Economics Bulletin

Volume 38, Issue 4

Innovation Strategies, Outcomes and Firm Performance: An Analysis of Firm Behaviour in India's Manufacturing Sector

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Abstract

This paper tries to contribute to the emerging stream of research on innovation in developing economies looking at the impact of different firm level strategies on innovation outcomes and the impact of these innovations on firm performance, using the data obtained from World Bank Enterprises Survey conducted for India (2013-14). Firstly, we analyse the relative role of different innovation strategies on product and process innovations. These strategies include technology creation, technology adoption and absorptive capacity building. Technology creation is measured through in-house R&D efforts and technology adoption indicates disembodied knowledge acquisition and embodied technology transfer. Successful product and process innovations occur through technology creation and a mixed strategy in which technology creation and adoption complement each other. The option of only relying on technology adoption is found to be not effective for process innovations. The second part of the study examines the role of product and process innovation as the driver of firm growth. Firm performance is measured through sales growth and productivity growth. We find that product innovations and particularly the combination of product and process innovation significantly improve firm performance. Both innovation and growth performance are supported by availability of finance and managerial skills.

I thank Prof. K.J. Joseph and Dr. P.L. Beena at Centre for Development Studies for all valuable inputs and suggestions to improve this paper. Thanks for the comments given by anonymous reviewers of the paper. I also acknowledge Dr. Kiran Kumar for the preparation of the manuscript. The usual disclaimers apply

Citation: George Paily, (2018) "Innovation Strategies, Outcomes and Firm Performance: An Analysis of Firm Behaviour in India's Manufacturing Sector", *Economics Bulletin*, Volume 38, Issue 4, pages 1769-1786

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Submitted: June 24, 2018. **Published:** October 10, 2018.

1. Introduction

Innovation and technological progress is a field that receive a great deal of attention for economic development, productivity growth and material welfare of both developed and developing economies. But the underlying strategies to achieve economic development through innovative activities may be remarkably different. For instance, the initial phase of economic development of the widely discussed catch up economies in the 1950s and 1960s were mainly characterised by attaining capabilities through imitative learning. In this phase, these countries adopted the method of assimilating and improving upon imported technology through certain forms of reverse engineering (Pavitt, 1985). Of course it can't be denied that learning to do what others already have done is not easy even if there are no barriers for imitation. Moreover it often involves a difficult learning process. But the recent decades of catching up process rapidly tended to focus more on expanding indigenous research efforts along with building up efficient higher education system especially in engineering and training (Nelson, 2003). Researches carried out in the universities and public libraries have also played an important role for late comer countries' innovation system than in the past (Mowery, 2004; Joseph and Abraham, 2009; Freitas et al, 2013; Huang et al, 2010).

The post liberalisation period in India has remarkably widened the arena of international linkages and interactive learning. Innovation has more become a collective action that involves a multitude of actors who co-operate and compete in networks and who are stimulated and constrained by institutional settings (Lundvall, 1992). The conscious effort to create an efficient innovation system in India is underlined in the Industrial Policy Statement of 1991. The statement among other objectives aims at 'injecting the desired level of technological dynamism in Indian industry' and 'the development of indigenous competence for the efficient absorption of foreign technology' and express the hope that 'greater competitive pressure will also induce our industry to invest much more in research and development than they have been doing in the past' (Krishnan, 2003; Joseph and Kakarlapudi, 2014).

The assumption that developing countries can generate technological change simply choosing and adopting technologies particularly from the developed countries has often obscured the importance of the accumulation of pertinent domestic assets. At the present context, viewing technology development as Dalhman et al (1987) defines as 'the central issue of technological development in developing countries is acquiring the capability to use existing technology to produce more efficiently to establish better production facilities and to use experience gained in production and investment to adapt and improve the technology in use' has got its own limitations. A more appropriate conceptualisation of technology led catch up as given by Stewart (1984) is 'indigenous technological capability as the capacity to create, adapt and modify technology thus including in its local adaptation and development of technology already known elsewhere as well as the creation of some completely new technology'. The current and future development environment for countries trying to catch up is different from what it has been in the past. New international treaties have changed the catching up the environment in a number of ways. Aggressive and effective protection of intellectual property rights, hard pressures for establishing the advanced countries' firms in most parts of the developing world, legal and punitive actions against developing countries' policies for infant industry protection, etc. instigate to adopt new catching up strategies (Nelson, 2007).

An examination on the different technology strategies and their impact on firm performance in the pre liberalisation period by Basant (1997) shows that the return of technology

purchases is substantially higher than that of indigenous R&D effort. The high effective rate of protection through physical constraints on imports and higher import duties along with industrial licensing leading to major entry barriers meant that local industries felt little need to innovate (Forbes and Wield, 2000; Krishnan and Prabhu, 1999). The present study looks into an updated picture of different strategies. Moreover, in contrast to other studies, the study concentrates on the impact of these strategies on innovation outcomes – product and process innovations. In a later section, these innovation outcomes are hypothesised as one of the determinants of firm performance and their impact is examined.

