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DOES INNOVATION OUTCOMES INFLUENCE PERFORMANCE OF INDIAN MANUFACTURING FIRMS?

Badri Narayan Rath* and Poulomi Bhattacahrya**

*Corresponding author. Department of Liberal Arts, Indian Institute of Technology Hyderabad, India.
Email: badri@la.iith.ac.in
**Tata Institute of Social Sciences, Hyderabad, India. Email: bpoulomi@gmail.com

ABSTRACT

This paper investigates the impact of innovation on the performance of selected manufacturing firms in India over the period 2008-2017. Specifically, we emphasize on the role of innovation outcomes in terms of number of patents on firms' performance and consider total factor productivity growth, firms' growth in terms of total gross sales, and profitability as indicators of firm performance. The results based on the panel Feasible Generalized Least Square estimator shows that the effect of innovation on firms' performance is positive. Further, the impact of innovation on performance is higher for large firms compared to small firms.

Keywords: Total factor productivity; Patent; R&D intensity; Panel FGLS; Manufacturing firms.
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I. INTRODUCTION

It is widely recognized in the literature that technological change and innovation are key drivers of economic growth and key industries (primary, secondary and tertiary). Schumpeter (1934) first ascertained the importance of innovation for higher economic growth and social welfare. By following the seminal works of Schumpeter (1934) and Solow (1957), numerous empirical studies have examined the linkage between innovation and firm performance (Crespi and Zuniga, 2012; Nadiri and Kim, 1996; Aghion and Howitt, 1998; Geroski, 1991; Griliches, 1979; Raymond *et al*., 2015). There are also empirical studies which show significant inter-industry differences in firms' innovation behaviour.

Indian manufacturing sector plays a crucial role in India's overall economic growth. There are a significant number of studies which have examined the performance of the manufacturing sector in India, both at the aggregate industry and firm-level, although from different perspectives and by using different approaches. Furthermore, there are a reasonable number of studies that examine the linkage of Research and Development (R&D), adoption of technology, trade, and Foreign Direct Investment (FDI) variables with total factor productivity in case of Indian manufacturing (Raut, 1995; Basant and Fikkert, 1996; Hasan, 2002; Kathuria, 2002; Franco and Sasidharan, 2010; Sharma and Mishra, 2011; Sharma, 2012; Sasidharan and Kathuria, 2011).

The National Innovation Survey (2014) initiated by NSTMIS and NISTADS also discusses the understanding of innovation in the Indian context. This report highlights various aspects related to design of the innovation survey. The survey collected data from 9,001 firms across all the major states and Union Territories of India covering agriculture, industry and services sectors. The primary objective of that study was to create a database related to innovation in India, comparable to the OECD countries innovation databases.

Similarly, there are only a few studies which examine the effect of innovation on firm performance in the case of the Indian manufacturing sector (Raut, 1995; Sharma, 2012; Ambrammal and Sharma, 2016; Seenaiah and Rath, 2018; Seenaiah and Rath, 2019; Chundakkadan and Sasidharan, 2019a, 2019b). However, to best of our knowledge, all these studies, except Ambrammal and Sharma (2014), either focus on R&D expenditure or measure innovation as a binary variable. In the literature, R&D expenditure is typically treated as input for innovation, but R&D itself may not always lead to innovation (Lee and Stone, 1994; Lee and Kang, 2007).

In this regard, our paper differs from the prevailing literature in the following ways. First, we consider innovation as an output by counting the number of patents created by firms using a relatively new source of database, particularly in the context of India. The government of India aimed to increase the manufacturing sector's GDP, which was almost stagnant over the last six decades. In order to strengthen the manufacturing sector, the government launched the make in India initiative in 2014 and also declared 2010 to 2020 as the decade of innovation. Since the Indian service sector is already perceived as an engine of India's growth, the country needs to target the sluggish manufacturing sector in order to reach the US$ 5 trillion economy by 2024-25 (Economic Survey, 2019-20, Govt. of India). Thus, to expand the Indian manufacturing sector's base, the country must invest to boost the innovation activities of the manufacturing sector. The innovation activities in the manufacturing sector will not only remove barriers and challenges to technological learning, and development, but it will help in upgrading the manufacturing industry to further strengthen innovation outcomes.

