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FDI, Technology and Innovation

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Preface

Forum for Global Knowledge Sharing (Knowledge Forum) is a specialised, interdisciplinary global forum. It deals with science, technology and economy interface. It aims at providing a platform for scholars belonging to different institutions, universities, countries and disciplines to interact, exchange their research findings and undertake joint research studies. It is designed for persons who have been contributing to R&D and publishing their research findings in professional journals. The papers included in this volume are drawn from those presented in an international seminar on "*FDI: Issues and Policy*" held at Indian Institute of Technology Bombay on 24 February 2018 and in the 12th annual international conference on the theme "*Changing Paradigms in Technology, Trade and Development*" held at Nabakrushna Choudhury Centre for Development Studies, Bhubaneswar, from 10 to 12 November 2017 as well as the 13th annual international conference on the theme "*Technology and Employment*" held at Tata Institute of Social Sciences, Mumbai, from 16 to 18 November 2018. All these events were organised by Knowledge Forum in partnership with TATA Trusts.

We thank the contributors for sharing their research papers to be included in this volume. We would like to place on record our sincere gratitude to all the peer reviewers, discussants and participants of the seminar and conference for their useful comments and suggestions on these papers. The discussion in these two events motivated us to select the included papers on the theme "FDI, Technology and Innovation". The edited volume opens up a new research agenda for empirical studies on the theme of multinationals and technology and also provides useful insights into policy formulation to promote innovative activities from an emerging economy perspective.

Chennai, India — N. S. Siddharthan
Mumbai, India — K. Narayanan

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About the Editors

N. S. Siddharthan is an Hon. Professor at the Madras School of Economics, Chennai, India; and President of the Forum for Global Knowledge Sharing. His current research interests include technology and globalisation, international economics, multinational corporations and industrial organisation. He has published several papers in journals such as *The Economic Journal, Oxford Bulletin of Economics and Statistics, The Journal of Development Studies, International Business Review, Indian Economic Review,* and *Sankhya*. He has been invited as a guest editor of special issues for journals such as *Science, Technology and Society* and *Innovation and Development*. He has also published books with publishers such as Springer, Routledge, Oxford University Press, Macmillan, Allied, Academic Foundation and New Age International Publishers.

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"Human Capital and Development" and a special issue of *Science, Technology and Society* on "Agglomeration, Technology Clusters and Networks". He is currently Honorary Secretary of the Forum for Global Knowledge Sharing, which brings together scientists, technologists and economists.

Introduction to the Volume

N. S. Siddharthan and K. Narayanan

1 Background

The world is witnessing major changes that are taking place in the fields of technology, foreign direct investments (FDIs), trade and development strategies. These changes are likely to be different from those that the world experienced during the last few decades in particular, after many countries have adopted globalization of their economies. The rules of the WTO and the onset of the information and communications technologies (ICTs) drastically reduced transaction costs and encouraged locations of manufacturing units based on efficiency rather than tariff jumping investments. One of the consequences of the relocation of manufacturing units across the globe has been the decline of the manufacturing activities in the USA and Europe and the emergence of Asia as the main manufacturing base. This has triggered protectionist tendencies and anti-free trade and protest against WTO rules in several developed countries. Thus while changing technologies are aiding globalization, the political atmosphere in the USA and many European countries is antiglobalization and outsourcing. However, the host developing countries especially China and India, who have been attracting FDI in a number of industries and sectors, are trying to get the best out of the presence of the FDI through multinational corporations (MNCs). One of the immediate benefits that they witnessed in a variety of industries is the shift in technological paradigms. The papers included in the book will concentrate on the process through which technological paradigm and trajectory shifts take place,

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the factors that facilitate such shifts, the changing pattern of FDI and technological efforts, shifting focus of international trade and development strategies, mostly focusing on India.

2 Changing Nature of FDI

Dunning (1979) was one of the early researchers to point out that FDI usually engages in cross-border value-added activities. The nature of FDI flows, however, has changed drastically in recent decades; consequently, the theories are developed earlier during the second half of the twentieth century and the testing procedures are adopted to analyse productivity and technology spillovers from FDI needs to be re-examined. The literature on FDI spillovers was developed in an era when multinational enterprises (MNEs) invested mainly in manufacturing and MNEs from developed countries enjoyed higher productivity levels. In recent times, the share of manufacturing in FDI flows has come down drastically. Currently, most FDI is in services. Furthermore, productivity levels of several Asian enterprises have increased drastically. It is not clear whether theories developed for the manufacturing sector could be used for services. It is difficult to identify intangible assets, ownership advantages and internalization advantage in the case of services in general and non-financial services in particular.

It is widely accepted that FDI generates both direct and indirect benefits in the host countries. Indirect benefits, popularly known as spillover benefits, include greater efficiency of domestic firms as a result of an increase in competition from the entry of foreign firms. Other economic benefits are faster adoption of new technologies by domestic firms and increase in the mobility of domestic resources—financial capital, improvement in the management structure of the domestic economy, net skilled labour migration as a result of centralization of substantive managerial decision-making in the parent firm, etc.

Following Dunning (2001), it could be argued that the internationalization of R&D activities is motivated by two factors, asset-augmenting and asset-exploiting activities. The former, also known as 'home-based augmenting R&D' through MNE, aims at increasing the existing knowledge capital advantages created at home country. The asset-exploiting signifies that MNE uses technological and capital knowledge created at home to increase value creation.

In a recent study, Dhrifi (2015) examined the contributions of FDI to an economy by examining the interaction focusing on the role of technological innovation using a simultaneous equation model describing the interrelationship between foreign direct investment, technological innovation and economic growth for 83 developed and developing countries estimated over the period 1990–2012. Their empirical results show that there is a positive and significant effect of foreign direct investment on economic growth only for middle- and high-income countries, whereas for low-income countries foreign direct investment does not have a positive impact on these economies. Their findings clearly reveal that technological innovation plays an important role in determining the foreign direct investment–economic growth relationship.

Loukil (2016) also argues that a large number of countries have been enacting laws aimed at making it easier for firms to invest in their country. The objective for attracting FDI is not only due to the fact that FDI brings in new investment boosting national income and employment, but also due to the expectation that inward FDI would also provide additional spillover benefits to the local economy that can result in higher productivity growth and increased export growth. Their estimation of a panel threshold model on a sample of 54 developing countries for the 1980–2009 period shows the presence of nonlinear effects in the relationship between FDI and innovation. They find a threshold value of technological development above which FDI has a significant positive impact on innovation. They suggest that it is necessary to support domestic firms to build an absorptive capacity allowing them to enjoy the benefits of multinational firms.

Lew and Liu (2016) in the regional context of China examine the extent to which absorptive capacity (ABC) contributes to the host country's utilization of inward foreign direct investment (IFDI) knowledge spillover and innovation. The findings, unlike the other studies, suggest that the presence of IFDI per se exercises a 'crowding-out' effect on local firms' innovation. The absorptive capacity has a significantly robust moderating effect on innovation so that host country firms' gains from IFDI knowledge spillover depend on whether their ABC offsets the negative impact of the IFDI. Such effects are more evident in coastal areas of China, where the economic mode permits more IFDI and also higher levels of ABC, thereby demonstrating the role of absorptive capacity as a moderator of knowledge spillover.

MNEs since the 2000s have rapidly increased foreign direct investment in R&D and related activities. Earlier, FDI in R&D activities was confined only to developed countries. But with increasing globalization, there is a shift in the trend as more and more FDI in R&D is taking place in developing countries like India and China. One of the reasons for this is cost-effectiveness and availability of skilled labourers at a lower cost in and presence of local research institutions in these emerging economies. Empirical studies on FDI in R&D in India suggest that MNE set up R&D units in India to tap the skilled human resources and scientific institutions. Sandhya et al. (2014) studied the pattern of FDI inflow to R&D in India and found that the total number of MNCs invested in R&D is reported at around 706 during this period, and the period for the analysis was 2003–09. Nearly 70% is directed towards select sectors in industrial clusters [88%], indicating that the majority of FDI in R&D is attracted into these clusters only.

The empirical evidence on FDI's role in facilitating technology spillovers in the host country is inconclusive. Blomström and Sjöholm (1999) found evidence for a strong relationship between foreign ownership and labour productivity in the case of Indonesian manufacturing industries. Their finding suggests that there exist intra-industry spillovers from FDI, and labour productivity in domestic firms increases due to increase in competitive pressure from the presence of foreign-owned firms in the same industry. In contrast, Aitken and Harrison (1999) found that FDI affects the productivity of domestic firms in Venezuela from 1976 to 1989 adversely. They used a sample of 4000 Venezuelan firms for the analysis and classified the firms into three categories based on the degree of ownership. The first category consists of national, with less than 20% foreign ownership, and the second category includes mixed degree with 20–49.9% foreign ownership. The last category grouped foreign firms, with majority of foreign control. To calculate productivity of firms, they regressed changes in output on changes in materials, skilled labour, unskilled labour, capital stock, changes in foreign investment at the plant and sector level. They concluded that domestic plants with higher foreign ownership are significantly less productive as compared to firms with a lower degree of foreign participation. They also highlighted that the difference in their findings and that of the previous finding lies in the fact that former failed to control the differences in the productivity across sectors, which might be correlated.

Apart from R&D and technology spillovers, it has been found that MNE is also responsible for generating knowledge spillovers. This type of spillovers occurs between local firms that are vertically integrated with the affiliates of MNEs. They can also occur between local firms that are in direct competition with foreign affiliates. There could be a number of ways through which knowledge spillovers from foreign affiliates can accrue to local firms. They include competition effect, interaction between foreign affiliates, upstream suppliers and downstream customers, and human capital spillovers arising because of movement of skilled labourers from foreign affiliates to local firms. Local firms also try to imitate high-technological firms introduced by foreign affiliates through the process of reverse engineering and personal contact. In one of the recent studies focusing on gender-based wage differentials between MNCs and local firms, Vahter and Jaan (2019) argued that knowledge transfer takes place through labour mobility from a foreign-owned firm to local firms which in turn explains the differential productivity of Estonian firms between 2006 and 2012. They concluded that hiring high-wage employees with prior work experience at MNEs is associated with increased productivity of the local firm where they are presently employed.

Although the majority of research on FDI spillovers focus on spillovers within the industry or intra-industry spillovers, it has been found that FDI spillovers can also occur to firms operating in other industries, leading to inter-industry or vertical spillovers. These types of spillovers arise mainly due to the customer–supplier relationship between foreign firms and domestic firms and are often attributed to buyer–supplier linkages. They are found to be larger in domestic firms that invest and indulge more in R&D-intensive firms. Also, they depend on the extent of vertical integration between local firms and foreign-owned firms. They operate at both upstream industries (suppliers) and downstream industries (buyers).

The book begins with documentation of the changing pattern of FDI flows and technologies among developed and emerging economies. The pattern of technological paradigm and trajectory changes and their determinants are then identified through specific studies on Indian industries. How do the knowledge spillover mechanisms get operationalized and the implications of internationalization of the IPR process are elaborated. The role of FDI on technological efforts, exports and productivity improvements is also analysed to make policy recommendations for fostering innovation in an emerging economy context like India.

The growth in international trade is mostly confined to medium- and high-tech industries. Trade in traditional sectors has not been growing. A large part if not most of the trade in high- and medium-tech industries is intra-firm, that is, between the MNE and its affiliates. Studies in intra-firm trade are dated. It is important to formulate appropriate hypothesis and analyse the determinants of intra-firm trade. Technological change has also given a boost to trade in services. Some of the papers included here are dealing with trade in services with emphasis on the role of technology. Some of the paper will discuss the phenomenon of MNEs investing in R&D in the Indian context. Several of these units are located in sectors where the MNE does not have a strong manufacturing base. They will discuss the determinants of FDI in R&D.

Changing patterns of FDI, technology creation and development, location of R&D units, and trade in goods and services would influence development strategies of countries. The earlier debate relating to import substitution versus export-led growth strategies is not very relevant in the current era. New dimensions in approach to development have been triggered with the adoption of Sustainable Development Goals (SDGs). The focus is more towards adoption of an environmentally benign, inclusive and specific target-oriented approach. Some papers would discuss these issues as well.

More specifically, the book will concentrate on the major changes that are taking place in the fields of technology, foreign direct investments (FDIs), trade and development strategies. It will mainly concentrate on issues relating to (1) FDI, productivity and knowledge spillovers, (2) market structure and innovative activities, (3) push and pull factors influencing FDI, (4) impact of FDI on environment, labour and welfare, and (5) the relative importance of demand and technology shocks on aggregate fluctuations. In all these areas, new issues have emerged and they have not been addressed adequately by the existing literature. The volume will fill this gap and give a lead for future research programmes.

3 FDI, Productivity and Knowledge Spillovers

The literature makes a distinction between spillovers and technology transfer against technology payments. There are no payments involved in spillovers. They are virtually free. However, they are not automatic. Some firms benefit by FDI spillovers, and certain others become victims. Several studies have analysed the impact of FDI on productivity and knowledge spillovers (Bitzer et al. 2008; Buckley et al. 2002; Javorcik and Spatareanu 2008) and have more or less established the productivity enhancement of FDI. However, it is not yet established whether the country of origin of FDI makes substantial difference to the spill overs. The volume will address this question. Moreover, there is no agreement on the spillover mechanism (Liu 2008).

The theoretical underpinnings are also not clear. The volume will address the theoretical issues and present case studies. A strict intellectual property regime (IPR) will substantially reduce the spillovers. That is one of the objectives of IPR. Will a strict IPR enhance growth and welfare or will it have an adverse impact? The volume will deal with this issue also.

4 Market Structure and Innovative Activities

The role of market structure in influencing innovative activities, originally postulated by Schumpeter (1942), is now well established. However, the simultaneity in the relationships between the two has not been sufficiently researched. Furthermore, most studies have used mainly concentration ratios to represent market structure. It is well known (Sleuwaegen and Dehandschutter 1986) that the relationship between concentration ratios and H-index is horn-shaped—they do not differ much at low levels of concentration but differ significantly at higher levels of concentration. Hence, they are not useful in the case of highly concentrated industries. Concentration ratios take only the top 4 or 8 firms and do not take into account all the firms. On the other hand, H-index not only takes into account all the firms but also gives higher weightage to larger firms. Thus, H-index is preferable. In this context, this volume takes into account H-index and also Lerner index. In this respect, it is an improvement over the earlier studies.

Under the current WTO regime, characterized by the absence of trade barriers and low tariff rates, the relationship between market structure and innovative activities might not turn out to be the same as predicted and found in the earlier studies. In the current regime, different parts of the goods are produced in different countries and the final product assembled in a different country. The consumer electronics is a case in point. As shown by Chen (2010) in the case of integrated circuits, the designing is done by one country, and integrated circuit itself is manufactured in another country and purchased by a firm manufacturing consumer electronics from a third country. In such cases, the relationship between market structure in a particular country (country A) and innovation activities that are taking place in all the countries and manufacturing activities in country 'A' gets complicated. Empirically, this has not been studied. One of the papers in this volume reports an interesting study.

The main Schumpeterian paradigm is dealt with the determinants of R&D and related it to market structure and size of the firm. In the globalized world, multinational enterprises (MNEs) also perform R&D in the host countries and influence R&D behaviour in the host countries. In such cases, the question arises, namely whether the R&D performed by MNEs in the host countries is different from the R&D performed by domestic firms. This issue is analysed in this volume for Indian data.

5 FDI—Push and Pull Factors

Most studies dealing with the determinants of FDI deal with either pull or push factors and concentrate on either advanced or developing countries (for a survey of an important literature, refer to Caves (2007), Dunning and Lundan (2008), and for a more recent survey, Siddharthan (2016)). They rarely deal with all these aspects in one study. The study in the volume shows that the determinants in all these cases are different and therefore an aggregate analysis encompassing all the countries will not give correct and interpretable results.

6 Impact of FDI on Labour, Welfare and Environment

Do IPR and FDI enhance the welfare of all countries? Or does it influence low-, middle- and high-income countries differently? Within a country also are there beneficiaries and victims? The book will deal with these issues. The impact of FDI on environment is a well-researched area. However, the findings of the research studies are not unambiguous. One of the chapters performs a meta-analysis based on 29 research studies to draw appropriate conclusions and policy inferences. With regard to labour and welfare also, it is not clear whether FDI will have the same impact on high-income countries and the rest. One of the papers included in the book uses a panel data for 64 countries for the period 1991–2015 and draws useful conclusions. Likewise, factors contributing to aggregate fluctuations are also not clear. Are they due to demand shocks and could macro-policies take care of them? Or are they due to technology shocks or both? What is the relative importance of the two factors? The volume attempts to provide an answer to them.

The book will discuss the following issues:

- FDI productivity spillovers and the country of origin
- Knowledge spillover mechanisms
- IPR and growth and welfare of nations
- Market structure, technological capabilities and technology policy
- Interrelationship between innovations and market structure
- R&D by foreign and Indian firms
- Push and pull factors of FDI
- Environmental impact of foreign investments
- FDI, labour market and welfare
- Demand shocks, technology shocks and aggregate fluctuations.

7 Guided Tour of Chapters

The first paper is by Bishwanath Goldar and Karishma Banga. By now, the productivity enhancement effects of FDI have been well established. However, it is not very clear whether the country of origin of FDI makes a substantial difference. The paper based on a sample Indian firm clearly shows that foreign firms operating in India enjoy higher total factor productivity (TFP) levels compared to local firms. However, firms from developed countries and, in particular, from the USA and Europe enjoy much higher productivity levels. FDI from developed countries results in higher productivity spillovers, and this benefits the Indian firms. The paper considers both horizontal and vertical spillovers.

The second paper by Stanley Nollen deals with knowledge spillover mechanisms. Spillovers are different from knowledge transfer for which the receiving firm makes a payment. Spillovers are unintentional, and no payments are made to the firm. They occur mainly by observations of the neighbourhood firms on the production and organizational practices of higher productivity firms in the neighbourhood. It can also happen due to labour mobility and managerial interaction. Spillovers give competitive advantage to firms, and therefore it is important to study the spillover mechanisms. The paper documents the experiences of Vietnamese software companies to demonstrate the dynamics of knowledge spillovers.

Sunil Kumar Ambrammal's paper analyses the impact of strong IPR on the welfare and growth of nations. The study shows that by and large, IPR encourages innovations and increases national welfare. However, the impact is not the same for lower middle-income, upper middle-income and high-income countries. For middle-income countries, IPR affects negatively in the initial stages of development but then becomes positive at later stages—suggesting 'U'-shaped relationship. Furthermore, IPR does not directly influence innovation and growth, and it needs to be supported by domestic investments on innovations.

The paper by Madan Dhanora and Ruchi Sharma deals with interrelationships between innovations and market structure. Most studies mainly deal with the impact of market structure on innovative activities of firms. Very few focus on the impact of innovations on market structure and the simultaneities involved. The paper bridges this gap in the literature and deals with medium- and high-tech Indian industries. Needless to say, this relationship is more relevant to high-tech industries. They use HHI and Lerner index as the measures of market structure and firm's patenting activities as the measure of innovation. With regard to market structure, they did not find it important in influencing innovative activities; however, innovative activities influenced market structure. The relationship was one of inverted 'U'. Furthermore, strengthening of patent protection had a positive influence on innovative activities.

The next paper by Bino Paul and Manasi Awasthi analyses the interplay of market structure and technological capabilities in the Indian consumer electronics industries. They conclude that while the market has been expanding in India, its growth has not translated to technological capabilities for the domestic industry. This is partly because changes in technologies have not resulted in increases in labour productivities. Furthermore, the industry is being dominated by imports. The paper advocates changes in technology policies to address this problem.

Are the determinants of R&D performed by foreign firms in India different from those of the local firms? The paper by Savita Bhat shows that they are not very different. If the research environment is good in India, then both sets of firms, namely foreign and domestic, will take advantage of the research climate and perform R&D. In addition to factors that are common to domestic firms, factors like outsourcing and distribution influence foreign firms R&D performed in India. Thus, foreign firms that outsourced manufacturing jobs performed more R&D in India. Furthermore, the analyses reveal that other factors like labour intensity, sales and distribution intensity, and outsourcing intensity are also relevant in determining R&D activities of the foreign firms.

The paper by Indrajit Roy and Narayanan brings out another important aspect of FDI flows. They consider FDI flows from (1) advanced economies to developing economies, (2) advanced economies to advanced economies, (3) developing economies to advanced economies and (4) developing economies to developing economies. Their study showed that the determinants of FDI flows were very different for different sets of countries. Some of the variables even showed opposite signs. Under these conditions, estimating one model across countries would not give useful and meaningful results. With regard to OFDI from developing countries, apart from various macroeconomic indicators, perception-based indicators on control of corruption, governance aspects and climate of ease of doing business which are much weaker in developing economies than that of advanced economies also act as push factors of OFDI from developing countries. The paper also finds the pull and push factors different for the four sets of FDI flows.

The next paper by Santosh Kumar Sahu and Unmesh Patnaik deals with another important aspect of the impact of FDI, namely the environmental impact of foreign investments. They do a meta-analysis based on 29 studies containing 700 estimates, undertaken between 1994 and 2018. It is widely feared that due to differences in environmental standards and differences in the capacity and ability of governments to implement the standards, pollution-intensive industries could shift to developing countries. Most of the papers test pollution haven hypothesis (PHH) which states that pollution-intensive production activities move to lenient countries through FDI. Their results suggest that the use of *pollution intensity* or *firms' spending* on environment-related expenses does not support PHH. On the other hand, government expenditure on environment-related measures supports PHH better. Hence, they advocate macro-level intervention on environment-related issues in preference to what they call micro-level interventions at firm/industry level. Consequently, they advocate a top-down approach.

The paper by Arfat Ahmad Sofi and Subash Sasidharan deals with the impact of FDI on the labour market and welfare. For this purpose, it uses a panel data of 64 countries for the period 1991–92 to 2014–15. The results reveal that FDI has a positive impact on the labour market for both developed and developing countries. However, in the long run they result in uneven outcome for different sectors. In the case of welfare loss, they find a substantial loss of welfare in income and labour market outcomes with a higher magnitude in middle- and high-income countries.

The paper by Sunil Paul, Santosh Kumar Sahu and Tinu Iype Jacob deals with the relative importance demand and technology shocks in explaining aggregate fluctuations. They show that technology shocks are much more important and long-lasting than demand and other market shocks. Their results indicate that the percentage of variance explained by aggregate demand shocks is larger at lower lag and decreasing. However, the share of technology shock shows an increasing trend over the period of time. By and large, the study indicates the transitory nature of aggregate demand shocks compared to technology shocks. Thus, technology shocks are much more important and policy should concentrate on dealing with them.

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Country Origin of Foreign Direct Investment in Indian Manufacturing and Its Impact on Productivity of Domestic Firms

Bishwanath Goldar and Karishma Banga

1 Introduction

There have been a large number of studies on the impact of foreign direct investment (FDI) on productivity of firms in the host country. Some of these studies have been undertaken in the context of developed countries, and it seems, a much larger number of studies have been done for developing countries. The significance of such studies (on the impact of FDI) for developing countries arises from the fact that the developing countries have a great deal of interest in attracting FDI with the hope of gaining substantially from it. FDI in such countries is expected to bring in advanced technology, superior management practices, export contacts, etc. Transfer of technology and knowledge from industrialized countries to developing countries is expected to help the domestic firms in developing countries improve their productivity and competitiveness, directly or indirectly.

Several studies have found that FDI firms, i.e. the firms with FDI (defined in terms of foreign promoters' equity holding in the firm being beyond a threshold of say 10% or 25%), have higher productivity than domestic firms (see, for example, Harris and Robinson 2002, 2003; Karpaty 2004; Harris 2009), or that the acquisition of equity in a domestic firm by a foreign firm beyond a threshold of say 10% (hereafter termed as foreign acquisition for brevity) makes the productivity of the acquired domestic firm to go up (see, for example, Karpaty 2007; Arnold and Javorcik 2009; Li et al.

[1]It should be noted that there are some studies which have found that foreign acquisition did not raise the productivity of the acquired domestic firm; Benfratello and Sembenelli (2006) for Italy, Petkova (2012) for India, Kaitila et al. (2013) for six small open economies of the EU (Austria, Belgium, Denmark. Finland, Sweden and the Netherlands), and Gelübcke (2015) for Germany.

