Innovation and competition in Indian medium and high technology industries

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Abstract

In traditional Structural-Conduct-Performance (SCP) paradigm, market structure is exogenous; however recent literatures suggest the existence of feedback effect. In this paper, we empirically examine the bidirectional relationship between innovation and market structure in Indian medium and high technology industries. We use HHI and Lerner index as the measures of market structure, and firm's patenting activities as the measure of innovation. By utilizing simultaneous equation framework, this study suggests that there exist bidirectional relationship between HHI and innovation in high technology industries only. Lerner index, which is a firm level proxy for market structure has no influence on innovation activities in any industries; however innovation activities positively affect the Lerner index in both high and medium technology industries. We also find inverted U-shape relationship between HHI, Lerner index and innovation activities only in high technology industries. In the case of medium technology industries there is a U-shape relationship between Lerner index and innovation. The results also reveal that strengthening patent policies have positive impact of firm's innovation activities. This study suggests that firm's in-house innovation activities are major source of their market performance in new patent regime.

Keywords: Innovation; Market structure; High and Medium technology industries.

JEL classification: **L10; L60; O30.**

1. Introduction

The Structural-Conduct-Performance (SCP) paradigm is an essential tool of industrial organization theory which shows the linkages between market structure, conduct and performance (Bain, 1968). Mainstream research on SCP paradigm shows the relationship between market structure, conduct and performance with no feedback effect with effective competition as a major source of efficiency and innovation. Mainstream research suggests that in setting public policy market structure is more important than conduct (Mason, 1939; Caves, 1967; Baldwin, 1969 and Shepherd, 1990). Further, Chicago School which was mainly emerged in 1970 argues that market dominance arise from superior efficiency of a firm. According to this school, causality runs from performance to structure which means superior innovations increase the firms' profitability which further results in market dominance. According to Baldwin (1969) and Shepherd (1990), there is feedback effect between market structure and conduct. Nelson and Winter (1982) also suggest that innovation is an important component of the response of firm to change market conduct. Nelson and Winter (1982), and Nelson (1994) treat technological advances as an evolutionary process where technological advances are cumulative in the nature. These technological advancements help firm's to maintain the market performance and are also the source of overall economic growth and development.

Patent policy also plays a very important role while estimating the relationship between innovation and market structure. Patent is a state granted monopoly power to the patent holder. A patent holder has a right to decide who can and who cannot use the particular invention for commercial purpose for the duration of 20 years. According to Kanwar and Evenson (2003), Hausmann et al. (2014), Naghavi and Strozzi (2015), Ivus (2015), Boring (2015), and Zhang and

Yang (2016), strong patent regime leads to more innovation activities. There are many changes in Indian patent policies from 1970-2005. For example the Patent Act 1970, which was finally implemented in 1972, provided the provision of only process innovations. This act increased the capabilities of domestic firms by increasing adaptive R&D. Under process patent regime, firm can easily copy the external technology and reproduce the similar products with efficient cost structure. In summary, process patent regime negatively affects the innovation capacity of a firm, although it increases the adaptive R&D. TRIPs came into the picture in 1995 with minimum standards for IPRs legislation for member countries of World trade Organization (WTO). As a member country of WTO India also made many changes in its domestic patent policy to comply with TRIPs agreements. Patent (Amendment) Act 1999 was brought into force retrospectively from January 1, 1995. Second Amendment in Patent Act 1972 was made in 2002 with Patent (Amendment) Act 2002. It replaced the rules of Patent Act 1972. Lastly, the third amendment to the Patent Act 1972 was made through Patent (Amendment) Act 2004 which was implemented by January 1, 2005. This Act provides the introduction of product patent in all fields of technology. This act also makes the provision of compulsory licensing for producing and exporting of pharmaceutical products to any country having insufficient or no manufacturing policy to accommodate the Doha Round Mandate about compulsory licensing. Clearly, these amendments have made imitation of new product difficult.

On the basis of above discussion, the objective of this paper is to investigate the bidirectional relationship between innovation and market structure for Indian medium and high technology industries. From above discussion, it is also evident that changing patent policy affects the technological dimensions of a firm. These changing patent policies which are exogenous to the firms are important source of in-house technology creation by switching from alternative technological strategies. Changing patterns of technology development also influence the overall economic development of countries. Therefore, this study evaluates the impact of major patent policy changes on firm's innovation output of Indian industries. In the literature of industrial organization, patenting and R&D expenditure are used as major proxies to capture firms' innovation activities. Most of the studies in Indian context utilized R&D as a major proxy of firms' innovation activities with fewer attention on firms' patenting activities (Subrahmanian, 1971; Kumar, 1987; Kumar and Saqib, 1996; Narayanan, 1998; Kathuria, 2008; Sasidharan and Kathuria, 2011; Basant and Mishra, 2013 and, Ambrammal and Sharma, 2014). According to Griliches et al. (1987), Patent count is most appropriate measure for innovative output of firms, whereas R&D expenditure by firms is a measure of innovative input. After TRIPs agreement, the relevance of patenting as a proxy for innovation has increased as there is surge in patent filing in India. Most of these patents are filed by multinationals of developed countries which are not manufacturing the product in the territory of host country (Chaudhuri, 2012). Hence, this study utilized patenting as a major proxy of firms' innovation activities.

The rest of the paper is organized as follow: Section 2 discusses the brief review of literature on the relationship between innovation and market structure. Sections 3.1 and 3.2 give description of dependent and control variables. Sections 4 discusses about data source and descriptive statistics. Sections 5.1 and 5.2 discuss the results of model estimations. Section 6 presents the conclusion and policy implications.

2. Literature review

Kamien and Schwartz (1982) and Einav and Levin (2010) explain that market structure influences firms' innovation activities via anticipated market power. According to Levin (1978), innovation may lead to excess profit and create barriers to entry in such a way that monopoly can be preserved by more innovation activities. According to Geroski (1990), monopoly power affects innovation in direct and indirect way. In case of direct effect, high monopoly power leads to more post-innovation rewards whereas indirect effect leads to the likelihood of achieving a given degree of post-innovation monopoly. Raymond and Plotnikova (2014) show that firms which are characterized by rapid changing technologies invest more to upgrade its' products and processes in response to increasing competition in the market. In Indian context, Subrahmanian (1971) investigated the impact of concentration on firms R&D expenditure in chemical industry and finds no significant relationship. Kumar (1987) finds negative impact of concentration on R&D expenditure in Indian manufacturing sector for the period of 1977-1981. Kumar (1994) argues that in the case of high entry barriers concentration does not encourage firms' innovation activities. Kumar and Saqib (1996) analyze the impact of concentration on R&D expenditure in Indian manufacturing sector and find no significant impact. Sasidharan and Kathuria (2011) analyze the impact of concentration on firm's R&D expenditure and find positive and significant impact of concentration on decision of doing R&D expenditure. Narayanan (1998) finds no impact of R&D expenditure on competitiveness in Indian automobile industry before de-regulation policy; however the coefficient of R&D intensity is positive and significant after de-regulation policy. It is very clear that most of the researchers in India explore the mainstream research on SCP paradigm where the market structure variable is exogenous in nature.