Figure 1.
Number of Patents in Selected Manufacturing Firms

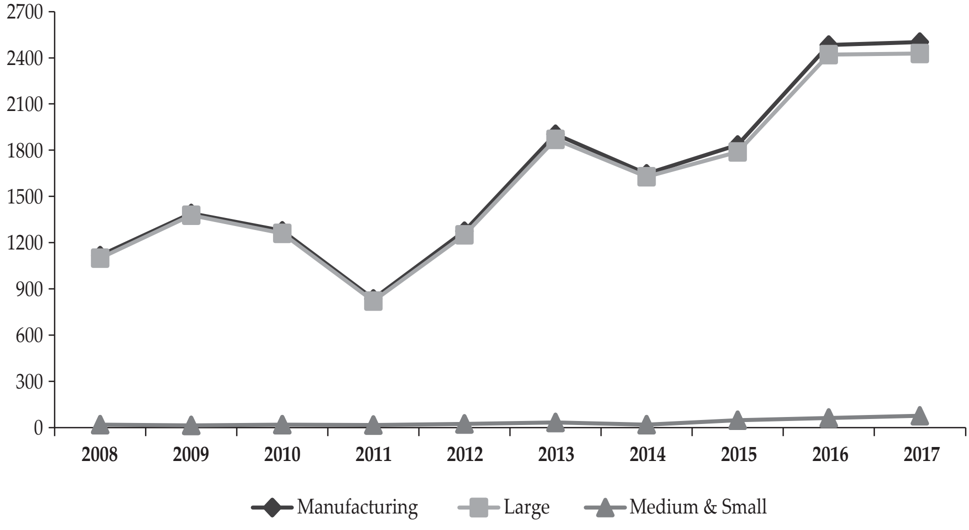
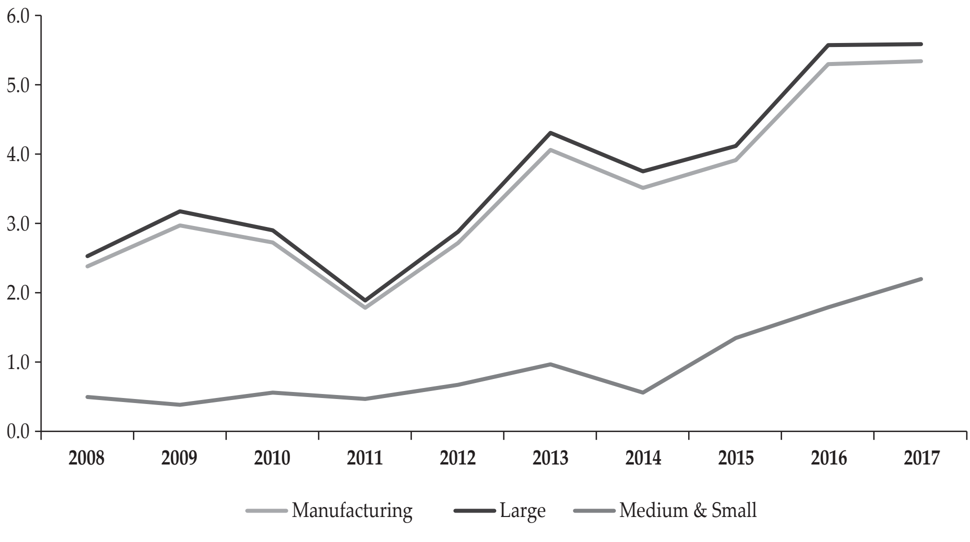


Figure 2.
Trend of Average Number of Patents in Manufacturing Sector



Second, both Figures 1 and 2 indicate that the number of patents in the case of the manufacturing sector has been increasing over the years. It is also further noticed that the average number of patents per year across large group of firms is higher as compared to medium and small firms. This further motivates us to investigate whether variation in innovation output has any similar or different effect on firms' performance based on firm size.

Third, although Ambrammal and Sharma (2016) have used the number of patents at the firm level as a measure of innovation, their sample of firms is different from the firms which we consider in this paper. They also use annual data from 2000 to 2010; however, our study investigates the research issue using recent year data from 2008 to 2017. Fourth, Ambrammal and Sharma (2016) consider gross fixed asset as a capital and subsequently estimated productivity using the Levinsohn and Petrin (2003) approach. However, there has been debate in the literature on measuring capital input (Biesebroeck, 2005). A large number of studies while measuring total factor productivity in the manufacturing sector estimate capital as a stock variable using the Perpetual Inventory Method (PIM); see for instance; Balakrishnan and Pushpangadan (1994), Unel (2003), Madheswaran *et al*. (2007), and Sharma and Mishra (2011). Therefore, the present study uses the PIM method to measure the capital stock. Fifth, we estimate the total factor productivity of firms by employing the Ackerberg, Caves and Frazer (ACF, 2015) and Levinsohn and Petrin (LP, 2003) methods and compare the impact of innovation on productivity between large and small firms. The effect of innovation on firm performance based firm size would provide more policy insights.