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2009; Liu and Qiu 2017).[1] One may ask: why should a foreign-owned firm have an advantage in productivity in comparison with a domestic firm? Going by the theoretical and empirical literature on foreign direct investment, referring particularly to the analyses undertaken by Aitken and Harrison (1999) and Pfaffermayr and Bellak (2002), it seems right to argue that foreign firms often possess some firm-specific advantages that give them an edge over domestic firms. These advantages include specialized knowledge about production, superior management and marketing capabilities, export contacts and coordinated quality-oriented relationships with suppliers and customers. Evidently, it is these advantages that drive the multinational enterprises (MNEs) to locate their subsidiaries overseas so that they can exploit the advantages. It is therefore not surprising that many empirical studies have found FDI firms to have typically higher productivity than domestic firms. By the same line of reasoning, as an MNE acquires a portion of the equity in a domestic firm, this act of the MNE creating bonds between the two firms makes it possible for the domestic firm to raise its technological standards, adopt superior management practices, exploit the new export contacts to increase sales, and thus raise its level of productivity.

It is important to note that FDI not only improves the level of productivity, competitiveness and technological capabilities in the domestic firms in which the investment is made but also in other domestic firms through the ‘spillover effects’. Indeed, there has been a great deal of research interest in the spillover effects of FDI, especially in developing countries, leading to the emergence of a huge literature on productivity spillover from FDI (hereafter referred to FDI spillover).

Though one can advance persuasive arguments for postulating/hypothesizing a positive FDI spillover effect in developing countries, empirical studies on developing countries have reported mixed results. Some studies have found evidence of a positive spillover effect, while some others have found evidence of a negative spillover effect. In a meta-analysis of FDI spillover estimates obtained in various studies undertaken for developing countries (1450 spillover estimates made in 69 empirical studies for 31 developing countries, for the period 1986–2013), Demena and van Bergeijk (2017) report that the results are mixed—17% of the spillover estimates are negative and statistically significant, 21% negative and statistically insignificant, 32% positive and statistically significant and 30% positive and statistically insignificant.[2] Some of the studies that have found a positive spillover effect include Kokko (1994, 1996) for Mexico, Sjöholm (1999) for Indonesia, Kokko et al. (1996) for Uruguay and Chuang and Lin (1999) for Taiwan. In a recent review of empirical studies on FDI spillovers, te Velde (2019) identifies six major determinants of the effects and spillovers of

[2]Lest one gets the impression that on balance the empirical evidence is indicative of a positive FDI productivity spillover in developing countries, it should be pointed out that Demena and van Bergeijk (2017) observe moderate to substantial publication bias in the spillover estimates reported in the studies, which means that the average of the spillover estimates reported in the studies tends to exaggerate to some extent the beneficial productivity spillover from FDI in developing countries. There is also the issue of model misspecification, which affects the spillover estimates obtained.

FDI in developing countries, including sector of investment, value-chain linkages, level of financial development, employee training and labour mobility, technological capabilities and firm-specific characteristics (such as firm size, degree of ownership, etc.).

The more recent studies in this area have recognized that the realization of potential productivity spillover from FDI is conditioned and moderated by domestic firms' technological capabilities. Even among these new-generation studies which take into account domestic firms' capabilities in assessing the spillover effects, the results are mixed. Several studies undertaken for developing countries of Latin America and Africa find negative or negligible FDI productivity spillover (for example, Mebratie and Bedi 2013 for South Africa and Jordaan 2008 for Mexico). On the other hand, several such studies for developing countries of Asia find positive spillover effects. These include the studies undertaken by Khalifah and Adam (2009) for Malaysia, Takii (2009) for Indonesia and Nguyen (2008) and Van Thanh and Hoang (2010) for Vietnam. For China, some empirical studies—such as Abraham et al. (2010), Ito et al. (2010), Xu and Sheng (2012) and Long et al. (2014)—find evidence of a positive FDI spillover effect, while others find different results.[3]

In the empirical literature on spillover effects of FDI, a distinction has been made between horizontal spillover (the effect from an FDI firm to other firms in the same industry) and vertical spillover (the effect from an FDI firm in an industry to domestic firms in other industries which supply to the FDI firm or buy from the FDI firm). The horizontal spillover effects occur through several channels—competition, demonstration effect and inter-firm workers mobility or turnover. If the competition faced by domestic firms in an industry from FDI firms in that industry is intense, the horizontal spillover can be negative. The negative effect of competition may offset or neutralize the positive effects arising from demonstration and worker mobility. Making an overall assessment of the available estimates of horizontal spillover effects, one may conclude that in most cases horizontal spillover effects are found to be either negative or insignificant, especially when the recipient is a developing country (see Guo 2016, who makes this observation based on a review of studies, and who finds such results from the analysis of FDI spillover undertaken for China).[4] For vertical spillover in developing countries, several studies document a positive effect—for example, Ito et al. (2010) and Xu and Sheng (2012) for China, and Newman et al. (2015) for Vietnam.[5] Some studies have found a positive spillover through backward linkage; some others have found a positive spillover through forward linkage. From

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[3]See Jefferson and Ouyang (2014) for review of 16 papers and a discussion on differences in results.

[4]Guo (2016) observes, however, that there is a measurement error in TFP in most of the existing studies since they do not consider the learning process among domestic firms triggered by FDI in the industry for which a portion of labour is devoted. This may give a wrong impression that horizontal spillover effect is negative. When the correction for learning is made, the effect would not be found to be negative and the future effect of FDI on productivity of domestic firms of the industry (horizontal spillover) will be positive.

[5]Javorick (2004) argues that FDI spillover is more likely to be vertical than horizontal. Also, spillovers are most likely to take place through backward linkage, i.e. domestic firms supplying to multinational firms operating in the country. Also see, Havranek and Irsova (2011) in this connection.

a meta-analysis of FDI spillover effects, Havranek and Irsova (2011) conclude that gains from backward linkages are relatively more likely than gains from forward linkages.[6]

There is increasing recognition that the country of origin of FDI makes a difference to the spillover effect. There is a nascent but growing literature on this subject. Javorick and Spatareunu (2011) emphasize the importance of geographic distance between the source country of FDI and the host country in determining the spillover effect. The core idea is that if the investor firm is located in a country very far from the host country, there is greater inducement for local sourcing, leading to productivity spillover. Monastiriotis and Alegria (2011) build a similar argument on the basis of cultural proximity. In this case, the argument is that greater cultural proximity leads to local sourcing which in turn generates spillover effects.[7]

Besides these two, there are several studies that have been undertaken to investigate if the country of origin of FDI makes a difference to spillover effects. Xu and Sheng (2012), in their study of FDI productivity spillover in China, distinguish between FDI from Hong Kong and Taiwan and that from other countries. Their results indicate that Western firms produce more substantive spillovers than do overseas Chinese firms.[8] Monastiriotis (2014) examines the spillover effect of FDI from EU as against that from other countries. The analysis is done for the central and eastern Europe (CEE), SEE (the Bulkans) and eastern neighbourhood policy (ENP) regions. The results show that investment from EU has a much more favourable productivity spillover effect than investment from other countries. Ni et al. (2015) study the spillover effects of FDI in Vietnam distinguishing between different source countries. They consider FDI from ASEAN, East Asia, Europe and North America. They find that horizontal spillover is negative for FDI from ASEAN, East Asia and Europe. There is positive vertical spillover in certain cases. According to their empirical results, the presence of Asian firms in downstream sectors positively impacts productivity of Vietnamese firms in the supplying industries, but no significant relationship is found in the case of European and North American affiliates being in the downstream industries.[9] Among Asian countries as sources of FDI, the gain to

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[6]Notwithstanding this conclusion drawn by Havranek and Irsova (2011), from their meta-analysis of spillover effect estimates, it should be noted that some studies do find evidence of positive forward linkage—sometimes even bigger than backward linkage (for example, Xu and Sheng 2012 for China; Takii and Narjok 2012, for Indonesia).

[7]A different line of argument connected with country of origin is that if there are FDI inflows from diverse countries then it is beneficial and promotes greater positive spillovers. In such a situation, a greater variety of FDI knowledge gets transmitted to local firms through vertical linkages. Also, there is a better demonstration effect. With diverse technologies and management practices available, domestic firms can recombine the technologies and practices to create their own competitive strength. Some studies have examined this issue. To give an example, such a study has been undertaken by Zhang et al. (2010) for Chinese firms. Their results support the hypothesis that diversity of FDI country of origin promotes productivity spillover.

[8]This finding is apparently consistent with the argument of Javorick and Spatareunu (2011) that bigger distance between the source and host country promotes greater spillover.

[9]This goes against the (distance-based) argument of Javorick and Spatareunu (2011), but may have an explanation in cultural proximity as argued by Monastiriotis and Alegria (2011). Note, however,

Vietnamese firms through vertical productivity spillover is relatively greater for FDI from East Asian firms excluding Japan and South Korea. Interestingly, the authors report that there is not much gain to productivity of Vietnamese firms if the buyer firms in the downstream industry belong to Japan and South Korea because such firms tend not to source locally.[10]

The country of origin should make a difference not only to the spillover effects, but also to the direct effect of FDI on the productivity of the firms in which the investment is made. This aspect has been investigated for the USA by Chen (2011) who looks at the source of FDI and how that impacts the performance of the target firms. The main empirical finding of the study is that increases in labour productivity in the target firms are greater when the acquiring firms are from industrialized countries than when the targets are acquired by domestic firms. On the other hand, labour productivity increases in the target firms are lower when these are acquired by firms from developing countries than when the target firms are acquired by domestic firms. It may be inferred accordingly that FDI from industrialized countries has a bigger productivity-enhancing effect on the acquired domestic firms in the USA than FDI from developing countries.

This paper attempts to analyse the impact of FDI on productivity of Indian manufacturing firms taking into account the country of origin of FDI. The study is perhaps the first of its kind for India and contributes to the growing international literature on the role played by country of origin of FDI in determining its impact on productivity of domestic firms. Both the direct effect of FDI and indirect effect through spillovers are examined. The period covered for the analysis is 2000–01 to 2014–15. The analysis is confined to the corporate manufacturing sector and is done using firm-(company) level data from *Prowess*.

The paper is organized as follows. The data sources and variable construction are discussed in Sect. 2. A key variable for the analysis is the level of total factor productivity (TFP) in different firms in different years. The methodology adopted for the measurement of TFP is explained in Sect. 2, which also contains a discussion on the variables used for estimation of econometric models aimed at assessing the impact of FDI. Sections 3 and 4 deal with the direct effect of FDI on the productivity of domestic firm in which investment takes place—the former compares TFP levels between FDI firms and domestic firms in India, to ascertain if it is relatively higher in FDI firms, and the latter examines whether TFP of a domestic firm is positively impacted when it gets acquired by a foreign firm. This is followed by an econometric analysis of spillover effects, which is taken up in Sect. 5. Finally, the main findings of the study are summed up in Sect. 6 along with some concluding remarks.

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that the cultural proximity argument does not seem to hold when one considers the Japanese and South Korean investments in Vietnam.

[10]In contrast, Anaya (2013) finds that Japanese FDI generates backward spillover effect in Mexico but US FDI does not generate such an effect. For both of them, Japanese and US FDI, no forward spillover effect is found. The absence of backward spillover effect from US FDI in Mexico (Anaya 2013) and that from Japanese and Korean FDI in Vietnam (Ni et al. 2015) is consistent with the argument of Javorick and Spatareunu (2011) that the distance between the source country of FDI and host country of FDI plays a role in determining backward spillover effects.

Before concluding this section, a brief discussion on earlier studies on the impact of FDI on productivity of Indian manufacturing firms would be in order. There have been only a small number of studies on the direct impact of FDI on the productivity of the acquired firm. These include Goldar et al. (2004), Banga (2004), Petkova (2012) and Sahu and Solarin (2014). By comparison, there have been a large number of studies on FDI productivity spillover effects in India. These include Kathuria (2001, 2002, 2010), Siddharthan and Lal (2004), Bergman (2006), Sasidharan and Ramanathan (2007), Bhattacharya et al. (2008), Pant and Mondal (2010), Marin and Sasidharan (2010), Mishra (2011), Malik (2011), Behera et al. (2012a, b), Mondal and Pant (2014, 2018), Sahu and Solarin (2014), Thakur and Burange (2015) and Klein (2017).

Goldar et al. (2004) in their study of engineering firms in India found that foreign firms have higher productivity than domestic firms. Sahu and Solarin (2014) too found that foreign firms have higher productivity than domestic firms (covering manufacturing companies in their study). By contrast, Petkova (2012) does not find a significant positive effect of FDI on productivity of acquired domestic manufacturing firms in India. Banga (2004) is perhaps the only study on the impact of FDI on productivity of Indian firms, which has taken into account the country of origin. She made a distinction between Japanese and US firms in India and found from her analysis that Japanese affiliation had a significant positive effect on productivity growth in Indian firms while the impact of US affiliation was not found to be significant.

Turning now to the studies on spillover effects of FDI in India, the results are mixed. A number of the studies do not find FDI to be productivity enhancing through spillover effects. These include Kathuria (2001, 2002, 2010), Bergman (2006), Sasidharan and Ramanathan (2007), Marin and Sasidharan (2010), Mishra (2011) and Mondal and Pant (2014). On the other hand, Siddharthan and Lal (2004), Bhattacharya et al. (2008) and Behera et al. (2012a, b) find evidence of positive FDI productivity spillover effect. Among the more recent studies, Klein (2017) finds evidence for productivity spillovers in technology-intensive sectors. Positive spillovers are also found in less technology-intensive sectors, but these are more concentrated at the top of the productivity distribution. Similarly, the empirical results obtained by Sahu and Solarin (2014) indicate positive productivity spillover effects of FDI in India.

2 Data Sources, Estimation of TFP and Construction of Variables

2.1 Data Sources

The primary database used for empirical analysis in this study is Prowess, a firm-level dataset for India. Created by the Centre for Monitoring Indian Economy Pvt. Ltd. (CMIE), it draws data from company balance sheets and income statements of listed, as well as some unlisted, public and private limited companies. For the purpose of this study, we restrict ourselves to manufacturing firms and collect data on company sales, output, labour, foreign direct investment,[11] export, import, etc. As part of data cleaning, we remove observations with real value-added to labour or capital ratio below the first percentile or above the 99th percentile, observations with negative values for sales/output or value-added and firms that report data for less than three years. We also exclude the following industries from analysis: NIC 34 (diversified), NIC 35 (electricity), NIC 42 (civil engineering), NIC 68 (real estate) and NIC 98 (undifferentiated goods). Finally, we have compiled a panel for around 7338 Indian firms and used data for 15 years from 2000–01 (hereafter 2001) to 2014–2015 (hereafter 2015). The number of firms reporting data in each year varies but is roughly between 3000 and 5000 in a year, except for 2015 for which there are only about 2000 firms.

2.2 Estimation of TFP

To estimate firm-level TFP, we follow the literature and use the Levinsohn–Petrin (L-P) approach (Levinsohn and Petrin 2003), where consistent productivity estimates are obtained by using firms' material inputs as a proxy for unobserved productivity shocks, which may be correlated with firm inputs. A similar technique was employed by Olley and Pakes (OP) (1996) who used investment as a proxy. However, given that the OP approach requires investment to be strictly increasing with productivity, only nonnegative values of investment can be used in estimations. Since this would lead to a significant loss of efficiency, we prefer the L-P approach in our paper and obtain the L-P TFP estimates using the 'levpet' command in Stata. Developed by Petrin et al. (2004), this command estimates a Cobb–Douglas value-added production function, with capital and labour as inputs.[12] We have taken real energy as a proxy for productivity shocks. Section 2.2.1 explains construction of variables used in TFP estimation, and Table 1 provides summary statistics for these variables.

[11]It needs to be pointed out that wholly owned foreign companies are not covered in Prowess. This is obviously a limitation of the data when used for the purposes of studying the impact of FDI.

[12]After applying the levpet command and obtaining the estimate of lnTFP for different firms for different years, i.e. $\ln TFP_{it}$ where *i* denotes firm and *t* denotes time (year), the TFP index has been rebased by subtracting $\ln TFP_r$ from $\ln TFP_{it}$ where TFP_r is the TFP level of the reference firm. For the TFP index formed in this study, the average firm in 2013–14 has been taken as the point of reference. Thus, TFP_r is the simple average of TFP estimates of various firms for the year 2013–14 obtained by the 'levpet' command.

Table 1 Summary statistics of variables used in TFP estimation

Variables	Observations	Mean	STD	Min	Max	Units
Real value-added	62,170	14.11	186.23	0	13,041	Rs. Million
Labour (total persons engaged)	36,310	1093	4840	0	193,628	Number of employees
Real energy	60,810	1.45	8.78	0	536	Rs. Million
Real capital	62,585	1296.2	13,274.5	0	1,238,902	Rs. Million
Service input	62,508	467.85	3561.36	0	288,857	Rs. Million
TFP (index)	34,230	0.966	1.417	0.008	27.5	

Source Prowess and authors' computations

2.2.1 Construction of Variables Used in TFP Estimation

Real Value-Added

We first estimate nominal value-added for a firm by subtracting the nominal value of intermediate inputs from the nominal value of gross output. We construct gross output of a firm by adding its sales with change in stock of finished and semi-finished goods. For value of intermediate inputs, we add expenses on materials (raw materials, stores and spares and value of packaging and packing expenses), energy and services. Next, we deflate nominal value-added using 3-digit industry-level price deflators, constructed from the wholesale price index (WPI) series obtained from the Office of the Economic Advisor, Ministry of Commerce and Industry, Government of India. Series with 1993/94 and 2004/05 as base years are spliced and rebased to 2004/05.

Labour Input

While Prowess provides data on wages and salaries given to employees, the number of employees is reported for very few firms. Therefore, for constructing firm-level labour input in our study, we use emoluments and employee data from Annual Survey of Industries (ASI), Central Statistics Office, Government of India. First, for each three-digit industry in ASI (according to National Industrial Classification, NIC), we calculate the average industrial wage-rate by dividing total emoluments with total employees. Next, we match each three-digit ASI industry to a five-digit NIC industry (2008 classification) in Prowess using concordances. This gives us the average industrial wage-rate for each firm in our panel. It is important to note here that in the existing literature, there is documented evidence of foreign-owned firms paying higher wages to their employees. To account for such heterogeneity in wages across firms, we follow Goldar et al. (2004) and add a 10% wage-premium on the average wage-rate calculated for foreign firms using the ASI data. Lastly, we divide wages and salaries reported by each firm in Prowess with its corresponding average wage-rate to get firm-level labour.

Capital Input

While some empirical studies that estimate industrial productivity using ASI data calculate fixed capital stock using the perpetual inventory method, others employ a blanket deflation procedure (see Haidar 2012 for an example). In this study, we use the latter approach, despite its known limitations. To construct real capital stock, we first collect data on net fixed assets for each firm in our panel, using the Prowess dataset, and then deflate it using the implicit deflator for fixed capital formation in manufacturing, computed using *National Accounts Statistics* with base year 2004–05 (combined with the new series on National Accounts).

Energy Input

We first calculate the nominal energy input for a firm as the sum of its expenses on power and fuel, in current prices, obtained from Prowess. To construct the energy deflator, we use price indices of coal, petroleum products, natural gas and electricity for industrial use from the official WPI series and other sources. We combine the price series with 1994/94 as the base year with series using base prices 2004/05, and splice and rebase the combined series to 2004–05.

Services Input

The services input of a firm is calculated as the sum of its expenses on heterogeneous services comprising of rent and lease, repair and maintenance, outsourced manufacturing jobs, outsourced professional jobs, insurance, selling and distribution expenses and financial services. This is measured in current prices. We also make an estimate of the component of imported services.

2.2.2 Descriptive Analysis for TFP Growth

In Fig. 1, we represent the value-added weighted average growth in TFP across different industries in the period 2001/02 to 2014/15 (based on firms level TFP estimates explained above). It shows that highest growth has been in ‘other manufactures’ sector, which includes firms engaged in manufacture of jewellery, sports goods, games and toys, medical and dental instruments and musical instruments. There has also been relatively higher productivity growth in sectors of: computer, electronics and optical instruments electrical equipment, wearing apparels and beverages. Low productivity growth is observed for tobacco, motor vehicle and basic metals sectors.

2.3 Construction of Foreign Ownership Variables

The main explanatory variables in our analysis are based on ownership data reported in Prowess. Consistent with the literature, we treat a firm as being foreign-owned if 10% or more than 10% of its equity shares are held by foreign promoters. If a firm

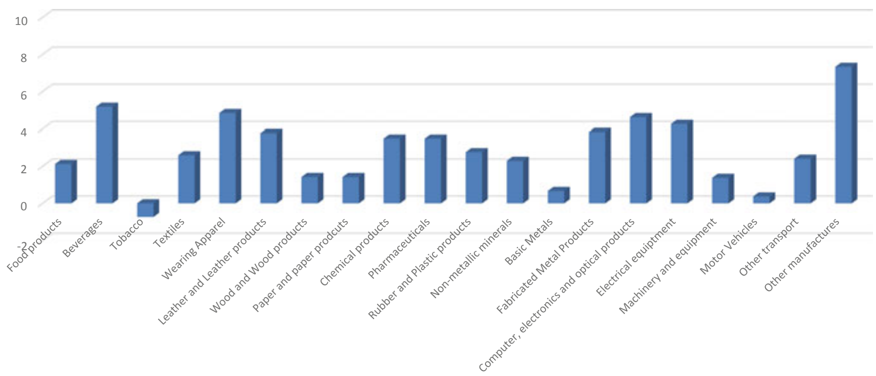

Fig. 1 Annual average growth rate in TFP (% per annum), 2001–02 to 2014–15, by industry. *Source* Based on authors' estimations

has been identified as a foreign-owned firm in a given year, then it remains (or is treated as) a foreign firm for the rest of the following years in our panel. We observe that 6.65% of observations in our panel are classified as foreign firms (alternatively called FDI firms).

Using firm-level foreign ownership data, we construct three spillover variables. First, we estimate horizontal spillovers as the sales-weighted average foreign shares in each two-digit industry. Next, we create a backward spillover variable for each industry that reflects the degree of foreign presence in the other industries to which it supplies, i.e. foreign presence in downstream industries. Similarly, we create a forward spillover variable for each industry, capturing the degree of foreign presence in the industries from which it buys its input, i.e. foreign presence in upstream industries. The spillover variables have been constructed at NIC 2–digit level and then applied to all firms belonging to those industries. The construction of these spillover variables is given in more detail in Sect. 5, and summary statistics are presented in Table 2.

Table 2 Summary statistics of FDI variables

Variables	Observations	Mean	STD	Min	Max
Foreign share	65,549	2.20	10.56	0	97.09
FDI share	64,900	6.12	3.90	0	28.95
Forward FDI spillovers	65,549	5.64	1.99	2.012	12.78
Backward FDI spillovers	64,900	3.57	2.25	0.0329	11.93

Note Foreign share variable represents equity share of foreign promoters in the firm (%). FDI share, on the other hand, is computed as sales-weighted average foreign shares in the industry to which the firm belongs. FDI share, forward FDI spillovers and backward FDI spillovers are computed at two-digit industry level as explained in the text
Source Authors' computations

An important piece of information for the study is the country source of origin of the FDI in the foreign-owned firms. Most of FDI directed to India originates from Europe and North America (each accounting for 37% of total investments in this country), while Japan and the Four Asian Tigers account for 9 and 6% of inward FDIs in India (Zanfei et al. 2019). However, at the firm level, Prowess does not report on origin of FDI, requiring the use of other sources. Even with these inputs, the country of origin could not be determined for a portion of the foreign-owned firms.[13]

In the sample, about 400 firms were identified as FDI firms. Of these, 49% have investment from USA or Europe, 12% from Japan, 11% from developing countries of Asia, and 5% from Mauritius (which is treated separately). In about 21% of cases, the country origin of FDI could not be determined.

2.4 Construction of and Summary Statistics on Control Variables

The estimation of the productivity spillover effects of FDI in Sect. 5 has been done by estimating econometric models. The same applies to the assessment of TFP differences between FDI firms and domestic firms in Sect. 3 and impact of foreign acquisition of domestic firms by foreign firm on the level of TFP of acquired firms in Sect. 4. For estimating the econometric model, a number of variables have been used as controls in the regression analysis. The definition of the variables and summary statistics are provided in Tables 3 and 4.

Table 3 Construction of variables used in regression analysis

Variable	Construction	Data sources used
Export intensity	Export of goods/sales (in %)	Prowess
Import intensity	Total imports/sales	Prowess
Size	ln (total assets), ln (deflated sales)	Prowess
Age of the firm	Reporting year − year of incorporation	Prowess
Services export intensity	Export of services/sales (in %)	Prowess
Services import intensity	Imported services/total services used	Prowess
R&D intensity	R&D expenditure/sales	Prowess
Leverage	ST debt/current assets	Prowess
Liquidity	(current assets − current liabilities)/total assets	Prowess

[13]Valuable inputs on country origin of investors in the identified FDI firm have been provided by Dr. K. S. Chalapati Rao (Institute for Studies in Industrial Development, New Delhi) and Dr. Amrita Goldar (Indian Council for Research in International Economic Relations, New Delhi). We are grateful to them for providing this information.