Innovation process occur over time may be of different kinds (e.g. technological and non technological) and influenced by many factors. The process through which technological innovation evolve consist of complex feedback mechanisms and interactive relations as well as the translation of these into new products and production processes. Further, this translation by no means may follow a 'linear' path of technological development from basic research to applied research and then to development and implementation of new products and processes (Edquist. 1997). Against this backdrop, the study deals with different innovation strategies in terms of 'make' and 'buy' adopted by manufacturing units in India and their impact on innovation development. Given the technology gap between the developed and developing world, the relative role of these innovation strategies may provide certain new insights about the effectiveness of indigenous technological efforts and the dependence on foreign technologies. In addition, the analysis of innovation strategies in terms of 'make' and 'buy' assumes greater significance in the globalisation era because there exist few firms which are self sufficient on technological grounds and capable of generating all their requirements through their own in-house research efforts. The study is organised in the following way. Section 2 deals with a survey of different innovation strategies and their impact in shaping the innovative behaviour and firm performance. Section 3 presents the data and variables used for the study and outline the econometric approach. Empirical results are presented in the in the fourth section. The last section concludes the findings.

2. **Review of Empirical Studies**

There is a flourishing research based literature on firm specific factors contributing to the success and failures of innovative activities in developing economies. The traditional mode of technological changes emphasises the fact that, technology can be transferred fully without any barriers among countries and therefore industrialising countries' optimised strategy should be searching and adopting the existing technology available elsewhere and leave the technology producing sectors. This doctrine is now considered as fundamentally misleading because in reality technology is so complex and can only be partly encompassed either by codified knowledge or physical capital (Saviotti, 1998). For instance, in much of the technology transfer took place from Japanese to Indian firms in the 1980s, engineers were competent enough to understand and master the technology supplied, but they were not good at modifying or improving it (Ito, 1985). It signifies that innovation requires more than the accessed codified knowledge or transferred embodied technology since the underlying scientific models and laws on which those technologies are based can't fully predict the introduction and performance of new products and processes (Bell and Pavitt, 1995). Empirical evidences from Danish firms also prove that, use of STI and DUI modes of

innovation strategies enable firms to come up with better innovation outcomes than relying on standalone strategies (Jensen et al, 2007).[1]

Veugelers and Cassiman (1999) examines the complementarily between technology 'make' and 'buy' innovation strategies for manufacturing firms in Belgium using Eurostat Community Innovation Survey. The study finds that small firms are more likely to rely on either one of the strategies – make or buy, but majority of the large firms use a combination of both technology creation and adoption. The use of different strategies in combination increases the marginal value of each strategy than being used in isolation. This idea has also been confirmed by Arora and Gambadella (1990) empirically in the case of large biotechnology firms in US, Europe and Japan[2]. It is logical to argue that small firms are more likely to be involved in product innovations because import of technology by itself may enable enterprise to start production of a new product. But generally some in-house capabilities are also needed to make effective use of imported know-how which largely result in both product and process innovations. Golovko and Valentini (2014) also argues that small and medium firms are likely to engage more in product innovations and large firms in process innovations and it is even more so in relation with the decision to enter into export market. It is because SMEs need to broaden their product lines especially prior to the entering into international market and large firms aim at increasing their efficiency. Relative innovative advantage of large and small firms depends on several factors such as market concentration, the extent of entry and exit barriers, composition of the firm size within the industry, relative factor intensity of different industries etc. For example Acs and Audretsch (1987) finds that large firms have relative innovative advantage in the markets which is more characterised by imperfect completion and small firms tend to be more innovative in closely approximating competitive market models. Further the study also provides evidence for the fact that large firms show relative innovative advantage in industries which are more capital intensive, concentrated and having more advertising intensities. With their accumulated stock of knowledge in specific technological areas and their competencies in research and development activities as well as distribution and the timely availability of relevant financial resources, large firm create relevant barriers to entry for small and medium sized firms (Breschi et al, 2000). Cohen and Keppler (1996) find that, as the firm becomes larger in size, it gets more incentive to pursue process R&D relative to product R&D. Cohen and Levinthal (1989) recognise the dual role of research and development activities not only to pursue new product and process innovations but also for the firms' ability to assimilate and exploit existing information.

