# Non-linear impact of product and process innovations on market power: A theoretical and empirical investigation

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## ARTICLE INFO

## ABSTRACT

An innovative firm enjoys market power either by creating differentiated products (through product innovations) or by increasing productivity (through process innovations). On the basis of theoretical model, we hypothesize that there exists an inverted U-shaped relationship between technological innovations and firms' market power. Creative destruction with respect to firms' own product innovation lessens market power after an optimal point of development and extensive costs of implementing new processes reduce firms' benefits beyond a certain level. Empirical findings based on Indian pharmaceutical firms affirm inverted U-shaped relationship between technological innovations and market power operationalized by Lerner index. The results are robust to alternative measure of market power namely profitability. The identification of such non-linear relationship between technological innovations and market power may help managers to restructure innovation investments to avoid reduction in benefits.

## 1. Introduction

Innovation activities provide opportunity to firms to create and maintain monopoly power in the industry (Levin, 1978; Gilbert and Newbery, 1982; Lunn, 1986; Koeller, 1995; Gruber, 2000; Niwa, 2016). Schumpeter (1912) defines innovation as introduction of new products, better method of production, newer market, novel source of raw materials and better organization techniques. Such innovations are being classified into two categories, namely technological innovations including product and process innovation, and non-technological innovations comprising marketing and organizational changes. According to OECD (2005), product innovation is defined as generation, introduction and diffusion of new product with the similar process and process innovation includes generation, introduction and diffusion of new production process for the same product. Further, marketing innovations include new methods like change in product design, packaging, promotional strategies and different pricing methods. And organizational innovation means introduction of new managerial practices that help firms to reduce the transaction costs and improve labor productivity. Organizational and marketing innovations enhance firms' performance

by catalyzing product and process innovations that have a direct bearing on the firms' performance (Gunday et al., 2011). Likewise, Nemlioglu and Mallick (2017) explain that better managerial practices and technological innovation jointly increase the overall performance of the firm.

Considering the direct impact of product and process innovation on firms' performance, the focus of this study is technological innovations. Product and process innovation change the market power of a firm (Schumpeter, 1950; Mueller and Tilton, 1969; Gilbert and Newbery, 1982; Segerstrom, 1991; Utterback and Suárez, 1993), albeit through different channels. Product innovation increases the price margin of firms by differentiating their product from that of rivals (Markides, 2006; Belleflamme and Peitz, 2015). The introduction of new product in the market increases the sale and market share of innovative firm that may satisfy the needs of existing customers and/or attract new customers (Pelham, 1997; Wang and Wei, 2005). According to Lunn (1986), process innovation is cost reducing and leads to change in the production function allowing firm to place the product at a competitive price (Kamien and Schwartz, 1982; Griliches, 1998; Deolalikar and Röller, 1989; Peters, 2008). Production performances like flexibility and cost reduction which are closely linked with process innovation have positive impact on firms'

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**Table 1**
Patenting in Indian pharmaceutical sector.

| Year | Total drug Patent applications | Total drug Patents granted | Share of drug patent applications in total patent applications | Share of drug patents granted in total patent granted |
|------|------|------|------|------|
| 2006 | 3239 | 798 | 11.19 | 10.58 |
| 2007 | 4267 | 905 | 12.11 | 5.90 |
| 2008 | 3672 | 1207 | 9.97 | 7.51 |
| 2009 | 3070 | 530 | 8.95 | 8.59 |
| 2010 | 3526 | 596 | 8.94 | 7.94 |
| 2011 | 2762 | 282 | 6.39 | 6.43 |
| 2012 | 2954 | 344 | 6.76 | 8.33 |
| 2013 | 2507 | 256 | 5.84 | 6.05 |

**Source:** Authors' calculations on the basis of data provided by Indian Patent Office.

**Table 2**
Variables definitions and data source.

| Variables | Definition | Source of Data |
|------|------|------|
| Lerner Index of monopoly power (LI) | Ratio of sales less labor cost, electricity cost and the raw material cost to the total sales. | CMIE (Prowess) |
| Profitability (PBT) | Ratio of operational profit to the total sales. | CMIE (Prowess) |
| Product patent intensity (PROD) | (Number of product patents granted to a firm in year t)/(lagged R&D expenditure by 3 years) | CGDTP |
| Process patent intensity (PROC) | (Number of process patents granted to a firm in year t)/(lagged R&D expenditure by 3 years) | CGDTP |
| Total patent intensity (TOPC) | (Total patents granted to a firm in year t)/(lagged R&D expenditure by 3 years) | CGDTP |
| Product patent intensity of foreign firms (PRODFOS) | [(Number of product patents granted to a firm in year t)/(lagged R&D expenditure by 3 years)]* Foreign ownership dummy | CMIE (Prowess) |
| Process patent intensity of foreign firms (PROCFOS) | [(Number of process patents granted to a firm in year t)/(lagged R&D expenditure by 3 years)]* Foreign ownership dummy | CMIE (Prowess) |
| Total patent intensity of foreign firms (TOPFOS) | [(Total patents granted to a firm in year t)/(lagged R&D expenditure by 3 years)]* Foreign ownership dummy | CMIE (Prowess) |
| Advertisement intensity (ADV) | Advertisement expenditure divided by sales. | CMIE (Prowess) |
| Raw material import intensity (RAWMAT) | Raw material imports divided by sale. | CMIE (Prowess) |
| Disembodied technology import intensity (DISTECH) | Royalties and technological fees divided by sale. | CMIE (Prowess) |
| Total assets (ASSETS) | Gross fixed assets of a firm | CMIE (Prowess) |
| Foreign ownership dummy (FOS) | Value 1 to those firms which have at least 10% foreign equity participation and 0 otherwise. | CMIE (Prowess) |

