between market concentration and in-house R&D efforts should be examined on the basis of expected market concentration. The existing studies have largely ignored this aspect. Besides, since the structure-conduct-performance-policy relationships are multi-directional in nature (Scherer and Ross, 1990), and in-house R&D is considered as an important business strategy, understanding the relationships between market concentration and innovative efforts requires controlling for other aspects of market structure, other types of conduct (other than R&D) of the firms, their performance and policy related aspects. The present paper attempts to fill in this gap. The objective of the present paper is to examine the role of market concentration in determining inter-industry variations in R&D efforts in the Indian manufacturing sector controlling for influence of other determinants. Understanding this issue is very important as policy induced restrictions on new entrants were seen to have reduced competitive pressures and retarded innovative efforts of the firms in the pre-liberalization era (Kumar, 1987). Although the existing studies explore different aspects of in-house R&D in Indian manufacturing sector (e.g., Basant, 1997; Kumar and Agarwal, 2000; Mani, 2009; Mishra, 2007; Mishra, 2010), examining the role of market concentration in influencing R&D efforts by the firms has not been adequately explored.

Further, the state of R&D efforts by the Indian firms is not very encouraging, particularly in comparison with many of the industrialized and newly industrializing economies[8], despite the fact that the process of liberalization has exposed the manufacturing sector to greater

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[7]As it is mentioned earlier, intellectual property rights result in significant increase R&D investment as a proportion of GDP of the OECD countries (Kanwar and Evenson, 2003).

[8]The R&D expenditure as a proportion of GNP for the world as a whole increased from 1.85 percent in the 1980s to 2.55 percent in the 1990s. Contrary to this, in India, the proportion of GNP spent on R&D was not only very low during this period, it, though increased from 0.58% in 1980-81 to 0.91% in 1987-88, declined subsequently and reached 0.82% in 1998-99.

market competition. The industry sector constitutes only 23 percent of the national R&D expenditure and the bulk comes from public funded institutions (Kumar, 2005). Real R&D expenditure by the firms has declined in 12 out of 28 broad industries in the 1990s (Basant, 2000). Recent estimates show that both the nominal and real growth rates have declined (Mani, 2009). However, while the government still accounts for over 63 percent of total in-house R&D performed in the country, expenditure by the business enterprises in this regard has increased in recent years (Mani, 2009)[9].

More importantly, even though all the major industries have shown an increasing trend in in-house R&D intensity and the rate of growth has been quite sharp in most of the industries barring a few like non-metallic minerals, and paper and paper products, the R&D intensity has varied significantly across industries (Basant and Mishra, 2012). Further, while most of the industries have reduced their expenditure on foreign technology purchase, the domestic firms still rely largely on trade, foreign direct investment, licensing, joint ventures, mergers, acquisitions and various other alliances to source technology.[10] It is observed that share of Indian firms in global technology alliances have increased from 0.22 percent during 1984-88 to 5.44 percent during 2004-08 (Belderbos, et al, 2011). Besides, many of the firms, particularly in Indian pharmaceutical industry, have used the route of M&A to strengthen their in-house R&D base during the post-reform period (Mishra, 2006)[11].

Besides, the three important amendments to the Indian Patent Act (1970), viz., *Patent First Amendment Act* in 1999, *Patent (Second Amendment) Bill* in 2002 and *Patent (Amendment) Bill* in 2005 have made a marked shift from the process patent regime towards an era of product patent. The amendment in 1999 introduced the mailbox provisions to receive

[9] It is observed that technology strategies in Indian corporate sector have undergone a major change in recent years. While in-house R&D intensity (although still low) has seen significant growth, the role of embodied and disembodied technology purchase, both from foreign and domestic sources, has declined (Basant and Mishra, 2012).

[10] The increasing importance of external source of technology for a firm may largely be due to technological convergence, declining transaction costs of acquiring external R&D inputs, and shortening product cycle times (Grandstrand et al. 1992; Narula, 2001). In addition, alliances may help a firm developing dynamic capabilities and in strengthening their competitive advantage over time (Teece et al., 1997; Eisenhardt and Martin, 2000).

[11] For example, the Ajay Piramal group acquired Boehringer Mannheim India Ltd. mainly to have access to the parent company's (Boehringer Mannheim of Germany) R&D base. Similarly, Nicholas Piramal India Ltd., an Ajay Piramal group company, acquired the basic research unit of Hoechst Marrion Russel (India) as a part of its R&D strategy. Besides, Sun Pharmaceutical Industries Ltd. merged Tamil Nadu Dadha Pharmaceuticals Ltd. with it to expand its R&D plan, whereas, Dr. Reddy's Research Foundation formed an R&D alliance with Novonordisk of Denmark for developing a compound of Glitazone (an anti-diabetes drug).

product patent applications, whereas that in 2002 extended the term of patent to 20 years. The amendment in 2005, on the other hand, finally recognized the WTO mandated product patent provision. It is expected that new patent laws will provide ex-post market power to the firms. But, given the costs and uncertainties of innovative efforts, to what extent the new patent regime would encourage the firms towards innovation requires further scrutiny. In addition, decision of a firm to invest in innovation may be determined by structure of the market and the firm's relative position therein, alternative strategic options, and ability to invest in R&D. For example, when there are imperfections in the capital market, only the larger firms with stability and internally generated funds can afford to invest in risky R&D projects. Similarly, for the innovating firm with larger scale of operation, the returns of R&D are likely to be higher due to spread of fixed costs of innovation over a large volume of sales.

In this perspective, the findings of the present paper will help to understand the influence of market structure on firms' R&D efforts as well as the role of other factors on such technology efforts. This is very important for designing appropriate innovation policy, given the possible inter-linkages between competition policies and that relating to trade and investment. The paper is divided into five sections. The functional model on the relationships between market concentration and in-house R&D is specified and the hypotheses are set in the second section. The third section discusses the estimation techniques and the sources of data. The regression results are presented and discussed in the fourth section. The last section summarizes the major findings and concludes the paper.