Sixth, firm performance can be measured either by productivity and efficiency, or sales growth or profitability (Clarke, 2003; Waldman and Jensen, 2005). While most of the studies linking innovation and firm performance do so by measuring total factor productivity growth, this study make uses of firms' growth and profitability as other forms of performance (see, for example, Karz, 2008; Demirel and Mazzucato, 2012; Deschryver, 2014; Guarscio and Tamagni, 2019). Then the present paper examines the effect of innovation outcome on firms' sales growth and profitability and considers it as a part of robustness checks.

Our study offers following insights. The results based on the panel Feasible Generalized Least Square (FGLS) estimator shows that the effect of innovation output on firms' performance is positive. Furthermore, in the case of large firms, the impact of innovation output on firms' performance is higher in comparison to small firms. From a policy perspective, focusing on innovation outcomes by increasing patent application and registration at the firm level can further strengthen the Indian manufacturing sector and assist in achieving the 'Make in India' strategic policy target.

The rest of paper proceeds as follows. Section II describes the methodology and data. Section III illustrates the econometric results and Section IV concludes.

II. METHODOLOGY AND DATA

A. Methodology

The origins of Total Factor Productivity (hereafter, TFP) estimation has roots in the seminal work by Solow (1957), which is popularly referred to as the Solow Index. Thereafter, numerous changes and methodological advances have appeared in the literature to measure TFP both for an aggregate country and the firm by paying special attention to the production function and its output and inputs. In this paper, the TFP estimation is done using the LP and the ACF techniques. Levinsohn and Petrin (2003) estimate the TFP by extending the work of Olley and Pakes (1996, hereafter OP). Both OP and LP have addressed the problem of endogeneity that is particularly embodied in the production function with reference to observed inputs. The crux of the OP and LP techniques is that under certain assumptions one can upset optimal input decisions to allow an econometrician to 'observe' unobserved productivity" (ACF, 2015). More specifically, in order to control for the unobserved productivity shock, LP follow the intermediate input demand function, whereas OP follow an investment demand function.

The production function based on the LP approach can be written as follows:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_e e_{it} + \omega_{it} + u_{it} \tag{1}$$

Let, y refers to real gross sales, k refers to capital, l represents labour, and e is the energy input. Similarly, ω_{it} is the measure of productivity, i and t stands for firm and time respectively. We also assume both ω_{it} and u_{it} are unobserved components.

The ACF identified the limitations of OP and LP methods on the ground of functional dependence problem (ACF, 2015). According to ACF, the moment condition underlying the first stage estimating equation does not identify the labour coefficient. Since labour can actually be treated as a state variable because of hiring and firing costs as well as long-term contracts, therefore, this input should be included as a proxy variable in equation (1)[1].

After estimating the TFP, in the next step, we examine the outcome of innovation on firms' performance. The linkage between innovation and performance measured through productivity has long been traced back to Schumpeter's concept of creative destruction: the process by which new innovations replace old technologies (Schumpeter, 1942). At the micro level, Hall (2011) has systematically reviewed a large number of studies and found a positive association between the innovative activities and a firm's productivity growth. Similarly, endogenous growth theory argues for a positive association between technological changes, through product or process innovations with economic growth (Aghion and Howitt, 1992; Grossman and Helpman, 1993; Romer, 1990). However, measurement of the relationship between innovation and productivity is perhaps one of the most contentious fields of work in empirical economics (Crespi and Zuniga, 2012). In the literature, a study by Crépon *et al*. (1998) was one of the first to examine the relationship between innovation and productivity and found a positive correlation between productivity and innovation output in case of France.