Superior innovative firms with high monopoly power lead to high concentration (Phillips, 1976; Kȍnig and Zimmermann, 1986, and Gruber, 2000). High R&D expenditure by existing firms is also one kind of entry barriers that results in market dominance, economics of scale and higher efficiency (Phillips, 1966; Muller and Tilton, 1969; Grabowski and Mueller, 1978; Levin, 1978;

Lunn, 1986 and 1989, and Gruber, 2000). Similar to R&D, patent system creates the opportunity for firms to maintain its' monopoly power in particular industry (Gilbert and Newbery, 1982). Patent owner enjoys the state granted monopoly through patent right. According to Arora (1997), during World-War II, patents were used to preserve cartels and oligopolies in Germany. Evangelista and Vezzani (2010) find that product and process innovations have positive impact on sales growth rate. According to Utterback and Suarez (1993), dominant design developed by any firm will deter entry of new firms and also increases the merger activities to change the overall market structure of the industry. Gupta (1983) empirically verifies the SCP paradigm in the context of Canadian manufacturing sector and finds that R&D intensity has positive impact on concentration. Using the data of Mannheim Innovation Panel (MIP), Gottschalk and Janz (2001) find positive and long run impact of R&D on concentration whereas concentration has a negative impact on R&D. According to Lunn (1986 and 1989), innovation and concentration are interdependent. Koeller (1995) finds that total number of innovation has a positive and significant impact on concentration whereas concentration has significant and negative impact on innovation. Using Kambhampati's (1996) simultaneous equation approach Delorme et al. (2002) find that R&D has a positive and significant impact on concentration. Heerde et al. (2004) explore the dynamic effect of innovation on market structure in Frozen Pizza market in US. Using market response model, Heerde et al. (2004) find that innovation increase cross brand and own brand price elasticities. Beneito et al. (2014) construct a new measure of competition and estimate the relationship between innovation and competition in Spanish manufacturing firms. Using GMM approach, Beneito et al. (2014) suggest that innovation has negative significant impact on competition index. From this discussion, it is evident that both innovation and market structure are interdependent. Therefore, we hypothesize that there exist bidirectional relationship between innovation and market structure in Indian high and medium technology industries. According to Pavitt (1984), there are sectoral patterns of innovations among different industries. These sectoral patterns of innovation suggest that there is heterogeneity between different industries in terms of types of innovation and propensity to innovate. Hence, we also empirically explore the bidirectional relationship between innovation and market structure separately for high and medium technology industries.

3. Description of variables

3.1 Endogenous variables

The objective of this paper is to explore the bidirectional relationship between innovation and market structure in Indian medium and high technology industries. This study treats both innovation and market structure as endogenous variables. We utilize Hirschman–Herfindahl index (HHI)[1] and Lerner index[2] as the measures of market structure. HHI is an industry- specific measure whereas Lerner index is a firm specific measure of market structure. In the case of industry specific measures of market structure, we assume that all firms in the industry face same

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[1] HHI is defined as follow: $HHI_{jt} = \sum_{i=1}^{n} s^2{}_{it}$. HHI_{jt} is the Hirschman–Herfindahl index of industry j in time period t. S_{it} is the market share of i^{th} firm in t time period. Market share (S) is calculated as sales of a firm divided by total sale of the industry.

[2] Lerner Index (L) was formulated by Lerner (1934). According to this index, L= [(P-c)/P] where, P is price and c denotes marginal cost. This index ranges between 0 and 1 ($0 \leq L \leq 1$). Where L =0, means perfect competition and L=1, implies absolute monopoly. Koetter et al. (2012) define adjusted Lerner index as: adjusted Lerner= $[(\prod_i + tc_i - mc_i\, q_i)/(\prod_I + tc_i)]$, where $\prod_i$ is profit, tc_i is total cost, mc_i is marginal cost and q_i is the output. If we assume that marginal cost is constant then adjusted Lerner can be defined as: $[(\prod_i / q_i)]$. Following Clerides et al. (2013) we calculate adjusted Lerner index by taking the weighted mean of the individual measures, with market shares as the weights.

competitive pressure; however in reality there exists heterogeneity across the firms. Firm specific measures of market structure helps us to overcome such problems and gives a real picture of competitive pressure in the market. We proxy firms' innovation by its patenting activities. Patents are direct outcome of R&D expenditure which has commercial impact and capture the competitive and proprietary dimension of technological advancement including rate and direction of innovation activities of a firm (Archibugi and Planta, 1996). Pakes and Griliches (1980), Acs and Audretsch (1988), Hitt et al. (1991), Hagedoorn and Schakenraad (1994), Hu and Png (2009), and Blazsek and Escribano (2010) utilize similar approximation to capture firms' innovation activities.