Goedhuys and Veugelers (2012) have also done a similar attempt of identifing the different innovation strategies including internal development and external acquisition using the data from Investment Climate Survey (2000-2002) conducted by the World Bank for Brazilian manufacturing firms. The effect of these strategies on different innovation outcomes reveals that successful product and process innovations mostly occur through technology adoption from abroad. The situation represents large technology dependence on other countries especially developed and industrially advanced countries. The study further finds that innovation performance is an important condition for firm growth. Breschi et al (2000) suggest that an increasing importance of externally sourced technological opportunities is

[1] STI mode is based on the production and use of codified scientific and technical knowledge whereas DUI mode relies more on informal processes of learning and experience based know-how.

[2] The study identifies four types of strategic linkages engaged by the large firms - agreements with other firms especially Small and Medium sized highly innovative firms, research agreements with universities, investment in capital stocks and acquisition of firms.

positively associated with the 'widening' pattern of innovation or the so called 'Schumpeterian Mark 1'. The finding is particularly relevant in the case of small firms which are immature to carry in-house technological efforts due to various technological and financial constraints. Greater technological opportunities may provide incentives to the entry of new innovative firms and leads to changing hierarchy of innovators and reduce the level of technological concentration towards large firms.

Benavente (2006) carries out a two step process of R&D – innovation and innovation – productivity nexus for Chilean firms. The study does not find any significant positive relationship between research and development activities and innovation and innovation and productivity of the firms. Although a number of studies have come up explaining the factors that determine the firm performance of Indian manufacturing firms, most of them have not taken care how different innovation outcomes contributes to the firm growth mainly because of data limitations.

Many often technological activities go beyond in house R&D effort, technology licensing or embodied technology transfer from abroad. It also involves efficient modes of organising, coordinating and managing activities (Nelson, 2007). Firms in capital scarce developing economies often use their trade contacts with developed countries to upgrade technology through the imports of knowledge intensive capital goods and learn from their partners' business practices and capabilities (Goldberg et al, 2010). Much of the technologies transferred through the import of capital goods are embodied in plants and equipments. Operational technologies often involve complex relationships involving equipment, process characteristics, product specifications and work organisation. Learning by doing per se will not make technology importing firms competitive and innovative.

Absorptive capacity is the ability of the firms to recognise the value of the new external information, assimilate it and apply it to the commercial ends and it is often a function of the firms' prior related knowledge (Cohen and Levinthal, 1990). These abilities to exploit the external knowledge are one critical component of the innovative behaviour of the firms. Technically competent and experienced managers are essential if the firms choose and implement new technologies as well as add up incremental features. Choosing the right technology requires evaluation of existing opportunities and information on the potential future benefits of the technologies to be adopted. These skills are internalised by previous experiences of learning by doing and the induced realistic methods of forming expectations about the likely benefits of alternative technological paths.

Apart from firm level innovation strategies, an effective financial system that can act as a network of institutions and connect the owners of finance capital with entrepreneurs plays an important role in shaping the innovative behaviours of the firms. Further, higher level of international exposure of the firm is expected to have a positive effect on innovative activities. For instance, Boermans and Roelfsema (2012) find that higher exporting leads to higher level of research and development efforts, outward FDI increases R&D efforts as well as international patents and international outsourcing leads to higher sales from product innovations. Increased internationalisation allows the domestic firms to take advantage of the technology spill-overs and organisational learning. Learning through exporting is more about absorbing more information about foreign markets rather than accessing new technologies. Cooper and Kleinschmidt (1985) find that adapting to foreign market conditions via product innovations. It seems to be more important for young and small firms. Secondly product innovation also helps these firms in terms of the mitigation of price discrimination in the

foreign markets. It has been verified by Goldberg and Knetter (1997) that identical products tend to be sold for the same currency price in different markets.

A considerable amount of literature has appeared especially from the last three decades on the assessment of productive and technical efficiencies, firm performance etc. The Indian experience provides mixed results depending on the context, methodology, and sectors. It is often argued that due to high protectionist regime followed before the 1990s, many firms could not react positively or in favour of the opening up of the economy. Likewise not all firms were able to take the advantage of due to the transition to a market oriented economy. This study tries to complement to the literature of innovative behaviour of Indian manufacturing enterprises in the post liberalisation phase.

3. Data and Methodology

3.1. Data

To analyse the link between different innovation strategies including technology creation, adoption and both, we use World Bank Enterprises Survey conducted for India between June 2013 and December 2014. The data provides a rich set of indicators of innovation capability compared to other data sources with various qualitative and quantitative responses. In addition to this, the survey ask the firms about various aspects of their business activities from general firm characteristics to national and institutional aspects regarding environment conducive to learning and innovate, relationship with government, labour, financial constraints etc through intensive interviews with owners and managers.