II. Model Specification

The functional specification of the present paper is based on the proposition of Kamien and Schwartz (1982) that market structure influences a firm's decision to innovate via *anticipated* market power. It is assumed that the greater anticipated market power encourages the firms in the industry more towards innovations. This is so because greater market power in future reduces the risks of doing business and also ensures higher profits that can compensate for the current R&D investment. Hence, we may assume that R&D intensity in industry i in year t (R_{it}) depends on the expected market concentration during next s years ($C^*_{i,t+s}$), i.e.,

$$R_{it} = \alpha + \sum_{j=1}^{s} \beta_j C^*_{i,t+j} + u_{it} \quad \text{................(1)}$$

Following Koyck (1954), let us assume that $\beta_j = \lambda^j \beta_0; 0 < \lambda < 1, j = 1,...., s$

Hence, $R_{it} = \alpha + \sum_{j=1}^{s} \lambda^j \beta_0 C^*_{i,t+j} + u_{it}$................(2)

Lagging (2) by 1 year and dividing both sides by λ,

$$\frac{1}{\lambda} R_{i,t-1} = \frac{1}{\lambda}\alpha + \sum_{j=1}^{s} \lambda^{j-1} \beta_0 C^*_{i,t+j-1} + \frac{1}{\lambda} u_{i,t-1} ....(3)$$

Subtracting (3) from (2)

$$R_{it} = \alpha^* + \lambda^* R_{i,t-1} + \beta_0 C^*_{it} + v_{it} ....(4)$$

As C^*_{it} is not directly observable, following Cagan (1956) and Friedman (1957), let us assume that the firms have adaptive expectation or error learning behaviour, i.e.,

$$C^*_{it} = C^*_{i,t-1} + \delta(C_{it} - C^*_{i,t-1}) + \gamma X_{it} = \delta C_{it} + (1-\delta) C^*_{i,t-1} + \gamma X_{it} ....(5)$$

Here, X_{it} is a vector of other variables that affect expectation with γ being the corresponding coefficient vector and σ for the coefficient of adjustment such that $0 < \sigma \le 1$

Substituting (5) in (4),

$$R_{it} = \alpha^* + \lambda^* R_{i,t-1} + \beta_0 [\delta C_{it} + (1-\delta) C^*_{i,t-1} + \gamma X_{it}] + v_{it} ....(6)$$

Lagging (4) by 1 year and multiplying by $(1-\delta)$

$$(1-\delta) R_{i,t-1} = (1-\delta)\alpha^* + (1-\delta)\lambda^* R_{i,t-2} + (1-\delta)\beta_0 C^*_{i,t-1} + (1-\delta) v_{it} .....(7)$$

Subtracting (7) from (6),

$$R_{it} = \delta\alpha^* + [\lambda^* - (1-\delta)] R_{i,t-1} - (1-\sigma)\lambda^* R_{i,t-2} + \beta_0 \delta C_{it} + \beta_0 \gamma X_{it} + \omega_{it} ....(8)$$

Or, $R_{it} = \theta_1 + \theta_2 R_{i,t-1} + \theta_3 R_{i,t-2} + \theta_4 C_{it} + \eta X_{it} + \omega_{it}$............(9)

Here, the lagged dependent variable accounts for the dynamic effects. Although equation (9) contains lag for both the first-year and the second-year separately, while estimating the equation we include lag for the first year only. However, this does not affect the basic proposition of the model as in the present paper three-year moving average of the variables, instead of their annual values, are used to make the dataset more consistent over the period of time. Accordingly, all the variables are measured as simple moving average of previous three years with the year under reference being the starting year. Further, the present paper attempts to examine the impact of expected market concentration on in-house R&D, but the transformed model includes current (actual) market concentration only as one of the explanatory variables with the assumption that the firms follow adaptive expectation or error learning behaviour. However, this does not restrict the present paper from addressing its basic objective. This is so because under the assumption of error learning behaviour, expected value of a variable is linearly related to its current value. In an autoregressive model, as it is in the present case, repeated linear transformation of current value of a variable approximates to its expected value. Hence, in the remaining part of the paper, the econometric exercises and subsequent discussions have been carried out in terms of market concentration only, and not 'expected market concentration'.

The vector *X* includes a set of structure, conduct, performance and policy related variables such as market size (MSZ), presence of the multinational corporations (MNC), capital intensity (KI), advertising intensity (ADVT), technology purchase intensity (TPUR), number of mergers and acquisitions (M&A)[12], export intensity (EXP), import intensity (IMP), profitability (PROF), and industry risks (IR). Here, market size, MNC participation, and capital intensity are expected to capture structural aspects of the markets, advertising intensity, technology purchase intensity, number of mergers and acquisitions, exports intensity and imports[13] intensity for behavioural aspects (conduct) of firms, and profitability and industry risks their performance.

However, advertising can also be seen as a structural variable which is partly a function of product features. Similarly, one can view industry risks as a structural variable in a cross-sectional sense as some industries are inherently more risky than others. In addition, given policy induced flexibilities, imports intensity can also been seen as a variable influencing market competition, whereas exports intensity as an indicator of firms' performance in the international market. Besides, some of the independent variables can also act as proxies for various policy changes by the government. For example, presence of the MNCs and the number of mergers and acquisitions are partly influenced by investment and competition

[12]Although mergers and acquisitions are different in their definitions and the statutory procedures, their effects from an economic perspective are the same, as in both the cases the control of one company passes on to another. Hence, in the present paper, no distinction is made between the mergers and the acquisitions.
[13] Here, we consider imports of final goods only.

related policies, whereas exports and imports are likely to capture the impact of changes in trade policies. Similarly, technology purchase can partly capture effects of policy changes relating to technology development, especially the ones relating to foreign technology acquisition. Hence, equation (9) can be written as the following:

$$R\,\&\,D = f(LR\,\&\,D, MSZ, CON, MNC, KI, ADVT, TPUR, M\,\&\,A, EXP, IMP, PROF, IR)$$

Here, LR&D and CON stand for lagged in-house R&D and market concentration respectively. As discussed in the introductory section, there have been many important amendments to the Indian Patent Act since the late 1990s. Hence, the ideal way of understanding inter-industry variations in in-house R&D efforts should be capturing the impact of these changes as well by adding appropriate variable(s) relating to intellectual property. This is very important as amendments to the Indian Patent Act may have diverse impact across different industries and in-house R&D efforts by the firms operating therein may be influenced accordingly. But, lack of systematic data restricts us from exploring this aspect explicitly. However, since the present paper estimates the above model by applying panel data estimation techniques, industry specific variations are captured. In other words, failure to include patent related variable(s) is unlikely to cause any significant limitation to the findings of the estimated regression models.

Probable Impact of the Explanatory Variables

The details of the measures used for variables discussed above are provided in Appendix II. We briefly discuss here the likely impact of these variables on R&D intensity.