3.2 Control variables

The model includes equations with innovation and market structure as dependent variables along with separate control variables. In case of innovation equation where granted patent (TOPI) is dependent variable, Size (SIZE) of the firm is an important determinant of firm's innovation activities. According to Cohen and Levinthal (1989) and Sasidharan and Kathuria (2011), larger firms are more innovative in comparison to small firms due to financial resources and economies of scale. However, Katrak (1990) explain that large firms strongly dominate the market and need not be affected by market competition leading to fewer innovations. There is no exact effect of SIZE on firm's innovation activities in the literature; therefore square term of SIZE is also included in the model. According to Hall et al. (1986), R&D is an important determinant of firm's patenting activities. Griliches (1979, 1981), Pakes and Griliches (1980) and Crepon et al. (1998) explain that production of new knowledge depends upon R&D expenditure. Export intensity (EXPI) also affects innovation**,** as according to Braga and Willmore (1991), Kumar and Saqib (1996), Kathuria (2008) and Sasidharan and Kathuria (2011), firms that are engaged in international business through exports are likely to conduct more innovation activities. Evenson and Joseph (1997) and Ambrammal and Sharma (2014) explain that export oriented firms are aware about the recent international technologies and as a result conduct more R&D activities. According to Siddharthan and Krishna (1994), Basant (1997) and Basant and Mishra (2013), royalties, licensing, and technical fees which are called as disembodied technology are important determinants of firms' innovation activities. Basant and Mishra (2013) explain that the relationship between disembodied technology imports and innovation depends on the nature of R&D expenditure. Hence, disembodied technology import intensity (DISEMBD) influence patenting and R&D expenditure. Similar to DISEMBD, embodied technology imports (EMBD) which include imports of capital and machineries also affect patenting and R&D expenditure. Basant (1997) finds positive impact of EMBD on firms' R&D expenditure. According to Narayanan (1998), firms also conduct in- house R&D expenditure to adopt imported technology and to modify these technologies. Advertisement intensity (ADI) is a proxy for product differentiation, as Basant (2013) explains that in highly differentiated industries firms conduct more R&D to dominate the market. Basant (2013) also explains that advertisement expenditure may be an alternative strategy for R&D to deter the entry of new firms which may result in low in house R&D expenditure. Age (AGE) is a good approximation about learning by doing, as older firms get more returns on R&D expenditure in comparison to younger firms (Sasidharan and Kathuria, 2011). Arrow (1962) also explains that experience help firms to perform in better way. However, Thornhill (2006) finds negative relationship between age and innovation. Many times new firms enter in the market with better technologies and produce innovative products and processes. Because of this ambiguous relationship between AGE and firm's innovation activities we utilize square term of AGE in the model. To evaluate the impact of patent policy changes on firms innovation activities, we introduce dummy variables in innovation equation. For this purpose, we create three dummy variables D1 = 1 if >1999; D2 = 1 if > 2003 and D3 = 1, if > 2005. In developing country context, innovation performance of foreign firms is superior to domestic firms. Foreign firms' have access to technology developed by their parent organization that provide them competitive advantage vis-à-vis domestic firms. Hence, we also incorporate foreign ownership dummy (FOS) in our model. We differentiate between foreign and domestic firms on the basis of 10% foreign equity participation. This classification is based on Reserve Bank of India (RBI) that has been used by other studies like Basant (1997), Ambrammal and Sharma (2014) and Khachoo and Sharma 2017). We give value 1 to those firms that have at least 10% foreign equity participation and 0 otherwise. On the basis of this discussion, the innovation equation is as follows:

$$\textit{innovation} = f\,(\textit{market structure, RD, EXPI, DISEMBD, EBMD, ADI, AGE, AGE}^{2}\textit{, SIZE, SIZE}^{2}\textit{, FOS, D1, D2, D3}) \quad \text{----------}(1)$$

In the above equation, we utilize two measures of market structure: HHI and Lerner index.

Now, we discuss about market structure equation where market structure (HHI and Lerner index) is the dependent variable. According to Resende (2007) and Yoon (2004) export intensity (EXPI) is an important determinant of the market structure as it captures the dynamic characteristics of the firm. According to Strickland and Weiss (1976), and Yoon (2004) advertisement expenditure increases the concentration of a firm due to economies of scale. We know that advertisement expenditure is also a proxy for product differentiation which is likely to be positively associated with high market concentration. Comanor and Wilson (1967), Gupta (1986) and Resende (2007) explain that advertisement intensity also create entry barriers due to high product differentiation which results in high market concentration. Market growth rate (MGR) is also an important determinant of concentration. According to Lunn (1986, 1989), Koeller (199) and Gupta (1986) high market growth rate is negatively associated with concentration. Yoon (2004) explains that open economy may have influence on domestic market structure; hence import intensity (IMPI) enhances the domestic market competition by increasing the efficiency of resource distribution (Yoon, 2004). Lall (1986) and Narayanan (1998) consider age of the firm (AGE) as a proxy for learning by doing experience. Narayanan (1998) explains that accumulation of technology by learning by doing gives a firm competitive advantage which results in high concentration in the industry. We also incorporate foreign ownership dummy in market structure equation. On the basis of this discussion, the market structure equation is as follows:

market structure = f (TOPI, EXPI, IMPI, ADI, AGE, MGR, FOS) ---------(2.1)

Here, we proxy market structure by HHI and Lerner index.

In the above equation, we have discussed that innovation has linear impact on market structure. We know that superior innovations increase the firm's profitability which results in high market concentration. Innovation at the centre of economic change leads to destruction of existing structure creatively (Schumpeter, 1942). According to Nemlioglu and Mallick (2017), there exists inverted-U shape relationship between innovation, intangible assets and firm performance. Innovation and intangible assets affect firm's performance positively up to an optimal point only afterwards they become sunk cost for that firm. It is also very obvious that if a firm do more innovations on same product line it generate differentiated product that may cannibalize into the market of earlier product. A study by Simpson et al. (2006) explains various negative outcome of the excess innovation activity by firms. According to Simpson et al. (2006), excess innovations do not satisfy actual consumer needs, commercialization of all the innovations is difficult and high market risk is associated with these innovations. In such a risky innovative environment, R&D investment increases the cost which further declines the firm's market dominance. Evidences suggest that with strengthening of patent policy firms are conducting more innovative R&D expenditure which further results in more patenting activities. Hence, we also estimate the nonlinear relationship between innovation and market structure. Now, the market structure equation become as follows:

$$\textbf{\textit{market structure}} = f\ (TOPI,\ TOPI^2,\ EXPI,\ IMPI,\ ADI,\ AGE,\ MGR,\ FOS)\text{---------}(2.2)$$

4. Data source and descriptive statistics

This study utilizes firm level panel data for Indian medium and high technology industries for the time period of 1995-2015. We identify firms in medium and high technology industries on the basis of OECD classification and concordance is drawn between International Standard Industrial Classification (ISIC) 2003 Revision 3 and National Industrial Classification (NIC) 2008 via NIC 2004. In this study, high technology industries includes following industries: (i) Aircraft and space craft (ii) Pharmaceutical (iii) Office, accounting and computing machinery (iv) Radio, TV and communication equipment, and (v) Medical, Precision and optical instrument. Similarly, medium technology industries includes: (i) Electrical machinery and apparatus (ii) Motor vehicle, trailers and semi- trailers (iii) Chemicals excluding pharmaceuticals (iv) Rail road and transport equipment (v) Machinery and equipment. The analysis is carried out at 5 digit NIC (2008) classification. Major source of data for this study includes Centre for Monitoring Indian Economy (CMIE) prowess database and website of Controller General of Design, Trademark and Patent (CGDTP, Government of India). CMIE database provides annual report data for firms that are listed in Bombay Stock Exchange (BSE). All firm level data in this study is collected from CMIE. We collected the list of granted patents from monthly publication of CGDTP and Indian Patent Advanced Search System (InPASS)[3]. We have gathered information for those firms which are active in innovation activities like R&D expenditure and patenting. We have also dropped all those firms that are reporting zero sales. After cleaning the data, we are able to collect the information for 512 firms with 129 (25.88%) high technology and 383 (74.12%) medium technology firms. In high technology industries, out of 129 firms, 113 firms are domestic and 16 firms are foreign multinationals. Out of 383 firms in medium technology industries, 313 firms are domestic firms and 70 firms are foreign multinationals. Table 1 presents concordance between ISIC Revision 3 and NIC 2008, and distribution of firms across different industries. Table 2 presents definitions of variables and their data source. Table 3 presents the descriptive statistics of full sample, high and medium technology industries.