organizational and administrative performance as well (Quadros et al., 2001). Innovation by a firm leads to organizational learning and also fastens the speed and quality of operations that have strong linkages with organizational performance (Koufteros and Marcoulides, 2006).

Innovation at the center of economic change leads to creative destruction of existing structures[1] including the monopoly power of the incumbent firms (Schumpeter, 1950; Minniti, 2010; Matsumura et al., 2013). Gaining of market power by newer firms, either through new products or processes, reduces the market value of the current technology and thereby making monopoly a temporary phenomenon (Gilbert, 2006).

Thus, technological innovations influence the current competition in an industry and studies explore the inverted U-shaped relationship between these two in line with Schumpeterian hypothesis (Aghion et al., 2005; Gorodnichenko et al., 2010; Goettler and Gordon, 2014). According to Aghion et al. (2005), escape-competition effect[2] and Schumpeterian effect[3] generate inverted U-shaped relationship between innovation and market power competition. Bucci and Parello (2009) investigate the inverted U-shaped relationship between competition and horizontal innovation related growth. They explain that the inverted U-shaped relationship between competition and innovation growth is conditional upon elasticity of substitution between intermediate goods. If intermediate inputs are perfect substitutes, then resource allocation effect[4] and profit incentive effect[5] will generate inverted U-shaped relationship between competition and innovation growth.

From the above discussion, it is evident that innovation strengthens market power though not in a linear way. There are few studies that explore the non-linear relationship between different types of innovation and firm specific performance indicator. For example, a recent study by Nemlioglu and Mallick (2017) tested the non-linear impact of managerial practices, intangibles and R&D intensity on firms' performance. This study suggests that with respect to managerial practices and intangibles there exists inverted U-shaped relationship, however, R&D intensity does not have such impact. The evidence on the impact of product and process innovation on market power is scant. In this context, the present study contributes to the existing literature as it attempts to explore both theoretically and empirically the impact of both types of technological innovations (product and process) on the market power, separately. Creative destruction with respect to firms' own product innovation may lead to reduction in market power after an optimal point of product development and extensive cost of implementing new processes may lessen market power of the firm beyond a certain level. Since the innovation types (product and process) may not influence the market power uniformly, it becomes pertinent to analyze them individually. Thus we address the non-linearity issue between product and process innovation, and market power in the current study. The empirical verification of the hypotheses is based on firm level data from Indian pharmaceutical sector from 2006 to 2013. We use Lerner index as a measure for monopoly power and also perform robustness check by utilizing profitability as an alternative measure of firms' market power.

The rest of the paper is organized as follows: Section 2 presents the theoretical model on the relationship between product and process innovation, and firms' monopoly power. Section 3 on empirical verification includes Sections 3.1 and 3.2 that give description of variables and data sources, respectively. Section 4.1 discusses the results and section 4.2 on robustness check presents results based on profitability as an alternative measure of market power. Section 5 presents the conclusion and policy implications of the study.

## 2. Technological innovations and market power

The influence of technological innovation on market power varies in case of product and process innovation. There is a need to clearly define product and process innovation to highlight the possible channels through which these impact market power of the firm. According to Pavitt (1984), product innovations are used outside the sector of production and process innovations are employed within. OECD (2005)

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[1] Shifting of print media (newspaper and magazine) into digital media (blog commentary and news information available on internet), transformation of medical practices from population based approach to individualized medicine through digital technologies, destruction of film based business market of Kodak by invention of digital photography are some examples of creative destruction.

[2] Escape-competition effect implies that competition increases the incremental profits derived from innovation activities to generate positive relationship between innovation and market structure.

[3] In case of Schumpeterian effect, competition decreases post entry benefits for new entrants. It generates negative relationship between innovation and market structure.

[4] Effective competition leads to efficient utilization of available resources.

[5] After a particular level, competition has a negative effect on firms' monopoly profit which further reduces the overall innovation activity of that firm.