Lagged R&D Intensity (LR&D): In-house R&D is a continuous process. Once an R&D project is taken up by a firm, it is often continued if there is a potential of positive outcomes; in situations where initial results are not positive, the project can also be shelved. Further, success in previous R&D projects may encourage the firms to raise current R&D expenses. Seen in this line, one may expect lagged R&D intensity to have positive impact on current R&D intensity. In other words, the industries with greater R&D intensity in the past are likely to have greater R&D efforts at present as well, unless the R&D outcomes have been consistently bad.

Market Size (MSZ): *Ceteris paribus*, larger domestic market of an industry is likely to increase the willingness of firms to invest more on innovation, whereas larger presence in the international market may, in addition compel firms in the industry to invest more in in-house R&D to enhance competitiveness. It is possible that a larger domestic market may also encourage entry of new firms and force the existing firms to enhance their competitiveness through in-house R&D. Moreover, larger markets are typically associated with more elastic demand (Barron et al., 2008), and thereby limited market power for an individual firm. Under these circumstances, in-house R&D helps the firms to have a distinct market with lower elasticity of demand through product differentiation. Insofar as the measure of market size used here includes both domestic and international sales, industries with larger market size are expected to have greater in-house R&D efforts by the firms in the industry.

Market Concentration (CON): As mentioned above, there is no consensus on the nature of impact of market concentration on in-house R&D efforts in the industrial organization literature. Firms in concentrated markets have greater ability and willingness to invest in in-house R&D but higher market concentration can also make the firms complacent and hence reduce their urge to innovate. Contrary to this, greater market competition may force firms to innovate to have competitive edge. The nature of relationship between market concentration and in-house R&D intensity, therefore, depends on which of these processes dominates empirically.

Presence of MNC (MNC): The expected impact of FDI on in-house R&D, particularly that of domestically-owned firms is not clear. While the demonstration effects or technology externalities and emerging competitive threats from FDI can increase innovative efforts of the domestic firms, entry of foreign firms, especially through Greenfield investments, can increase competition in the local market resulting in a reduction in R&D intensity of other firms because of diminishing monopoly rents. Insofar as MNCs are more R&D intensive, their presence may enhance average R&D intensity in the industry. Due to the same reason if the successful foreign firms force local firms to exit the market, average R&D intensity would also go up. However, it is generally observed that the foreign affiliates operating in India invest significantly less in in-house R&D as compared to their domestic counterparts (Kumar, 1987; Kumar and Saqib, 1996; Kumar and Agarwal, 2000), as they have access to the R&D base of the parent companies. Thus, the exact nature of impact of MNC participation on innovation is an empirical issue. For example, by examining R&D in Chinese state-owned enterprises (SOEs), Girma et al. (2006) found relatively high R&D in firms with more foreign capital participation. In contrast, Veugelers and Vanden Houte

(1990) found that the domestic firms in the industries with higher share of FDI have lower innovation intensities in Belgian manufacturing sector.

Capital Intensity (KI): High capital intensity in an industry can act as an entry barrier and deter entry reducing possible competitive threat. This may encourage the firms towards in-house R&D insofar as the firm can appropriate the benefits of new technologies. However, if the existence of capital intensity oriented entry barrier results in complacency among incumbents, their R&D intensity may decline. This is more likely to be the case in situations where capital markets are imperfect. Thus, the nature of impact of capital intensity on R&D efforts depends on the relative strength of these diverse forces.

Advertising Intensity (ADVT): Efforts towards in-house R&D and technology imports are higher in industries where products are differentiable (Philips, 1966; Comanor, 1967; Kumar, 1987; Siddharthan and Krishna, 1994). Firms in such industries invest more in in-house R&D and also import technology to offset the competitive threats from the rivals in the form of new or differentiated products. If advertising is used as a proxy for product differentiation, one can, therefore, assume a positive association between advertisement intensity and innovation. However, it is also possible that the firms use advertising as strategic alternatives to innovation to create entry barriers, and when it is so, the industries with greater advertising intensity may experience lower R&D efforts by the firms.

Technology Purchase Intensity (TPUR): There are a number of studies that have examined the relationship between technology purchase and in-house R&D efforts (e.g., Katrak, 1991; Siddharthan and Krishna, 1994; Basant, 1997), and the links are often found to be complex (Kumar, 1987). Many of the firms source technologies from external sources due to their limited financial and intellectual capabilities for in-house R&D. In general, purchase of technology in embodied or disembodied form substitutes in-house R&D activity of the receiving firms of the developing countries, at least at a point in time.[14]. However, in many cases, import of foreign technology, particularly in disembodied form requires in-house R&D on the part of importing firm for its effective absorption, adaptation and assimilation. The relationship between R&D and technology purchase may, therefore, be

[14]Here, technology expenditure includes expenses towards payment for royalties, technical know-how fees (both domestic and foreign), import of capital goods.

complementary or substitute and the exact nature between the two depends on the requirement of the firms and the nature of R&D.

Exports Intensity (EXP): As suggested earlier, given the size of the market, higher export orientation is expected to affect innovative efforts of a firm positively (Braga and Willmore, 1991; Kumar and Saqib, 1996; Kumar and Agarwal, 2000). As a firm penetrates more in the international market, competitive pressures from the foreign firms also increase. Sustaining in the international market, therefore, requires greater competitiveness, especially, in terms of offering new quality products at lower prices vis-à-vis the competitors. In addition, exposure to foreign markets may also result in knowledge flows that might provide inputs for R&D endeavours. This, in turn, raises innovation intention of the domestic firms. Hence, the industries with greater exports intensity of the firms are likely to experience more investment in innovation.

Imports Intensity (IMP): When imported products are of better quality or cheaper, one may expect higher competitive pressures insofar as the imports are of final goods sold in the industry. Greater import competition may, therefore, force the rival firms in the industry to be more innovative (Bhattacharya and Bloch, 2004). However, when the importing firms dominate the market, greater import competition may reduce in-house R&D efforts of the firms concerned and hence that of the industry. The nature of impact of import intensity on innovation, therefore, depends on the relative strength of these diverse forces, more specifically on whether the importing firms dominate the market.