[Table 1]

[Table 2]

[Table 3]

Table 4 presents the patenting and R&D statistics of domestic and foreign firms in high and medium technology industries over the period of 1995-2015. The average R&D intensity (in terms of % of sales) of domestic firms in high technology industries between 1995-2000 is 1.54% which increased to 2.62% between 2006-2010. The average patenting of domestic firms

[3] Indian Patent Advanced Search System (InPASS) is introduced in 2015 which is updated version of Indian Patent Information Retrieval System (IPAIRS).

in same industries from 1995-2000 is 0.0073 that increased to 1.0508 during 2006-2010. With respect to foreign firms, we find that the average R&D intensity during 1995-2000 is 1.14% and we do not find any patent granted to the sample foreign firms in same time period. From 2006-2010 the average R&D intensity of foreign firms is 4.46% and average patenting is 12.24. Here, we find that in comparison to 2001-2005 the average R&D intensity of foreign firms has declined whereas average patenting has increased. Similarly, in medium technology industries the average R&D intensity of domestic firms during 1995-2000 is 0.48% and during 2006-2010 it is 0.53%. Average patenting of domestic firms in same industries during 1995-2000 it is 0.0079 and during 2006-2010 is 0.7648. With respect to foreign firms the average R&D intensity during 1995-2000 is 0.63% and during 2006-2010 it is 0.45%. Average patenting of foreign firms is 0.0047 during 1995-2000 and 3.2742 during 2006-2010. From Table 3, we find that the overall patenting and R&D expenditure in high technology industries is higher than medium technology industries. This analysis also reveals that the R&D and patenting performance of foreign multinationals in high technology industries is superior in comparison to domestic firms. However, in medium technology industries, we find that patenting performance of foreign firms is better than domestic firms; whereas R&D performance is not significantly different between domestic and foreign firms. These primary statistics suggests that strengthening patent policy is more beneficial to foreign firms in comparison to domestic firms in terms of innovation output.

[Table 4]

5. Results of the model estimation

Based on models 1, 2.1 and 2.2, we have following simultaneous equation model (SEM):

$$\mathbf{Z_{it} = a_2 + \beta_2 Y_{it} + X_{it2}\alpha_2 + \mu_{it2}}$$

$$\mathbf{Y_{it} = a_1 + \beta_1 Z_{it} + X_{it1}\alpha_1 + \mu_{it1}}$$

Where i = 1, 2, 3 …n and t = time period.

In above equations, Z_{it} represents innovation (TOPI) and Y_{it} is Hirschman–Herfindahl index (HHI) or Lerner index (LERNER). X_{it1} and X_{it2} are exogenous or predetermined variables, and μ_{it1} and μit_2 are error terms. Two-stage least square estimation (2SLS) is utilized for empirical estimation (Baltagi, 2008). We utilize Error component two-stage least square (EC2SLS) for econometric specifications. In simultaneous panel data model, EC2SLS has more instruments than generalized two-stage least square (G2SLS) (Baltagi and Li, 1992). Baltagi and Liu (2009) also explain that in the case of infinite sample the difference between asymptotic variance of G2SLS and EC2SLS tends to zero, however, in finite sample EC2SLS is more efficient than G2SLS.

Firstly, we estimate the results for innovation equation for full panel which include both medium and high technology industries and then segregate the panel into medium and high technology industries. This classification helps us in understanding firm's heterogeneity and competition issues in different industrial segments. Similarly, we estimate the results of market structure equation. For econometric estimations all the variables are used in logarithms scale.

5.1 Results of innovation equation

Results of innovation equation are presented in Table 5. Columns I, II and III present the results based on full sample, high technology and medium technology industries respectively where HHI is proxy for market structure. Similarly, Column IV, V and VI present the results for same industries where Lerner index is proxy for market structure.

In Column I, the coefficient of HHI is positive but insignificant which indicate the weaker impact of market structure on firms' innovativeness in medium and high technology industries jointly. However, mainstream researcher expects the positive and significant impact of market structure on firms' innovation performance. We know that the patenting and R&D performance of medium and high technology industries are different. Hence, on the basis of full sample estimation we cannot conclude the results. In Column II, we estimate the results of innovation equation for high technology industries. The coefficient of HHI is positive and significant. This result supports the Schumpeterian hypothesis that in a concentrated market firms innovate more to further sustain their monopoly dominance. High technology industries are R&D and patent sensitive industries and major part of their revenue is committed for innovation activities. After TRIPS agreement, these industries specially pharmaceutical and medical are conducting extensive R&D to withstand the competition. The results of innovation equation for medium technology industries that are presented in Column III. The coefficient of HHI is negative and insignificant which indicates that there is no impact of market structure on innovation in medium technology industries. Once we utilize Lerner index (LERNER) as a measure of market structure which is a firm specific measure we do not find any significant impact of this variable on innovation in Columns IV, V and VI. However, the coefficient of LERNER for high technology industries is high and positive but insignificant in Column V as opposed to positive and significant coefficient in Column II where market structure is proxy by HHI. For these diverse results regarding different proxy for market structure we can say that HHI is an industry level variable which represent the competitive pressure of whole industry irrespective of firms heterogeneity. Under high competitive pressure, firms spend a major portion of their revenue for innovation activities; hence the coefficient of HHI is positive and significant. However, Lerner index is a firm level proxy which contains firms profit as a main variable which can be negative also for some years; hence LERNER is not producing significant result in Column V. From these results it is very clear that in the competitive pressure firms try to engage in more innovation activities irrespective of their price cost margin.