Table 4 Summary statistics, variables used as controls in regression analysis

Variable	Observations	Mean	STD	Min	Max
Export intensity (in %)	65,510	12.20	23.12	0.00	132
Import intensity	65,549	0.09	0.629	0.00	86.84
Deflated Sales	64,900	38.22	379.34	0.0004	2371
Total assets	62,422	37.58	299.49	0.00	18,416
Service import intensity (in %)	62,203	1.24	7.58	0.00	150
Services export intensity (in %)	65,547	0.32	3.88	0.00	100
R&D intensity (in %)	65,547	0.18	1.28	0.00	97
Age (years)	65,014	24.86	17.82	0.00	136
Liquidity	60,540	0.17	0.30	−15.59	0.71
Leverage	50,697	0.16	0.11	0.00	0.63

Note Total assets are reported in Rs. Million. The same applies to deflated sales
Source Prowess and authors' computations

3 Do FDI Firms Have Higher Productivity?

The methodology of estimation of TFP for Indian manufacturing firms undertaken in this study has been discussed in the previous section. This section is devoted to an analysis of inter-firm differences in the level of TFP. The aim is to ascertain whether the level of TFP is relatively higher among FDI firms in comparison with non-FDI firms, referred to as domestic firms. Also, a comparison is made between FDI firms with FDI from developed countries and those with FDI from developing countries. A similar comparison is made between FDI originating in the USA and Europe (excluding emerging economies of Europe) and FDI originating in Asian countries.

For the purpose of these analyses, aimed at making inter-firm TFP (level) comparisons, a multiple regression equation is estimated. The regression equation for making a comparison between FDI firms and domestic firms is specified as:

$$\ln \text{TFP}_{ijt} = \alpha_0 + \alpha_j + \alpha_t + \beta_1 F_{ijt} + \gamma X_{ijt} + u_{ijt} \tag{3.1}$$

In this equation, TFP_{ijt} is the level of TFP of firm i in industry j in year t, F_{ijt} is a dummy variable for FDI firms (takes value one if the share of foreign promoter(s) in equity of the firm is 10% or more, zero otherwise),[14] X_{ijt} is a set of control variables, and γ is the corresponding vector of parameters, and u_{ijt} is the random effort terms. The terms α_j and α_t are for the industry and time (year) fixed effects. This model specified above bears some similarity to the approach taken in the study of Harris (2009) who estimated a Cobb–Douglas production function from panel data and introduced FDI firm dummy as one of the explanatory variables. While Harris used a one-step approach to assess the impact of foreign ownership on TFP which has

[14]As pointed out earlier, if a domestic firm turns into an FDI firm in a year, it is treated as an FDI firm for all subsequent years in the panel.

been used in a number of other studies, in this study, a two-step approach is used: estimation of TFP at firm level in the first step and assessment of the impact on foreign ownership on TFP in the second step.[15] One can find other studies in which an equation similar to Eq. 3.1 has been estimated from firm-level data (see, for example, Karpaty 2004).

In the above equation, no distinction is made in regard to the country of origin of FDI. An alternative specification that has been used takes note of this distinction. This may be written as:

$$\ln \text{TFP}_{ijt} = \alpha_0 + \alpha_j + \alpha_t + \beta_1 F_{ijt}^{\text{DVLD}} + \beta_2 F_{ijt}^{\text{DVLG}} + \beta_3 F_{ijt}^{\text{OTHR}} + \gamma X_{ijt} + u_{ijt} \tag{3.2}$$

In this equation, three FDI firm dummies are used: one for those firms which have FDI from developed countries (denoted by F_{ijt}^{DVLD}), second for firms which have FDI from developing countries (denoted by F_{ijt}^{DVLG}) and the third for other FDI firms (denoted by F_{ijt}^{OTHR}). To explain this further, the first dummy (denoted by F_{ijt}^{DVLD}) takes value one for a firm with FDI from a developed country (with foreign promoters share in aggregate being 10% or more) and zero otherwise.[16] If the foreign promoter share in the firm was more than 10% in year t and below 10% in year $t-1$, then dummy variable takes value one for year t and zero for year $t-1$. If the foreign promoter share falls below 10% in year $t+1$, the dummy variable is still assigned value one (as explained earlier). Evidently, after estimating the model above, a comparison of parameters, β_1, β_2 and β_3 will reveal the relative productivity level of the three categories of FDI differentiated according to the country origin of FDI.

It should be noted here that in the dataset used for the analysis, detailed data are available on the pattern of equity holding. It thus becomes possible to ascertain the percentage of equity held by the foreign promoter(s), and this information is used to designate FDI firms. However, as noted in Sect. 2 earlier, the dataset does not contain information on the country origin of the foreign promoter(s). For determining country of origin of investment in FDI firms, additional information obtained from diverse sources has been used. While for a large portion of the FDI firms, it has been possible to determine the country of origin of major foreign promoter(s), for others it has not been possible to do so. Also, for a number of FDI firms, the source country is found to be Mauritius. There are grounds to believe that certain investments

[15]There is an econometric issue of endogeneity in the model specified. It may be argued that there is heterogeneity among domestic firms in terms of their productivity level, and foreign investments which turned the domestic firms into FDI firms may have been made selectively in the relatively more productive firms (and therefore, the status of the firm, FDI or domestic, may be determined by its level of productivity). This issue is ignored in the analysis presented in this section. In some ways, the concern is addressed in the analysis presented in the next section.

[16]There is a possibility that the foreign promoters of a company may belong to different countries. In this situation, the condition we use is that the aggregate equity share of promoters should be 10% or more, and the country of origin of FDI is decided by the country to which the main foreign promoter belongs.

are being routed through Mauritius because of tax benefits and the true country of origin is not known (in addition there is the issue of round-tripping investments, i.e. investments being made by Indian entrepreneurs through Mauritius). It seems, therefore, that for the estimation of the model described above, it would not be right to treat investments being made through Mauritius as FDI originating in developing countries. Thus, for FDI firms having FDI from Mauritius, the third dummy variable (F_{ijt}^{OTHR}) is used, which also covers firms in which investments have been made by non-residents Indians (NRIs) on individual capacity rather than a corporate body and firms for which the country of origin of FDI could not be ascertained due to lack of data.

An alternate model that has been estimated makes a distinction between FDI originating in the USA and Europe, FDI originating in Asia (including Japan) and FDI from other sources. The model is specified as:

$$\ln \text{TFP}_{ijt} = \alpha_0 + \alpha_j + \alpha_t + \beta_1 F_{ijt}^{\text{US/Europe}} + \beta_2 F_{ijt}^{\text{Asia}} + \beta_3 F_{ijt}^{\text{OTHR}} + \gamma X_{ijt} + u_{ijt} \tag{3.3}$$

The equation is similar to Eq. 3.2 and hence does not require to be explained.

The estimates of Eq. 3.1 are presented in Table 5. In Regressions (1) and (2), all

Table 5 TFP difference between FDI and domestic firms, regression results (dependent variable: ln TFP)

Explanatory variable	Regression-1	Regression-2	Regression-3	Regression-4
FDI firm dummy	0.150 (6.68) #	0.149 (6.57) #	0.165 (6.73) #	0.182 (7.31) #
Firm size	0.141 (42.35) #	0.143 (41.62) #	0.151 (38.62) #	0.145 (36.23) #
Age	0.016 (17.33) #	0.017 (18.81) #	0.018 (16.66) #	0.017 (15.84) #
Age-squared	−0.0001 (−7.94) #	−0.0001 (−9.95) #	−0.0001 (−8.78) #	−0.0001 (−8.07) #
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes (3-digit NIC)	Yes (5-digit NIC)	Yes (3-digit NIC)	Yes (5-digit NIC)
R-squared (*F*-value)[Prob > *F*]	0.192(209.3) [0.000]	0.251(201.8) [0.000]	0.163(171.6) [0.000]	0.216(161.5) [0.000]
No. of observations	33,960	33,960	23,240	23,240

Note Firm size is measured by logarithm of total assets. For defining FDI firms, the cut-off level of foreign promoter equity ownership is taken as 10%. Data for industries belonging to NIC codes 20–30 are covered in Regressions (3) and (4). All manufacturing industries (NIC codes 10–32 and 58) are covered in Regressions (1) and (2)
t-values in parentheses. # statistically significant at 1% level
Source Authors' computations

manufacturing industries are covered (NIC codes 10–32 and 58 according to NIC-2008). In Regressions (3) and (4), data for industries belonging to NIC codes 20–30 are covered. This has been done because about 80% of the FDI firms belong to these industries, and in most of these two-digit industries, FDI firms account for more than 5% of total firms in the industry. Regressions (1) and (3) differ from Regressions (2) and (4) in regard to the industry fixed effects. In the former cases, 3-digit industry dummies have been included, and in the latter cases, 5-digit industry dummies are included.

Two control variables have been included in the regressions. These are firm size measured by logarithm of total assets and age of the firm (based on year of incorporation). Age-squared variable is included to allow for nonlinear effect of age on TFP.

The model estimates presented in Table 5 clearly indicate that after controlling for firm size, age of the firm, industry affiliation and time (year fixed effects), the TFP level of FDI firms is significantly higher than domestic (non-FDI) firms. The gap in the level of TFP is found to be about 15–18%.

A similar analysis done by Sasidharan (2006) for Indian firms reveals that FDI firms have significantly higher TFP than non-FDI firms. He has taken the cut-off for equity share of foreign promoters as 10% for defining FDI firms as done in this study. The results reported by Sasidharan indicate that the gap in the level of TFP between FDI firms and domestic firms is about 13%, which is broadly in agreement with the estimates obtained in this study.

The empirical results of Goldar et al. (2004) for firms of engineering industries in India and the empirical results of Sahu and Solarin (2014) for manufacturing firms of India also indicate that FDI firms have higher productivity than domestic firms. These findings match with the findings of this study.

The model estimates looking into the differential impact of FDI on firm productivity according to the source country of origin is taken up next. The estimates of Eqs. (3.2) and (3.3) are presented in Tables 6 and 7, respectively. In both cases, the sample is restricted to NIC codes 20–30. The inter-industry heterogeneity is captured by using industry dummy variables at 5-digit level of NIC.

In both Tables 6 and 7, the results obtained by using the sample for the industries NIC 20 to NIC 30 are shown in the first column of the table. Then, separate estimates of the model are presented for the following three broad industrial groups: (a) chemicals and chemical products, pharmaceutical products, rubber and plastic products and non-metallic mineral products (NIC codes 20, 21, 22 and 23), (b) basic metals, metal products and non-electrical machinery (NIC codes 24, 25 and 28) and (c) electrical machinery, computers and electronic products and transport equipment (NIC codes 26, 27, 29 and 30).

The results presented in Table 6 indicate that the TFP level of FDI firms with FDI from developed countries is significantly higher than that of domestic firms. This is, however, not found for FDI firms in which the investments have originated from developing countries. Rather, from the regression results, it appears that TFP level of FDI firms having investment from developing countries is lower than that of domestic firms. Similar results are found when a comparison is made between

Table 6 TFP difference between FDI and domestic firms, regression results, distinguishing by source country of origin of FDI (dependent variable: ln TFP)

Explanatory variable	Category of manufacturing industries			
	Industries belonging to NIC 20–30 (covering industries listed in the next three columns)	Chemicals and chemical products, pharmaceutical products, rubber and plastic products and non-metallic mineral products	Basic metals, metal products and non-electrical machinery	Electrical machinery, computers and electronic products and transport equipment
Firm with FDI originating from developed countries (dummy)	0.265 (9.39)***	0.265 (6.33)***	0.276 (4.84)***	0.271 (5.38)***
Firm with FDI originating from developing countries (dummy)	−0.428 (−4.82)***	−0.484 (−4.07)***	−0.279 (−1.77)*	−0.186 (−0.77)
Firm with FDI from other sources (dummy)	−0.011 (−0.27)	0.027 (0.54)	−0.197 (−1.78)*	0.061 (0.58)
Firm size	0.144 (35.96)***	0.159 (28.40)***	0.110 (14.62)***	0.159 (18.17)***
Age	0.017 (15.39)***	0.014 (9.11)***	0.021 (10.27)***	0.015 (6.66)***
Age-squared	−0.00009 (−7.55)***	−0.00007 (−4.39)***	−0.00017 (−6.57)***	−0.00005 (−1.59)
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes (5-digit NIC)	Yes (5-digit NIC)	Yes (5-digit NIC)	Yes (5-digit NIC)
R-squared (F-value)[Prob > F]	0.218(148.7) [0.000]	0.242(84.4) [0.000]	0.170(32.9) [0.000]	0.230(43.9) [0.000]
No. of observations	23,240	10,431	7432	5377

Note For defining FDI firm, the cut-off level of foreign promoter equity ownership is taken as 10%. These firms are then sub-divided into three categories according to the country sources of FDI, considering the main source
t-values in parentheses. *, ** and *** statistically significant at 10, 5 and 1%, respectively
Source Authors' computations

FDI from USA/Europe with FDI from Asia (Table 7). While the regression results indicate that the firms with FDI from USA and Europe have, on average, higher TFP than domestic firms, this is not found for firms with FDI originating in Asia. It seems that the average TFP of firms with FDI from Asia does not significantly exceed the average TFP of domestic firms.

Table 7 TFP Difference between FDI and domestic firms, regression results, distinguishing by source country of origin of FDI (alternate grouping of countries) (dependent variable: ln TFP)

Explanatory variable	Category of manufacturing industries			
	Industries belonging to NIC 20–30 (covering industries listed in the next three columns)	Chemicals and chemical products, pharmaceutical products, rubber and plastic products and non-metallic mineral products	Basic metals, metal products and non-electrical machinery	Electrical machinery, computers and electronic products and transport equipment
Firm with FDI originating from USA and Europe (dummy)	0.305 (9.46)***	0.371 (8.01)***	0.310 (5.06)***	0.214 (3.21)***
Firm with FDI originating Asia (dummy)	0.001 (0.01)	−0.268 (−3.56)*	−0.307 (−2.44)**	0.315 (4.51)****
Firm with FDI from other sources (dummy)	−0.010 (−0.25)	0.013 (0.26)	−0.042 (−0.43)	0.040 (0.39)
Firm size	0.144 (35.97)***	0.160 (28.63)***	0.108 (14.38)***	0.160 (18.20)***
Age	0.017 (15.64)***	0.014 (9.36)***	0.021 (10.42)***	0.015 (6.74)***
Age-squared	−0.0001 (−7.95)***	−0.00008 (−4.68)***	−0.00017 (−6.82)***	−0.00005 (−1.61)
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes (5-digit NIC)	Yes (5-digit NIC)	Yes (5-digit NIC)	Yes (5-digit NIC)
R-squared (F-value)[Prob > F]	0.217(147.4) [0.000]	0.244(85.8) [0.000]	0.171(33.0) [0.000]	0.229(43.9) [0.000]
No. of observations	23,240	10,431	7432	5.377

Note For defining FDI firm, the cut-off level of foreign promoter equity ownership is taken as 10%. These firms are then sub-divided into three categories according to the country sources of FDI, considering the main source

t-values in parentheses. *, ** and *** statistically significant at 10, 5 and 1%, respectively

Source Authors' computations

The regression results presented in Table 6 indicate that after controlling for firm size, age of the firm, industrial heterogeneity and time, the average level of TFP of FDI firms with FDI originating in developing countries is lower than that of FDI firms with FDI originating in developed countries in all three industry groups considered for the analysis, particularly in industry groups (a) and (b) which cover chemicals, rubber, plastics, non-metallic mineral products, metals and metal products and non-electrical machinery. Somewhat similar results are found in the comparison made between FDI from USA/Europe and FDI from Asia (Table 7). Thus, firms with FDI from Asia have a disadvantage in terms of TFP vis-à-vis firms with FDI from USA and Europe in industry groups (a) and (b). However, there is no disadvantage in industry group (c) which includes electrical machinery, computers and electronic products and transport equipment. Rather, firms with Asian investment (sample being dominated by Japan and Korea) seem to be performing better than the firms with US/European investment in industry group (c).

From the results of regression analysis presented in Tables 6 and 7, one would infer that TFP level of FDI firms in India with FDI from developed countries is normally higher than that of FDI firms in India with investment from developing countries. This applies also to a comparison of TFP between FDI from US/Europe and FDI from Asian countries. These findings are corroborated by the Kolmogorov–Smirnov tests, undertaken using data for 2013–14. The test statistic is found to be statistically significant at one per cent level when firms having US-European FDI are contrasted with firms having Asian FDI and at 5 per cent level when firms having FDI from developed countries are contrasted with firms having FDI from developing countries.

4 Does Foreign Acquisition of Domestic Firms Raise Their Productivity?

The analysis presented in the previous section indicated that after controlling for industry affiliation and some other firm characteristics, an FDI firm tends to have higher TFP than a domestic firm. Such findings have been reported in several earlier studies including some studies undertaken for India. The next issue to be considered is a related one: whether acquisition of a domestic firm by a foreign firm causes the TFP of the domestic firm to rise. This question is investigated in this section.

The finding that FDI firms tend to have relatively higher TFP than domestic firms, revealed by the results of the econometric analysis in Sect. 3, does not by itself mean that foreign acquisition has led to an improvement in TFP. There is a possibility of cherry picking by foreign investors, and they may have invested in relatively more productive firms, a point noted earlier.[17]

An approach that may be taken to study the impact the foreign acquisition on productivity, which will not be affected by the issue of cherry picking raised above, is to consider the change that took place in the level of TFP is a domestic firm when it got acquired by a foreign firm and thus got transformed into an FDI firm, and

[17]For a discussion of the issue of cherry picking, see Kaitila et al. (2013), among others. Kaitila and associates have reviewed a number of earlier studies. They report that out of the 31 studies they have analysed, they find that 14 studies have come to the conclusion that foreign firms acquired the relatively more productive firms. On the other hand, only two studies concluded that foreign firms acquired local firm with below average productivity.

compare it with the change that took place in a similarly placed domestic firm which did not get transformed into an FDI firm (making use of the difference-in-difference estimator). This type of analysis can be undertaken by applying the commonly used methods of assessing treatment effect. To give an example here, Arnold and Javorcik (2009) have undertaken such an analysis and found a significant positive effect of foreign investment on productivity of industrial plants in Indonesia. Other studies in which such a methodology has been applied for the purpose of assessing FDI impact on firm productivity include Bandick (2011), Chen (2011) and Petkova (2012).[18]

A brief discussion on the methodology in question is in order here. Let the change of ownership, from domestic to foreign (foreign ownership in equity going over a particular threshold, say 10%), occurring in a particular year T, be called an event taking place in time T, and the firms that experience the event be called treated firms (i.e. the firms that get treated in that year). Also, let the firms that remain in domestic hands and do not experience the event be called control group firms. Thus, to judge the effect of foreign acquisition, the average change in a performance indicator (say logarithm of TFP) between years T and $T - 1$ for treated firms could be compared with that for control groups firms, after ensuring proper matching. This provides the average treatment effect on the treated (ATT).

It is evident that for making a valid comparison, the control group firms need to be properly matched with the treated firms. There are several different ways by which matching may be done. When one works with panel data, there are some additional issues to be addressed in the method employed for matching. For their analysis of Indonesian manufacturing plants, Arnold and Javorcik (2009) have applied a procedure which enables them to ensure that for each acquired/treated firm/plant, the match from the control group is assigned from the same year and same industry/sector. The analysis presented in this paper, however, does not make use of the procedure suggested and applied by Arnold and Javorcik though it has certain merits.[19] Instead, a simpler method of matching control group firms and treated firms is adopted. Estimation of ATT has been done by using 'psmatch2' command in *Stata*. Some further details are provided below.

As mentioned earlier, this study covers about 7000 firms. Among them, about 400 are identified as FDI firms. For a majority of these firms, it is found that the foreign equity share was 10% or more in the first year of observation during the period under study, 2000–01 to 2014–15. For the other FDI firms, the foreign equity

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[18] Petkova's study is on Indian manufacturing firms. She has considered the effect of foreign investment on TFP and a few other firm performance indicators. It may be pointed out in this context that in a study on Indian manufacturing firms, Goldar and Sharma (2015) have applied treatment effects analysis to examine the impact of FDI on certain indicators of firm performance. They did not consider productivity performance.

[19] Chen (2011) has used a matching method different from that adopted by Arnold and Javorcik, and the same holds for Petkova (2012) and Kaitila et al. (2013). Petkova who has examined the effect of FDI on TFP in Indian manufacturing firms using Prowess data (undertaking a study similar to Arnold and Javorcik 2009) has addressed the issue of timing by following the method given in Eichler and Lechner (2002). She considers the percentage of foreign investment-targeted firms that received treatment each year and proportionately assigns at random hypothetical event dates to the firms that never received treatment.

share was initially less than 10% and then rose to 10% or beyond in some year during the period under study. The former group is excluded from the analysis, since the event of transformation from domestic to FDI is not observed in the data. The latter group provides observations on the event of transformation from domestic to FDI firm. There are 131 such cases in the sample. This reduces to 100 when the analysis is confined to industries with two-digit NIC codes 20–30, as has been done in the study.

For the 100 firms mentioned above which are the treated firms, the growth in TFP accompanying the event is compared with TFP growth attained by the control group of firms (after matching). The choice of control group which includes only domestic firms is made on the basis of matching of propensity score.

Propensity score is computed by estimating a probit model designated to explain which domestic firm gets transformed into FDI firm and which does not. In the probit model, firm size, export intensity, import intensity,[20] leverage, broad industry group affiliation and a time period dummy[21] for the period from 2008–09 onwards are taken as explanatory variables.

Since the transformation of a domestic firm into an FDI firm may take time to have an impact on TFP, the change in ln (TFP) in one year, two years and three years, i.e. years $T = 0$, $T = 1$ and $T = 2$ [relative to the ln (TFP) level in the year $T = -1$, preceding the year of transformation] are considered. Time Period 0 (or year $T = 0$) is the year when the domestic firm got acquired by a foreign firm, i.e. it got transformed into a FDI firm. Thus, TFP growth in Time Period 0 is the increase in *ln*(TFP) in the current year over that in the previous year.

The estimates of ATT are presented in Table 8. First, all cases of foreign acquisition of domestic manufacturing firm are considered together. Then, the foreign acquisition cases are divided into groups according to country source of origin of FDI and a comparison is made with control group firms.

Two points emerge from Table 8. First, when all foreign acquisition cases are taken together, the estimated ATT is found to be statistically insignificant. This gives the impression that, in general, the transformation of a domestic firm into an FDI firm in India does not lead to a significant increase in TFP. Secondly, there are differences in the impact of FDI on TFP according to the country source of origin of FDI. When a distinction is made between FDI from developed countries and that from other countries/sources,[22] the estimated ATT in the former case is found to be positive for

[20] It may be seen from Table 4 that the import intensity variable takes extremely high values in some observations. The mean is 0.09 and the 99th percentile is about 0.7. Yet, in some observations, the value of the variable exceeds 40. Therefore, for using it as an explanatory variable in econometric analysis, this variable has been winsorized at the 99.5th percentile, i.e. values of the variable above this percentile have been capped at the 99.5th percentile.

[21] The rationale for the period dummy is that in the period 2001–02 to 2007–08, there were on average about 11 cases of foreign acquisition each year (in the sample considered for the study) and in the period 2008–09 to 2014–15, the corresponding figure was much lower at about only 3–4 cases per year. The average per year is 5 for the years 2008–09 to 2010–11 and only 2 for the years 2011–12 to 2014–15.

[22] Since the number of cases of FDI transformation used for the analysis is small, the second and third categories have been clubbed, i.e. cases of FDI from developing countries are clubbed with

Table 8 Estimates of ATT, impact of foreign acquisition on TFP of acquired firm

Time (year)	All foreign acquisition cases	Foreign acquisition cases divided into		Foreign acquisition cases divided into	
		FDI from developed countries	FDI from other countries/sources	FDI from USA and Europe	FDI from other countries/sources
0	−0.027 (0.077)	0.226 (0.136) [1.66]	−0.239 (0.155)	0.100 (0.188)	−0.131 (0.145)
1	0.086 (0.123)	0.080 (0.152)	−0.067 (0.274)	0.278 (0.160) [1.74]	0.035 (0.154)
2	0.074 (0.148)	0.498 (0.243) [2.05]	−0.424 (0.282)	0.380 (0.185) [2.05]	−0.280 (0.208)

Note Standard error in parentheses; *t*-values in square brackets (only those cases where *t*-value is around 1.6 or more than 1.6 are shown)
ATT Average treatment effect on the treated
Source Authors' computations

all three years ($T = 0$, $T = 1$ and $T = 2$), and it is statistically significantly for years $T = 0$ and $T = 2$, but the estimated ATT is negative and statistically insignificant in the latter case for all three years. It may be inferred on the basis of these findings that the acquisition of equity in a domestic manufacturing firm in India by a firm from developed country has a beneficial TFP enhancing effect on the acquired firm, but such acquisition by a firm from developing country does not have a beneficial effect on TFP, which agrees with the findings of Chen (2011) for USA.