Mergers and Acquisitions (M&A): Given that M&As can influence almost every determinant of innovation, there is a formidable problem to analyze the merger-innovation relationships. As a result, there is no consensus on this front in the literature. Even empirical studies have shown divergent results. For example, while Ravenscraft and Scherer (1987) and Hitt et al. (1991) have found negative impact of M&As on in-house R&D, Bertrand and Zuniga (2006) have observed an increase in such efforts of the *firms* following M&As. Since the R&D intensity among MNCs in India is low (see earlier discussion), when a domestic firm is acquired by or merged with a foreign firm, it gets easy access to better technology of the latter and may reduce its in-house R&D efforts. Many of the M&As in Indian pharmaceutical industry in the 1990s were guided by the motive of strengthening R&D bases (Mishra, 2006). This is likely to reduce in-house R&D efforts of the domestic firms. Besides, M&As may also enhance the scale of operation of the firms and thereby reduce the average costs of operations. When it is so, the participating firms may have a distinct competitive edge in the market and their in-house R&D efforts may be low. There may also be economies of scale in R&D activity, resulting in lower R&D intensity[15]. Further, the M&As, that are of conglomerate in nature, help the firms to mitigate risks and hence role of R&D in this regard declines. On the other hand, if M&As raises market power of the firms, their R&D efforts may increase. However, M&As can also enhance oligopolistic rivalry and enhance degrees of competition. This, in turn, may force the firms to invest in in-house R&D to enhance competitiveness and/or to mitigate market uncertainties. Thus, the nature of impact of M&As on in-house R&D efforts would depend on which of these diverse forces dominate.

Profitability (PROF): The firms with better financial performance are expected to have greater ability as well as willingness to invest in innovation. However, it is also possible that the firms with better financial performance become complacent and reduce emphasis on innovation. The impact of profitability on in-house R&D intensity, therefore, depends on relative strength of these diverse forces.

Industry Risks (IR): High industry risks, conventionally measured in terms of variability in an industry's profitability over time, may compel the firms to make in-house R&D efforts to stabilize their performance, especially when the variability is due to increasing inter-firm competition. High industry risks may also discourage the risk-averse firms to invest in innovation. Instead, high industry risks may induce such firms to rely more on technology sourcing and other strategic alternatives that have less uncertain outcomes, to enhance their competitiveness.

III. Methodology and Data

In order to examine the relationships between market concentration and in-house R&D efforts in the present paper, we estimate the regression model discussed above by applying the Arellano-Bond (1991) dynamic panel data estimation techniques. The regression model

[15]Economies of scale in R&D seem to have significant role due to the high fixed costs associated with innovation. This may reduce post merger R&D intensity by eliminating of duplicated efforts, whereas R&D efficiency may be higher (Cohen and Levin, 1989; Roller et al., 2001).

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envisaged includes lagged dependent variable as one of the independent variables. Hence, the model estimated is of the form,

$$y_{it} = \alpha + \beta y_{i,t-1} + \sum_{j=1}^{m} \gamma_j x_{j,it} + u_{it}$$

In a dynamic model as specified above, the lagged dependent variable is likely to be correlated with the random disturbance term even if it is assumed that the latter is not autocorrelated. When it is so, the estimators of the fixed effects model and the random effects model become biased and inconsistent. Many of the existing studies (e.g., Balestra and Nerlove, 1966; Anderson and Hsiao, 1981 and 1982; Bhargava and Sargan, 1983) have applied the method of instrumental variables to estimate dynamic panel data regression model. However, the proposed study will apply the Arellano-Bond (1991) dynamic panel data estimation techniques, which is based on the generalized method of moments (GMM). As compared to the method of instrumental variables, the GMM estimators can bring in more information on data during the course of estimation (Ahn and Schmidt, 1995).

The Arellano-Bond (1991) dynamic panel data estimation technique uncovers joint effects of the explanatory variables on the dependent variable. It also controls for the potential bias due to endogeneity of the explanatory variables including the lagged dependent variable[16]. In order to control for potential bias due to endogeneity of the explanatory variables, one-year lag value of the lagged dependent variable and that of other explanatory variables are used as the instruments. Besides, marketing and distribution intensity is used as additional instrument while estimating the model. Presence of autocorrelation problem and validity of the instruments are tested by applying Arellano-Bond test for autocovariance and Sargan test (1958) of over-identifying restrictions respectively.

We use both the one-step and the two-step estimators of Arellano-Bond dynamic panel data model. While the statistics based on two-step estimators are used to test for the over-identifying restrictions and overall significance of the model, inferences on the individual coefficients are drawn on the basis of the one-step estimators with robust standard errors. This is so because the asymptotic standard errors of one-step estimators are unbiased and are reliable to draw inference on the individual coefficients. But, in the one-step estimator, the

[16]Since the industry is the unit of observation in the present context, endogeneity bias of the explanatory variables is unlikely to be acute as it normally is when the firm or the line of business is the unit of observation (Salinger, 1990).

Sargan test over-rejects the null of over-identifying restriction in the presence of heteroscedasticity. On the other hand, the robust standard errors of one-step estimators can control for heteroscedasticity, but the distribution of Sargan test statistic is not known[17].

The above model is estimated with a panel dataset of 34 manufacturing industries over the period from 2001-02 to 2008-09. Since the basic objective of the paper is to examine concentration-R&D relationships, four alternative measures of market concentration, viz., Entropy Index (CON_ENT), Herfindahl-Hirschman Index (CON_HHI), and Horwath Index (HHI_HOR), and the GRS Index (GRS) are used to substantiate the findings[18]. The paper uses secondary data collected from the Centre for Monitoring Indian Economy, Mumbai, India. The necessary information M&A are compiled from the *Business-Beacon* database, whereas data on rest of the variables are collected from the *Prowess*.

IV. Results and Discussions

Table 1 provides the summary statistics for the variables used in estimating the regression model. The regression results including the tests for autocorrelation and the validity of the instruments (Sargan test) are summarized in Tables 2, 3, 4 and 5. It is observed that Wald-Chi^2 is statistically significant for all the estimated models with both one-step and two-step estimators. This means that all the estimated models are statistically significant. Since the Sargan Test statistic is not statistically significant, the estimated models do not suffer from the problem of over-identified restrictions. Further, the z-Statistics for Arellano Bond test of both AR (1) and AR (2) are not statistically significant implying that the estimated models are free from the problem of autocorrelation.