Regarding control variables, we find that the coefficient of EXPI is positive but insignificant in all the columns. One probable reason for this insignificant relationship can be the level of economic development of different countries which are importing the products from Indian medium and high technology industries. As Sasidharan and Kathuria (2011) explain that if Indian firms export their products to less developed countries, than their innovativeness will not improve. The coefficient of DISEMBD in all the columns is positive but insignificant which indicate that disembodied technology purchases are neither complements nor substitutes to firms patenting activities. Basant (1997) also finds similar results with respect to R&D activities where R&D and foreign technology licensing are neither perfect complements nor perfect substitutes of each other. The coefficient of EMBD is negative and significant for medium technology industries which suggest that embodied technology imports and innovation activities are substitutes to each other. RD also does not have any significant impact on patenting activities. One can expect positive impact of RD on patenting with some lag (Griliches, 1979; Pakes and Griliches, 1980; Griliches, 1981 and Crepon et al., 1998). The coefficient of ADI is positive and significant in the case of medium technology industries only. Basant (2013) explain that ADI is proxy for product differentiation which may have both positive and negative impact on firms innovation activities. In medium technology industries, high product differentiation is a source of conducting more innovation activities. The coefficient of SIZE is negative and $SIZE^2$ is positive and both are significant in all the estimations, giving a U-shape relationship between size and innovation. This U-shape relationship suggests that initially with increase in the size of a firm patenting goes down but latter goes up after an optimal level of size. These results also match with some of earlier empirical findings like Siddharthan (1988), Pradhan (2003), Kumar and Aggarwal (2005), and Khachoo and Sharma (2017). The coefficients of AGE and AGE^2 suggest U-shape relationship between patenting and age; however this U-shape relationship exists only for high technology industries. This result suggests that older firms do more innovation activities in the phase of high competitive pressure to update their products and processes. This result also matches with earlier findings of Golder and Renganathan (1998), Ghosh (2009) and Khachoo and Sharma (2017). We also test these nonlinear relationships by conducting Sasabuchi–Lind–Mehlum (SLM)[4] U test in Table 6. Lind and Mehlum (2010) explain that inclusion of nonlinear term in the model in a necessary but not sufficient condition for U-shape or inverted U-shape relationship. According to Lind and Mehlum (2010), if the true relationship is convex but monotone over relevant data than nonlinear term may erroneously yields extreme point which results in U-shape or inverted-U shape relationship. Estimations of SLM t-statistics in Table 6 suggest that there is a U-shape relationship between SIZE and TOPI in full sample and high technology industries only. However, with respect to medium technology industries this result does not collaborate with inclusion of nonlinear term of SIZE in Table 5. With respect to AGE, SLM t-statistics suggest U-shape relationship with TOPI in both high and medium technology industries.

The coefficient of FOS is positive and significant in high technology industries. We know that average patenting and R&D of foreign firms is higher in comparison to domestic firms in high

[4] This test is based on framework of likelihood ratio test of Sasabuchi (1980) and named by Sasabuchi–Lind–Mehlum (SLM) U test.

technology industries. In new patent regime foreign firms are protecting their newly invented products and process by filing more patents in developing countries. With respect to patent policy changes (D1 = 1 if >1999; D2 = 1 if > 2003 and D3 = 1, if > 2005) we do not find very consistent results for D1 and D2; however D3 has positive and significant impact on firm patenting activities. This result suggests that introduction of the product patent for inventions in all fields of technology under the third amendment to the Act of 1970 which is introduced through the Patents (Amendment) Act 2005 has significant impact on firms innovation output in Indian medium and high technology industries.

[Table 5]

[Table 6]

5.2 Results of market structure equation

The results of market structure equation are presented in Table 7. Column I, II and III present the results of full sample, medium technology industries and high technology industries respectively where dependent variable is HHI. Similarly, in Columns IV, V and VI we estimate the results by utilizing dependent variable as LERNER. When we use HHI as dependent variable we find that TOPI has positive and significant impact only in high technology industries which confirms the hypothesis of Chicago School of thought about feedback effect of innovation on market structure. Gupta (1983), Lunn (1989), Koeller (1995), Delorme et al. (2002) and Yoon (2004) also find similar results by using R&D expenditure as a proxy for innovation. This result shows that the innovation capacity in terms of patenting is capable to alter the competitive structure of whole high technology industries. However, once we utilize LERNER as a dependent variable we find that TOPI has positive and significant impact in both high and medium technology industries. As we have already explained that the basic components of HHI and LERNER are different; hence we can get some diverse results.

The coefficients of EXPI and IMPI are insignificant in all the estimations akin to Yoon (2004) who finds similar results for Korean manufacturing industries. The coefficient of ADI is negative and significant in Columns IV and V. Narayanan (1998) estimates the impact of ADI on industries' competitiveness and finds negative and significant impact of ADI on industries' competitiveness for Indian automobile industry in post de- regulation period. He explains that in the post deregulation period industries' advertisement expenditure is too small to affect their competitiveness. Large ADI also reflects on high product differentiation in the industry that results in high prices of products making consumers switch to substitutes that may decrease the concentration in the market. The coefficient of MGR is positive and significant in Column II whereas it is negative and significant in Column III. Lunn (1986, 1989), Koeller (199) and Gupta (1986) find negative relationship between market growth rate and concentration. We know that MGR is demand side variable which represents the overall demand of consumer in the market. High market demand also attracts new firms into the market which further increase the market competition. Here we are finding contradictory results with respect to high technology industries where the coefficient of MGR is positive and significant. We know that high technology sector also covers Pharmaceutical and Medical, Precision and Optical instrument which have different demand patterns in comparison to other industries. In pharmaceutical sector, demand is driven by prescription of doctors which is based upon experience of doctors. A consumer cannot decide to choose the product based upon relative prices and features of the product. In these industries the growing demand is normally fulfilled by existing firms only who developed their capabilities by learning by doing. These industries are also patent sensitive industries where other firms cannot easily imitate the patented products. The coefficient of AGE is negative and significant in column III; however significance level is very low (10%). In Columns IV, V and VI we find that the coefficient of AGE is positive and significant. This result suggests that experienced firms are enjoying more price-cost margin by cumulative technology. Foreign ownership dummy is also insignificant is all the estimations which suggests that foreign firms do not have competitive advantage over domestic firms.