A plethora of studies highlight that typical static panel data models are expected to show substantial cross-sectional dependence (Robertson and Symons, 2000; Pesaran, 2004: Anselin, 2001; Rath, 2018). In the presence of cross-sectional dependence, the fixed effect and random effect models are only consistent but not efficient, as results, the standard errors lead to biasedness in the estimation (Pesaran, 2006). To overcome this problem, the present study uses the panel FGLS model. We begin with FGLS model by writing the following equation.

[1] For detailed methodology, please refer to Ackerberg, Caves, and Frazer (2015).

$$Y_{it} = \alpha + X_{it}^{'}\beta + \delta_i + \gamma_t + \varepsilon_{it} \qquad (2)$$

where, Y is the regressand, α is intercept, X is a vector of regressors, β is the coefficients associated with regressors, ε_{it} is an error term, δ_i and γ_t are firm and time specific characteristics, respectively. The specific equation for FGLS model can be highlighted in equation 3:

$$g(\beta) = \sum_{i=1}^{M} g_i(\beta) = \sum_{i=1}^{M} Z_i^{'} \hat{\Omega}^{-1} \varepsilon_i(\beta) \qquad (3)$$

where $Z_i^{'}$ refers to instrument matrix, $\hat{\Omega}$ is a consistent estimation of the variance-covariance matrix Ω, and $\varepsilon_i(\beta) = (Y_{it} - \alpha - X_{it}^{'}\beta)$. In the OLS method, the variation in the error term across the groups can impact the consistency property. However, the GLS estimation can resolve this issue (Green, 2008). We can expand the Equation (3) by fitting the objective of the study in following manner:

$$TFPG_{it} = \alpha + \beta_1 INO_{it} + \beta_2 EXI_{it} + \beta_3 IMI_{it} + \beta_4 RDI_{it} + \mu_i + \varepsilon_{it} \qquad (4)$$

$$lnY_{it} = \alpha + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \beta_3 INO_{it} + \beta_4 EXI_{it} + \mu_i + \varepsilon_{it} \qquad (5)$$

$$lnPAT = \alpha + \beta_1 lnY_{it} + \beta_2 INO_{it} + \beta_3 EXI_{it} + \mu_i + \varepsilon_{it} \qquad (6)$$

All Equations (4-6) are related to firm performance. Equation (4) refers to total factor productivity, Equation (5) represents to factors that affect firms' performance in terms of gross sales and Equation (6) indicates firms' performance in terms of profitability. Here, *TFPG* is the total factor productivity growth, *INO* is the innovation output, *EXI* refers to export intensity, *IMI* refers to import intensity, *RDI* is R&D Intensity, *Y* refers to real gross sales, *L* is the labour input and *K* is the capital input, PAT refers to profit after tax, μ is the individual firm specific characteristics, ε is the error term, i refers to number of firms and t stands for time periods. Prior to using FGLS method, we test for the Cross-sectional Dependence (CD) among firms by employing Pesaran (2004) CD test under null of presence of cross-sectional independence.

B. Data

The present section discusses the selection of various variables with their sources and measurement of variables. First, since there in no direct data on innovation related variables available for Indian manufacturing, this study gathered a list of manufacturing companies associated with patents. The Controller General of Patents, Designs and Trademarks under the Ministry of Commerce and Industry, the Government of India, publishes the Patent Office Journal once a week. There are 52 issues per year and in each issue, this journal provides the list of firms with the name of the patent(s) that the company submitted. We listed all the manufacturing companies who have come up with patents from 2008 to 2017. Second, we came up with the number of patents corresponding to each firm by counting these products name for each volume. Third, we compiled by adding the number of patents for each firm over 52 volumes in a year. Fourth, we replicate the same procedure for each year from 2008 to 2017. In this process, a total of 5,711 manufacturing firms are identified and 630 firms have come up with patents at least once in three years (over the 2008- 2017 period). Once we identified these firms then in fifth step, we searched those firms in the Prowess database, which provides list of more than 27000 firms those registered under Bombay Stock Exchange. Finally, we picked 467 out of 630 firms those listed in the Prowess database. We confine to 467 firms because although the remaining 167 firms provide patent data but those firms are not registered in the Prowess database. Thus, we picked these 467 firms following purposive sampling. After obtaining the patent data and matching those firms in the Prowess, we then collect other important variables such as GFA, gross sales, total remunerations, exports, imports, profit after tax, and R&D expenditures from the Prowess database[2].