When a distinction is made between FDI from USA/Europe and that from other countries/sources, it is found that the estimated ATT for FDI from USA/Europe is positive for all three years and statistically significant for years $T = 1$ and $T = 2$. On the other hand, the estimated ATT is statistically insignificant for firms in which investments were made from Asian countries or other sources. It may therefore be inferred that the effect of FDI on TFP of a domestic firm in which the foreign investment takes place from USA/Europe is significantly positive, but such positive effect may often be absent when the investment takes place from other countries.

The finding of statistically insignificant estimate of ATT when all treated firms are considered together is in agreement with the findings of Petkova (2012). In her estimates too, the estimated ATT for FDI impact on TFP in Indian manufacturing firms was found to be statistically insignificant. However, since the estimate of ATT is found to statistically significant for some sub-group of treated firms, this aspect has been investigated further. Table 9 shows three alternate sets of estimates of ATT that have been obtained when all treated firms are considered together and

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cases where the FDI is from Mauritius, NRIs and unknown sources. A similar treatment is given when FDI from USA/Europe is contrasted with that from the rest of the countries including Asian countries.

Table 9 Estimates of ATT, all foreign acquisition cases, alternate estimates

Time (year)	Estimate-1	Estimate-2	Estimate-3	Estimate-4
0	−0.027 (0.077)	−0.108 (0.094)	0.058 (0.079)	0.016 (0.086)
1	0.086 (0.123)	0.272 (0.140) [1.95]	0.156 (0.131)	0.276 (0.150) [1.85]
2	0.074 (0.148)	0.032 (0.157)	0.322 (0.158) [2.04]	0.283 (0.177) [1.60]

Note Standard error in parentheses; *t*-values in square brackets (only those cases where *t*-value is around 1.6 or more than 1.6 are shown). Estimate-1 is taken from Table 8
Source Authors' computations

propensity score-based nearest-neighbour matching is done. In the first alternate estimate (Estimate-2 in the table), the period dummy has been changed. In this estimate, a dummy variable for the years 2011–12 to 2014–15 has been used (instead of a dummy variable for the period 2008–09 to 2014–15). Additionally, a greater number of industry dummy variables have been used in the probit model to capture better inter-industry diversity—besides the two aforementioned dummies for two broad industry groups, four individual two-digit industry dummies have been used. In the second and third alternate estimates (Estimate-3 and Estimate-4 in the table), the specification of the probit model is similar to that in Estimate-2 except that in the former case (Estimate-3) firm-age is introduced as an explanatory variable along with liquidity, and in the latter case (Estimate-4), in addition to firm-age and liquidity another new explanatory variable is introduced, namely total assets per employee.

It is seen from Table 9 that in Estimate-2 which is based on a methodology similar to that for Estimate-1, the estimate of ATT for $T = 1$ (time periods 1, i.e. the growth in TFP between the year following the year of foreign acquisition and the year previous to the foreign acquisition) is positive and statistically significant. The same applies to Estimate-4 which is based on a probit model similar to that for Estimate-2 except that three new explanatory variables are introduced; the estimated ATT is positive and statistically significant for year $T = 1$. In the second alternate estimate of ATT (Estimate-3 in the table), ATT is positive and statistically significant for year $T = 2$, i.e. time period 2. Thus, even though the estimates of ATT in Estimate-1 are found to be statistically insignificant, which are qualitatively in agreement with the ATT estimates of Petkova (2012) [23] for Indian manufacturing firms based on Prowess data for the period 2001–2008, other estimates of ATT presented in Table 9 point in a different direction. Indeed, going by the estimates of ATT presented in Table 9, it appears that foreign acquisition of equity in Indian manufacturing firms did lead to an improvement in TFP in the acquired firm in a majority of cases. This is consistent with the econometric results presented in the previous section.

[23] Petkova's estimates for time period $T = 0$, $T = 1$ and $T = 2$ are −0.019, 0.038 and −0.009, respectively. All these are statistically insignificant.

One weakness of the analysis presented in Table 8 is that these are based on propensity scores computed with the help of a probit model which is based on a dichotomous choice. Thus, when an event associated with FDI from US/Europe is contrasted with control group firms, the domestic firms that got transformed into an FDI firm by getting FDI from other countries/sources are ignored. This is evidently a pairwise average treatment effect, as applied in Chen (2011).[24] A more satisfactory assessment can be done by using a multivalued treatment model which allows multiple treatment possibilities. Such an analysis has been undertaken by using 'teffects ipw' command in *Stata* which involves inverse probability weighting. The methodology is based on a multinomial logit model. For the model, firm size, export intensity, import intensity (winsorized), and leverage have been taken as explanatory variable along with industry group affiliation dummies, age of the firm and a dummy variable for time period beyond 2007–08 (taking value one for years 2008–09 onwards, zero otherwise). The estimates of ATT (average treatment effect on treated) are shown in Table 10.

The results reported in Table 10 are similar to those in Table 8. There are indications that FDI from developed countries has a positive effect on TFP on acquired domestic firm, but this does not hold for FDI from other countries and sources. Similarly, FDI from US/Europe has a positive effect, but FDI from other countries does not have a similar positive effect on TFP. These results are consistent with those reported in Table 8 and in line with the findings of Sect. 3.

Table 10 Estimates of ATT, impact of foreign acquisition on TFP, model incorporating multiple treatment possibilities

Time (year)	Foreign acquisition cases		Foreign acquisition cases	
	FDI from developed countries versus domestic firms	FDI from other countries/sources versus domestic firms	FDI from USA and Europe versus domestic firms	FDI from other countries/sources versus domestic firms
0	0.097 (0.051) [1.89]	−0.178 (0.089) [−1.98]	0.083 (0.064)	−0.132 (0.076) [−1.73]
1	0.230 (0.093) [2.49]	−0.159 (0.099) [−1.62]	0.223 (0.112) [1.99]	−0.124 (0.105)
2	0.307 (0.119) [2.57]	−0.445 (0.143) [−3.11]	0.384 (0.143) [2.69]	−0.376 (0.173) [−2.17]

Note Standard error in parentheses; *t*-values in square brackets (only those cases where *t*-value is around 1.6 or more than 1.6 are shown)
Source Authors' computations

[24] In Chen's study, there are three possible treatments: acquisition by a domestic firm, acquisition by a firm from an industrialized country other than the USA and acquisition by a firm from a developing country. Instead of using a methodology that considers all these choices together, pairwise analysis has been done.

5 FDI Spillover Effects on Domestic Firms

The previous two sections were devoted to the analysis of direct benefits from FDI in terms of the productivity enhancement it causes in firms in which the investment is made. As noted in the introductory section of the paper, besides the direct productivity-enhancing effect of FDI, there is an indirect impact through productivity spillovers on domestic firms. A great deal of econometric research has been undertaken on the spillover effect, including studies undertaken for developing countries. A number of studies have been undertaken on the spillover effect of FDI for Indian manufacturing firms, as mentioned and briefly discussed in the introductory section of the paper.

This section presents an analysis of FDI productivity spillover effect on domestic firms in Indian manufacturing. It is divided into two subsections. Section 5.1 describes the construction of spillover variables and specification of the econometric model estimated. Section 5.2 presents the empirical results. First, an analysis quite similar to that done in a number of earlier studies for India is presented. For this analysis, all FDI firms are considered as a group and the impact of FDI on the productivity of domestic firms through horizontal and vertical spillover effects is studied. In the next step, attention is paid to country of origin of FDI. An attempt is made to assess if the spillover effects of FDI differ according to the country origin of FDI.

5.1 Spillover Variables and Model Specification

The question to be studied is how productivity of a domestic manufacturing firm in India is impacted by (a) FDI in the industry to which the firm belongs and (b) FDI in other industries from which the domestic firm buys its inputs or to which it sells its products. For this purpose, a multiple regression equation is estimated. The level of TFP of the domestic firms is taken as the dependent variable, being determined by a set of explanatory variables including variables representing spillover effects. The explanatory variables include firm size, age and a set of other variables representing various characteristics of the domestic firms. To capture the spillover effects, three spillover variables are used, as has been done in many earlier studies on spillover effects. The three spillover variables are: (i) horizontal spillover variable, (ii) vertical spillover variable capturing backward linkage and (iii) vertical spillover variable capturing forward linkage.

For each domestic firm, the horizontal spillover variable is measured by the extent of FDI in the industry to which the firm belongs. These have been computed at two-digit industry level of NIC-2008 for each year and applied to all domestic firms belonging to that industry in that year. Construction of the horizontal spillover variable follows Javorick (2004). Horizontal spillover for industry j in year t is given by:

$$\mathrm{HRZ}_{jt} = \frac{\left[\sum_{i \text{ for all } i \in j} \mathrm{FS}_{it} Y_{it}\right]}{\sum_{i \text{ for all } i \in j} Y_{it}} \tag{5.1}$$

In this equation, FS_{it} denotes foreign equity share in firm i in year t belonging to industry j and Y_{it} is output (proxied by sales) of firm i in year t. This is hereafter referred to as HRZ or horizontal spillover variable or FDI share.

Again, following Javorick (2004), the backward (BKD) and forward (FRD) spillover variables are defined as:

$$\mathrm{BKD}_{jt} = \sum_{k \text{ if } k \neq j} \alpha_{jk} \mathrm{HRZ}_{kt} \tag{5.2}$$

$$\mathrm{FRD}_{jt} = \sum_{m \text{ if } m \neq j} \sigma_{jm} \left(\frac{\left[\sum_{i \text{ for all } i \in jm} \mathrm{FS}_{it} D_{it}\right]}{\sum_{i \text{ for all } i \in m} D_{it}} \right) \tag{5.3}$$

In Eq. 5.2, α_{jk} denotes the proportion of industry j output that is supplied to industry k. The variable BKD_{jk} basically reflects the degree of foreign presence in the industries that are being supplied by firms of industry j.

In Eq. 5.3, D_{it} represents the portion of output of firm i that is sold domestically; it is equal to production minus exports. The expression in parentheses is a measure of foreign share in equity in industry m using domestic sales of firm output as weights. This ratio is computed for each industry. Then, for each industry j, the variable $\mathrm{FRD}_{\mathrm{jt}}$ is computed as a weighted aggregation, using σ_{jm} as weights, which represent the share of inputs bought by industry j from industry m. This variable reflects the degree of foreign presence in the upstream sectors, i.e. the sectors or industries from which industry j buys its inputs.

To operationalize the variables HRZ_{jt}, BKD_{jt} and FRD_{jt}, computations have been done at two-digit level of NIC and α_{jk} and σ_{jm} have been obtained from the input-output table for India for the year 2007–08 published by the CSO. The values of these variables computed for each two-digit industry for each year have been applied to all domestic firms belonging to those industries for that year.

The regression equation that has been estimated to assess the spillover effects may be written as:

$$\begin{aligned} \ln \mathrm{TFP}_{ijt} = \alpha_0 + \alpha_j + \alpha_t + \beta_1 \mathrm{HRZ}_{jt} + \beta_2 \mathrm{HRZ}_{jt}^2 + \beta_3 \ln \mathrm{BKD}_{jt} \\ + \beta_4 \ln \mathrm{FRD}_{jt} + \gamma X_{ijt} + u_{ijt} \end{aligned} \tag{5.4}$$

In this equation, HRZ, BKD and FRD denote the horizontal spillover, vertical-backward spillover, and vertical-forward spillover, respectively. X denotes firm characteristics, taken as controls for assessing the spillover effects, and γ is the corresponding vector of parameters. A much larger number of firm characteristics[25] have been considered for estimating Eq. 5.4 than done for estimating Eqs. 3.1–3.3 the results of which were presented in Sect. 3. The level of foreign equity participation in the firm is also included among the firm characteristics considered for regression analysis. This helps in verifying the results obtained in Sect. 3 in respect of productivity differences between FDI firms and domestic firms.

When the country source of origin of FDI is taken into account, the spillover variables get split. The foreign share variable (Eq. 5.1) is computed separately for FDI originating from (i) developed countries, (ii) developing countries and (iii) other countries/sources. A similar splitting is down among FDI from USA/Europe, Asia and other countries. This permits separate assessment of horizontal spillover effects for FDI originating from different countries/regions. In a similar manner, the forward spillover variable has been split, which is discussed later.

Attention may be drawn here to possible reverse causality running from productivity to the FDI share variable in the regressions estimated for studying productivity spillover (see Eq. 5.4). Since the fixed effects model has been applied to estimate Eq. 5.4, the presence of reverse causality will affect the parameter estimates obtained. It seems to us, however, that since FDI share is measured at the industry-level and the dependent variable, ln (TFP), is at the firm level, this might not be an issue, at least not a serious one. Yet, some biases in the parameter estimates caused by reverse causality cannot be ruled out.

Two other issues regarding model specification require a brief discussed here. First, in several studies, an equation similar to the one given in Eq. 5.4, or an equation specifying the production function which implicitly incorporates an equation similar to Eq. 5.4 has been estimated. In some of them, the level of TFP is taken as the dependent variable (directly or indirectly) as done here (e.g. Ito et al. 2010; Long et al. 2014), but in other studies, the equation is estimated in difference form so that the dependent variable is defined as the rate of change or the rate of growth in TFP (e.g. Newman et al. 2015). The rationale for estimating the equation in difference form is that it takes care of unobservable firm-specific and industry-specific effects. In this study, the equation has been estimated in the level form, not in the difference form.

Second, the horizontal spillover variable and its squared term have been included in the equation. This form has been used in Xu and Sheng (2012), but one can find several studies in which the squared term of horizontal spillover variable has not been used. Again, it would be noted from Eq. 5.4 that the vertical spillover variables have been taken in logarithms. This has not been done in Javorick (2004), Xu and Sheng (2012) or Long et al. (2014). Indeed, it is hard to find an earlier study in which the vertical spillover variable was taken in logarithms.

[25]Import intensity is one of the explanatory variables considered. As done in the analysis in Sect. 4, this variable has been winsorized at the 99.5th percentile for the analysis presented in this section.

5.2 Empirical Results

5.2.1 Regression Results Disregarding Country of Origin of FDI

The regression equation described above (Eq. 5.4) has been estimated by the fixed effects model. In the first step, this has been done disregarding the country of origin of FDI. The results obtained are presented in Tables 11, 12 and 13.

From the results in Tables 11, 12 and 13, it is found that there is a positive horizontal spillover effect till a threshold in terms of FDI share and an adverse effect occurs on domestic firms as FDI goes beyond that point (probably reflecting the adverse effect of competition faced by domestic firms from FDI firms). It may be mentioned here that the results reported by Xu and Sheng (2012) for Chinese firms is quite similar to

Table 11 FDI spillover effect on firm TFP, fixed effects results, 2000–01 to 2014–15 (dependent variable: ln TFP)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Log FRD	0.138* (0.0766)	0.138* (0.0760)	0.160** (0.0739)	0.160* (0.0822)	0.161** (0.0741)	0.140* (0.0760)
Log BRD			−0.0384 (0.0428)	−0.0384 (0.0352)	−0.0370 (0.0428)	
FDI share	0.0472** (0.0170)	0.0470** (0.0170)	0.0454** (0.0163)	0.0454*** (0.0153)	0.0456*** (0.0161)	0.0472** (0.0167)
FDI share sq.	−0.00228** (0.000810)	−0.00227** (0.000808)	−0.00222*** (0.000782)	−0.00222*** (0.000753)	−0.00224*** (0.000766)	−0.00228*** (0.000792)
Log R&D inten.	0.00297 (0.00185)	0.00302 (0.00183)	0.00296 (0.00180)	0.00296* (0.00159)	0.00292 (0.00180)	0.00297 (0.00184)
Log age	0.338*** (0.0690)	0.338*** (0.0685)	0.337*** (0.0687)	0.337*** (0.0693)	0.336*** (0.0692)	0.337*** (0.0690)
Log liquidity	0.118*** (0.0101)	0.118*** (0.0101)	0.118*** (0.0102)	0.118*** (0.00879)	0.118*** (0.0101)	0.118*** (0.0101)
Log leverage	−0.00549* (0.00306)	−0.00547* (0.00306)	−0.00543* (0.00307)	−0.00543* (0.00317)	−0.00552* (0.00308)	−0.00555* (0.00307)
Foreign share		0.0199* (0.0100)	0.0197* (0.0101)	0.0197* (0.00996)	0.0195* (0.0101)	0.0198* (0.00999)
Log import intensity					0.00307* (0.00173)	0.00312* (0.00169)
Constant	−5.415*** (0.269)	−5.418*** (0.268)	−5.413*** (0.269)	−5.413*** (0.277)	−5.389*** (0.275)	−5.393*** (0.274)
Standard errors	Robust, clustered on 2-digit industry	Robust, clustered on 2-digit industry	Robust, clustered on 2-digit industry	Robust, clustered on 3-digit industry	Robust, clustered on 2-digit industry	Robust, clustered on 2-digit industry
Observations	21,521	21,521	21,521	21,521	21,521	21,521
R-squared	0.057	0.057	0.058	0.058	0.058	0.058
Number of firms	4013	4013	4013	4013	4013	4013

Note Robust standard errors in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
FRD forward linkage, *BKD* backward linkage
Source Authors' computations

Table 12 FDI spillover effect on firm TFP, fixed effects results, 2000–01 to 2014–15, including the effect of trade in services (dependent variable: ln TFP)

Variables	(1)	(2)	(3)	(4)	(5)
Log FRD	0.160* (0.0823)	0.161* (0.0819)	0.165** (0.0820)	0.161* (0.0818)	0.164* (0.0824)
Log BKD	−0.0377 (0.0352)	−0.0370 (0.0352)	−0.0377 (0.0355)	−0.0365 (0.0350)	−0.0360 (0.0348)
FDI share	0.0458*** (0.0152)	0.0456*** (0.0152)	0.0454*** (0.0151)	0.0457*** (0.0152)	0.0464*** (0.0151)
FDI share sq.	−0.00225*** (0.000742)	−0.00224*** (0.000743)	−0.00222*** (0.000744)	−0.00224*** (0.000744)	−0.00227*** (0.000740)
Log R&D inten.	0.00288* (0.00160)	0.00292* (0.00159)	0.00298* (0.00160)	0.00286* (0.00158)	0.00284* (0.00158)
Log age	0.335*** (0.0699)	0.336*** (0.0699)	0.335*** (0.0698)	0.333*** (0.0702)	0.334*** (0.0703)
Log liquidity	0.118*** (0.00881)	0.118*** (0.00881)	0.118*** (0.00881)	0.118*** (0.00885)	0.118*** (0.00886)
Log leverage	−0.00554* (0.00317)	−0.00552* (0.00317)	−0.00543* (0.00313)	−0.00564* (0.00315)	−0.00554* (0.00316)
Log import intensity	0.00308 (0.00191)	0.00307 (0.00191)	0.00298 (0.00191)	0.00260 (0.00201)	0.00258 (0.00200)
Foreign share		0.0195* (0.00999)	0.0197* (0.0101)	0.0190* (0.0101)	0.0191* (0.0102)
Log services export intensity			−0.00137 (0.00239)		
Log export intensity				0.00166 (0.00151)	0.00123 (0.00151)
Log services import intensity					0.00243** (0.00111)
Constant	−5.386*** (0.283)	−5.389*** (0.282)	−5.419*** (0.284)	−5.378*** (0.283)	−5.361*** (0.285)
Times FE	Yes	Yes	Yes	Yes	Yes
Standard errors	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries
Observations	21,521	21,521	21,477	21,521	21,520
R-squared	0.058	0.058	0.058	0.058	0.059
Number of firms	4013	4013	4013	4013	4013

Note Services import intensity = imported services/total services
Robust standard errors in parentheses, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$
Source Authors' computations

Table 13 FDI spillover effect on firm TFP, fixed effects results, 2000–01 to 2014–15, including the effect of trade in services and controlling for firm size (dependent variable: ln TFP)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Log FRD	0.175** (0.0726)	0.156* (0.0825)	0.135 (0.0857)	0.160* (0.0824)	0.156* (0.0822)	0.158* (0.0827)
Log BKD	−0.0193 (0.0233)	−0.0392 (0.0356)		−0.0386 (0.0360)	−0.0376 (0.0356)	−0.0372 (0.0355)
FDI share	0.0387*** (0.0123)	0.0452*** (0.0153)	0.0470*** (0.0156)	0.0452*** (0.0151)	0.0455*** (0.0152)	0.0461*** (0.0151)
FDI share sq.	−0.00182*** (0.000545)	−0.00221*** (0.000753)	−0.00228*** (0.000759)	−0.00221*** (0.000745)	−0.00223*** (0.000744)	−0.00226*** (0.000741)
Log R&D inten.	−0.000798 (0.00149)	0.00309** (0.00148)	0.00312** (0.00150)	0.00313** (0.00149)	0.00303** (0.00148)	0.00303** (0.00149)
Log age	−0.00990 (0.0707)	0.344*** (0.0727)	0.346*** (0.0727)	0.344*** (0.0726)	0.343*** (0.0727)	0.345*** (0.0730)
Log liquidity	0.112*** (0.00828)	0.118*** (0.00903)	0.118*** (0.00901)	0.117*** (0.00905)	0.117*** (0.00910)	0.117*** (0.00912)
Log leverage	−0.0156*** (0.00312)	−0.00524 (0.00323)	−0.00531 (0.00323)	−0.00519 (0.00318)	−0.00537* (0.00320)	−0.00523 (0.00321)
Log sales	0.487*** (0.0274)					
Foreign share	0.0125 (0.0105)	0.0197* (0.00997)	0.0199** (0.00992)	0.0198* (0.0101)	0.0190* (0.0101)	0.0191* (0.0102)
Log total assets		−0.0134 (0.0240)	−0.0173 (0.0240)	−0.0169 (0.0243)	−0.0203 (0.0240)	−0.0224 (0.0244)
Log import intensity			0.00340* (0.00186)	0.00326* (0.00186)	0.00288 (0.00199)	0.00289 (0.00198)

(continued)

Table 13 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Log service export int.				−0.00130 (0.00246)		
Log export intensity					0.00187 (0.00150)	0.00143 (0.00150)
Log services import int.						0.00252** (0.00113)
Constant	−5.231*** (0.279)	−5.407*** (0.273)	−5.383*** (0.278)	−5.407*** (0.280)	−5.364*** (0.278)	−5.345*** (0.279)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Standard errors	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries	Robust, clustered on 3 digit industries
Observations	21,521	21,521	21,521	21,477	21,521	21,520
R-squared	0.189	0.058	0.058	0.058	0.058	0.059
Number of firms	4013	4013	4013	4013	4013	4013

Note Services import intensity = imported services/total services
Robust standard errors in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source Authors' computations

our results. In their estimates too, the coefficient of FDI share is found to be positive and statistically significant and the coefficient of FDI share squared is negative and statistically significant.

As regards the vertical spillover effect, the backward linkage variable has a negative coefficient which is contrary to expectations. The coefficient is not statistically significant. On the other hand, the forward linkage variable has a positive coefficient which is found statistically significant—in some cases at five per cent level and in a larger number of cases at ten per cent level. Evidently, the results are not strong, but there are indications of a positive vertical spillover effect arising from the forward linkage, i.e. firms in a particular industry gaining in productivity from the foreign presence in the upstream industries perhaps through purchase of intermediate inputs and knowledge spillover associated with such business relationship.

The foreign share variable in the results presented in Tables 11, 12 and 13 stands for the share of foreign promoters in the non-FDI firms in the sample. The coefficient of this variable is found to be positive consistently in all equations estimated and statistically significant at ten per cent level in almost all of them. This result is consistent with the findings of the analysis in Sect. 3.

A limitation of the FDI share variable used in the analysis the results of which are reported in Tables 11, 12 and 13 is that the variable has been constructed at two-digit industry level. Since, typically, a wide range of products are covered in a two-digit industry, there is a possibility that FDI presence is predominant in certain segments of the industry and the domestic firms in other segments may not face much competition from foreign firms nor gain from demonstration effect. To address this issue and thus check the robustness of regression results, the FDI share variable has been constructed also at three-digit level and regression analysis has been undertaken with this changed FDI share variable. The results are reported in Table 16 in the annexure. The coefficient of FDI share is found to be positive and statistically significant and the coefficient of the squared FDI share is found to be negative and statistically significant. These results are similar to those reported in Tables 11, 12 and 13.