World Bank Enterprises Survey for India (2014) is a collection of a fair nationally representative sample selected using stratified random sampling. Among the whole population of the study, we selected all manufacturing firms comprising 11 subsectors according to the group classification of ISIC Revision 3.1[3]. Final total samples include 6986 firms from these sectors which is located all across the states[4].

The dataset allows us to construct innovation strategies of 'making technologies', 'buying technologies', 'both making and buying' 'embodied technology transfer' etc. Taking into considerations of product and process innovation, it also allows measuring its impact on firm performance. In addition we are able to use a rich set of controlling factors which go beyond the firm size and firm age. Thee control variable include

a) Absorptive capacity creation which is measured in term of human capital creation of the firm measured from workforce side as well as management side. The proxy variables used for absorptive capacity creation are percentage of workforce who has got tertiary education and number of years of experience of the manager in the specific sector.

[3] These subsectors include food and Tobacco (15+16), Basic Metals (27), Chemicals (24), Electronics (31+32), Machineries and Equipments (29+30+33+34+35), Textiles and Garments (17+18), Fabricated Metal Products (28), Wood and Furniture (20+36), Non-Metalic mineral products (26), Leather (19), Paper (21), and Plastic and Rubber (25).

[4] The state-wise distribution of firms are like this – Andhra Pradesh (373), Arunachal Pradesh (187), Assam (252), Bihar (260), Chhattigarh (259), Delhi (356), Goa (100), Gujarat (375), Haryana (377), Himachal Pradesh (199), Jammu & Kashmir (198), Jharkhand (198), Karnataka (357), Kerala (378), Madhya Pradesh (379), Maharashtra (358), Orissa (253), Punjab (380), Rajasthan (384), Tamil Nadu (370), Uttar Pradesh (375), Uttarakhand (262), and West Bengal (373)

b) Financial constrains, the firm faces in doing business. Financial availability plays a crucial role in creating a favourable business environment. Financial easiness is measured using the dummy whether the firm possesses overdraft facility or not.
c) The exposure to international market and technology is investigated through exports and import of foreign components including capital goods. The possibility of the firms to have an international exposure via exporting is measured using the dummy whether the firms is located in an export processing zone or not. Table 1 provides the description of variables used in this study.

Table 1
Variables and Description

Variable Name	Description
FAGE	Age of the firm, in number of years
FSIZE	Size of the firms measured by log of sales
TMAKE	Dummy of Technology creation through in-house R&D effort
TBUY	Dummy of Technology acquisition through technology licensing
TBOTH	Dummy of Complementary strategy in which technology creation is supplemented with buying
ETT	Embodied technology transfer measured through percentage of imported inputs
LEDU	Percentage of workforce who have attained tertiary education
MEXP	Experience of the manager in that particular sector , in number of years
EXPO	Dummy of whether the firm is located in an export processing zone
FIN	Dummy of whether the firm having an overdraft facility

One of the limitations of the dataset is the restriction towards a cross section dimension. The lack of panel data structure of the data set particularly restricts the analysis of firm performance part of the study. More details of the data structure, number of observations etc are presented in empirical analysis part.

3.2. Methodology

We try to explain the factors that are responsible for the firms' innovation performance in the manufacturing industry and its impact on the firm growth using the World Bank Enterprises Survey (2014). The full description of the variables used in this study is provided in Table 1.

3.2.1.Innovation Strategies:

At first, we have identified the different innovation strategies on both 'make' and 'buy' dimension and embodied technology transfer through imports of inputs and capital goods. In the survey questionnaire, firms are asked about these innovation strategies through intensive interviews with owners and managers. Among the 'make' and 'buy' strategies of disembodied technology, technology creation through in-house or contracted effort is found to be the dominant strategy. Among the total firms of 6986, 35.5 percent of them do either in-house or contracted R&D effort. 10 percentage firms have reported as technology licensors and 4.5 percent of firms do both technology creation and adoption. 9 percentages of the firms depends on embodied technology imported from abroad. The average of foreign inputs used by the firms in our sample is 2.63 percent (See Table 2 for the summary of the variables).the correlation matrix of the variables used suggests that apart from firm size and firms' age, no

other variables are highly correlated (Table 3). Table 4 provides the size-wise and sector-wise distribution of firms in our sample.

We concentrate on four major innovation strategies – technology creation, technology adoption, both creation and adoption and embodied technology transfer. In addition to this we take into account two element of absorptive capacity creation along with other firm specific control variables. In order to account for the first three, we have constructed three different exclusive categories for firms' innovation strategies – a) firms that report only in-house or contracted R&D efforts (Technology Creation), b) firms that only acquire technology from abroad via technology licensing and c) firms that combine these two strategies of technology creation and adoption.