To measure the total factor productivity growth, we use output and input variables at firm level. The real gross sales are taken as a proxy for output. Similarly, capital, labour, consumption expenditure on power and fuel and expenditure on raw materials are the four inputs used. The Wholesale Price Index (WPI) of two-digit respective manufacturing disaggregated industry is used for converting nominal to real gross sales. The labour input, which is measured as number of employee are not available for all firms in the Prowess database. To overcome this problem, we use both Annual Survey of Industries (ASI) and Prowess database for obtaining labour input (Sharma and Mishra, 2011; Sharma, 2012; Ambrammal and Sharma, 2016; Rath, 2018). The following steps have been followed. First, industry-wise data on total earnings and number of persons engaged are collected from ASI. Second, industry-wise wage rate is obtained with following formula:

$$Wage\ rate = \frac{Total\ emouluments}{total\ persnons\ engaged} \tag{7}$$

Third, the employee data is calculated by dividing the wage rate obtained in equation (7) to total salaries and wages data, which are collected from the Prowess database.

$$No\ of\ employee = \frac{Salaries\ and\ wages\ (firm\ level)}{Industry\ wise\ wage\ rate} \tag{8}$$

To measure the capital, the present paper follows Levinsohn and Pertin (2003) construction process and capital stock is estimated using Perpetual Inventory Method (PIM). The present study first obtains the initial capital stock of the beginning year (*i.e.* 2008) by taking twice the book value. After obtaining the capital stock for the initial year, the capital stock series for subsequent years is generated by using following formula.

$$K_t = (1 - \delta)K_{t-1} + I_t \tag{9}$$

[2] Please see the Appendix Table A1.

where K_t is capital at period t, I_t refers to real investment, δ is treated as depreciation rate of 7% following similar studies (Unel, 2003; Sharma, 2011). The firm level nominal gross fixed capital series has been deflated using WPI of machinery and machine tools to obtain real investment series. The data on expenditure on raw materials, stores and spares are deflated using WPI of all commodities at the all-India level. The *EXI* refers to export intensity which is measured as total foreign earning as ratio to gross sales, *IMI* is import intensity measured as a ratio of total foreign spending to gross sales, *RDI* is measure as the ratio of R&D expenditure to gross sales. All these variables are collected from the CMIE Prowess data base.

III. RESULTS AND DISCUSSION

We begin by examining the TFP growth. Table 1 presents the TFP growth which are estimated using ACF and LP methods while Table 2 shows the descriptive statistics.

Table 1.
Productivity Estimator

This table presents the results of total factor productivity growth based on Ackerberg, Caves, and Frazer (ACF) productivity and Levinsohn-Petrin (LP) productivity estimators. The dependent variable is lnY which refers to log gross sales, lnL = number of employee, lnK = capital stock, and lnRM = expenditures on raw materials. ***, and * indicates 1% and 10% level significance, respectively.

Variable	ACF Productivity Estimator		LP Productivity Estimator	
	Coefficient	**SE**	**Coefficient**	**SE**
lnL	0.71***	0.260	0.52***	0.03
lnK	-0.02	0.034	0.03*	0.02
lnRM	0.30*	0.27	0.09	0.17
Wald test of constant returns to scale: χ^2	0.00 (0.988)		0.17 (0.678)	

Table 2.
Descriptive Statistics

Note: TFP-LP = total factor productivity growth based on Levinsohn and Petrin, TFP-ACF = total factor productivity based on Ackerberg, Caves, and Frazer, Y = gross sales, L = labour input, K = capital stock, PAT = profit after tax, EXI = export intensity, IMI = import intensity, RDI = R&D Intensity, and INOV = innovation. The results reveal that the mean of TFP based on LP approach is higher than the TFP estimated based on ACF method. The mean of log gross sales is 8.46 and standard deviation is 1.98. Similarly, the mean of innovation is 3.48, which implies that on an average, the manufacturing firms are developing/submitting 3.48 patents per year.