[Table 7]

In Table 8, we model the nonlinear impact of TOPI on market structure. In Column I and II, we find that the coefficient of TOPI is positive and significant whereas the coefficient of $TOPI^2$ is negative and significant, suggesting inverted U-shape relationship between patenting and HHI. Similarly in Column V, we find inverted U-shape relationship between patenting and LERNER. These results reveal that initially with increase in innovation activities concentration and price-cost margin increases but up to an optimal level only afterwards these start declining. These relationships hold only for high technology industries. In medium technology industries, TOPI does not have any influence on HHI; however it has significant impact on LERNER. In Column VI, the coefficient of TOPI in negative and significant and $TOPI^2$ is positive and significant, giving a U-shape relationship between patenting and LERNER. This result is contradictory to high technology industries where we find inverted U-shape relationship between patenting and LERNER. Medium technology industries basically include scale- intensive industries (autos, steel, consumer durable) where process innovation is more relevant as opposed to high technology industries where firms are involved in both product and process innovations (Pavitt, 1984). In scale intensive industries which contain heavy equipments and machineries in production plant, it is very difficult to make frequent changes in manufacturing process because of high involvement of transaction costs. Hence, initial R&D and patenting activities are sunk cost for such firms; however these innovations benefit firms after an optimal level only. These results also collaborate with SLM t-statistics presented in Table 9. With respect to control variables, we find similar results as explained in Table 7.

[Table 8]

[Table 9]

6. Concluding remarks

By using firm level information for Indian high and medium technology industries spanning from 1995-2015, we explore the bidirectional relationship between innovation and market structure. The main purpose of this study is to analyze the feedback effects between innovation and market structure in Indian Medium and high technology industries in new patent regime. We utilize HHI and Lerner index as measures of market structure, and granted patents to firms as the measure of firm level innovation activities. After TRIPs agreement, investigation of such relationship using patent as a proxy of innovation is very important from the perspectives of policy makers. In strong patent regime there is possibility that firms utilize in–house innovation activities as an alternative strategy to dominate the market.

Empirical analysis based on simultaneous equation framework suggests the interdependence between HHI and innovation in high technology industries where HHI is industry level representation of competitive structure. This result reveals that in setting public policy both competitive pressure and firm level innovation capabilities play an important role for innovation sensitive firms. With respect to Lerner index which is a firm level proxy for market structure we find unidirectional relationship and the causality runs from innovation to market structure. These estimations also suggests nonlinear relationship between innovation and Lerner index. In high technology industries we have evidences of inverted U-shape relationship whereas in medium technology industries there exists U-shape relationship between innovation and Lerner index. We have also confirmed these nonlinear results by performing SLM t-statistics. These results suggest that firm level innovation capabilities play very important role in increasing market dominance. Empirical results also suggest that introduction of product patent regime through the Patents (Amendment) Act 2005 has increased the innovation performance of Indian high and medium technology industries. We also find that innovation performance of foreign firms is superior over domestic firms in high technology industries.

From policy point of view, this study suggests that in-house innovation activities are potential source of market performance. Strengthening patent protection leads to in-house technology creation by means of R&D and patenting. An innovative firm can dominate the market by producing differentiated products in strong patent regime. Empirical findings suggest that innovation performance of foreign firms is superior over domestic firms in new patent regime. We need to adopt appropriate policy mechanism targeting domestic firms so that the innovation output of domestic firms should also increase. Patent is a state granted monopoly to innovators; however abusing of such monopoly may leads to consumer deadweight losses. Hence, Competition Commission of India and other government agencies should play important role in maintaining healthy competition in the market.

Table 1: Concordances between ISIC Revision 3 and NIC 2008

Sectors	Industries	ISIC Rev 3 code	NIC 2008 code	Number of firms in sample
		3 digit / 4 digit	3 digit/4 digit	
High technology industries	Aircraft and space craft	353	303	02
	Pharmaceutical	2423	210	94
	Office, accounting and computing machinery	300	262+332+2817	01
	Radio, TV and communication equipment	321+322+323	261+263+,264+322+ 3313+3314+9512+9521	23
	Medical, Precision and optical instrument	331+332	325+266+267+332+2651+331 3+3319	09
Medium technology industries	Electrical machinery and apparatus	311+312+313+31 4+ 315+319	271+272+273+274+279+ 332+3312+3314	41
	Motor vehicle, trailers and semi- trailers	341+342+343	291+292+293+3311	07
	Chemicals excluding pharmaceuticals	241+242+243 excluding 2423	201+202+203+268+1079	164
	Rail road and transport equipment.	352+359	302+309+3315	72
	Machinery and equipment,	291+292+293	281+282+275+252+304+ 3311.3312.3320.2593 excluding 2817	99

Table 2: Definition of variables and source of data

Variables	Definition	Source of Data
Total patent (TOPI)	Number of total patent granted to a firm	CGDTP
R&D expenditure (RD)	R&D expenditure by a firm divided by sales.	CMIE (Prowess)
Hirschman–Herfindahl index (HHI)	Sum of the square of the sales' share of each firm in a year.	CMIE (Prowess)
Market share (MS)	Sales of a firm divided by total sale of industry.	CMIE (Prowess)
Profitability (PBT)	Operational profit divided by sales.	CMIE (Prowess)
Export intensity (EXPI)	Export of goods and services divided by sales.	CMIE (Prowess)
Disembodied technology import intensity (DISEMBD)	Royalties and technological fees divided by sales.	CMIE (Prowess)
Embodied technology import intensity (EMBD)	Imports of capital (machinery and equipment) goods divided by sales.	CMIE (Prowess)
Size of firm (SIZE)	Natural logarithm of sales.	CMIE (Prowess)
Age (AGE)	Age is the difference between present year and the year of incorporation	CMIE (Prowess)
Advertisement intensity (ADV)	Advertisement expenditure divided by sales.	CMIE (Prowess)
Market growth rate (MGR)	Current year value of sales minus previous year value of sales divided by previous year value of sales.	CMIE (Prowess)
Import intensity (IMPI)	Import of finished goods and raw materials divided by sales.	CMIE (Prowess)
Foreign ownership dummy (FOS)	Value 1 to those firms which have at least 10% foreign equity participation and 0 otherwise.	CMIE (Prowess)

Table 3: Descriptive statistics on Indian high and medium technology firms, 1995-2015