Table 2
Summary of the Variables

Variables	No. of. Observations	Mean	Std. Deviation	Min	Max
FAGE	6973	23.64	14.56	4	154
FSIZE	6801	2.98	0.6	1.39	5.03
TMAKE	6964	0.36	0.48	0	1
TBUY	6928	0.1	0.3	0	1
TBOTH	6907	0.044	0.21	0	1
ETT	6977	2.64	11.59	0	100
LEDU	6983	22.26	22.23	0	100
MEXP	6871	14.36	9.43	2	64
EXPO	6955	0.67	0.47	0	1
FIN	6919	0.62	0.49	0	1
PRODIN	6980	0.45	0.50	0	1
PROCIN	6978	0.46	0.50	0	1
Note: Full description of the variables are given in Table A.1 in appendix					

Table 3
Correlation Matrix

Variable	FAGE	FSIZE	TMAKE	TBUY	TBOTH	ETT	LEDU	MEXP	EXPO	FIN	PRODIN	PROCIN
FAGE	1											
FSIZE	0.93	1										
TMAKE	0.00	0.00	1									
TBUY	-0.04	-0.023	0.06	1								
TBOTH	-0.02	-0.022	0.29	0.64	1							
ETT	0.033	0.02	0.1	0.09	0.12	1						
LEDU	0.00	-0.04	0.19	0.06	0.06	0.12	1					
MEXP	0.40	0.40	0.00	-0.05	0.02	0.05	0.01	1				
EXPO	-0.11	-0.09	0.17	0.12	0.08	0.02	0.09	-0.09	1			
FIN	0.00	0.01	0.17	0.14	0.08	0.09	0.21	0.02	0.14	1		
PRODIN	0.04	0.05	0.39	0.20	0.17	0.1	0.15	0.05	0.11	0.25	1	
PROCIN	0.05	0.05	0.48	0.05	0.20	0.07	0.13	0.09	0.08	0.14	0.48	1

Having identified the above strategies, we try to link them to the innovative performance of firms. We measure innovation performance of the firms through introduction of a new or significantly improved product (product innovation) and introduction of new production processes (process innovation). In order to measure the innovation performance of the firms, both product and process innovation is modelled by a probit and bi-probit model. These models relate the probability of being an innovator with respect to the characteristics of the firm and identified innovation strategies after controlling the sectors. Apart from the firm specific features of firms' age and size, we consider variables of absorptive capacity creation in the firm, exposure to international market, and financial constraints of the firm. We thus estimate the following probit model as in equation (1) and (2).

$$P(Prodin = 1) = \beta_0 + \beta_1 FAGE + \beta_2 FSIZE + \beta_3 TMAKE + \beta_4 TBUY + \beta_5 TBOTH + \beta_6 ETT + \beta_7 LEDU + \beta_8 MEXP + \beta_9 EXPO + \beta_{10} FIN + \varepsilon \quad (1)$$

and

$$P(Procin = 1) = \beta_0 + \beta_1 FAGE + \beta_2 FSIZE + \beta_3 TMAKE + \beta_4 TBUY + \beta_5 TBOTH + \beta_6 ETT + \beta_7 LEDU + \beta_8 MEXP + \beta_9 EXPO + \beta_{10} FIN + \varepsilon \quad (2)$$

We have also constructed a biprobit model explaining the product and process innovation jointly because quite often, the launching of new products is associated with the introduction of new production processes. This model allows to take into account the complementarily between product and process innovation explicitly. The use of bivariate probit regression allows taking into account the correlation between produc and process innovation explicitly as shown in equation (3).

$E(V_1) = E(V_2) = 0$, $Var(V_1) = Var(V_2) = 1$, $Cov(V_1, V_2) = \rho$ (3)

3.2.2.Role of Innovation in Firm Performance

Having analysed the impact of different innovation strategies in producing different innovation outcomes in the first step, we proceed to the analysis of how far these innovation outcomes are responsible for firm growth. Considering the data limitations, we use the relative sales growth and productivity growth from the last three years as the indicators of firm performance. One of the reasons to convert the absolute growth to relative is that the self reported sales at present and three years back is not deflated by an appropriate price index and therefore the growth rates are most likely inflated. In order to convert the absolute growth to relative, we made them in a scale of 0 to 1 using the following equations (4) and (5).

$$\text{Normalised Sales Growth (NSG)} = \frac{Sactual - Smin}{Smax - Smin} \quad (4)$$

$$\text{Normalised Productivity Growth (NPG)} = \frac{Pactual - Pmin}{Pmax - Pmin} \quad (5)$$

After converting them into a uniform scale ranging from 0 to 1, we have fitted a tobit model to analyse the role of innovation in sales growth and productivity growth since the dependent variable is restricted from 0 to 1. The fitted model is as in equation (6) and (7).