How do the results obtained in this study in respect of horizontal and vertical spillover compare with the results of earlier studies? It may be mentioned here that a significant positive horizontal spillover effect has been found for Indian manufacturing firm in the study undertaken by Klein (2017). Thus, the findings obtained in this study are in agreement with the findings of Klien. Behera et al. (2012a, b) and Sahu and Solarin (2014) also found evidence of positive FDI spillover effects, and thus, the findings of this study are in accordance with the findings of Behera et al. (2012a, b) and Sahu and Solarin (2014).

At the same time, it needs to be recognized that many earlier studies on FDI spillover for Indian manufacturing have found the spillover effects to be negative or negligible. Evidently, the findings of our study are at variance with the findings of those studies. To discuss here briefly the findings of some recent studies which conflict with the findings of this study, Thakur and Burange (2015) found positive spillover effects through forward and backward linkages, but horizontal spillover effects are found to be negative. Thus, the finding of Thakur and Burange (2015) in regard to forward linkage spillover agrees with our finding, but our findings regarding horizontal spillover and backward linkage vertical spillover differ from the findings of Thakur and Burange. It may be added here that Mondal and Pant (2018) in their recent study note that their initial results indicated negative horizontal spillover effects and insignificant spillover effects through vertical linkages, but from further analysis of the data, they find that the domestic firms with some initial technological capabilities, low technology gap with the foreign firms and high complementary capabilities are able to reap productivity benefits from FDI in contrast to other firms within the industry.

5.2.2 Regression Results Taking into Account Country of Origin of FDI

The model results that are obtained when the country source of origin of FDI is taken into account are presented in Tables 14 and 15. In the regression equation estimates presented in Table 14, only the horizontal spillover variable has been split. Since the estimates for backward linkage vertical spillover is not found to be statistically significant in Tables 11, 12 and 13, splitting of the BKD variable does not seem worthwhile. By contrast, the estimate of forward linkage vertical spillover turned out to be positive and statistically significant in our results. Therefore, splitting of the FRD variable has been done and the results are reported in Table 15.

In trying to split the FRD variable according to country of origin of FDI, some difficulties in model estimation were encountered because of inter-correlation among the FRD variables constructed separately for different country groups/regions. To tackles this problem, only two-way splitting has been done. Thus, in the model results presented in Table 15, FDI from USA/Europe and FDI from Asia are considered for the analysis of vertical spillover through forward linkage, leaving out the other sources of FDI. In the same way, FDI from developed and developing countries are considered, leaving out the other sources.

Model results presented in Tables 11, 12 and 13 above indicated that there is a significant horizontal FDI spillover effect till a threshold level of FDI share. The estimates presented in Table 14 bring out that this result holds for FDI from developed countries, not for FDI from developing countries. Similarly, the significant positive horizontal spillover effect holds for FDI from USA/Europe, not for FDI from Asia. These results are broadly in agreement with the findings of Xu and Sheng (2012) who found that FDI from Westerns firms produces more substantive spillovers than FDI from overseas Chinese firms.

It is interesting to note that when country source of FDI is taken into account the estimates of direct impact of FDI on productivity matches the indirect effect through horizontal spillover. In both cases, the productivity-enhancing effect is greater for FDI from developed countries than developing countries and for FDI from USA/Europe than FDI from Asia.

Turning now to Table 15, it is seen that the vertical spillover effect through forward linkage is statistically insignificant for FDI from developed countries and for FDI from USA/Europe. For FDI from developing countries, the spillover effect appears to be small since the relevant coefficient, though positive, is found to be statistically

Table 14 FDI spillover effect, country source of origin of FDI, 2000–01 to 2014–15 (dependent variable: ln TFP)

Variables	(1)	(2)	(3)	(4)
Log FRD	0.172** (0.0720)	0.194*** (0.0726)	0.192*** (0.0720)	0.231*** (0.0731)
Log BKD	−0.0182 (0.0229)	−0.0106 (0.0222)	−0.0107 (0.0216)	−0.0204 (0.0262)
FDI share	0.0388*** (0.0122)			
FDI share sq.	−0.00182*** (0.000537)			
FDI share_developed		0.0394*** (0.0126)	0.0397*** (0.0125)	
FDI share_developed sq.		−0.00184*** (0.000552)	−0.00185*** (0.000548)	
FDI share_developing		−0.0803 (0.0743)	−0.0773 (0.0744)	
FDI share_developing sq.		−0.00307 (0.0130)	−0.00360 (0.0130)	
FDI share_other		0.0461 (0.0295)	0.0472 (0.0297)	
FDI share_other sq.		−0.00298 (0.00526)	−0.00326 (0.00531)	
FDI share_US/Europe				0.0450*** (0.0152)
FDI share_US/Europe sq.				−0.00211*** (0.000750)
FDI share_Asia				−0.00226 (0.0126)
FDI share_Asia sq.				3.58e−05 (0.000700)
FDI share_othercountries				0.0496 (0.0301)
FDI share_othercountries sq.				−0.00428 (0.00514)
Log R&D intensity	−0.000972 (0.00146)	−0.00105 (0.00144)	−0.00104 (0.00144)	−0.000957 (0.00146)
Log age	−0.00398 (0.0723)	0.00249 (0.0707)	0.00245 (0.0711)	0.00139 (0.0720)
Log sales	0.485*** (0.0278)	0.485*** (0.0273)	0.486*** (0.0274)	0.484*** (0.0275)

(continued)

Table 14 (continued)

Variables	(1)	(2)	(3)	(4)
Log liquidity	0.113*** (0.00826)	0.113*** (0.00833)	0.113*** (0.00837)	0.113*** (0.00823)
Log leverage	−0.0157*** (0.00305)	−0.0156*** (0.00303)	−0.0155*** (0.00303)	−0.0157*** (0.00301)
Foreign share	0.0124 (0.0105)	0.0119 (0.0105)	0.0119 (0.0105)	0.0130 (0.0105)
Services import intensity	8.53e−05*** (3.13e−05)		8.51e−05*** (3.18e−05)	
Constant	−5.238*** (0.282)	−5.284*** (0.273)	−5.282*** (0.274)	−5.377*** (0.292)
Standard errors	Robust, clustered on 3 digit industry	Robust, clustered on 3 digit industry	Robust, clustered on 3 digit industry	Robust, clustered on 3 digit industry
Time fixed effects	Yes	Yes	Yes	Yes
Observations	21,623	21,626	21,623	21,626
R-squared	0.189	0.189	0.190	0.189
Number of firms	4018	4018	4018	4018

Note Robust standard errors in parentheses, $***p < 0.01$, $**p < 0.05$, $*p < 0.1$
Services import intensity = imported services/total services
Source Authors' computations

significant only at 10% level. By contrast, the coefficient for FDI from Asia is positive and statistically significant at one per cent level.

To check robustness of these results in respect of vertical spillover effect through forward linkage reported in Table 15, the models have been re-estimated with a slight change in specification; the forward linkage spillover variable has been used as it is without taking logarithms (as done in several earlier studies). These results are shown in Table 17 in the annexure. The results in respect of the forward linkage variables in Table 17 are similar to those in Table 15. The vertical spillover effect through forward linkage is found to be statistically insignificant for FDI from developed countries and for FDI from USA/Europe, as in Table 15. Also, the coefficient of the forward spillover effect of FDI from developing countries is found to be statistically insignificant. The coefficient for FDI from Asian countries is found to be statistically significant which matches the results in Table 15.

The results in Table 15, considered along with the results in Table 17 in Annexure, suggest that FDI from Asian countries has contributed in a significant measure to productivity increase of domestic firms through forward linkage vertical spillover effects. Since such an effect is not found for developing countries, it appears that the observed positive vertical spillover effect through forward linkage is attributable mainly to the contributions being made by Japanese investment in India.

Table 15 FDI spillover effect, country source of origin of FDI, 2000–01 to 2014–15, additional results (dependent variable: ln TFP)

Variables	(1)	(2)	(3)	(4)	(5)
Log FRD_US/Europe	0.0183 (0.0711)	0.0335 (0.0647)	0.0325 (0.0642)		
Log FRD_Asian	0.0810** (0.0401)	0.108*** (0.0371)	0.106*** (0.0380)		
Log FRD_Developed				0.0912 (0.0685)	0.0897 (0.0679)
Log FRD_Developing				0.0544* (0.0289)	0.0532* (0.0294)
Log BKD	−0.0390 (0.0347)	−0.0237 (0.0221)	−0.0238 (0.0217)	−0.0184 (0.0217)	−0.0185 (0.0212)
FDI share	0.0397*** (0.0149)	0.0311** (0.0124)	0.0312** (0.0125)	0.0355*** (0.0123)	0.0356*** (0.0123)
FDI share sq.	−0.00210*** (0.000733)	−0.00164*** (0.000525)	−0.00164*** (0.000525)	−0.00175*** (0.000530)	−0.00175*** (0.000529)
Log (R&D intensity)	0.00288* (0.00155)	– 0.000972 (0.00147)	−0.000967 (0.00147)	−0.000933 (0.00146)	−0.000929 (0.00146)
Log age	0.340*** (0.0711)	−0.00585 (0.0721)	−0.00590 (0.0724)	−0.00349 (0.0719)	−0.00360 (0.0723)
Log liquidity	0.119*** (0.00867)	0.113*** (0.00820)	0.113*** (0.00823)	0.113*** (0.00819)	0.113*** (0.00822)
Log leverage	−0.00560* (0.00309)	−0.0157*** (0.00305)	−0.0157*** (0.00305)	−0.0156*** (0.00305)	−0.0156*** (0.00305)
Foreign share	0.0193* (0.00985)	0.0120 (0.0104)	0.0120 (0.0104)	0.0124 (0.0105)	0.0125 (0.0105)
Log (size)		0.486*** (0.0276)	0.486*** (0.0277)	0.484*** (0.0277)	0.485*** (0.0278)
Services import intensity			8.55e−05*** (3.19e−05)		8.50e−05*** (3.15e−05)
Constant	−5.076*** (0.239)	−4.858*** (0.240)	−4.859*** (0.240)	−4.991*** (0.236)	−4.990*** (0.236)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	21,626	21,626	21,623	21,626	21,623
R-squared	0.058	0.189	0.190	0.189	0.189
Number of firms	4018	4018	4018	4018	4018

Note Robust standard errors in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Services import intensity = imported services/total services
Source Authors' computations

6 Conclusion

The paper investigated the productivity-enhancing effects of FDI in Indian manufacturing firms, with a particular focus on the differences in FDI impact according to the county of origin of FDI. Data on about 7000 manufacturing companies drawn from Prowess, covering the period 2000–01 to 2014–15, were used for the analysis. A comparison of TFP was made between domestic firms and FDI firms. Then, an analysis of the impact of foreign acquisition of domestic firms on TFP in those firms was undertaken with the help of treatment effect assessment methods. An analysis of productivity spillover from FDI firms to domestic firms was undertaken with the help of regression analysis, considering both horizontal and vertical spillover effects. A comparative analysis of horizontal spillover effects and forward linkage vertical spillover effects by the country of origin of FDI was undertaken, making a distinction between FDI from developed and developing countries and also between FDI from USA/Europe and that from Asian countries.

The main findings of the study are as follows:

- FDI firms have higher TFP than comparable domestic firm.
- FDI firms with FDI from developed countries have higher TFP than such firms with FDI from developing countries.
- FDI firms with FDI from USA/Europe have higher TFP than such firms with FDI from Asia.
- Acquisition of equity in a domestic firm by a foreign firm (beyond a threshold of 10%) has a significant positive effect on TFP of the domestic firm. Generally, this effect is present when the investment is made by a firm from a developed country, but not when the investment is made by a firm from a developing country. Similarly, acquisition of equity in a domestic firm by a foreign firm belonging to USA or Europe often raises the TFP in the domestic firm, but this does not hold for foreign equity participation from a firm in Asia.
- Empirical evidence presented in the paper indicates presence of significant positive horizontal FDI spillover effects, leading to increases in productivity of domestic manufacturing firms in India. Such an effect is found for FDI originating in developed countries, particularly USA and Europe. But, the effect is nil or negligible when we consider FDI originating from developing countries or FDI originating in Asian countries.
- Empirical evidence presented in the paper indicates that vertical spillover effect through backward linkage is negligible or at best rather limited. Estimates of vertical spillover effect through backward linkage were found to be negative and statistically insignificant. On the other hand, the empirical results are indicative of a significant positive vertical spillover effect through forward linkage. The observed forward linkage vertical spillover effect seems to be relatively stronger for FDI from Asian countries, particularly Japanese investment in India.

One limitation of the analysis presented in the paper is that fully owned foreign companies operating in India are not included in the Prowess database. As a result, some well-known companies are missing. This has affected the measurement of spillover variables, and thus affected the econometric estimates of spillover effects. Many of the earlier studies on FDI spillover in India have been based on Prowess, and therefore share this limitation.

The finding of the study that FDI in India from Asian countries does not have a significant positive effect on productivity of domestic manufacturing firms in India (except for forward linkage vertical spillover effect arising probably from Japanese FDI) needs further scrutiny. Further investigation needs to be carried out to verify this finding of this study. It is important to make an attempt to understand why investments of Asian country firms in India particularly those from developing countries of Asia have not contributed to productivity improvement in Indian domestic firms.

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Annexure

See Tables 16 and 17.

Table 16 Robustness checks with FDI share calculated at the three-digit industry level

Variables	(1)	(2)	(3)	(4)	(5)
	Model 1	Model 2	Model 3	Model 4	Model 5
Log FRD	0.154* (0.0856)	0.154* (0.0860)	0.155* (0.0858)	0.171** (0.0748)	0.151* (0.0858)
Log BKD	−0.0459 (0.0365)	−0.0448 (0.0362)	−0.0442 (0.0360)	−0.0229 (0.0244)	−0.0453 (0.0366)
FDIshare_3digit	0.0124* (0.00725)	0.0128* (0.00724)	0.0128* (0.00726)	0.0144** (0.00592)	0.0126* (0.00728)
FDIshare_3digit_sq	−0.000338*** (9.95e−05)	−0.000346*** (9.92e−05)	−0.000344*** (9.90e−05)	−0.000324*** (7.80e−05)	−0.000340*** (9.91e−05)
Log (R&D intensity)	0.00278* (0.00154)	0.00274* (0.00154)	0.00268* (0.00153)	−0.00105 (0.00145)	0.00284* (0.00143)
Log (age)	0.341*** (0.0703)	0.341*** (0.0705)	0.338*** (0.0709)	−0.00488 (0.0709)	0.348*** (0.0748)
Log (liquidity)	0.119*** (0.00867)	0.120*** (0.00873)	0.120*** (0.00876)	0.113*** (0.00822)	0.119*** (0.00902)
Log (leverage)	−0.00572* (0.00307)	−0.00561* (0.00307)	−0.00574* (0.00307)	−0.0159*** (0.00307)	−0.00548* (0.00311)

(continued)

Table 16 (continued)

Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5
Foreign share	0.0199* (0.0100)	0.0199* (0.0101)	0.0194* (0.0102)	0.0124 (0.0104)	0.0194* (0.0102)
Log (services import intensity)		0.00262** (0.00110)	0.00244** (0.00110)		0.00251** (0.00111)
Log (export intensity)			0.00146 (0.00143)		0.00168 (0.00139)
Log (sales)				0.486*** (0.0275)	
Log (total assets)					−0.0185 (0.0246)
Constant	−5.290*** (0.279)	−5.262*** (0.282)	−5.250*** (0.284)	−5.149*** (0.267)	−5.240*** (0.278)
Times fixed effects	Yes	Yes	Yes	Yes	Yes
Standard error	Cluster robust	Cluster robust	Cluster robust	Cluster robust	Cluster robust
Observations	21,626	21,622	21,622	21,626	21,622
R-squared	0.057	0.058	0.058	0.188	0.058
Number of firms	4018	4018	4018	4018	4018

Notes Robust standard errors in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, standard error clustered on three-digit industries. FDI share has been contrasted at the three-digit level

Table 17 FDI spillover effect, country source of origin of FDI, 2000–01 to 2014–15, Additional results with changed specification (dependent variable: ln TFP)

Variables	(1)	(2)	(3)	(4)
FRD_Developed	0.0165 (0.0162)	0.0117 (0.0153)		
FRD_Developing/other		0.0470 (0.0320)		
FRD_US/Europe			0.0142 (0.0175)	0.00365 (0.0168)
FRD_Asia/other				0.0617** (0.0281)
Log BKD	−0.00634 (0.0247)	−0.0149 (0.0260)	−0.00477 (0.0247)	−0.0187 (0.0267)
FDI share	0.0377*** (0.0126)	0.0356*** (0.0116)	0.0378*** (0.0126)	0.0343*** (0.0117)
FDI share sq	−0.00183*** (0.000545)	−0.00173*** (0.000507)	−0.00184*** (0.000547)	−0.00170*** (0.000509)
Log (R&D intensity)	−0.000945 (0.00146)	−0.000949 (0.00146)	−0.000938 (0.00146)	−0.000953 (0.00145)
Log age	−0.00426 (0.0724)	−0.00650 (0.0722)	−0.00441 (0.0724)	−0.00695 (0.0728)

(continued)

Table 17 (continued)

Variables	(1)	(2)	(3)	(4)
Log liquidity	0.113*** (0.00828)	0.113*** (0.00832)	0.113*** (0.00829)	0.113*** (0.00833)
Log leverage	−0.0156*** (0.00306)	−0.0157*** (0.00304)	−0.0156*** (0.00306)	−0.0157*** (0.00303)
Foreign share	0.0122 (0.0107)	0.0124 (0.0107)	0.0122 (0.0107)	0.0124 (0.0106)
Log (size)	0.485*** (0.0279)	0.486*** (0.0277)	0.485*** (0.0279)	0.486*** (0.0277)
Services import intensity	8.50e−05*** (3.16e−05)	8.52e−05*** (3.17e−05)	8.48e−05*** (3.16e−05)	8.53e−05*** (3.17e−05)
Constant	−5.014*** (0.238)	−5.016*** (0.233)	−4.999*** (0.241)	−4.992*** (0.234)
Time fixed effects	Yes	Yes	Yes	Yes
Observations	21,623	21,623	21,623	21,623
R-squared	0.188	0.189	0.188	0.189
Number of firms	4018	4018	4018	4018

Note Robust standard errors in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Services import intensity = imported services/total services
Source Authors' computations

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Knowledge Spillover Mechanisms

Stanley Nollen

1 Introduction

The typical question asked about knowledge spillovers is do they occur? The answer to this question in the empirical literature is mixed. The mixed findings may be the result of the multiple pathways by which knowledge spillovers can be realized, by the chances of negative as well as positive spillovers and by imprecise measurement.

In this paper, we ask a different question: How do knowledge spillovers occur? Under what conditions do knowledge spillovers occur and when do they not occur? Here, we take up cases in which company managers report giving or receiving knowledge. We analyze the pathways of knowledge spillovers and illustrate them using experiences form Vietnamese software firms.

We define knowledge spillovers to be the unintentional and nearly costless transfers of knowledge from a leader to a follower. They are externalities (usually thought to be positive).[1] It is peer-to-peer learning. Knowledge spillovers may be horizontal (intra-industry)—between firms in the same business—in which case the firms are potential competitors. Or they may be vertical (inter-industry)—across stages of the value chain, upstream to suppliers or downstream to assemblers or distributors—in which case the firms may be customers. We can think of knowledge spillovers as a type of technology transfer or diffusion. The source, from whom knowledge flows, is a particular firm or a business unit in that firm, or a small set of people, or an

[1]Because knowledge spillovers are externalities, too little knowledge may be produced. For example, technical knowledge spillovers may cause the recipient firm to reduce its own R&D spending. See Heggedal et al. (2017) on the topic of externalities and spillovers from labor mobility.

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individual actor devoted to a particular task. The source is the leader. The follower who receives the knowledge similarly may be any one of these units of analysis.

Why do firms care about knowledge spillovers? The answer is that knowledge is the currency of competitive advantage. If we understand the pathways of knowledge spillovers, we understand the potential for gain or loss of knowledge. This applies especially to tacit or intangible knowledge that is difficult to obtain otherwise. Because it is nearly zero cost to obtain, it may be an underappreciated source of competitiveness.

The research questions in this study are:

(1) What exactly are the knowledge spillovers? What are the sources?
(2) What is the spillover transmission pathway? How does knowledge get from leader to follower?
(3) What is the cost, direct and indirect, perceived or measured, of the spillover to the recipient and to the leader companies?
(4) How much value does the knowledge spilled over have? How is that value assessed?

2 Types of Knowledge Spillover Pathways

We categorize the pathways or transmission mechanisms for knowledge spillovers into three types:

1a. Observation and imitation. Horizontal
1b. Managerial interaction. Horizontal

The follower firm observes the knowledge practices of the leader firm and adapts them to its own purposes (it is a demonstration effect). Employees attend organized conferences and training programs to gain knowledge intentionally. But spillovers may take place from informal sidelines conversations and professional relationships formed there. Company managers meet formally in business meetings and industry association events and exchange ideas, or they meet informally socially (at lunches or on the golf course). Here also, informal conversations take place that my yield spillovers. Although we distinguish spillovers from intentional learning, such as training programs, both often occur simultaneously. They are complementary (Isaksson et al. 2016).

2. Labor mobility. Horizontal and vertical

There are two pathways by which labor mobility can produce knowledge spillovers. First, the leader firm attracts more skilled labor to the geographic area, trains existing labor, and thereby enlarges the skilled labor pool. Follower firms can then find better employees more easily without incurring additional recruiting cost. Second, employees move from a leader firm to a follower firm and take with them the knowledge gained at the leader firm for use at the follower firm. If the follower firm seeks a particular employee with specialized knowledge that it needs but does not have from a leader firm, it is “poaching.” Employees from a leader firm may also shift to a follower firm on their own initiative.

For example, if a new small software services company lacks critical skills needed to complete its package of services to clients, it hires an expert experienced person from another larger firm to obtain the skills needed.

3. Value chain upgrading. Vertical

The leader firm that is a new entrant attracts new upstream suppliers or downstream distributors that have better quality and reliability, or it trains existing suppliers and distributors to be better performers. This pathway is typically associated with foreign direct investment. For example, a foreign firm begins operations in an emerging market economy and works with local suppliers to upgrade their quality and reliability; other local firms can utilize the same upgraded suppliers. In addition, the leader firm may develop or import better capital equipment than was previously used, and follower firms develop or import similar capital equipment. This is an imitation pathway that does not depend on personal interaction.

Competitive Pressure

A fourth pathway is often mentioned, which is competitive pressure. However, we treat it differently. Competitive pressure differs from the three pathways described above insofar as it is an external force that serves as a motivator for follower firms to improve their performance; it is not a method by which knowledge moves from one firm to another.

3 The Role of Foreign Direct Investment

Much of the empirical research on knowledge spillovers is set in an emerging market or region or country. Foreign direct investment (FDI) is the explanatory variable. The availability and value of knowledge spillovers would appear to greatest in this setting. The basis for this approach is that foreign firms must have a firm-specific advantage in order to compete successfully in the local market. If that advantage is to some extent technological or managerial consisting of knowledge that can be transferred and learned by others, then FDI can be a source of knowledge spillovers through any of the pathways described. There is a substantial literature that shows that usually multinational corporations are more productive than domestic firms (e.g., see Helpman, Melitz, and Yeaple 2004).

This implies that foreign-invested operations are leaders and local firms are followers. Much of the literature adopts this posture. However, it need not be the case. Knowledge leadership in specific domains can be sourced from local firms also. The same firm can be both a leader and a follower. A single firm may be a follower for some technical or managerial knowledge but a leader in other areas.

The potential for knowledge spillovers from FDI is variable. It depends on the market-seeking or resource-seeking objective of the foreign investor, whether the FDI is greenfield or by merger and acquisition, and whether the operation is a joint venture with a local firm.

If the foreign-invested operation is a resource-seeking export platform (and imports a substantial share of components), it is minimally engaged with the local host country economy. The scope for knowledge spillovers is limited (Meyer and Sinani 2009). On the other hand, FDI that is market seeking from services firms is very much engaged in the local economy with corresponding chances for knowledge spillovers.

Greenfield FDI is likely to offer more opportunities for knowledge spillovers to be realized than foreign investment by merger or acquisition (Perri and Peruffo 2016), at least in the short run. If a new operation is built with new employment opportunities and the introduction of new technologies, local people are more engaged. A local operation that is acquired will likely undergo change at the behest of the new foreign owner, but the scale of change and the time frame is surely longer.

International joint ventures, whether equity or non-equity, should be an especially promising source of knowledge spillovers because of the close relationship between the foreign and domestic partners. This affords accessible opportunities for knowledge spillovers via the channels of observation and imitation and informal managerial interaction.