The z-statistics of the regression coefficients for one-step estimates are based on robust standard errors. As mentioned above, we use the z-statistics of one-step estimates for inference on the individual coefficients. It is observed that in all the estimated models the coefficient of LR&D, MNC, KI, M&A, EXP and IMP are statistically significant. This means that inter-industry variations in in-house R&D efforts by the firms depends on their previous R&D efforts, extent of MNC participation, capital intensity, number of mergers and acquisitions,

[17] Although the two-step estimators yield standard errors that are asymptotically robust to both heteroscedasticity and autocorrelation, the asymptotic standard errors of these estimators can be severely downward biased in small samples.
[18] This is very important as the degree and trends of market concentration are not consistent across different measures. For the details in this regard as well as on the indices, see Mishra et al (2011).

exports intensity, and imports intensity in the industry. Further, while coefficient of LR&D, MNC, KI and EXP are positive and that of M&A and IMP are negative. This means that the industries with greater R&D efforts by the firms in the past, larger participation of the MNCs, higher capital intensity, or greater penetration in the international market through exports experience more investment in innovation. On the other hand, in-house R&D efforts are less in the industries with larger incidence of mergers and acquisitions or greater imports intensity.

However, the coefficient of market concentration for the indices CON_HHI, CON_ENT and CON_HOR are not statistically significant in case of both one-step and two-step estimators. The coefficient of the other measure of market concentration, i.e., CON_GRS is also not statistically significant in case of one-step estimator, though it is statistically significant for the two-step estimators. Similarly, the coefficients of MSZ, ADVT, TPUR and PROF and IR are not statistically significant as well. This means that the degree of sellers' concentration in a market, its size, efforts by the firms towards creation of product differentiation and image advantage, purchase of technology, and the level and variations in their profitability do not make any significant difference in in-house R&D intensity across the industries.

The findings of the present paper have some important implications. First, market concentration has no significant impact on innovation efforts of the firms. In other words, inter-industry variations in in-house R&D efforts by the firms are not caused by the degree of sellers' concentration in the respective market. This is contradictory to the findings of Fellner (1951), Williamson (1965), Scherer (1967), Levin (1981), and Mukhopadhyay (1985) which support the Schumpeterian (1942) proposition that concentrated industries are more favourable for innovation. It also conflicts with the findings of Arrow (1962) and Aghion et al (2002) that a pre-innovation monopolist has a weaker incentive to innovate than a firm operating in a competitive market.

The reason for such a finding may be the complexities in the relationship between market competition and extent of R&D efforts. For example, in an industry with greater market competition, the firms may have the need to spend more on R&D to raise their competitiveness. On the other hand, greater market competition may reduce firms' expected return from in-house R&D, especially when they assume competition to increase further and hence their willingness to invest for innovation. On balance, the degree of sellers' concentration in the industry may not have any significant impact on firms' R&D efforts.

Second, it is observed that the industries with large number of M&A experience low in-house R&D intensity of the firms in the industry. In other words, M&A undermine firms' innovative efforts in an industry. Although such a negative impact of merger on innovation is consistent with many of the earlier studies (e.g. Ravenscraft and Scherer, 1987; Hitt et al., 1996), potentially, mergers can change almost every determinant of innovation incentives and this multidimensionality of impact poses a formidable problem in analyzing merger-innovation relationships (Schulz, 2007). In general, a merger is expected to benefit the participating firms in terms of economies of scale and scope, risk diversification, managerial improvements, increased market power, and attainment of intangible assets (Sonenshine, 2010). For example, integration through M&A, particularly with the MNCs may help the firms to have easy access to better technology, and thereby may discourage them from investing in in-house R&D. Possibly that is why presence of the MNCs is found to have significant positive impact on in-house R&D efforts. The demonstration effects or technology externalities and emerging competitive threats from FDI seem to have increased innovative efforts of the firms. It is also possible that the wave of M&A has led to higher monopoly power and as a result firms have a weaker incentive to innovate.

However, in the present paper, MNC participation and concentration ratio are added as separate explanatory variables along with the number of mergers and acquisitions. While MNC participation captures the spillover effects, market power related influence is captured by the concentration ratio. The negative coefficient of M&As may be due to a set of other factors. As suggested, M&As may have enhanced the scale of operations of the participating firms and hence their competitiveness. This might have eventually reduced the need for in-house R&D apart from benefiting firms in terms of economies of scale in R&D activity. It is also possible that decline in market competition following M&As has discouraged the firms to invest in in-house R&D for enhancing their competitiveness and/or for mitigating market risks. Even though majority of the deals appear to be horizontal in nature at a broader level of classification of industries (as it is done in the present paper), most of the participating firms have diversified product portfolio that help them to mitigate risks. As a result, role of in-house R&D in mitigating risks seem to have declined. The decline in R&D investment might also be a response to the cash outflow owing to mergers[19]. Hence, the observed negative impact of M&As on in-house R&D efforts may be a combination of all these diverse forces. However, any definite conclusion in this regard requires further exploration.

Third, while higher export intensity increases innovative efforts of the firms, greater imports intensity of *final goods* reduces the same. This is so possibly because greater penetration in the international market through exports increases competitive pressure from the foreign firms and sustaining competitive advantage under such business conditions requires in-house R&D. It may also have increased innovative efforts through knowledge spillovers from foreign markets that provide useful technological ideas to follow-up for enhancing competitiveness. On the other hand, in the industries where imports intensity is high, the importing firms seem to dominate the market, and lack of competitive threat from the rivals possibly undermines the need for in-house R&D efforts by the firms concerned[20].

V. Concluding Remarks:

The basic objective of the present paper was to understand the role of market concentration in determining inter-industry variations in in-house R&D efforts in Indian manufacturing sector, controlling for the influence of other aspects of market structure, conduct of firms in the industry (other than R&D), their performance, and policies of the government. It is found that the firms in industries with greater R&D efforts in the past, larger participation of the MNCs, higher capital intensity, and greater penetration in the international market through exports invest more in innovation. On the other hand, in-house R&D efforts of the firms are less in the industries with larger incidence of mergers and acquisitions and greater imports intensity. However, the degree of sellers' concentration in the market, its size, efforts by the firms towards creation of product differentiation, purchase of technology, and the level and variations in their profitability do not make any significant difference in in-house R&D intensity across the industries. (See Table 6 for summary of regression results)

[19] In addition, acquisitions may adversely affect the interests of the managers towards development of new products, technologies or processes as there may be fewer internal post-acquisition rewards for innovative activities (Hitt et al., 1991). Instead, M&As are often followed by a short-term financial control system (Ernst and Vitt, 2000; Hitt et al., 1991). This is likely to result in a decline in R&D expenditures by the firms.

[20] Such relationships are observed at firm level as well. By applying panel data estimation techniques for a set of 52 listed drugs and pharmaceutical companies over the period from 2000-01 to 2007-08, Mishra (2010) has found that larger presence in the international market boosts innovation intention of a firm in the industry, whereas a firm with higher import intensity invests less on in-house R&D.