	Mean	Standard Deviation.	Minimum	Maximum	Observation
Full sample					
TOPI	.10528	.45696	0	5.31812	10,752
HHI	.06298	.04509	2.38e-07	.28039	10,752
LERNER	.000800	.00317	-.04593	.05901	10,752
EXPI	.12036	.16417	0	3.64994	10,752
DISEMBD	.00247	.00819	0	.39849	10,752
EMBD	.01111	.07170	0	5.22570	10,752
RD	.00984	.03448	0	1.63141	10,752
ADI	.00694	.01860	0	.19020	10,752
SIZE	7.17796	1.93428	.09531	13.29125	10,752
AGE	3.36920	.64730	0	4.91265	10,752
IMPI	.107255	.15634	0	6.21860	10,752
MGR	2.42438	.83847	-4.96925	4.12690	10,752
High technology industries					
TOPI	.17162	.57319	0	4.49981	2,709
HHI	.01711	.00612	2.38e-07	.04100	2,709
LERNER	.00090	.00303	-.04593	.02460	2,709
EXPI	.17978	.21980	0	3.64994	2,709
DISEMBD	.00194	.01052	0	.398491	2,709
EMBD	.01452	.07974	0	3.23789	2,709
RD	.02318	.06488	0	1.63141	2,709
ADI	.00949	.02238	0	.19020	2,709
SIZE	6.77942	2.073588	.095310	12.18079	2,709
AGE	3.14965	.707764	0	4.68213	2,709
IMPI	.140450	.22805	0	6.21860	2,709
MGR	2.55395	.74105	-4.96925	4.12690	2,709
Medium technology industries					
TOPI	.08294	.40809	0	5.31812	8,043
HHI	.07843	.04193	.00678	.28039	8,043
LERNER	.00076	.00321	-.03114	.05901	8,043
EXPI	.10035	.13482	0	1.96795	8,043
DISEMBD	.00264	.00724	0	.13506	8,043
EMBD	.00996	.06876	0	5.22574	8,043
RD	.00535	.00957	0	.20972	8,043
ADI	.00608	01706	0	.17805	8,043
SIZE	7.31219	1.86612	.182321	13.29125	8,043
AGE	3.44315	.60807	.69314	4.91265	8,043
IMPI	.09607	.12111	0	5.22574	8,043
MGR	2.37913	.86542	-.27050	3.75708	8,043

Table 4: R&D and patenting in Indian high and medium technology industries

	High technology industries				Medium technology industries			
Year	Average R&D intensity (% of sales)		Average patenting		Average R&D intensity (% of sales)		Average patenting	
	Foreign firms	Domestic firms	Foreign firms	Domestic firms	Foreign firms	Domestic firms	Foreign firms	Domestic firms
1995-2000	1.14	1.54	0.0000	0.0073	0.63	0.48	0.0047	0.0079
2001-2005	7.14	1.78	0.1375	0.0318	0.56	0.52	0.0314	0.0198
2006-2010	4.46	2.62	12.2375	1.0508	0.45	0.53	3.2742	0.7648
2011-2015	12.28	2.87	4.4000	0.3592	0.55	0.62	1.3285	0.4523

Source: Calculated based on information available in CMIE PROWESS and CGDTP.

Table 5: Impact of market structure on innovation

	I	II	III	IV	V	VI
	Full sample	High technology	Medium technology	Full sample	High technology	Medium technology
HHI	.55967 (0.69)	25.86242*** (3.44)	-.58829 (-0.78)			
LERNER				-1.31355 (-0.14)	20.92922 (0.79)	-.97241 (-0.10)
EXPI	.02092 (0.53)	.010067 (0.19)	.01341 (0.26)	.04757 (1.02)	.03927 (0.45)	.01694 (0.32)
DISEMBD	2.58426 (1.25)	.29387 (0.20)	4.60534 (1.44)	2.44158 (1.21)	.14124 (0.10)	4.69103 (1.46)
EMBD	-.05660 (-1.47)	-.06038 (-1.33)	-.08474* (-1.72)	-.07211* (-1.83)	-.06792 (-0.90)	-.09786* (-1.87)
RD	.38542* (1.76)	.25568 (1.30)	1.08813 (1.36)	.56759 (1.59)	.37999 (1.19)	1.11303 (1.41)
ADI	2.31503** (2.15)	1.58474 (1.16)	2.63627* (1.73)	2.36591** (2.17)	1.37959 (1.03)	2.87227* (1.85)
SIZE	-.19269*** (-4.75)	-.17865*** (-4.28)	-.22444*** (-3.76)	-.22801*** (-4.59)	-.16583*** (-3.35)	-.258013*** (-3.55)
$SIZE^2$	.01796*** (5.34)	.01837*** (4.84)	.01950*** (4.10)	.02016*** (4.89)	.016766*** (3.58)	.02140*** (3.72)
AGE	-.21608** (-2.50)	-.47192*** (-3.33)	-.18552 (-1.28)	-.19384** (-2.15)	-.47594*** (-3.49)	-.13720 (-0.98)
AGE^2	.03068** (2.25)	.074005*** (3.24)	.025291 (1.13)	.02907** (2.02)	.07901*** (3.47)	.01954 (0.89)
FOS	.08998** (2.20)	.36316*** (2.76)	.01589 (0.45)	.09415** (2.30)	.35184*** (2.73)	.01672 (0.48)
D1	.02237 (1.28)	.00223 (0.06)	-.00462 (-0.26)	.01025 (0.82)	.05094* (1.91)	.00832 (0.59)
D2	.01832 (0.58)	-.15016** (-2.39)	-.03209 (-0.87)	-.00740 (-0.52)	.02196 (0.64)	-.00562 (-0.36)
D3	.16503*** (4.56)	.19786*** (2.64)	.08546*** (2.44)	.14406*** (5.96)	.27986*** (4.04)	.11232*** (4.78)
CONSTANT	.54800*** (2.94)	.28197 (0.90)	.90907*** (3.17)	.67902*** (3.79)	.31523 (0.68)	.91738*** (3.56)
TIME DUMMY	YES	YES	YES	YES	YES	YES
INDUSTRY DUMMY	YES	YES	YES	YES	YES	YES
WALD TEST#	171.72 [0.000]	150.25 [0.000]	80.35 [0.000]	181.95 [0.000]	189.28 [0.000]	88.71 [0.000]
OBS.	10,127	2,621	7,506	10,127	2,621	7,506
MODEL	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**

Notes: Values in parenthesis are Z values and P values are given in square brackets.
***, ** and * denote that the coefficients are statistically significant at 1, 5 and 10 percent levels respectively.
#Wald test (F) is to check if all coefficients in the model are different than zero.
(Dummy coding: D1 = 1 if >1999; D2 = 1 if > 2003 and D3 = 1, if > 2005)

Table 6: Sasabuchi–Lind–Mehlum (SLM) test for U shape relationship between innovation (TOPI), size (SIZE) and age (AGE)

	Variables	**t value**	**P> |t|**	**Decision**
Full sample	SIZE	4.74***	1.06e-06	We reject H_0 at 1% level of significance, H_0: Monotone or inverse U shape H_1: U shape
	AGE	1.73**	.0421	We reject H_0 at 5% level of significance, H_0: Monotone or inverse U shape H_1: U shape
High technology	SIZE	4.27***	9.99e-06	We reject H_0 at 1% level of significance, H_0: Monotone or inverse U shape H_1: U shape
	AGE	2.72***	.00326	We reject H_0 at 1% level of significance, H_0: Monotone or inverse U shape H_1: U shape
Medium technology	SIZE	0.82	.205	We do not reject H_0 H_0: Monotone or inverse U shape H_1: U shape
	AGE	3.75***	.000089	We reject H_0 at 1% level of significance, H_0: Monotone or inverse U shape H_1: U shape

Note: ***, ** and * denote significance levels of 1, 5 and 10 percent respectively.