$$NSG = \beta_0 + \beta_1 FAGE + \beta_2 FSIZE + \beta_3 PRODIN + \beta_4 PROCIN + \beta_5 PBOTH + \beta_6 ETT + \beta_7 LEDU + \beta_8 MEXP + \beta_9 EXPO + \beta_{10} FIN + \varepsilon \quad (6)$$

and

$$NPG = \beta_0 + \beta_1 FAGE + \beta_2 FSIZE + \beta_3 PRODIN + \beta_4 PROCIN + \beta_5 PBOTH + \beta_6 ETT + \beta_7 LEDU + \beta_8 MEXP + \beta_9 EXPO + \beta_{10} FIN + \varepsilon \quad (7)$$

4. Empirical Results

4.1. Descriptive Statistics

Before we present the result of the econometric analysis in section 4.2 on innovative performance on the firms and growth, we present some useful descriptive statistics on different innovation strategies, outcomes and firm growth. Table 4 presents the sector-wise and size-wise distribution of the firms. Our analysis consists of a total of 6986 firms among

which the largest share comes from machineries and equipments, textiles and garments and plastic and rubber.

Table 4
Composition of the Sample

Sector	Small	Medium	Large	Total
Food and Tobacco	254	276	119	649
Basic Metals	181	285	189	655
Chemicals	160	274	165	599
Electronics	154	243	189	586
Machineries and equipments	355	647	304	1306
Textiles & Garments	176	385	269	830
Fabricated metal products	232	296	123	651
Wood & Furniture	95	88	36	219
Non Metalic Mineral Products	253	215	64	532
Leather	14	45	38	97
Paper	56	91	19	166
Plastic and Rubber	249	311	136	696
Total	2179	3156	1651	6986

Table 5 summarises the information about the firms' innovation strategies of STI mode and innovation outcomes. These strategies include technology making and technology buying. The most frequently observed innovation strategy in technology creation – in-house or contracted research and development effort (35.5%). The strategy of disembodied technology adoption through technology licensing is observed as the second most frequent (10%). The strategy of complementing domestic technology with adopted foreign technology is observed in 4.5 percent of the total number of firms. Nearly half of the firms in our sample report having successfully introduced product and process innovations.

Table 6 and 7 provide certain interesting results. Majority of the product and process innovators adopts at least one strategy of technology creation, adoption or both. In our sample, among the firms who complements indigenous technology with foreign technology, 82 percent are product innovators and 92 percent are process innovators. Moreover, these firms show more sales growth as well as productivity growth in the last three years compared to other firms. Among the R&D firms, the proportion of product and process innovators is 69 and 76 percent respectively. It must be noted that the firms which only relying on foreign technology shows substantially less process innovation and productivity growth compared to all the other category firms. The firms who are successful in product and process innovation simultaneously have experienced more sales growth and productivity growth during the reference period. And the firms which doesn't involve in any innovative activities have experienced poor firm performance.

Table 5
Innovation Strategies and Outcomes – A Summary (in percentage)

Sector	Product Innovators	Process Innovators	R&D firms	Technology licensing	R&D and Technology licensing
Food and Tobacco	36	39	22	7	2
Basic Metals	37	41	31	7	3
Chemicals	48	46	44	10	6
Electronics	57	52	48	15	7
Machineries and equipments	50	50	42	13	5
Textiles & Garments	47	49	34	12	5
Fabricated metal products	45	49	37	9	6
Wood & Furniture	42	39	30	8	4
Non Metalic Mineral Products	31	39	18	3	2
Leather	56	54	50	13	6
Paper	42	32	26	8	2
Plastic and Rubber	45	48	38	8	4
Total	45	46	35.5	10	4.5

Table 6
Frequency occurrence of Innovation strategies

Strategies	Number of Firms	Product Innovators (in %)	Process Innovators (in %)	Annual Sales Growth (in %)	Annual Productivity Growth (in %)
Technology Make only	2147	69	76	6.70	4.50
Technology Buy only	387	67	23	6.70	1.95
Technology Make and Buy	307	82	92	7.05	4.85
No Make and Buy	4066	27	29	6.0	3.80

Table 7
Innovation and Firm Performance

Firm	Frequency of occurrence (in %)	Annual Average Sales Growth (in %)	Annual Average Productivity Growth (in %)
Product Innovators	45	8	5
Process Innovators	46	7.6	5
Product and Process Innovators	33	8	5.6
Product only Innovators	12	8	4
Process only Innovators	14	7	4
No new product and no process innovators	41	6	3.6
Total	100	7	4.3

4.2. Regression Results

This section deals with the multivariate analysis in which the drivers of innovative and growth performance.

4.2.1. Innovation Strategies and Innovation Outcomes

We analyse the determinants of product and process innovations as indicators of innovative performance. Column 1 and 2 in Table 8 contain probit results on product and process innovations respectively. Likewise column 3 and 4 contain the result of biprobit model.