A joint venture between an MNC and a local company has multiple possible outcomes for knowledge spillovers. The local partner may find no more knowledge spillover opportunity than a free-standing local firm if the MNC partner does not transfer its most valuable knowledge, particularly if the knowledge is proprietary intellectual property (Malik 2015) and the joint venture is minority foreign-owned. On the other hand, the fact that the joint venture is a partnership implies more opportunity for observation, imitation, and managerial interaction—the pathway is more available. The joint venture also implies a measure of trust.

Empirical evidence that links FDI and the performance of domestic firms is mixed, with positive, negative, and no relationships found (e.g., Poole 2011; Caves 1974; Persson and Blomstrom 1983; Blomstrom 1986; Aitken and Harrison 1989, 1999; Haddad and Harrison 1993; Irsova and Hravanek 2013). The mix of results may be in part due to the way in which measurements are taken along with the sample studied.

4 The Measurement of Spillovers

If knowledge spillovers take place, the performance of the follower or recipient firm should be improved: Greater productivity and efficiency, lower costs, improved product or service quality, higher sales revenue, or increased market share or profitability. Differences in knowledge spillovers are hypothesized to be associated with differences in total factor productivity (Jude 2016; Girma and Gorg 2005). As always, a set of control variables is required to attempt to find the partial effect on knowledge spillovers.

Empirically, most studies measure spillovers by the intensity of foreign presence or participation in the local market. For horizontal spillovers, that indicator is the ownership stakes of foreign firms and the sales revenue of foreign firms as a share of all firms in the market. For vertical spillovers, a more targeted indicator is the share of the foreign firm's output that is purchased from all firms in the market (backward) or sold to all firms in the market (forward). These data typically are not available; a surrogate measure is the share of the industry's output that is purchased from upstream industries or sold to downstream industries (Jude 2016). This measure reveals the volume of inter-industry transactions within the market but does not pinpoint the activity of foreign firms.

In firm-level studies of knowledge spillovers in emerging market economies, horizontal spillovers tend to be negative (Mondal and Pant 2016), whereas, in developed countries, horizontal spillovers tend to be positive. It appears that the effect of spillovers depends to some extent on the size of the firm. Many local firms are small or medium-sized with limited absorptive capacity. They do not have the human or financial resources to absorb new knowledge sufficiently. They cannot compete with the typically larger foreign firms or advanced larger domestic firms and they lose market share. Their performance as measured is harmed and the effect of spillovers is negative. However, if local firms are heterogeneous (different sizes, ages, and productivities), then some will not fit the aggregate finding. Some small firms in developing countries will gain competitiveness due to knowledge spillovers (Table 1).

Table 1 How knowledge spillovers depend on absorptive capacity and foreign firm presence

	Foreign firm presence via direct investment	
Absorptive capacity	High	Low
High	Positive horizontal spillovers	Small positive spillovers
Low	Negative horizontal spillovers	No net spillovers

These measures of spillovers are quite macro. Even if the unit of analysis is the firm, they do not measure actual spillovers, but only the potential for spillovers. They do not tell us where the spillover-induced performance change comes from and consequently do not help us to understand how spillovers do or do not contribute to the firm's performance. We need to open the "black box."

5 Knowledge Gap and Absorptive Capacity

The greater the gap in the knowledge possessed by the leader firm compared to the follower firm, the greater the potential for knowledge spillover. There is more to be learned—spilled over (Girma and Gorg 2005; Jovanovic and Rob 1989). But for the spillover to occur, the follower firm must have the ability to learn it, to take it in, and adapt it to its own uses. Does it have sufficient absorptive capacity? Firms are heterogeneous on this respect (Aitken and Harrison 1999; Javorcik 1989).

The firm's absorptive capacity depends on a microsense on the ability of its employees to comprehend and take in the leader firm's knowledge. The employee's capability to absorb new knowledge, in turn, depends on their formal education, training on the job, and relevant experience. Surely one interacts with another, but is one more important than another? Empirical evidence suggests that experience is critical (e.g., Balsvik 2011). Absorptive capacity may also be aided by the technological similarity between the leader and the follower firms, although this effect was not found by Isaksson et al. (2016).

In a macrosense, absorptive capacity depends on the setting in which the newfound knowledge might be implemented—inter-firm networks, organizational culture, financial resources—nor only the individual's capabilities.

The relationship between the size of the knowledge gap and the amount of knowledge spillover is curvilinear—an inverted U shape. A knowledge gap that is too great yields less, not more, spillovers (Girma and Gorg 2005).

The content of the knowledge possessed by the leader firm is also important. We can associate a low knowledge gap with adaptive spillovers—applying known methods to a local situation—and a high knowledge gap with innovative spillovers—knowledge that is new to the region, country, or world (not just to the follower firms). A high knowledge gap with innovative knowledge content is likely to have high intellectual property content, be proprietary, and be specialized. In this case, less is spilled over either because the intellectual property is protected or because it is less applicable to the range of uses that the recipient has for it (Fig. 1).

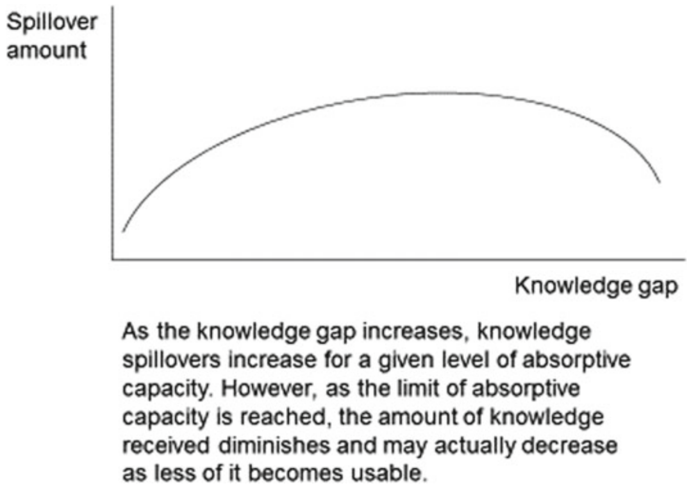


Fig. 1 The curvilinear relationship between knowledge gap and spillovers

A local firm with a high level of human capital in its workforce, and substantial absorptive capacity, may actually receive a small amount of knowledge spillovers if the high level of human capital implies a high beginning level of knowledge with less to learn—a small knowledge gap.

6 The Observation–Imitation–Interaction Pathway

To gain knowledge unintentionally would appear to be ubiquitous. Yet it is difficult to ascertain the extent to which it occurs and its value. If the spillover comes easily and informally, how much can it be worth? Furthermore, knowledge spillovers from observation at training programs, or in the course of doing normal business with customers, occur simultaneously. They are complementary to intentional learning.

Follower firms that are co-located or agglomerated with leader firms in clusters have greater opportunities to benefit from knowledge spillovers. The observation–imitation–interaction pathway is more available geophysically (Perri and Peruffo 2016). Events in which company people can meet informally are more frequent and the direct costs of travel are smaller.

Case 1. Domain Knowledge Spillovers from Observation and Interaction
LARION is Vietnamese-owned software services company located in Ho Chi Minh City. Its business is developing software applications and managing data, focusing on the health care, banking, real estate, and education verticals. The

company was founded in 2003 and now exports services to 15 countries with a staff of 150 people. The company has had a large US healthcare industry customer for the past eleven years. The relationship is close and collaborative. From knowledge spillovers from its customer contact, LARION has gained domain knowledge; it understands the healthcare business in the USA.

The work that LARION does for the US company is “data normalization.” It is software developed by LARION using artificial intelligence. The task that is accomplished is to identify items, products, people, locations, companies, codes, geographies that are the same despite bearing two or more different names or numbers. For example, MMM and 3 M are the same company. After the data are normalized, the next task is to classify the items into meaningful groups, such as companies. This work is used by the customer to improve its supply chain management.

At the outset of this business, the US client sent two or three of its people to Vietnam for 2–3 weeks; this occurred roughly 10 times. In turn, LARION sent 2–3 of its people to the USA. In between times, online communication was continued. This type of training of a new supplier by the customer is intentional and standard practice. But LARION’s management believes that the knowledge acquired by LARION people far exceeded the content of the formal training. LARION people gained domain knowledge above and beyond the intentional training—maybe 70% of the domain knowledge LARION people acquired came via the knowledge spillover pathway. The repeated onsite interactions enabled the tacit knowledge component of domain knowledge to be gained.

In the course of executing its contract with the US company, LARION made an additional discovery: the same software that is developed to be used in supply chain management could also be used in e-commerce marketing/sales. To gain this knowledge is not a direct knowledge spillover because its source was not the US customer directly; it was created by LARION people. However, this new knowledge was an indirect result of the customer contact and the associated knowledge spillover that yielded the domain knowledge.

If the knowledge spillover received by LARION is to be useful, LARION must have sufficient absorptive capacity to comprehend it, and there must be an outlet for it. In this case, LARION reports sufficient absorptive capacity because all of its people engaged in the US firm’s contract are engineering or business administration graduates; some have master’s degrees (about 10–20%), with experience ranging between five and 20 years. They had both formal learning capabilities and the experience to apply the new knowledge.

The value or use to be made from the spilled-over domain knowledge is not to get another US healthcare company as a customer—this is barred by confidentiality and non-disclosure provisions. Instead, it finds value in strengthening LARION’s relationship to the US company. This results in more and bigger contracts. It makes the relationship with the US client “sticky.”

In summary, knowledge spillovers occurred, consisting mainly of the tacit knowledge component of domain knowledge. They were complementary with intentional training. Their value consisted of strengthening LARION's relationship with its US customer that yields a long-term future flow of new business.

Case 2. Managerial Knowledge Spillovers from Observing a Partner Firm: Two Cases

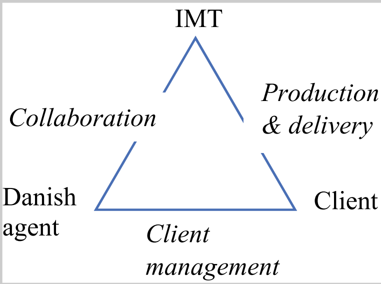
IMT Solutions is a nine-year old-Vietnamese-owned company with 150 employees. It has clients in the USA, Europe, Japan, Australia, and Southeast Asia. It is a software services provider that does custom application development, engineering processes, and testing. It is a Microsoft partner.

Case 2a.

IMT has a partner firm in Denmark with whom it works. The Danish firm acts mainly as an agent to get customers for whom IMT does the work. The customers are mainly software products firms or platform makers in Denmark. IMT was connected to the Danish firm initially in a Denmark–Vietnam business-to-business event promoted by the Danish government.

The Danish agent manages the customer relationship. IMT uses its technology to produce and deliver the service to the customer. IMT interacts with the customer as part of its contract fulfillment. IMT is paid by the customer; the Danish agent takes a commission.

Frequently, IMT observes that its Danish agent offers to its customers an alternative business model—to establish operations in Vietnam in a captive cost center instead of outsourcing—to achieve greater control. The Danish agent offers assistance to the customer to set up its own operations; it means new business for the Danish agent but less business for IMT. However, IMT observes that this offer is seldom taken up and the Danish agent's customer does not follow through on the plan suggested.



What is the knowledge spillover to IMT from observing this business dynamic? It is a lesson in customer relations. It is that good customer relationships require that one speaks the customer's language (figurately as well as literally), know the customer's needs, and is flexible to meet them. By observing the agent's (ineffective) practices, IMT gains knowledge about how to manage other customers.

Case 2b.

IMT is a partner and supplier to the US-owned software platform maker. Observing the way in which a business crisis in this relationship was handled was another spillover of value to IMT. The US platform maker's client was a Japanese telecom company. IMT supplies software to the US platform maker that is in turn sold to the client.

In the case at hand, the completed software package created by IMT for its US platform maker partner and supplied to its Japanese client did not run correctly on the client's server. This was a surprise because the Java-based software had been used routinely for this type of job by IMT and many others.

How was the crisis resolved? The US platform maker sent its Japan team including the country manager to its Japanese telecom client immediately. Its US team was also engaged. Oracle, the producer of Java, was engaged. Work continued for 24 h around the clock. IMT suspected the problem was in the server hardware and ran laboratory-type experiments. All the players took responsibility for solving the problem. It was proactive. No one was blamed and charged with finding the answer. Each company's team collaborated continuously. It was not acceptable to devise a temporary work-around; the solution had to be whole and permanent. In the end, the source of the problem was the Japanese client's server. It was a hardware fault. It was an unusual combination of Java, the US platform maker's software supplied by IMT, and the hardware itself. The solution was the system.

The knowledge spillover gained by IMT was the way in which the crisis was handled and resolved. It was a lesson in crisis management that could be used again for future crises.

7 The Labor Mobility Pathway

Labor mobility is the main channel for knowledge spillovers (Jude 2016). It arises both when the employee moves by his or her own initiative from one firm to another, and when the employee is specifically sought by the receiving firm and hired away from the firm to which he or she goes. Most labor mobility yields horizontal spillovers, although mobility from supplier to assembler or conversely can also take place.

The extent to which spillovers from labor mobility take place depends on an array of conditions.

- Typically skilled and experienced labor moves from large to small companies. The small companies are less able to train workers both due to lack of money and time spent away from work.
- Labor mobility is likely to be greater among firms in a cluster compared to firms separated by geographic distance because of the relative ease of moving short distances.
- Labor mobility should be especially important in emerging market economies in which absorptive capacity is limited and therefore the imitation channel is limited.
- If knowledge is tacit, labor mobility can be an effective pathway for knowledge spillovers, whether horizontal or vertical.
- The short-term value of knowledge spillovers is likely to be greatest when the mobile employees possess specific technical or managerial skill that matches the immediate needs of the recipient firm.

If a firm purposefully seeks the mobile employee, it is poaching. Firms that are head-to-head competitors in a cluster may tacitly agree to minimize or ban poaching. On the other hand, the risk of losing competitive advantage is small in the short run if the exiting employee's specific knowledge is too partial to be a threat unless it is combined with other pieces of knowledge that the recipient firm has yet to develop. The leader firm that loses an employee via poaching may regard the loss as an affirmation of its strength. In any event, a roughly equal poaching trade balance minimizes concern about poaching, especially if the specific knowledge becomes quickly obsolete.

Poaching is a term that is infrequently used by Vietnamese software executives. This may be due to the fact that the industry is young and fast growing and the firms in it are usually not head-to-head competitors.

Empirically, greater labor mobility is associated with greater employment by foreign-invested firms in the market, and intra-industry horizontal labor mobility is associated with higher productivity (Jude 2016).

The experience of the employee who moves is more important than his or her formal education in explaining the productivity gain in the follower firm from the labor mobility channel (Balsvik 2011).

Case 3. Knowledge Spillovers from Labor Mobility: Disappointing Outcomes for Savvycom

Savvycom is owned and located in Vietnam. It develops software applications for mobile devices and websites, and it provides software testing services. Most of its revenue is earned from exports. It is a small company (less than 100 employees) and it is young (less than 10 years since founding).

In 2014, the company hired a person with testing experience and expertise away from a much larger and well-known Vietnamese software firm. The new employee made the shift of employers because of a belief that promotion opportunities were limited in the current large company, and because a salary was offered by Savvycom that was about 10% above the market rate. The shift was within the same geographic cluster so that the costs to make the shift were low.

The need for Savvycom was to find a testing team leader who could revise and improve the firm's testing process, including shifting it from manual to automated. This included adjusting employees' job descriptions, creating internships, and organizing events that would showcase the company's capabilities and establish its brand. The target new employee was well acquainted with organizations that conferred certifications that the company sought to achieve.

Some of the performance that the company expected the new employee to achieve consisted largely of tangible or explicit knowledge. Job descriptions are written. Internships are defined and concrete. Showcase events are literal. Certifications follow specific and well-known procedures. On the other hand, conversion from manual to automated testing includes an element of tacit knowledge. Nevertheless, the success of transferring the knowledge to the incumbent employees depended in part on tacit knowledge—observation and interaction between new team leader and existing team members. In fact, it was this element of absorptive capacity that stood in the way of full success of the labor mobility.

The expectations that Savvycom had for upgrading its testing services business were not completely fulfilled. It was not from lack of education among its employees. It could be seen as lack of experience—attributed to an age gap between the new employee and the no-experience young incumbent workers. A knowledge gap was present and could not be overcome.

In summary, knowledge spillovers were limited because there were a sizable knowledge gap and absorptive capacity limited by an experience gap between new team leader and existing employees. Knowledge spillovers due to labor mobility, in this case, were positive but small.

8 The Double Effect of Competitive Pressure: Positive and Negative Spillovers

Among the knowledge spillover channels described above, competitive pressure is qualitatively different. It is not a transmission mechanism that connects or runs from leader to follower. Instead, it is an external force to the follower firm (Fig. 2).

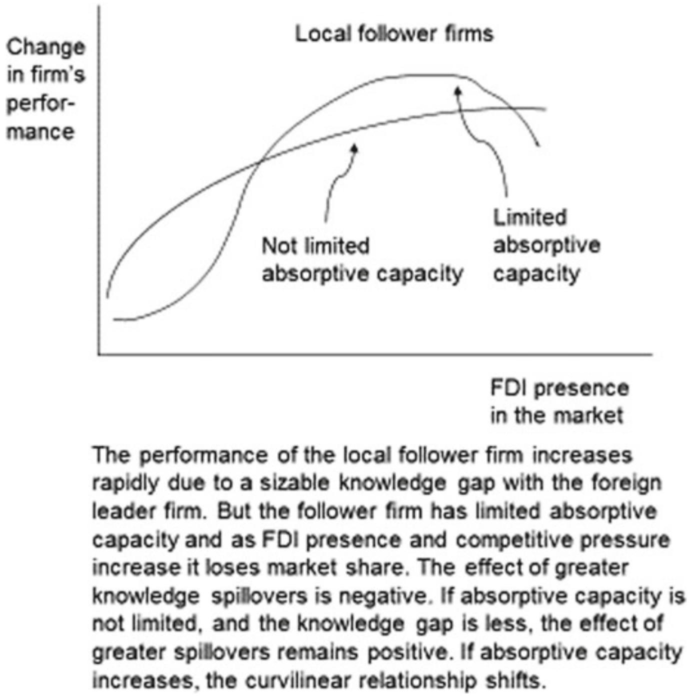


Fig. 2 How absorptive capacity moderates the effect of FDI on local firm performance

Competitive pressure comes from foreign-invested firms or from leading domestic firms. The presence of these leader firms affects the performance of follower firms in two ways. The first way is potentially positive: the presence of foreign or leading domestic firms compels the follower firm to raise its game—to improve the quality of its goods or services or expand its offerings, or reduce its costs and prices to customers. It is motivated to become more competitive due to the stimulus of the foreign or domestic leading firm. This positive response to competitive pressure is likely to come from firms with sufficient managerial, technical, and financial resources—larger rather than smaller local firms. A positive response to horizontal spillovers is also likely if the domestic firm is similar technologically to the foreign firm, which implies it has greater absorptive capacity (Fons-Rosen 2017). The greater the presence of foreign firms the greater the competitive pressure and the greater the improvement in local firm performance.

However, this positive relationship between foreign firm presence and local firm response may turn around after a critical foreign firm presence is reached. The initial positive performance effect may turn to a negative effect if the local firm has insufficient absorptive capacity to match the competitiveness of the foreign firms. These firms are likely to be small in size and lack the human capital and financial resources to utilize the advanced knowledge. As FDI presence in the market increases, these local firms lose market share. By this measure of performance, the relationship between FDI presence and performance becomes negative (see Fons-Rosen 2017).

However, if the local firm has sufficient absorptive capacity (resources proxied by size), increasing competitive pressure may slow down its growth in performance due to increasing competitive pressure but not turn it negative.

If absorptive capacity increases, the curvilinear relationship may shift and the slowing down of local firm positive response to competitive pressure staved off—the curves in the figure shift upward.

We represent the spillover potential by the knowledge gap between leader and follower. The spillover realized depends on the absorptive capacity of the follower in a curvilinear relationship (Table 2).

Table 2 Effects on local follower firm performance with competitive pressure

	Knowledge gap	
Absorptive capacity	High	Low
High	Potential is high Realized is high Effect is positive, maximum	Potential is high Realized is low Effect is negative, maximum
Low	Potential is low Realized is low Effect is positive, minimum	Potential is low Realized is low Effect is negative

Case 4. How Competitive Pressure Affects Knowledge Spillovers: Hanel Software Solution's Actions to Prevent Loss of Market Share

Hanel Software Solutions is a Vietnamese company with 200 employees and a decade of experience in the market. It is one of several companies in the Hanel Group of companies. Hanel Software produces both products and ITO services for the enterprise, transportation, government, and banking sectors. It has ISO 27001 and CMMI-3 certifications. It occupies several stages of the value chain with its own people: design, engineering, code writing/production, testing, implementation, and maintenance. Hanel Software's services apply both to its software products and those of other companies.

Hanel Software has a client in Vietnam that is a Japanese firm. It is domestic business for Hanel with a foreign-owned client. The Japanese client produces electronic appliances such as printers, multifunctional machines, fax machines, labelers, and sewing machines for household and industry. Hanel supplies software for human resource management and administrative documents processing and transmission.

Recently, a Japanese multinational competitor entered the market by starting operations in Vietnam. The new entrant provides similar software services as does Hanel; they are potentially direct competitors. The competitive threat posed by the Japanese firm arose from two factors. The first was that the new entrant's management people all used the Japanese language, and probably Hanel's client preferred this compared to its people, only some of whom were able use the Japanese language sparingly. The second was an apprehension: Hanel did not fully understand the client's requirements due to the language difference and was therefore hampered in customizing its product to suit its business. Hanel was not fully adapted to Japanese styles of negotiation. Did the Japanese entrant have superior quality or reliability or both? Was Hanel likely to lose its Japanese client?

An expected reaction from the Vietnamese is to observe and imitate the entrant's capabilities, and to interact with its managers in informal events—these are standard knowledge spillover pathways. But direct observation was not possible, and informal managerial interaction, if possible, would take time. The two firms were competitors. If the Japanese competitor had proprietary intellectual property, it would not be directly observable. However, Hanel was able to gather competitive intelligence from its client's employees who were acquainted with the Japanese entrant's business and its strengths. The service quality and reliability apprehensions were confirmed.

Hanel's reaction was the one that the competitive pressure pathway suggests: "We must get better." But how? Could Hanel close the knowledge gap? Four actions were taken:

1. Engaged all of its top managers to determine a strategic response, the tactics to implement it, and the resources required to do so.

2. To the extent, there was lack of confidence about the planned response, considered hiring an external consultant to evaluate and improve the internally designed strategic response.
3. Hired new people who had the skills and experience to match the advantages that the entrant had.
4. Assessed the firm's financial capacity to implement the planned response to be implemented.

Keep the traditional market with Vietnamese clients by customer care and support; cooperate with the new entrant, if possible, to promote their products that Hanel does not have to Vietnamese clients so that Hanel has a chance to assess their knowledge and expertise.

In the end, Hanel retained the Japanese client in Vietnam; Hanel's response to competitive pressure was partly successful—but the story did not end there. The Japanese client continued to use Hanel's software services but switched to the Japanese MNC's software product. And the other clients of Hanel who might have switched to the Japanese entrant were also retained, but not the biggest firms in Vietnam who preferred the Japanese entrant. To compensate for the loss of some clients, Hanel developed other ITO services and now has business with new clients, such as Vietnamese contractors to Japanese firms.

"We also keep in mind that the issue/problem always happens. In many cases, we can not fully resolve it but we need to minimize its effect and develop other business to keep growing."

9 The Value Chain Upgrading Pathway

A foreign multinational corporation or a leading domestic firm that enters the local market is likely to be the source of vertical spillovers—backward to its upstream local suppliers or forward to its downstream assemblers or distributors. The original flow of knowledge from the MNC to its local suppliers is largely intentional and therefore not strictly a knowledge spillover. The spillover is received by other local firms that can utilize the upgraded performance of the MNC's supplier (see Fig. 3).