Variable	Obs	Mean	Std. Dev.	Min	Max
TFP-LP	3215	3.95	0.95	-4.76	7.2
TFP-ACF	3215	0.87	0.58	-6.0	4.7
lnY	3973	8.46	1.98	-2.7	15.0
lnL	4008	7.71	1.86	-1.03	14.34
lnK	3994	7.05	1.85	-1.61	14.26
lnPAT	3474	5.97	2.25	-1.61	12.73
EXI	4670	0.69	10.57	0	569.15
IMI	4670	3.69	138.04	0	9045.6
RDI	4670	0.09	4.91	0	335.82
INOV	4669	3.48	16.85	0	420

The mean of LP and ACF estimated TFP growth estimated are 3.95 and 0.87, respectively. This implies that the productivity measured through LP approach is much higher as compared to ACF approach, implying that the exact measurement of TFP is highly related to two estimation techniques. The mean log of gross sales value is 8.46 and standard deviation is 1.98, which implies that the mean gross sales of Indian manufacturing sector is higher than the productivity. Meanwhile, the mean of export intensity (*EMI)* is 0.69 and mean of import intensity (*IMI*) is 3.69. The mean RDI intensity seems to be very low (0.09), which as expected. Since most of the Indian manufacturing firms spend less on R&D expenditures in comparison to wages and capital, thus, it reflects on the unit of RDI. Looking at the innovation variables, we observed that the mean value of innovation (INOV) which is measured as number of patents produced or submitted by firms is 3.48 and the maximum number of patents is 420.

Next, the panel model estimated results clarifying the impact of innovation on firm performance are presented in Tables 3-6. The present study considers productivity growth, firms' sales growth and profit as the measure of firm performance. Tables 3 and 4 presents the results of impact of innovation on total factor productivity growth developed based on the ACF and LP methods, respectively. The key results are as follows. First. focusing on the results based on ACF productivity estimator in Table 3, we find that innovation measured in terms of patent does not affect the productivity, although, the R&D intensity has negatively affected the productivity growth. In the literature, there is numerous debate on whether R&D can be treated as a proxy for innovation. While several empirical studies (Raut, 1995; Sharma and Mishra, 2011; Sharma, 2012) consider R&D expenditures as an input for Innovation, quite reasonable number of studies (Crepon *et al*., 1998; Ambrammal and Sharma, 2016) also treat R&D as an innovation output. Again, there is mix evidence on the effect of R&D on productivity growth. This study reveals that higher the R&D expenditures as a ratio to gross sales can lead to higher input costs and hence reduces the productivity growth. The study further divided firms into two categories, large and medium plus small firms based on their investment in machinery and equipment. The overall results did not show any differences in these two categories except export intensity, which positively affect the productivity growth in case of large firms.

Table 3.
Impact of Innovation on TFP Growth (ACF Approach)

This table presents the results of impact of innovation on TFP based on Ackerberg, Caves, and Frazer (ACF) approach. The results show that innovation does not significantly affect the TFP. This table also indicates that R&D intensity has negatively affect the TFP. Note: INO = innovation, EXI = export intensity, IMI = import intensity, RDI = R&D Intensity; *** indicates 1% level significance. Figures in the parentheses indicate standard errors.

	Aggregate Coeff.	Large Coeff.	Medium and Small Coeff.
Constant	0.86*** (0.004)	0.87 (0.004)	0.83 (0.012)
INO	0.0002 (0.0002)	0.0002 (0.0003)	-0.006 (0.006)
EXI	0.002 (0.002)	0.007*** (0.002)	0.013 (0.013)

Table 3.
Impact of Innovation on TFP Growth (ACF Approach) (Continued)

	Aggregate Coeff.	Large Coeff.	Medium and Small Coeff.
IMI	0.0002 (0.0006)	0.0006 (0.000)	-0.06 (0.058)
RDI	-0.619*** (-0.067)	-1.39*** (0.140)	-0.38*** (0.07)
Wald test	110.97 (0.00)	107.16 (0.00)	57.60 (0.00)
No. of observation	3215	3014	201

Table 4.
Impact of Innovation on TFP Growth (LP Productivity Estimator)

This table presents the results of impact of innovation on TFP based on Levinsohn and Petrin (LP) approach. The results show that innovation positively affect the productivity in case of aggregate and large manufacturing firms. However, there is no effect on innovation on TFP. The table also reveals that other variables such as export intensity, import intensity and R&D intensity also significantly affect the TFP. Note: INO = innovation, EXI = export intensity, IMI = import intensity, RDI = R&D Intensity; ***, **, and * indicates 1%, 5% and 10% level significance, respectively. Figures in the parentheses indicate standard errors