The findings of the present paper suggest that inter-industry variations in R&D efforts of the firms do not depend on market concentration and size. They seem to be influenced by certain types of competition and spillovers in the market; larger presence of the MNCs and greater exports intensity of an industry enhance in-house R&D efforts of the firms in the industry. In both cases, there is a potential of an increase in competitive threat as well technology spillovers and both these seem to result in higher innovative efforts of the firms in the industry to enhance their competitiveness. Hence, factors that enhance contestability as well as provide a potential technology spillover are likely to be more conducive for R&D investment.

The paper, therefore, raise some important policy dilemmas. While greater MNC participation in an industry seem to induce firms in the industry to invest more in in-house R&D, an increase in M&A activity reduces the same. A simple interpretation of these results could be that entry of MNCs needs to be encouraged while restricting M&A to enhance in-house R&D efforts firms. However, if the M&A activity is reducing R&D intensity due to scale economies and may probably be enhancing efficiency of R&D, the policy prescription ceases to be simple. But the issue is real as M&A have become predominant channel of FDI inflows into India during the post-reform period. Nearly 39 per cent of FDI inflows into the country during 1997-1999 have taken the route of M&A, whereas inward FDI in the pre-reform era were invariably in the nature of Greenfield investments (Kumar, 2000). The trend has continued in the recent past as well. Acquisition of shares by the foreign investors has constituted around two-fifths of the total FDI equity inflows during 2005-07 (Rao and Dhar, 2011). Hence, emphasis should probably be given on encouraging the foreign firms to enter into Indian markets through Greenfield investment, as it has other advantages as well, the issue of scale economies associated R&D efficiency may remain unresolved. Besides, how exactly this needs to be achieved will need further scrutiny, For example, should it be done through incentives for Greenfield investment or regulation of FDI through M&A restrictions, needs closer examination.

Moreover, since higher exports intensity increases innovative efforts of the firms and imports of final goods reduce the same, should India have trade policies that can encourage exports and restricts imports of such commodities? While encouraging exports is necessary to facilitate in-house R&D and widen the markets, restricting imports would reduce market contestability. Interestingly, enhancement of contestability through imports of final products does not result in higher R&D intensity in the industry. Is it because unlike exports and FDI, such imports do not provide significant learning opportunities through technology spillovers along with competition? Our results seem to be consistent with the idea that forces that simultaneously increase contagion (positive spillovers) and competition effects may have a positive effect on R&D intensity in an industry. Identifying such factors is a policy challenge. .

Finally, some important methodological limitations that primarily arise due to data inadequacies need to be mentioned. First, the database used in the paper allocates a merger or an acquisition across industries on the basis of the industry, which contributes the maximum to the sales of the target firms. But, as many of these target firms might be diversified having a number of products in their portfolios, such distribution may underestimate the impact in other industries. This may be important, particularly, when a firm has a strong presence in these industries. One of the possible ways to overcome this problem would have been to distribute a particular merger or acquisition across all industry categories of the target firm. However, non-availability of necessary information restricts us from undertaking such an exercise. Second, an ideal measurement of M&A should consider both the number as well as the size of the deals. Since the present paper considers only the number of M&A, equal weights are assigned to each of the deals. In other words, the present paper does not distinguish the deals depending on their size. Third, coverage of firms for different industries in the *Prowess* database of CMIE is not consistent over the years. This forces us to measure the variables by taking their three years' moving average to make the dataset consistent. But, such an approach can also result in loss of variability and hence dynamics of adjustment over the years. Possibly a firm level analysis would help in overcoming these limitations and hence having a better understanding of the determinants of in-house R&D efforts.

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Appendix – I: Tables

Table 1: Summary Statistics of the Variables

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
R&D	272	0.0039	0.0066	0.0000	0.0520
MSZ	272	4.2703	0.5376	3.0538	5.7992
CON_HHI	272	0.0901	0.0820	0.0097	0.3858
CON_ENT	272	1.4677	0.4041	0.7189	2.3297
CON_HOR	272	0.2560	0.1500	0.0507	0.6384
CON_GRS	272	0.1904	0.1297	0.0378	0.6074
MNC	272	0.0030	0.0057	0.0000	0.0410
KI	272	0.6588	0.3318	0.1920	2.3259
ADVT	272	0.0091	0.0138	0.0001	0.0855
TPUR	272	0.0163	0.0114	0.0021	0.0715
M&A	272	72.1360	77.3160	4.0000	539.0000
EXP	272	0.1574	0.1428	0.0005	0.8160
IMP	272	0.0101	0.0152	0.0000	0.0823
PBIT	272	0.0959	0.0490	-0.0387	0.2568
IR	272	0.0392	0.0273	0.0022	0.1508
MDI	272	0.0428	0.0205	0.0057	0.1147

Table 2: Regression Results for Herfindahl-Hirschman Index of Market Concentration

Variable	Two-Step Estimates		One-Step Estimates	
	Coefficient	z-Statistic	Coefficient	z-Statistic
Intercept	-0.01150	-1.44	-0.02871	-1.64
LR&D	0.62793	13.48*	0.60168	3.80*
MSZ	0.00207	1.04	0.00607	1.58
CON_HHI	0.0067	1.37	0.00174	0.24
MNC	0.14865	3.66*	0.22368	3.11*
KI	0.00348	2.53*	0.00632	1.78**
ADVT	-0.03239	-0.90	-0.03285	-0.53
TPUR	-0.01667	-1.54	-0.02251	-1.26
M&A	-0.00001	-3.10*	-0.00001	-2.13*
EXP	0.01449	2.66*	0.01834	1.88**
IMP	-0.02268	-1.90**	-0.03480	-1.70**
PROF	0.00182	0.31	-0.01426	-1.13
IR	-0.00253	-0.97	-0.00313	-0.81
Wald–Chi^2	1094.60*		192.93*	
Sargan Test for over-identification	9.26 (0.16)			
Arellano Bond Test for AR (1)	-0.34 (0.74)		-0.40 (0.69)	
Arellano Bond Test for AR (2)	0.33 (0.74)		0.73 (0.47)	
Number of Observations	204		204	

Notes: (i) The z-statistic in one-step estimation is based on robust standard errors; (ii) Figures in the parentheses indicate level of statistical significance of the respective test statistic; (iii) *Statistically significant at 5 per cent level; (iv) **Statistically significant at 10 per cent level.