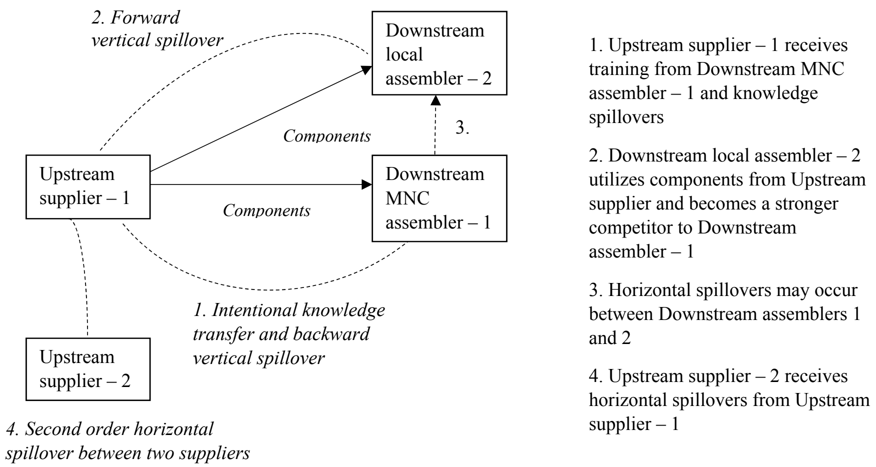


Fig. 3 Vertical knowledge spillovers from upstream supplier to downstream assembler

Knowledge spillovers can be multiplied via second-order effects spillovers. The knowledge initially transferred can travel up and down the value chain; the spillover effect is magnified.

Empirically, backward or upstream vertical spillovers from a multinational firm in an emerging market economy to its suppliers do occur and are positive via increased quality of inputs from upgraded suppliers (Jude 2016; Malik 2015; Isaksson et al. 2016). However, in one study, vertical knowledge spillovers were judged to have a lesser effect than horizontal spillovers (Perri and Peruffo 2016).

10 Conclusions

Knowledge spillovers occur via three pathways: Imitation–observation–interaction, labor mobility, and value chain upgrading. Each of the pathways has the potential to increase the performance of follower firms that can benefit from the superior knowledge of leader firms. Competitive pressure is a further force that affects the performance of follower firms, either positively or negatively. The extent of the knowledge spillover depends on the size of the knowledge gap, the absorptive capacity of the follower firm, and the presence of foreign firms in the market. We illustrate the ways in which knowledge spillovers take place using the experiences of Vietnamese software firms as reported by their top executives. We show how informal observation of a customer's business strengthened the supplier's long-term business with its customer, and how a supplier's relationship with its foreign partner imparted new tacit knowledge of customer relations. We see that a spillover that might have occurred from labor mobility did not happen satisfactorily. We learn how a local firm responded to competitive pressure and how its business was affected with both wins and losses.

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Implications of International Harmonization of IPR on Growth and Competitiveness Among the Developing Nations

Sunil Kumar Ambrammal

1 Introduction

What does the word competitiveness mean for and what makes a country competitive? It is Porter (1990) and Krugman (1994) separately brought the idea of competitiveness into the academic literature in the late 1980s and early 1990s, respectively. According to Krugman (1994), competition stands for a location's 'external balance'. Inspired from a firm's focus on sale and market share, Krugman's idea of external balance includes a location's ability to sell products, defend international market share and to make sufficient amount to pay for its import as the competitiveness. Since the idea has emerged from the firm's activity, it has been criticized on many grounds.[1] Competitiveness can be analysed from a location's productivity level as well (Porter 1990). This idea of competitiveness is motived from a location intrinsic property to create value based on the production factors it has its disposal. This productivity definition of competitiveness is supposed to focus on long-term growth and prosperity rates. World economic forum defines competitiveness as 'the set of institutions, policies and factors that determine the level of productivity of a country'. We believe productivity leads to growth, which leads to higher-income levels and that further improves the well-being of the citizen of the country.

In the literature, the term competitiveness is further interpreted in two different ways, viz. technological competitiveness and price competitiveness (Cantwell 2006). Price competitiveness (PC) is a short-term phenomenon in which a lower interest rate declines the value of the domestic currency and that further leads to PC. A nation achieves 'price competitiveness' through two ways: one, by reduced export price in

[1] Features which are exclusively aligned to firms like: firm's rivalry, running out of business and zero sum view of competition are not functional for the 'location'.

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foreign currency terms for domestically produced goods and two, by a rise in import prices in domestic currency terms. This price competitiveness is, however, unlikely to be sustainable. Long-term ‘technological competitiveness’, on the other hand, is likely to be sustainable as it is deriving from higher export-led currency appreciation as a result of the improved quality of products. While looking at various definitions, we can understand that competitiveness is a complex phenomenon where there is no unique way of defining it.

It may be easy to quantify the competitiveness based on the given attributes, but it may not be the case while assessing the factors that drive to the competitive advantage. There are intermediate factors that transform competitiveness into economic well-being. These intermediate factors include indicators like export, research and development (R&D), investment, foreign direct investment (FDI) inflows and the like. The strong performance of these indicators usually associated with the effective transformation of competitiveness into well-being. This is what makes these indicators as a powerful tool to diagnose the transformation. These indicators, however, can be influenced by various policies and laws. Intellectual Property Rights (IPRs) are one of such laws that can act as a ‘two-edged sword’ if it is not properly designed.

For developing countries, a robust IPR policy is becoming increasingly more significant as their companies need to compete with firms from developed countries on a global platform. Success stories of emerging economies like Singapore and South Korea expose the effectiveness of Intellectual Property as a tool for wealth creation for nations (Kim 2016). Inspiring from these success stories, most of the developing countries have started experimenting with IP policies to enhance their potential possibility as a growth enhancer and enabler. It is exciting to see that the knowledge component in manufacturing has been increasing considerably during the last few decades and it is that technology, know-how and human creativity can help for growth, competitiveness and development. To achieve this, however, one could make use of IP policy effectively. To ascertain this, we could argue in line with Basant and Sebastian (2000), as it says that for an active competitive environment, we could make use of all such policy instruments related to trade, investment and technology development for attaining the competition. IPR policy is one such plan that is believed to enhance trade, investment and technology.

A stable IPR regime is likely to draw investment, especially from foreign direct investment (FDI), and thereby laying the foundation for competitiveness. A higher IPR likely leads to more innovation and that further brings national competitiveness (higher IPR → more innovation → competitiveness), and however, the approach is yet to be empirically proved. It remains unproven because of the following reasons. One, there are not many empirical attempts have been made in this area (Muzaka 2013 is an exception). Second is the identification of proper indicators of innovation and competitiveness. Many studies employed to research and development (R&D) expenditure as well as GDP growth, respectively, as the proxies for innovation and competitiveness. Both these measures have their own weaknesses. We know that not all innovating firms do formal R&D and R&D-doing firms do not innovate every year. Most of the firms likely to keep R&D centres only to avail the tax benefits from the government. By considering all these issues, we could generalize that R&D

may not be a suitable indicator of innovation in all cases. The present study, therefore, considers more relevant indicators for innovation as well as competitiveness to identify the possible IPR–innovation–competitiveness relationship.

There have been a considerable number of studies that discuss the relationship between IPR and growth and few studies on the IPR and competitiveness relationship (Muzaka 2013). Hardly few studies talks on the link IPR is having with innovation and competitiveness, especially in developing country context. The study, therefore, considers how the strategic use of IPR helps to achieve the stated goals like the innovative capability of a country as well as their competitiveness and growth.

1.1 Conceptual Framework

The impact of IPR on the competitiveness of a nation is unclear mainly due to its peculiar attributes. Firstly, IPR may not work in the same way for both developed and developing countries. Scholars have a different opinion where one group of researchers believe that the enhancement of IPR improves the economic conditions of the entire nation, while the other group argues that it benefits only to the developed nations. Stronger IPR protection is likely to produce both positive and negative impacts on the economy that further depends on conditions prevailing in each nation (Maskus and Fink 2005). One of such conditions is the level of economic development, and hence, one can argue that strong IPR encourages competitiveness and innovation only in an advanced industrialized economy. The argument is that developing countries not relied on IPR to foster their domestic innovation as they are in favour of swift diffusion of technology. Keeping in view, IPR may not work both for developed and developing nations in the same way; increasing the protection for innovation in these two sets of countries is always open to debate. Secondly, a higher IPR is criticized even in the developed countries also based on the following ground: (i) it is likely to be anti-competitive (Richards 2004). Developing countries still need to build their competition laws, rules and policies and those governing IPR laws and (ii) in the north also its inability to foster innovation and knowledge development is severely criticized (Chang 2002). Finally, while enabling tighter protection in all the countries simultaneously, the scope for further innovation will be very less. Figure 1 shows the trend in average IPR scores of various countries. A comparison of average IPR scores over the years and between the three groups of countries reveals that, for HICs, the average score stood at just below 7 during 2007 and 2015, whereas for middle-income countries (both upper and lower), this has been increased during the same period. This is a clear indication of bridging the gap among the countries with respect to their IPR scores.

In this context, it will be beneficial for policymakers if we could analyse the performance of developing countries after the implementation of TRIPS mandate. A further study, based on recent data set and new econometric technique, would not add much to the literature; instead, it contributes one more research into the debate. The present study, therefore, looks at the relationship from another angle—the contribution of

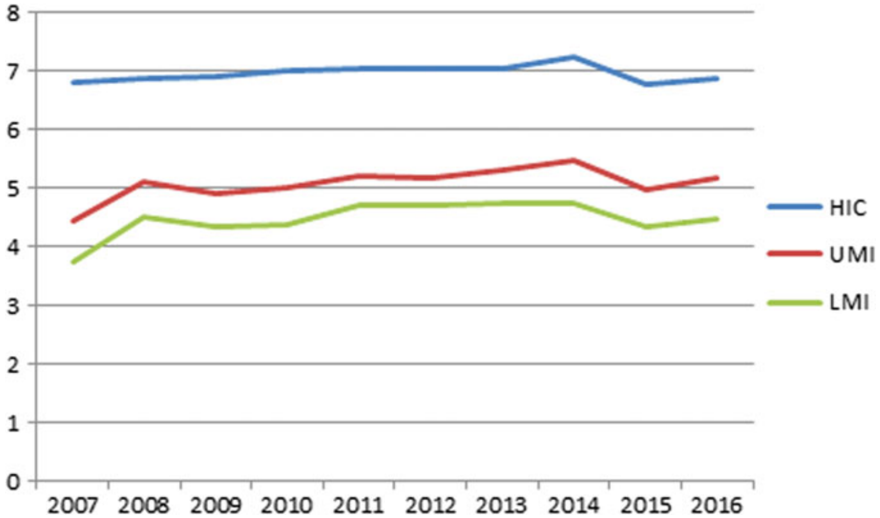

Fig. 1 Average IPR scores of developing and developed countries. *Source* Author calculated

enhanced IPR on growth and technological competitiveness through innovation by giving special emphasis to developing nations. The study further gains its importance from one of the arguments of Helpman (1993), who stated that: '*Who benefits from tight intellectual property rights in less developed countries? My analysis suggests that if anyone benefits it is not the south*' (Helpman 1993). For him, 'North' denote advanced developed nation that produces highly refined technologies and 'South' refers to the developing nation that adopts technology from North. Therefore, there arises a question—if the so-called South is not so benefitted from strengthening their IPR, why those nations should follow the stringent TRIPS obligations.

Developing countries are mainly known for their 'incremental innovations', and their objectives and mechanisms are different from that of developed nations. These countries are often responding to their local needs for a better outcome. One of the examples is Chile's experiment with mineral extraction. Chile, the world's largest copper supplier, has come up with a smart mining technology to improve their productivity and operational efficiency with an objective of satisfying their local needs. Another instance is the so-called inclusive innovation in India with the aim of improving the welfare of middle-income household. The small segment four-wheelers, Nano car, is the best example. In both cases, IPR helps to protect these innovations, but the growth of the economy is not the sole aim. Therefore, in developing countries innovations are likely to focus on competition and economic welfare.

Further, the changing nature of the economy regarding production and manufacturing could also affect the relationship. The successive paradigm shift in the manufacturing sector could also change the determinants of innovation as time elapses. For example, during 1913—the second stage of paradigm—society's need was a 'customized product'. However, when it reaches the fifth stage of the production, what society demanded is a 'clean product'. Moreover, the technology enabled in the production process has been changing from electricity to bio/material technology during the same period.[2] Therefore, what was not crucial to the innovation and competitiveness may be turning out as an unimportant factor and vice versa, according to the present circumstances.

The present study, therefore, argues that stronger IPR induces more significant innovations in developing nations and that further improves the economic and social conditions. Many works of the literature identify various mechanisms by which IPR could affect innovation and vis-à-vis competitiveness of a nation (Grossman and Helpman 1991a). The study hence would like to analyse the effect of IPR on innovation at the first stage and the impact of innovation on the competitiveness and in the second stage, separately for developed and developing nations. Further, the study would like to analyse the effects of strong IPR on the general indicator of economic performance, i.e. growth of a country. The present study attempt to make a comparative report on what—competitiveness or economic growth—is mostly influenced by the IPR improvement.

Global-scale IP reform is likely to bring cost and benefits to various nations. One way to analyse such effects is the North–South model (Krugman 1979). The model argues that innovation typically occurs in the North, the region of developed countries. Technology produced in the North diffuses to the South with a lag either through licensing or FDI. These technological lags give rise to trade, with North exporting new products to the South. Strengthening of IPR in developing countries hence becomes an important factor from the perspective of the developed nation. Effective enforcement of IPR accelerates technology transfer from the developed nation to developing nations and therefore contributes to economic benefits in the form of growth and competitiveness (Lai 1998; Glass and Wu 2007). The case is, however, not possible when the transfer of technology is limited to rent transfer from developing to developed nations. Further, stronger IP enforcement will hamper the ability of local firms in developing countries to experiment with foreign technology at a lower cost. The same will also restrict the diffusion of technology (Glass and Saggi 2002; Branstetter et al. 2007).

The variety-growth model developed by Helpman (1993), on the other hand, explains the production shift effect, in which stronger IPR in the south could lower the long-run rate of innovation in the North. The tightened IPR reduces the scope of imitation and therefore production back to the North. What is noteworthy here is the modified version of the variety-growth model (Lai 1998). The revised version considers FDI as the primary source of foreign technology. However, the model emphasizes a lag between South and North firms in the production process. Stronger IPR is likely to attract more FDI in the South, and therefore, the production occurs in the South through the local subsidiaries of North firms. Thus, both agents will be benefited through welfare improvements.

All the models explained above argue that the invention process begins in the North. The South imitates the same with a lag and comes to the market at a competitive

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[2] See Table 6 in Appendix.

price. The quality-ladder model argues that both South and North will be benefited from this act as both sets of countries race to improve each of a continuum of industrial product, earlier for 'the last generation' and later for 'next generation' (Grossman and Helpman 1991b).

2 Review of Literature

2.1 Discussion on Why Developing Countries Need to Enhance Their IPR Strength

Developing countries usually follow the strategy of imitation as a source of their technological development. High cost and risk involved in the appropriation and development of new technology are the main reasons behind this. However, with the advancement of globalization and subsequent international trade, domestic recipients of the modern technology are expected to provide the minimum standard of protection to the product and process manufactured in the developed nations. The discussion, therefore, mainly concentrates on the requirement of maintaining a global IPR standard.

The main argument for protecting IPR comes from the 'public good' attributes of the knowledge. The 'non-excludable' character of knowledge has increased the possibility of imitating the innovator's idea and that further reduces the potential profitability of the innovator. Since imitation is less costly than innovation, the later should be protected from imitation for promoting the value innovation. IPR provides adequate ownership to IP by giving legal power to innovators to recoup from their costlier innovation. Although knowledge is 'non-rival' in nature and has been provided at free of cost to maximize the benefit out of innovation, it argues that the profit will be optimized in the shorter period only. In the long run, however, the principle will severely damage the incentive for further innovation.

Foreign trade and investment are the second and third reasons. International trade allows developing nations to acquire high value-added goods through import. Similarly, FDI inflows enhance the innovative domestic capacity of a nation by augmented investment in R&D and better training. Sufficient protection to IP in developing countries is a prerequisite to ensure cross-border trade and investment into the nation (Hassan et al. 2010). Empirical evidence also showed that stronger IPR as a crucial factor while deciding cross-border investment and trade.

2.1.1 FDI Inflow: A Case of Developing Nations Versus Developed Nations

In this section, we examine the evidence of FDI inflows into developing and developed country separately during 2005–2015. Figure 2 shows the average growth rate

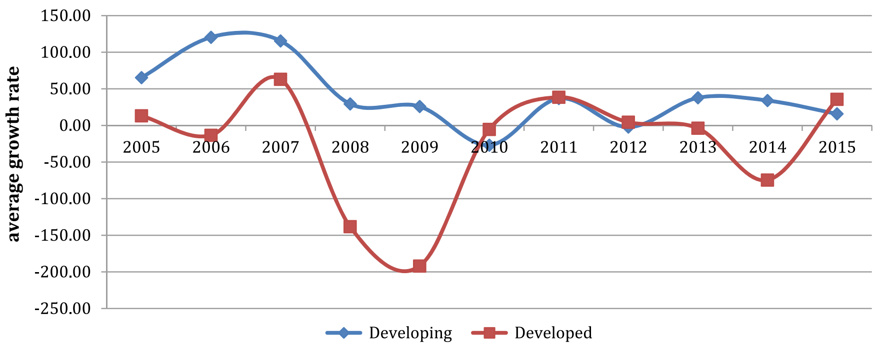

Fig. 2 Growth rate in FDI inflow: developing nations versus developed nations. *Source* Analysed from world development report (various issues)

in FDI inflows into developing as well as developed nations. The analysis shows the apparent differences in the inflow of FDI among these two sets of the country where developing nation's having the edge over the developed one. This difference is likely to be an outcome of enhanced protection of property rights in those nations. During 2007–2010 and 2013–2015, the growth rates in FDI inflow have become negative. However, such a negative trend in developing countries appears only in 2010. This trend indicates investor's preference in developing nations as the safest place to put their investment, though the motive behind this is unclear.

Dunning's (1980) ownership–location–internalization (OLI) theory explains why a firm is investing abroad. Transnational corporation's advantage in 'ownership' is a necessary condition for their overseas investment. This advantage may take in the form of new technologies: technical know-how, organizational skill and so on. In addition to this, 'location' and 'internalization' advantages are sufficient condition to invest abroad. Location advantages are associated with low transportation cost and input prices, whereas internalization advantage allied with avoiding transaction cost with prospective licensees.

The strength of the relationship between IPR and FDI depends on how the level of IPR affects those three (OLI) factors. Regarding ownership, it is unclear whether they would be able to protect the whole part of their intellectual assets. It is, however, believed that the firm who created the intellectual knowledge is likely to invest in the foreign nation rather than extending a licence to any external firms. Reduction in technology transfer cost is the main argument behind this strategy (Saggi 1999). Various levels of IPR protection may also influence the internalization decision and locational advantages of a firm. Given these facts, many researchers argue a positive IPR-FDI relationship. One probable explanation of this positive relationship could be the smaller risk of imitation due to the high protection and that further leads to high demand for protected goods (Mansfield 1994). Some researchers, on the other hand, argue that higher protection leads to licensing their knowledge rather than directly investing in the specific nation (Maskus and Penubarti 1995). Thus, the theoretical support of the influence of IPR on FDI is ambiguous. The statistics we have explained above reveal that transnational corporations are relying more on developing nation to transform their investment into a valuable one. It could be a case of 'locational' advantage because 'ownership' advantage is more significant in the developed nation compared to developing countries as the level of IPR is already high in the developed states.

Fourth, developing nations are likely to be in the back seat in the production of technology, and by principally, they depend on the developed states for the same. Hence, without ensuring sufficient protection for their creation, north countries would not make the technology needed for developing nations (Diwan and Rodrik 1991). North developed firms may react to the weak IPR in south states by enhancing their techniques more challenging to reproduce which will adversely affect developing nations (Yang and Maskus 2001). Domestic innovation consideration is also a matter for strengthening IPRs in developing countries. There are innovative local activities that shall rise under strong IPR (Chen and Puttitanun 2005). It is quite ambiguous to say whether stronger IP protection encourages or discourages in-land innovation in developing nations. Theoretical models predict that stronger patent protection in developing countries may not add much to the productive R&D and further to the innovation and, therefore, reduces the output in the domestic economy (Chin and Grossman 1990; Deardorff 1992; Helpman 1993). Counter-argument is that stronger patent protection provides a favourable local environment for local innovators. Hence, even firms in developing countries can also benefit from innovation. But according to Deardorff (1992), the benefits of such protection gradually diminish as and when more and more states adopt stronger IPR protection for their creativity. Therefore, there should be an optimum level of IPR in developing countries that enables imitation of the foreign technologies as well as provide an incentive for domestic innovation. From these arguments, we could interpret that the impact of harmonization of IPR is vague regarding the competitiveness and growth of developing nations.

2.2 Factors Affecting Innovation and Competitiveness

Since the study argues that IPR stimulates innovation and innovation further accelerates growth and competitiveness, this section concentrates on significant determinants of innovation, competitiveness and growth. Studies say that strengthening of IPR could lead to more significant innovations in developed nations and that indirectly benefits developing nations (Taylor 1994; Kanwar 2003, 2006). These indirect benefits arise through FDI, trade or licensing. By creating an environment conducive to human knowledge accumulation, IPR may spur innovation and growth. IPR could affect developing countries negatively if they are not in a position to undertake R&D activities for further development of IPR-based product and processes (Sakakibara and Branstetter 2001; Falvey et al. 2006; Horii and Iwaisako 2006). R&D expenditure (RDE), considered as an input of the innovation, is the second major factor that affects the same (Chen and Puttitanun 2005).

Qian (2007) finds that IPR, particularly domestic patent protection, alone does not stimulate economic growth and competitiveness. It requires a higher level of technical development along with educational attainment and economic freedom. We measure technological ability through annual per capita GDP growth rate. To measure the education variable (EDU), we use the percentage of total enrolment in the tertiary sector among the school-age population. To measure the openness of a nation (OPEN), we use international trade volume (import and export) as a percentage of GDP.

We consider three variables resident patent application (PAT), OPEN and domestic investment (INV) as explanatory variables in the competitive equation. INV is the residual of the difference between FDI inflow and gross fixed investment. Kumar and Pradhan (2002) employed the same method. Apart from these three variables, we have considered FDI inflows and RDE as independent variables in the growth equation. Based on the above discussion, the research would like to test the following aspects:

1. Re-examine the direct link between IPR and growth both in developed and developing nations based on a recent set of indicators.
2. Estimate the relationship between IPR and domestic innovation.
3. Examine the relationship between IPR and competitiveness through innovation. That is, there could be an association between IPR and innovation in the first hand and between innovation and competitiveness in the second.

3 The Model, Econometric Issues and the Data

The present model consists of a system of two simultaneous equations: one deals with innovation and other for growth and welfare.

$$\text{INN} = f(\text{IPR}, X_{it}) \tag{1}$$

$$\text{GCI/GROWTH} = f(\text{INN}, Z_{it}) \tag{2}$$

where INN is domestic innovation, represented by residents patenting, GCI is global competitiveness index—a measure of competitiveness, and IPR is intellectual property right score attained by each country. GROWTH denotes per capita income growth, and X_{it} and Z_{it} are the explanatory variables that influence the corresponding dependent variable.

To measure competitiveness, we use the Global Competitiveness Report (GCR) published by the World Economic Forum. The GCR, after considering crucial factors that drive to growth, welfare and competitiveness, constructed an index known as the Global Competitiveness Index (GCI). GCI consists of 12 pillars that include,

(i) institutions, (ii) infrastructure, (iii) macro-economy, (iv) health and primary education, (v) higher education and training, (vi) market efficiency, (vii) technological readiness, (viii) business sophistication and (ix) innovation. The impact of these variables on a nation's competitiveness may vary according to the nation's characteristics. The GCI, therefore, has given adequate weight to each variable while constructing the index. The present study, however, does not consider GCI score per se for evaluating the relationship. Since the index includes 'innovation' as one of the pillars, we removed the innovation score from the GCI score after considering the due weight associated with each country.[3] IPR can stimulate a nation's growth as well. Therefore, the second dependent variable in the performance equation is the growth, measured by per capita income growth of a nation. We consider per capita income growth instead of the level of per capita to tackle the business cycle aspect (Chen and Puttitanun 2005).

R&D expenditure and patent counts are the widely used measures of innovation, the earlier as the input and the later as the out of innovation (Ambrammal and Sharma 2014). We use patent application by residents (PAT) as a dependent variable in the innovation equation and as an independent variable in the competitiveness and growth model. R&D expenditure (RDE), as a percentage of GDP, is considered as an explanatory variable in all the models. IPR is the significant determinants of innovation (Hu and Jaffe 2007). We include the International Property Right Index (IPRI), a publication of the Property Rights Alliance, for measuring the IPR strength. The IPRI consists of three components, (i) legal and political environments, (ii) physical property rights and (iii) intellectual property rights. We have also obtained data on several other variables that can affect innovation and competitiveness. Data on the measure of economic freedom (EF) are obtained from www.freethewold.com. The index ranges from 0 to 10 with a higher index indicating a higher level of economic freedom. We have collected data from various sources. Most of the data come from the World Development Indicators (WDI), World Economic Forum and Freetheworld.