	Aggregate Coeff.	Large Coeff.	Medium and Small Coeff.
Constant	3.45*** (0.007)	3.53*** (0.008)	3.53*** (0.027)
INO	0.01*** (0.000)	0.01*** (0.000)	-0.006 (0.008)
EXI	-0.02*** (0.004)	-0.012** (0.005)	-0.77*** (0.026)
IMI	0.003 (0.002)	0.004* (0.002)	-0.348*** (0.095)
RDI	-1.05*** (0.12)	-2.29*** (0.24)	-0.691*** (0.133)
Wald test	236.90 (0.00)	217.72 (0.00)	91.86 (0.000)
No. of observation	3215	3014	201

Table 4 shows the effect of innovation on TFP growth based on Levinsohn-Petrin (LP) method. Second, innovation positively affects TFP growth at the 1% significance level for both aggregate as well as large manufacturing firms. However, innovation (INO) does not affect the productivity of medium and small firms. Although the magnitude of this impact on productivity growth is minimal, the finding of this study is consistent with previous studies which used the LP method to measure the TFP growth in case of Indian manufacturing sector (Sharma and Mishra, 2011; Sharma, 2012; Ambrammal and Sharma, 2016; Seenaiah and Rath, 2018; Seenaiah and Rath, 2019). The inconsistencies that we notice for the impact of innovation on firm productivity growth in Table 4 and Table 3 are due to different TFP growth measures. Third, however, R&D Intensity (RDI) has negatively affected productivity growth in Table 4, which is again consistent with results obtained in Table 3. The expenditures on research and development in manufacturing sector typically associate with risk factors. The Indian manufacturing sector which is undergoing a steady share of GDP as well as in terms of gross value addition over last three to four decades, it is highly possible that the increase in the R&D expenditures will further increase the production costs and inputs in short-run. As a results, it may adversely affect the productivity growth in short-run particularly for small and medium level firms.

Fourth, the export intensity (EXI) also shows a negative and statistically significant impact on productivity growth based on LP approach. Theoretically, one would expect a positive relationship between export intensity and productivity, but our results show a negative relationship. Our finding is also consistent with Sharma and Mishra (2011), who found that export intensity does not always gain in productivity in case of Indian manufacturing sector. The other plausible reason for the negative effect of export intensity on productivity growth could be the emergence of Global Value Chains (GVC) particularly in the emerging market economies like India. The fragmentation of trade in the form of GVC can increase the exports of the firms or industries, but it may not necessarily increase the productivity growth because of backward GVC participation (scenario where domestic firms imports foreign inputs to produce goods they export). The higher inputs due to fixed and variable costs of exporting decrease the productivity. Crino and Epifani (2008) also found that increase in export intensity has declined the productivity measured in total factor productivity in low-income countries. This impact of EXI on productivity growth is severe in case of medium and small firms (-0.77) in comparison to large firms (-0.012).

A. Robustness Check Up

Here, we assess the effect of innovation on firms' sales growth, which is considered as another indicator of firm performance. The results are displayed in Table 5. Our main findings are as follows. First, innovation (INO) has a positive and significant impact on firms' growth, which is measured in terms of real gross sales. However, the coefficient of innovation is negative (-0.030) in case of medium and small firms and this finding is not surprising. In case of medium and small firms, the mean innovation outcome (measured as number of patent count) is much lower than the large firms. The increase in number of patents may not provide exclusive monopoly power to the medium and small manufacturing firms, the way it helps for large firms. Thus, since most of the medium and small Indian firms operate under less production expansion capacity, hence, the innovation outcome really not favour those firms to boost the overall sales. Second, two important inputs – labour and capital also positively affect the firms' growth, which is again as per the *a priori* expectation. Third, the export intensity (EXI) also negatively affects the firms' growth but its effect is minimal. Fourth, R&D intensity (RDI) negatively affect the productivity growth of Indian manufacturing firms. To sum up, our findings suggest that increase in number of patents at firm level can boost the productivity.

Table 5.
Impact of Innovation on Firms' Growth

This table presents the results of impact of innovation on firms' sales growth. The results show that innovation positively affect the firms' growth in case of aggregate and large manufacturing firms but it negatively affects the sales growth in case of medium and small firms. Apart from innovation, labour and capital variables also positively affect the firm's sales growth. Note: INO = innovation, EXI = export intensity; ***, **, and * indicates 1%, 5% and 10% level significance, respectively. Figures in the parentheses indicate standard errors.