Table 3: Regression Results with Entropy Index of Market Concentration

Variable	Two-Step Estimates		One-Step Estimates	
	Coefficient	z-Statistic	Coefficient	z-Statistic
Intercept	-0.00674	-0.71	-0.03211	-1.49
LR&D	0.62977	14.14*	0.59485	3.91*
MSZ	0.00177	0.84	0.00595	1.56
CON_ENT	-0.00151	-0.82	0.00243	0.74
MNC	0.13076	2.34*	0.24792	2.70*
KI	0.00319	2.40*	0.00658	1.84**
ADVT	-0.04927	-1.25	-0.06890	-1.11
TPUR	-0.01697	-1.52	-0.01739	-1.01
M&A	-0.00001	-3.05*	-0.00001	-1.94**
EXP	0.01319	2.24*	0.01932	1.86**
IMP	-0.02101	-1.76**	-0.03223	-1.72**
PROF	0.00207	0.34	-0.01199	-1.06
IR	-0.00252	-0.90	-0.00216	-0.52
Wald–Chi^2	1267.58*		183.93*	
Sargan Test for over-identification	8.15 (0.23)			
Arellano Bond Test for AR (1)	-0.37 (0.71)		-0.40 (0.69)	
Arellano Bond Test for AR (2)	0.29 (0.77)		0.73 (0.47)	
Number of Observations	204		204	

Notes: (i) The z-statistic in one-step estimation is based on robust standard errors; (ii) Figures in the parentheses indicate level of statistical significance of the respective test statistic; (iii) *Statistically significant at 5 per cent level; (iv) **Statistically significant at 10 per cent level.

Table 4: Regression Results with Horvath Index of Market Concentration

Variable	Two-Step Estimates		One-Step Estimates	
	Coefficient	z-Statistic	Coefficient	z-Statistic
Intercept	-0.01123	-1.41	-0.02847	-1.65
LR&D	0.63350	13.55*	0.60052	3.81*
MSZ	0.00196	0.96	0.00614	1.57
CON_HOR	0.00397	1.20	-0.00155	-0.30
MNC	0.13629	2.97*	0.22331	2.97*
KI	0.00347	2.53*	0.00638	1.83**
ADVT	-0.03738	-0.99	-0.04550	-0.73
TPUR	-0.01722	-1.56	-0.02110	-1.18
M&A	-0.00001	-3.16*	-0.00001	-2.10*
EXP	0.01379	2.48*	0.01840	1.90**
IMP	-0.02215	-1.85**	-0.03448	-1.71**
PROF	0.00222	0.37	-0.01382	-1.10
IR	-0.00257	-0.95	-0.00284	-0.72
Wald–Chi^2	1139.28*		186.96*	
Sargan Test for over-identification	8.83 (0.18)			
Arellano Bond Test for AR (1)	-0.38 (0.70)		-0.40 (0.69)	
Arellano Bond Test for AR (2)	-0.31 (0.76)		0.73 (0.47)	
Number of Observations	204		204	

Notes: (i) The z-statistic in one-step estimation is based on robust standard errors; (ii) Figures in the parentheses indicate level of statistical significance of the respective test statistic; (iii) *Statistically significant at 5 per cent level; (iv) **Statistically significant at 10 per cent level.

Table 5: Regression Results with GRS Index of Market Concentration

Variable	Two-Step Estimates		One-Step Estimates	
	Coefficient	z-Statistic	Coefficient	z-Statistic
Intercept	-0.01243	-1.59	-0.02921	-1.68*
LR&D	0.62743	13.33**	0.60168	3.75**
MSZ	0.00217	1.10	0.00610	1.60
CON_GRS	0.00496	2.56**	0.00274	1.02
MNC	0.15348	3.98**	0.22521	3.19**
KI	0.00349	2.56**	0.00628	1.79*
ADVT	-0.02648	-0.77	-0.02667	-0.46
TPUR	-0.01695	-1.64	-0.02326	-1.34
M&A	-0.00001	-3.04**	-0.00001	-2.11**
EXP	0.01512	2.79**	0.01854	1.92*
IMP	-0.02347	-1.97**	-0.03549	-1.73*
PROF	0.00185	0.32	-0.01459	-1.13
IR	-0.00256	-1.00	-0.00308	-0.83
Wald–Chi^2	1120.39**		547.29**	
Sargan Test for over-identification	9.38 (0.15)			
Arellano Bond Test for AR (1)	-0.32 (0.75)		-0.38 (0.70)	
Arellano Bond Test for AR (2)	0.30 (0.76)		0.72 (0.47)	
Number of Observations	204		204	

Notes: (i) The z-statistic in one-step estimation is based on robust standard errors; (ii) Figures in the parentheses indicate level of statistical significance of the respective test statistic; (iii) *Statistically significant at 5 per cent level; (iv) **Statistically significant at 10 per cent level.

Table 6: Summary of Regression Results

Variable	Statistical Significance	Sign of the Coefficient
Lagged R&D Intensity	Statistically Significant	Positive
Market Size	Statistically Not Significant	Positive
Market Concentration	Statistically Not Significant	Positive
MNC Participation	Statistically Significant	Positive
Capital Intensity	Statistically Significant	Positive
Advertisement intensity	Statistically Not Significant	Negative
Technology Purchase Intensity	Statistically Not Significant	Negative
Mergers and Acquisitions	Statistically Significant	Negative
Exports Intensity	Statistically Significant	Positive
Imports Intensity	Statistically Significant	Negative
Profitability	Statistically Not Significant	Negative
Industry Risks	Statistically Not Significant	Negative

Appendix II: Measurement of the Variables

All the variables are measured as simple three previous years' averages from the year under reference to make the data set more consistent over time along with taking care of the adjustment process and eliminating the problem of simultaneity amongst the variables. Accordingly, all the variables are measured as simple moving average of previous three years with the year under reference being the starting year.

Dependent Variable:

R&D Intensity (R&D): In the present paper we use R&D intensity as a measure of innovation efforts by the firms in an industry. It is measured as the ratio of total expenditure on in-house R&D (RDE) to sales (S), i.e.,

$$R\&D_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} RDE_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} RDE_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} RDE_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}} \right)}{3}$$

Here, $R\&D_{jt}$ stands for technology intensity in industry j in year t.

Independent Variables

Market Concentration (CON): The present paper uses four alternative measures of market concentration, viz., the Herfindahl-Hirschman Index (HHI), the Entropy Index (ENT), the Howarth Index (HOR), and the GRS Index (GRS).