Both probit and biprobit estimations reveal a strong and significant effect on different innovation strategies on innovative performance. Innovation strategies - make only, buy only and both make and buy have significantly positive coefficients on product innovation. But the strategy of solely relying on foreign technology doesn't appear to be a significant variable for process innovation. This result is consistent with the finding of Katrak (1991) that much of the Indian enterprises use their imported technology mainly to start a new product line as quickly as possible and do not prepare themselves with their own technological effort. Our results also suggest that the marginal effects of complementary strategy appear to be more effective than relying entirely on indigenous technology development both in the case of product and process innovations. In other words, various sources of technological capability building are more likely to be complementary rather than inter changeable (Archibugi and Coco, 2004). In overall, the data seems to suggest the fact that for Indian manufacturing units, all the three strategies of creation and adoption is significant for product innovation. Technology creation and complementary strategy affect process innovation positively.

Embodied technology transfer measured through import of intermediate inputs and capital goods is found to be significantly affecting product innovation. This is consistent with the result of Adeyeye et al (2016) for Nigerian manufacturing firms that acquisition of machinery and equipments leads to product innovations but not process innovations. The innovation system conducive to efficient absorptive capacity building significantly affects both product and process innovations. The elements of absorptive capacity are considered through tertiary

education of the labour force and managerial experience in the particular sector. Goedhuys and Veugelers (2012) show that, secondary education is more significant for process innovation than tertiary education in Brazil. But the contrasting result for India may be because of its efforts especially in the post liberalisation phase towards making skilled workforce particularly in science and engineering based sectors. Among the developing economies, India has one of the strongest bases of scientific and technical manpower and other infrastructure for research and development. International linkages of the firm measured by the location of the firm (i.e. whether the firm is located in an export processing zone) is affecting only process innovation positively and not product innovation. Financial constraints are found to be a significant factor of innovation process. Firms that are less financially constrained (i.e. having overdraft facilities) are more likely to be successful innovators in terms of both product and process.

Apart from these results, our regression analysis suggests that firm size is positively affecting process innovation, but not product innovation. In fact it shows negative significance in the case of product innovation. Large firms may have developed greater capabilities to make effective use of imported know-how with their on research and development effort. Combining this with earlier result of solely relying on technology adoption, it can be concluded that firm that lacks in-house capabilities, especially small ones are likely to use those imports merely to start producing new products. Such firm are unlikely to be able to make any further use of their imported technologies.

Age of the firm doesn't appear to be a significant factor of the innovation activities. Though the experience is relevant, technological capability can't merely acquired from it. Capability comes from a conscious effort in monitoring and keeping track of global technological developments, accumulation of additional skills, and responding to new needs and opportunities (Dahlman et al, 1987 as cited in Kumar and Sddharthan, 1997)

Table 8

Variables	**Probit**		**Biprobit**	
	Product (1)	**Process (2)**	**Product (3)**	**Process (4)**
Fage	0.0034**	0.0016	0.003**	0.0016
	(0.0013)	(0.0014)	(0.0013)	(0.0013)
Fsize	-.008266	0.029***	-0.007	0.03***
	(0.011)	(0.011)	(0.011)	(0.011)
Tmake	1.05***	1.21***	1.05***	1.21***
	(0.039)	(0.04)	(0.04)	(0.040)
Tbuy	0.99***	-0.26	0.95***	-0.198**
	(0.075)	(0.08)	(0.07)	(0.076)
Tboth	1.42***	1.9***	1.41***	1.84***
	(0.093)	(0.11)	(0.09)	(0.11)
Ett	0.0044***	0.0007	0.0049***	0.0006
	(0.0016)	(0.0016)	(0.0015)	(0.0016)
Ledu	0.0028***	0.002***	0.003***	0.002**
	(0.00082)	(0.0008)	(0.0009)	(0.0008)
Mexp	0.0065***	0.013***	0.0007***	0.013***
	(0.002)	(0.002)	(0.002)	(0.0020)
Expo	0.058	0.0602*	0.048	0.065*
	(0.039)	(0.03)	(0.039)	(0.04)
fin	0.46***	0.152***	0.44***	0.14***
	(0.038)	(0.040)	(0.04)	(0.040)
Const	-1.06	-1.46	-1.05	-1.45881
	(0.19)	(0.18)	(0.187)	(0.19)

Note: Marginal effect reported, Robust Standard Errors are in parentheses, the estimation includes 12 sector dummies
* 10 percent significance
** 5 percent significance
*** 1 percent significance