	Aggregate Coeff.	Large Coeff.	Medium and Small Coeff.
Constant	0.860*** (0.04)	0.88** (0.005)	0.153 (0.198)
lnL	0.972*** (0.004)	0.969*** (0.005)	1.02*** (0.02)
lnK	0.008** (0.004)	0.008** (0.004)	0.12*** (0.03)
INO	0.001* (0.000)	0.001** (0.004)	-0.030** (0.01)
EXI	-0.009*** (0.001)	-0.008*** (0.001)	-0.016** (0.002)
Wald test	52893.23 (0.000)	47980.59 (0.000)	2955.4 (0.00)
No. of observation	3421	3215	206

Table 6.
Impact of Innovation on Firms' Profitability

This table presents the results of impact of innovation on firms' profitability. The results show that innovation positively affect the firms' profitability in case of aggregate and large manufacturing firms, but it does not affect the profitability of medium and small firms. Note: Y = gross sales, INO = innovation, EXI = export intensity; *** indicates 1% level significance. Figures in the parentheses indicate standard errors.

	Aggregate Coeff.	Large Coeff.	Medium and Small Coeff.
Constant	-3.23*** (0.052)	-3.14*** (0.054)	-4.02*** (0.172)
lnY	1.07*** (0.006)	1.06*** (0.006)	1.16*** (0.020)
INO	0.001*** (0.000)	0.002*** (0.000)	0.014 (0.013)
EXI	0.0004 (0.001)	0.001 (0.002)	-0.028*** (0.007)
Wald test	37064.68 (0.00)	33914.41 (0.00)	3368.12 (0.00)
No. of observation	3386	3148	238

Finally, we use profit as an alternative variable for measuring firm performance. The results are discussed in Table 6. In this Table, our results also show that innovation (INO) is having a positive impact on profitability for aggregate manufacturing and for large firms, but it does not affect the profitability in case of medium and small firms. Innovation activities is always costly matter for medium and small manufacturing firms. Thus, increase in innovation outcome in terms of patent may not necessarily enhance the profitability. An increase in firms' growth in terms of gross sales also boost the profitability for overall as well as large and medium manufacturing firms. Finally, the coefficient of export intensity negatively affects the profitability only in case of medium and small firms, but no significant impact on large manufacturing firms.

IV. CONCLUSIONS

This paper attempts to investigate the impact of innovation activities on the performance of 467 manufacturing firms in India over period 2008-2017. By doing so, we emphasize on the role of innovation outcome in terms of number of patents on firms' performance. The study considers total gross sales, TFP growth, and profitability as the indicators of firm's performance. We estimated TFP growth using both Levinsohn-Pertin and Ackerberg-Caves-Frazer techniques and employed panel Feasible Generalized Least Square (FGLS) estimation technique to examine the effect of innovation on firms' performance. The findings from the study are as follows. First, increase in innovation output has significantly boost the firms' productivity, sales growth and profitability. Second, R&D intensity negatively affects the TFP growth. Third, an increase in export intensity has reduced the firms' productivity growth as well as sales growth. Finally, the effect on innovation on firms' performance is relatively better in case of large manufacturing firms in comparison to medium and small manufacturing firms.

From policy perspective, it is imperative to focus more on innovation activities to further boost the performance of Indian manufacturing sector. As R&D intensity negatively affect the firms' productivity, gross sales and profitability, it indicates that expenditures on R&D does not necessarily reflect in terms of innovation output. Thus, it is imperative for firms or industries to not only spend more on R&D but to ensure how the R&D expenditures as an input creates innovation output.

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APPENDIX

Table A1.
Definition of Variables, Measurement and Data Source

ASI = Annual Survey of India, CMIE = Centre for Monitoring India Economy

Variable	Measurement	Data source
TFP-LP	Total factor productivity growth based on Levinsohn and Petrin approach	CMIE Prowess database
TFP-ACF	Total factor productivity based on Ackerberg, Caves, and Frazer	CMIE Prowess database
lnY	Real gross sales	CMIE Prowess database
lnL	Labour Input	ASI and CMIE Prowess database
lnK	Capital stock measured through PIM	CMIE Prowess database
lnPAT	Profitability measured as profit after tax	CMIE Prowess database
EXI	Export intensity = Export/ Sales	CMIE Prowess database
IMI	Import intensity = Import/Sales	CMIE Prowess database
RDI	R&D intensity = R&D exp/Sales	CMIE Prowess database
INOV	Innovation = Number of patents	Patent Office Journal, Government of India

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