(i) Herfindahl-Hirschman Index (HHI): The Herfindahl-Hirschman Index of market concentration is constructed by using the formula,

$$HHI_{jt} = \frac{\left(\sum_{i=1}^{n} s^2_{it} + \sum_{i=1}^{n} s^2_{i,t-1} + \sum_{i=1}^{n} s^2_{i,t-2} \right)}{3}$$

Here, HHI_{jt} is Herfindahl-Hirschman Index for industry j in year t and s_i stands for market share of the i^{th} firm in the industry. Market share of a firm is defined as the ratio of the firm's sales to total industry sales.

(ii) Entropy Index (ENT): The Entropy Index of market concentration is constructed by using the formula,

$$ENT_{jt} = \frac{\left(-\sum_{i=1}^{n} s_{it} \times \ln(s_{it}) - \sum_{i=1}^{n} s_{i,t-1} \times \ln(s_{i,t-1}) - \sum_{i=1}^{n} s_{i,t-2} \times \ln(s_{i,t-2}) \right)}{3}$$

Here, ENT_{jt} stands for Entropy Index of market concentration for industry j in year t.

(iii) Horwath Index (HOR): The Horwath Index of market concentration constructed by using the following formula:

$$HOR_{jt} = \frac{\left(\left\{s_{1t} + \sum_{i=2}^{n} s_{it}^2 (2 - s_{it})\right\} + \left\{s_{1,t-1} + \sum_{i=2}^{n} s_{i,t-1}^2 (2 - s_{i,t-1})\right\} + \left\{s_{1,t-2} + \sum_{i=2}^{n} s_{i,t-2}^2 (2 - s_{i,t-2})\right\}\right)}{3}$$

Here, HOR_{jt} stands for Horwath Index of market concentration for industry j in year t and s_1 for market share of the largest firm in the industry.

(iv) GRS Index (GRS): The GRS index of market concentration is defined as,

$$GRS_{jt} = \frac{\sum_{i=1}^{n}\left(\frac{n^2 s_{1t} + 0.3 s_{it}^2}{n^2 + 0.3 n s_{1t} s_{it}} s_{it}\right) + \sum_{i=1}^{n}\left(\frac{n^2 s_{1,t-1} + 0.3 s_{i,t-1}^2}{n^2 + 0.3 n s_{1,t-1} s_{i,t-1}} s_{i,t-2}\right) + \sum_{i=1}^{n}\left(\frac{n^2 s_{1,t-2} + 0.3 s_{i,t-2}^2}{n^2 + 0.3 n s_{1,t-2} s_{i,t-2}} s_{i,t-2}\right)}{3}$$

Here, s_1 stands for market share of the largest firm in the industry. The GRS index is based on Taylor's series[21].

Market Size (MSZ): We use the natural logarithm of sales as a measure of MSZ, i.e.,

$$MSZ_{jt} = \frac{\left(\ln\left\{\sum_{i=1}^{n} S_{it}\right\} + \ln\left\{\sum_{i=1}^{n} S_{i,t-1}\right\} + \ln\left\{\sum_{i=1}^{n} S_{i,t-2}\right\}\right)}{3}$$

Here, MSZ_{jt} is the size of the market of industry j in year t.

MNC Participation (MNC): The ratio of FOREX spending as dividends (FDIV) to total sales is used as a measure of the presence of MNCs in an industry, i.e.,

$$MNC_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} FDIV_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} FDIV_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} FDIV_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}}\right)}{3}$$

Here, MNC_{jt} stands for the extent of the presence of MNCs in industry j in year t.

Capital Intensity (KI): Here, KI is measured by using the following formula:

$$KI_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} CE_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} CE_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} CE_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}}\right)}{3}$$

Here, KI_{jt} stands for capital intensity in industry j in year t and CE for capital employed.

Advertising Intensity (ADVT): The ratio of advertising expenses (AE) to sales is used as a measure of ADVT, i.e.,

[21] For the details on derivation of this index, see Ginevicius and Cirba (2009) and Mishra et al. (2011).

$$ADVT_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} AE_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} AE_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} AE_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}} \right)}{3}$$

Here, $ADVT_{jt}$ stands for the advertising intensity in industry j in year t.

Technology Purchase Intensity (TPUR): The ratio of total expenditure on technology purchase (TE) to sales is used as a measure of technology purchase intensity, i.e.,

$$TPUR_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} TE_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} TE_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} TE_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}} \right)}{3}$$

Here, $TECH_{jt}$ stands for technology purchase intensity in industry j in year t.

Exports Intensity (EXP): The variable EXP is measured as the ratio of FOREX earning from final goods and services (FE) to sales, i.e.,

$$EXP_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} FE_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} FE_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} FE_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}} \right)}{3}$$

Here, EXP_{jt} stands for exports intensity of industry j in year t.

Imports Intensity (IMP): We use the ratio of FOREX spending on final goods and services (FS) to sales as a measure of imports intensity, i.e.,

$$IMP_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} FS_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} FS_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} FS_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}} \right)}{3}$$

Here, IMP_{jt} stands for imports intensity of industry j in year t.

Mergers and Acquisitions (M&A): Total number of mergers and acquisitions taking place in an industry during last three years is used as a measure of M&A, i.e.,

$$M\&A_{jt} = \sum_{i=1}^{n} M\&A_{it} + \sum_{i=1}^{n} M\&A_{i,t-1} + \sum_{i=1}^{n} M\&A_{i,t-2}$$

Here, $M\&A_{jt}$ represents number of mergers and acquisitions in industry j in year t.

Profitability (PROF): The ratio of profit before interest and tax (PBIT) to sales is used as a measure of profitability, i.e.,

$$PROF_{jt} = \frac{\left(\frac{\sum_{i=1}^{n} PBIT_{it}}{\sum_{i=1}^{n} S_{it}} + \frac{\sum_{i=1}^{n} PBIT_{i,t-1}}{\sum_{i=1}^{n} S_{i,t-1}} + \frac{\sum_{i=1}^{n} PBIT_{i,t-2}}{\sum_{i=1}^{n} S_{i,t-2}} \right)}{3}$$

Industrial Risks (IR): The standard deviation (σ) of returns on capital employed during the last five years is used as a measure of industrial risks, i.e.,

$$IR_{jt} = \sigma(ROCE_{jt}, ROCE_{j,t-1}, ROCE_{j,t-2}, ROCE_{j,t-3}, ROCE_{j,t-4})$$

Here, IR_{jt} stands for extent of risks in industry j in year t.

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