Table 7: Impact of innovation on market structure

	Dep. Variable: HHI			Dep. Variable: LERNER		
	I	**II**	**III**	**IV**	**V**	**VI**
	Full sample	High technology	Medium technology	Full sample	High technology	Medium technology
TOPI	.00145 (0.47)	.00020** (1.92)	.003091 (0.88)	.00354*** (4.07)	.00270*** (3.22)	.00318*** (2.86)
EXPI	.00112 (0.50)	-.00011 (-0.60)	-.00535 (-1.58)	.000016 (0.04)	.00078 (1.12)	-.00017 (-0.53)
IMPI	-.00101 (-0.45)	.000043 (0.17)	.00222 (0.65)	.00033 (1.05)	.00047 (0.64)	.00012 (0.51)
ADI	-.010959 (-0.63)	00035 (0.40)	-.025026 (-0.93)	-.01182** (-2.14)	-.00595 (-1.09)	-.014067* (-1.81)
MGR	-.00466 (-17.91)	.001087*** (6.30)	-.00529*** (-10.24)	-8.59e-06 (-0.27)	-.000033 (-0.36)	-.000024 (-0.69)
AGE	.00032 (0.60)	-.000054 (-1.43)	-.00111* (-1.90)	.00093*** (3.63)	.00104*** (3.27)	.00080** (2.46)
FOS	.00031 (0.56)	-.000083 (-1.64)	.00065 (1.02)	-.00022 (-0.64)	-.00038 (-0.63)	.000080 (0.22)
CONSTANT	.12431*** (9.30)	.00705*** (10.25)	.12664*** (44.87)	.00179 (0.59)	.00707 (1.14)	-.00117 (-1.41)
TIME DUMMY	YES	YES	YES	YES	YES	YES
INDUSTRY DUMMY	YES	YES	YES	YES	YES	YES
WALD TEST#	2.49e+07 [0.000]	6.45e+07 [0.000]	852129.75 [0.000]	163.04 [0.000]	78.59 [0.000]	122.14 [0.000]
OBS.	10,127	2,621	7,506	10,127	2,621	7,506
MODEL	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**

Notes: Values in parenthesis are Z values and P values are given in square brackets.
***, ** and * denote that the coefficients are statistically significant at 1, 5 and 10 percent levels respectively.
#Wald test (F) is to check if all coefficients in the model are different than zero.

Table 8: Nonlinear impact of innovation on market structure

	Dep. Variable: HHI			Dep. Variable: LERNER		
	I	**II**	**III**	**IV**	**V**	**VI**
	Full sample	High technology	Medium technology	Full sample	High technology	Medium technology
TOPI	.02426** (2.36)	.00128** (2.23)	.00696 (0.50)	.00746** (2.06)	.00891*** (2.70)	-.01587* (-1.75)
$TOPI^2$	-.00949** (-2.36)	-.00052** (-2.02)	-.00146 (-0.34)	-.00165 (-1.15)	-.00312** (-2.06)	.00820** (2.10)
EXPI	-.000095 (-0.04)	-.00018 (-0.84)	-.00546 (-1.60)	-.00025 (-0.60)	.00022 (0.36)	.00032 (0.53)
IMPI	-.00106 (-0.46)	.00007 (0.30)	.00211 (0.61)	.00027 (0.81)	00047 (0.62)	.00060 (1.31)
ADI	.00589 (0.28)	.00130 (1.19)	-.02355 (-0.92)	-.00969** (-1.98)	-.00011 (-0.02)	-.02669 (-1.05)
MGR	-.00470*** (-17.89)	.00108*** (6.22)	-.00529*** (-10.25)	-.000015 (-0.45)	-.00004 (-0.46)	-.000020 (-0.36)
AGE	.00027 (0.50)	-.00005 (-1.43)	-.00112* (-1.91)	.000832*** (3.80)	00068*** (3.52)	.00055*** (2.80)
FOS	.00120* (1.76)	.00015 (1.52)	.000694 (1.21)	-.000046 (-0.13)	.00121 (1.43)	-.00028 (-0.66)
CONSTANT	.12418*** (9.26)	.00697*** (9.94)	.12663*** (44.72)	.001983 (0.66)	.00747 (1.22)	-.00018 (-0.32)
TIME DUMMY	YES	YES	YES	YES	YES	YES
INDUSTRY DUMMY	YES	YES	YES	YES	YES	YES
WALD TEST#	1.96e+06 [0.000]	1.67e+07 [0.000]	803859.07 [0.000]	169.13 [0.000]	93.21 [0.000]	93.21 [0.000]
OBS.	10,127	2,621	7,506	10,127	2,621	2,621
MODEL	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**	**EC2SLS**

Notes: Values in parenthesis are Z values and P values are given in square brackets.
***, ** and * denote that the coefficients are statistically significant at 1, 5 and 10 percent levels respectively.
#Wald test (F) is to check if all coefficients in the model are different than zero.

Table 9: Sasabuchi–Lind–Mehlum (SLM) test for U shape relationship between innovations (TOPI) and market structure (HHI and LERNER)

		Variables	t value	P> |t|	Decision
Dependent variable: HHI	Full sample	TOPI	2.30**	.0107	We reject H_0 at 5% level of significance, H_0: Monotone or U shape H_1: Inverse U shape
	High technology	TOPI	1.93**	.0267	We reject H_0 at 5% level of significance, H_0: Monotone or U shape H_1: Inverse U shape
	Medium technology	TOPI	0.27	.395	We do not reject H_0 H_0: Monotone or U shape H_1: Inverse U shape
Dependent variable: LERNER	Full sample	TOPI	0.86	.195	We do not reject H_0 H_0: Monotone or U shape H_1: Inverse U shape
	High technology	TOPI	1.83**	.034	We reject H_0 at 5% level of significance, H_0: Monotone or U shape H_1: Inverse U shape
	Medium technology	TOPI	1.75**	.0399	We reject H_0 at 5% level of significance, H_0: Monotone or inverse U shape H_1: U shape

Note: ***, ** and * denote significance levels of 1, 5 and 10 percent respectively.

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