4.2.2. Innovation Outcomes and Firm Performance

Table 9 presents our results of the role of innovation outcomes in influencing the firm performance. In other words, our main interest is the effect of product and process innovations on sales growth and productivity growth. For this purpose we categorised the innovation outcomes into four – product only, process only, both product and process and no product and process as the base category. As we have mentioned in the previous section, we have normalised the sales growth and productivity growth into a scale of 0 to 1 and applied tobit regression for our estimations. Firm age is highly negatively significant on sales growth and productivity growth. It means that young firms have greater firm performance in the three years reference period. Whereas larger firms have witnessed remarkable increase in the sales growth at 1 percent level of significance and productivity growth at 10 percent level of significance. Education of the labour force positively affects productivity growth. Managerial experience and availability of finance is important both for sales growth and productivity growth. International linkages measured through export markets have improved the sales performance of the firm.

Successful introduction of new product and new process reap benefits to the firms in terms of sales and productivity increase. Both product and process innovation and their simultaneous occurrence influence sales growth highly significantly, whereas only simultaneous occurrence of product and process innovation translates into greater productivity growth.

Table 9

Variables	**Normalised Sales Growth**	**Normalised Productivity Growth**
Fage	-0.00087***	-0.00035***
	(.00010)	(0.00011)
Fsize	0.0028***	0.0014*
	(0.0008)	(0.00089)
Ledu	-0.0000671	0.00012*
	(0.00007)	(0.00007)
Mexp	.00045***	0.00066***
	(0.00016)	(0.00017)
Expo	0.0070**	-0.0008
	(0.0031)	(0.0034)
Ett	0.00025	0.000015
	(0.00012)	(0.00013)
Fin	0.011***	0.0082**
	(0.0031)	(0.0033)
Prodin	0.016***	-0.0012
	(0.0045)	(0.0047)
Procin	0.0063	0.0005
	(0.0043)	(0.005)
Pboth	0.011***	0.0132***
	(0.0033)	(0.0035)
Const	0.35	0.33
	(0.015)	(0.016)
Sectoral Dummies	Yes	Yes

Note: Marginal Effects reported, robust Standard Errors are in parentheses
* 10 percent significance
** 5 percent significance
*** 1 percent significance

5. Conclusion

This paper is trying to contribute to the literature on innovation development and technological progress in developing economies focussing on more than 6000 manufacturing units in India. We try to bring out an econometric perspective on the factors that determine innovation outcomes and firm growth. As a developing economy, it provides an interesting case for India to examine the relative role of different strategies in innovation development since the firms have started to show more linkages with the international market in the last two decades.

There are a number of findings this study is able to present. Firstly it empirically supports the view that developing countries like India is not the passive recipients of technology created elsewhere, there occurs creation of new technologies and adaptation of existing technology which also necessitates rigorous learning and capability building. Creation of technology by in-house R&D efforts, acquisition of foreign technology through licensing and a mixed strategy in which technology acquisition is complemented with internal development contributes to product innovation highly significantly. Embodied technology transfer through import of capital goods is also a significant determinant of introduction of new products. It should also be noted that technology acquisition alone is not contributing to the introduction of new processes.

What is evident in the case of absorptive capacity building within the firm is also not surprising. We have considered two elements of absorptive capacity – tertiary education of the labour force and number of years of experience of the manager in that particular industry, both of them can be attributed to good proxies for skill level. Both of these elements are found to be highly significant for product and process innovation. In the case of international exposure, we considered the location of the firm – whether it is located in an export processing zone, gives the indication that exports influence mostly process innovation rather than product innovations. The link between exports and product innovation often occur on the other way round. Like any other developing countries, availability of finance is also very important for innovations both at product and process level innovations. But the marginal effect is significantly higher for product innovations. Since process innovations are a long term process and involve greater risk, the firm specific characteristics say that larger firms tend to be more involved in process innovations than product innovations. We also find that firm age is positively related to development of new products.

The second step of our analysis shows that young firms are growing faster than older firms both in terms of sales and productivity. It is also the case that larger firms grow faster compared to small firms. Our main aim in this part is an assessment of the role of innovation in firm growth. We find that product innovation is translated into superior growth rates and it is particularly true when combined with process innovations. Process innovations alone without the introduction of new products run the risk of being associated with lower sales performance. The benefits of process innovations could be appropriated only after a minimum time period beyond which our data set does not permit the analysis. Both product and process innovation combined together influence the productivity growth of the firm. We could not find any evidence that product or process innovation alone improve the productivity of the firm. As expected tertiary education of the labour force affects productivity growth whereas managerial experience affects both sales and productivity growth. The role of exports is more significant in the case of sales performance. One robust factor that affects the firm performance both in terms of sales and productivity is the access to

finance. This reiterates the relevance of policy interventions to eliminate financial constraints by improving method of functioning as well as increasing incentives.

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