A large sample of countries (99 countries) has been assembled for this study, covering the period 2005–2015. The selection of 2005 as a base year had its own important and justified in the sense that developing countries have to enhance their IPR by 2005.[4] The sample of countries is diverse, representing different income groups and institutional environments.[5] Therefore, based on World Bank (2017), all the nations are classified into three: lower-middle-income ($1026–$4035), upper-middle-income ($4036–$12475), Higher-income countries ($12476 and above).

[3]The exclusion factor will be (Current innovation value × Innovation weight in the current year)/100.

[4]Many can argue that a comparison of pre-IPR era with post-IPR era will get better understanding of the issue that we are considering. The paucity of data is, however, hindering us to carry out the work.

[5]See Table 7 in Appendix.

3.1 Econometric Specification

The empirical model is a system of two simultaneous equations. One is for the domestic innovation, and the other is for competitiveness/growth. The two equations are:

$$\text{INN} = f\left(\text{IPR}, \text{IPR}^2, \text{RDE}, \text{EDU}, \text{OPEN}, \text{GROWTH}\right) \tag{3}$$

$$\text{GCI} = f(\text{INN}, \text{INV}, \text{OPEN}) \tag{4}$$

$$\text{GROWTH} = f(\text{INN}, \text{INV}, \text{FDIINF}, \text{OPEN}, \text{RDE}) \tag{5}$$

For Eq. 3, based on theory, both EDU and R&D will have positive effects if they encourage innovation. According to the literature, RDE is likely to be an endogenous regressor of innovation. Therefore, we have adopted the two-stage least square technique to tackle with endogeneity. For Eqs. 4 and 5, we expect a positive relationship between INN and dependent variables, again if innovation encourages competitiveness and welfare.[6]

4 Empirical Results

4.1 Description of the Data

Table 1 provides the summary of data used in this analysis. For all variables with a standard deviation greater than one is in natural logarithm format, while all other variables are considered in their original format.

4.2 Regression Analysis

The present section describes all the results obtained from the regression analysis. Section 4.2.1 explains results from determinants of innovation. In Sect. 4.2.2, we have the results of welfare equations followed by a growth equation in the next section.

[6]Since GCI is a composite index of many variables that are supposed to be there as explanatory variables, we have considered only three as independent variables.

Table 1 Summary statistics of the data

Variable	Observations	Mean	Std. dev.	Min	Max
GCI	1100	3.62	0.49	0.00	4.94
EF	1085	7.02	0.85	2.93	11.00
IPRI	1089	5.57	1.54	0.00	8.70
EDU	795	46.60	26.13	0.47	113.87
POPL	1089	6.11E+07	1.84E+08	403,834	1.37E+09
INN	863	8865.04	31265.29	1.00	301075.00
RD	636	1.20	1.02	0.02	4.41
GDP CONSTANT	1087	8.57E+11	2.19E+12	9.35E+09	1.86E+13
OPEN	1078	94.65	66.52	21.45	455.42
INFLATION	1072	29.16	746.20	−4.86	24411.03
FDIIN FLOW	1086	6.87	24.84	−58.98	451.72
INV	1066	17.20	26.24	−430.74	79.38
GDP GROWTH	1087	3.76	4.11	−17.67	26.28
PER GDP GROWTH	1089	2.34	3.90	−19.06	24.67

4.2.1 Factors Influencing Domestic Innovation

This section analyses the results obtained from innovation equations. We consider innovation as a function of IPR and other related variables. The results of GMM are given in Table 2 in three heads. Column 1 includes combined results of all

Table 2 GMM estimation of innovation equations

INN	FULL		LMI		UMI		HIC	
	Coef.	Std. Err/Z	Coef.	Std. Err/Z	Coef.	Std. Err/Z	Coef.	Std. Err/Z
IPRI	−0.153	0.152 (−1.01)	**−0.731**	**0.396 (−1.85)***	**−2.795**	**1.676 (−1.67)***	0.269	0.244 (1.11)
$IPRI^2$	**0.033**	**0.015 (2.26)****	0.053	0.047 (1.13)	**0.318**	**0.185 (1.72)***	−0.007	0.02 (−0.33)
RDE	−0.380	0.355 (−1.07)	**0.408**	**0.185 (2.21)****	−1.494	1.924 (−0.78)	0.163	0.491 (0.33)
EDU	**0.649**	**0.205 (3.16)*****	**1.115**	**0.331 (3.37)*****	**2.109**	**1.102 (1.91)***	−0.169	0.189 (−0.9)
OPEN	−0.044	0.251 (−0.17)	0.554	0.33 (1.64)	−1.317	0.827 (−1.59)	0.065	0.365 (0.18)
GROWTH	0.013	0.031 (0.41)	0.045	0.075 (0.6)	−0.052	0.14 (−0.37)	−0.009	0.034 (−0.27)
LM stat	25.74 (0)***		4.84 (0.09)***		1.712 (0.42)		20.31 (0)***	
Hansen J	0.079 (0.78)		0.66 (0.42)		0 (0.99)		4.079 (0.04)***	
Observation	354		58		81		215	

Note ***, ** & * are significant at 1%, 5% and 10 % level respectively. *Source* Calculated buy the author countries, whereas columns 2–4 show the results of lower-middle-income, upper-middle-income, and higher-income countries, respectively.

The nonlinear relationship between IPR and domestic innovation is established in the regression as the estimated coefficients are negative for IPRI and positive for $IPRI^2$. For HICs, the coefficient of IPRI is positive, and $IPRI^2$ is negative. However, it is not significant. These results argue that IPRI may not work in the same way for both developed and developing nations. In developing countries, the impact of imitation dominates over innovation in the early stages. At this stage, these countries technological ability is well suited for imitating the foreign technology rather than putting effort into the efficient domestic innovations. However, as the IPR law becomes prominent, innovation getting dominating over imitation and showing some signs of improvement. Therefore, IPRI becomes positively significant in the later stages. This result supports the 'U' shape relationship established in the earlier literature (Maskus 2000; Primo Braga et al. 2000). This result is valid for both the LMI and UMI countries, whereas the relationship does not hold for HICs. The reason could be, for HICs, IPR has been active even before 2005. Since there is no recent improvement in IPR level of HIC, one cannot expect any positive relationship between IPR and innovation in those countries. As we see from the literature, rather than focusing on their own domicile, now HICs are setting up their production units in LMI countries to exploit the opportunities available with them.

Education, a proxy of the quality of the researcher, is positively significant for FULL, LMI and UMI. However, this is not significant for HIC. The result is not making any surprise as the IPR is not significant for the latter group of countries. Across the models, only LMI produce positive and significant coefficients of RDE. These economies having firms and industries at the technology frontiers and they need to innovate for their survival. Further, there is evidence that even in the take-off stage; R&D played a leading role in the development process of developing economies.

4.2.2 Innovation–Competitiveness Analysis

Table 3 analyses the results from the relationship between domestic innovation and the nation's competitiveness. Regression with all countries shows that there is an improvement in the nation's well-being from local innovation. Competitiveness of all the countries increases by 0.003% when there is a 10% increase in domestic innovation (INN). Among the group of countries, UMIs are the most benefited, as the increment is about 0.007 for every 10% increase in domestic innovation. And for LMIs it is estimated as 0.006. The important thing to be noted here is that INN does not influence the welfare of HIC. One of the probable reasons is, LMI and UMI group of countries enjoy immediate benefits from stronger IPR in the form of GCI. HIC, on the other hand, would benefit from stronger IPR (both in North and South) in the form of economic growth. To test this, we have considered the growth of per capita income as a dependent variable, and the result of the same is discussing in the next session.

Table 3 Competitiveness equations

GCI	FULL		LMI		UMI		HIC	
	Coef.	Std. Err/Z	Coef.	Std. Err/Z	Coef.	Std. Err/Z	Coef.	Std. Err/Z
INN	**0.034**	0.002 (14.6)***	**0.055**	0.010 (5.6)***	**0.068**	0.005 (14.3)***	−0.007	0.004 (−1.5)
INV	0.080	0.014 (5.7)***	0.215	0.038 (5.7)***	0.176	0.037 (4.8)***	−0.025	0.015 (−1.6)
OPEN	0.075	0.014 (5.3)***	−0.082	0.048 (−1.7)*	0.272	0.031 (8.9)***	−0.074	0.020 (−3.7)***
CONS	2.936	0.088 (33.4)***	3.013	0.223 (13.5)***	1.724	0.179 (9.6)***	4.179	0.135 (30.9)***
OBSER	**779**		**200**		**189**		**390**	

Note ***, ** & * are significant at 1%, 5% and 10 % level respectively. *Source* Calculated buy the author

The openness, the volume of export and import as a percentage of GDP, produces mixed evidence on the welfare. Both LMI and HIC are negatively affected while opening their country to the world, whereas UMI is positively affected by it. The reason why LMI is adversely affected might be their strong dependence on import of fuel. For HICs, the case is, however, attributed to income growth. What we can judge from UMI's positive response to OPEN is their dependence on import of high technology product. By providing a sufficient environment for upgrading the imported high tech product, UMI is gaining its competitiveness.

4.2.3 Innovation–Growth Analysis

Analysis based on per capita GDP growth as a dependent variable shows that it is not innovation, but domestic investment (INN) plays the crucial role in the growth process of nations from various income groups (Table 4). The investment elasticity (0.63) is high among UMI and low (0.32) for HIC. We can see that the innovation elasticity is 0.6 for LMI which is not so different from the elasticity of UMI. Another variable which is crucial for the growth of all countries is FDI. The variable is positively significant among all the group of countries. For LMI, openness affects negatively, whereas for HIC, the variable produces a positive influence. For HIC, openness helps them to grow positively, whereas for other countries, the variable is not produced any significant effect. It is remarkable to note that, as I stated earlier in this article, the variable OPEN is influencing HIC's growth contrary to the positive influence on welfare.

Table 4 Growth function

LGDP	FULL		LMI		UMI		HIC	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
INN	**0.027**	0.012 (2.27)**	0.019	0.045 (0.42)	0.038	0.043 (0.9)	0.009	0.021 (0.44)
INV	**0.402**	0.056 (7.11)***	**0.569**	0.182 (3.13)***	**0.631**	0.209 (3.02)**	**0.322**	0.065 (4.94)***
FDIIN	**0.325**	0.031 (10.44)***	**0.263**	0.081 (3.25)***	**0.471**	0.097 (4.88)***	**0.292**	0.039 (7.4)***
OPEN	0.021	0.048 (0.44)	**−0.356**	0.165 (−2.16)**	−0.086	0.125 (−0.69)	**0.183**	0.075 (2.42)**
RDE	−0.227	0.026 (−8.71)***	0.044	0.059 (0.74)	0.013	0.128 (0.1)	**−0.214**	0.049 (−4.38)***
CONS	−0.646	0.292 (−2.22)**	1.030	0.670 (1.54)	−0.888	0.646 (−1.37)	−1.046	0.540 (−1.94)*

Note ***, ** & * are significant at 1%, 5% and 10 % level respectively. *Source* Calculated buy the author

5 Discussion, Policy Implications and Conclusion

In this paper, we discuss the impact of enhanced IPR on the competitiveness and growth of a nation. The effect of strong IPR varies across countries according to their level of development. The present study, therefore, considers three categories of nations separately, i.e. LMI, UMI and HIC. Based on the nature of the data, we follow proper econometric strategies that take into account the issues like count data, endogeneity and heterogeneity among the variables.

There was an ambiguity among the previous researchers regarding the impact of IPR on the growth and competitiveness of a nation. Firstly, many researchers and policymakers have argued that there is not any direct impact of IPR on those two variables. The study, therefore, considers domestic innovation as an intermediate variable that connects between IPR and competitiveness. The study showed that IPR encourages domestic innovation and that further stimulates growth and competitiveness. The statement is, however, not applicable in the same way for all group of countries. The results showed that for LMI and UMI group, IPR affects negatively at the initial stages and turns to be decisive in the later stages, inferring a possible 'U' shape relationship. It is argued that, in these two sets of countries, a huge amount of R&D is required to adapt to foreign technology in the early stages of their innovation. Therefore, the return to R&D will be negative in those early stages. Later, once they have fully adjusted with foreign technology, return to R&D will be positive and started to show a significant impact on innovation. For HIC, on the other hand, IPR is at the optimum level and hence does not bring any significant (marginal) impact on the innovation.

In these two sets of countries (LMI and UMI), innovation is the crucial factor for welfare improvement in the competitiveness but not for growth. Since both the IPR-INN and INN-competitiveness functions are significant and positive, we can summarize that IPR is one of the crucial factors for the competitiveness of a nation.

Table 5 Summary of results

	FULL	LMI	UMI	HIC
IPR → INN	– (Not significant)	U shaped (sig)	U shaped (sig)	+ (Not sig)
INN → GCI	+ (Sig)	+ (Sig)	+ (Sig)	– (Not sig)
INN → GROWTH	+ (Sig)	+ (Not sig)	+ (Not sig)	+ (Not sig)

Source Deduced from Tables 2, 3 & 4

Growth, on the other hand, is not determined by the level of IPR. For HIC, neither competitiveness nor growth has improved from IPR and domestic innovation. One probable reason could be the change in focus of business operations from HIC to other developing economies primarily due to their improvement in IPR protection and secondarily to enjoy other benefits like 'tax sops' offered by the countries, cheap labour availability, abundant natural resource and so on (Table 5).

It is observed that strong IPR does not directly influence competitiveness welfare and growth as it needs to be supported by domestic investment and innovation. Since there is substantial evidence on the influence of IPR on innovation and further to competitiveness and growth particularly among the LMI and UMI, the study is in favour of the present levels of IPR among these two sets of countries. A further increase in IPR can harm the economy as there exists a nonlinear relationship between IPR and innovation. In addition to this, we find that a healthy IPR could contribute more to the competitiveness than the growth per se among the lower-income countries.

The study is limited in the sense that we could not measure the welfare gains/losses to the consumer due to stronger protection of intellectual property rights. According to the theory, stronger IP could harm the welfare of consumers, but total welfare gain is offsetting the loss. Hence, we got a positive welfare effect due to strong IPR.

Appendix

See Tables 6 and 7.

Table 6 Successive paradigm shifts in manufacturing

Paradigm	Craft production	Mass production	Flexible production	Mass customization and personalization	Sustainable production
Paradigm started	1850	1913	1980	2000	2020
Society needs	Customized products	Low-cost products	Variety of products	Customized products	Clean products
Market	Very small volume per product	Demand > supply steady demand	Supply > demand smaller volume per product	Globalization fluctuating demand	Environment
Business model	Pull *sell-design-make-assemble*	Push *design-make-assemble-sell*	Push-pull *design-make-sell-assemble*	Pull *design-sell-make-assemble*	Pull *design for environment-sell-make-assemble*
Technology enabler	Electricity	Interchangeable parts	Computers	Information technology	Nano/bio/material technology
Process enabler	Machine tools	Moving assembly line and DML	FMS robots	RMS	Increasing manufacturing

Adapted from Jovane et al. (2003)

Table 7 List of countries according to their classification

HIC		UMI		LMI and LIC	
Australia	Latvia	Albania	Malaysia	Armenia	Pakistan
Austria	Lithuania	Algeria	Mauritius	Bangladesh	Philippines
Bahrain	Luxembourg	Angola	Mexico	Bolivia	Sri Lanka
Belgium	Malta	Botswana	Panama	Cameroon	Tunisia
Canada	Netherland	Brazil	Paraguay	Egypt	Vietnam
Chile	New Zealand	Bulgaria	Peru	El Salvador	Zambia
Croatia	Norway	China	Romania	Guatemala	Argentina
Cyprus	Poland	Colombia	Russia	Honduras	Ethiopia
Czech Republic	Portugal	Costa Rica	South Africa	India	Madagascar
Denmark	Qatar	Dominican Republic	Thailand	Indonesia	Malawi
Estonia	Singapore	Ecuador	Turkey	Kenya	Mali
Finland	Slovakia	Jamaica	Venezuela		Mozambique
France	Slovenia	Jordan		Morocco	Nepal
Germany	South Korea			Nicaragua	Tanzania
Greece	Spain			Nigeria	Zimbabwe
Hong Kong	Sweden				
Hungary	Switzerland				
Ireland	Trinidad and Tobago				
Israel	UAE				
Italy	UK				
Japan	Uruguay				
Kuwait	USA				

Source World development indicators

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Patent Policy and Relationship Between Innovation and Monopoly Power: Evidence from Indian High and Medium Technology Industries

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1 Introduction

Relationship between innovation and market structure is widely explored in the industrial organization literature including one-way relationship (Schumpeter 1942; Arrow 1962; Bain 1968). Further developments from Chicago School focused on the feedback effect of innovation on market structure. Firms' innovation activities and its' relationship with the market are evolutionary processes (Nelson and Winter 1982; Nelson 1994) that are influenced by the technological regime including the appropriability conditions among other factors. Studies show that intellectual property rights protection (IPRs) that determine appropriability conditions in a market, influence the relationship between innovation and market structure (Kortum and Lerner 1998; Moser 2005; Correa 2012). IPRs are formal institutions which incentivize firm-level innovations by reducing the transition cost and the uncertainty in the decision-making process (North 2012). Patents, a type of IPRs, are a state-granted monopoly to the innovator. And patent policy changes that increase the innovators' rights affect the innovation activities of a firm and concomitantly market structure of the industry.

There are many changes in the Indian patent policy from 1970 to 2005. Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) came into the picture in 1995 with minimum standards for IPRs legislation for member countries of World Trade Organization (WTO). Evidences show that TRIPs has significantly increased R&D and patenting in India (Chadha 2009; Haley and Haley 2012; Jagadeesh and Sasidharan 2014; Sharma et al. 2018). Due to strong patent laws and

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other IPRs protections, developing countries are now specializing in some fields of technology and are innovating at the frontier of such technology fields (Kumar et al. 1999; Srholec 2007; Fu and Gong 2011).

On the basis of above discussion, this study evaluates the impact of major patent policy change on the relationship between innovation and monopoly power in Indian high and medium technology firms. This study is an attempt to empirically analyze the bidirectional relationship between innovation and monopoly power in two different technology regimes which are 1995–2005 and 2006–2015. The period of 1995–2005 is the transition phase during which the Indian Government three times amended the patent policy to comply with TRIPs agreement. For the period of 2006–2015, the real impact of TRIPs can be realized. The study helps us to understand the implications of TRIPs on the innovation and competition issues in Indian manufacturing sector.

The rest of the paper is organized as follows: Section 2 discusses about various patent policy change in India. Section 3 provides brief review of literature on patent policy change and the relationship between innovation and market structure. Section 4 gives description of variables. Section 5 discusses data sources and descriptive statistics. Section 6 focuses on the results of model estimations. Section 7 presents the conclusion.

2 Patent Policy Change in India

According to The Patent Act 1970 which was finally implemented in 1972, only process innovation could be patented in fields of food and medicine for the duration of 7 years, whereas in other fields of technology, the protection was for 14 years. This act increased the capabilities of domestic firms by increasing adaptive R&D. Under process patent regime, firm can easily copy the external technology and reproduce similar products with efficient cost structure. In summary, process patent regime negatively affects the innovation capacity of a firm, although it increases adaptive R&D expenditure. The Patent (Amendment) Act 1999 was brought into force retrospectively from January 1, 1995. This amendment provides permission to file the application for product patent in the field of pharmaceutical, drugs, and agrochemical. However, such applications were examined only after 2004. This amendment also provides provision of granting Exclusive Marketing Rights (EMRs).[1] Second amendment in the Patent Act 1970 was made in 2002 with the Patent (Amendment) Act 2002. In this act, many changes were made like term of protection was extended up to 20 years, requirement to disclose the source and geographical location of the biological material was introduced, licensing right was removed, publication of application after 18 months was started and provision of pre- and post-grant opposition was also started. The third amendment to the Patent Act 1972 was made through the Patent

[1]EMRs were given based on two conditions (i) a patent should have been granted for the same product in another WTO member country after 1995 and, (ii) marketing approval should have been obtained for this product in the other member country.

Table 1 Average patent application and grant in India during different patent policy regime

Year	Average patent grant	Average patent application
1995–1996 to 1998–1999	1521.00	8676.75
1999–2000 to 2001–2002	1596.66	7973.00
2002–2003 to 2004–2005	1919.66	13848.33
2005–2006 to 2015–2016	7450.09	38059.16

Source Authors' calculations on the basis of information available in annual reports of Indian Patent Office

(Amendment) Act 2004 which was implemented by January 1, 2005. This amendment required the introduction of product patent in all fields of technology. This act also makes the provision of compulsory licensing for producing and exporting of pharmaceutical products to any country having insufficient or no manufacturing policy to accommodate the Doha Round Mandate about compulsory licensing. Clearly, these amendments have made imitation of new technology difficult. In new patent regime, survival of a firm on the basis of reverse engineering is not possible.

During the transition phase of patent regime (1995–1996 to 2004–2005), we find that the average patent application in India was 10017.1 and average granted patent was 1663.3. In the new patent regime (2005–2006 to 2015–2016), average number of the patent application and granted patent are 38,059 and 7450, respectively. We observe that around 279.94% surge in the average patent application in new patent regime as compared to transition phase. Similarly, the average of granted patent has increased with a growth rate of 347.90% in new patent regime. Table 1 shows that the patenting has increased tremendously in India with the change in patent policy.

3 Literature Review

According to Grossman and Helpman (1993), strong IPRs encourage entrepreneurs to increase their R&D investment which further increases their post-innovation profit and reduces the cost of future innovations. Strengthening IPRs positively influence technological progress of a country (Kanwar and Evenson 2003; Hausmann et al. 2014; Naghavi and Strozzi 2015; Boring 2015; Zhang and Yang 2016). Successful innovators use new technology by their own and/or they commercialize it by selling or licensing to others. In the weak IPRs regime, innovators do not get full advantage by using and/or selling new technologies as there are high chances of imitation (Autio and Acs 2010). Strong IPRs also increase technology transfer[2] to developing countries which also make firms more innovative (Maskus 2004; Sasidharan and Kathuria 2011; Khachoo et al. 2018). Strong IPRs protection also increases competition in the market by incentivizing the entry of new firms (Djankov et al. 2002; Klapper et al. 2006) that depends on the quality of opportunity available in the market (Davidsson 1991). Kahneman and Tversky (1979) also explain that the impact of strong IPRs will be greater for new business formation rather than established ones. However, Gilbert and Newbery (1982) explain that in strong IPRs protection, cost of imitation is very high which increases the monopolistic behavior in the market (Gilbert and Newbery 1982).

Utilizing innovation data from Crystal Palace Exhibition in London (1851) and the Centennial Exhibition in Philadelphia (1876), Moser (2005) suggests that the patent laws are the important determinant of direction of technological change. Kortum and Lerner (1998) and Correa (2012) find upsurge in US patenting due to domestic patent policy change. Establishment of the United States Court of Appeals for the Federal Circuit (CAFC) increased number of patent applications and grants. The establishment of CAFC increased the propensity of innovation by broadening the right of patent holder. Kortum and Lerner (1998) named it as friendly court hypothesis. Correa (2012) analyzed the relationship between market structure and innovation using dataset of 311 firms listed in London Stock Exchange over 1973–1994. This study utilized the establishment of CAFC in 1982 as a structural break in the dataset. This study finds that competition has positive and significant impact on innovation for the period of 1973–1982; however, this relationship becomes insignificant over 1983–1994. The findings of this study suggest that patent policy change plays a very important role in explaining the innovation–market structure relationship. Estimating the relationship without considering structural breaks may mislead the researchers and policy makers.

In Indian context, Sharma et al. (2018) find a positive impact of patent policy change on R&D of Indian industries. This study incorporated different components of patent policy index developed by Ginarte and Park (1997). The findings of this study suggest that duration of protection, enforcement mechanism, and membership in international agreement has positive and significant influence on the innovation capacity of Indian industries. Utilizing firm-level data, Jagadeesh and Sasidharan (2014) analyze the R&D behavior of Indian pharmaceutical firms before and after TRIPs. This study also finds that policy changes have significantly increased R&D expenditure of pharmaceutical firms. According to Haley and Haley (2012), Indian pharmaceutical firms were globally competitive in the production of generics from 1972 to 2004 due to process patent regime. This study suggests that Indian pharmaceutical firms positively responded to changes in patent policy by decreasing the filing of process patents. Study by Chadha (2009) has analyzed the impact of

[2] In literature, various channels of technology transfer are discussed like trade of goods and services, FDI, licensing, joint ventures, departure of employees, temporary migration, and patent application data (Maskus 2004).

TRIPs on patenting activities of Indian pharmaceutical firms. This study finds that the patenting activities have been increased in post-TRIPs era.

It is evident that both innovation and market structure are interdependent. Literature also suggests that the patent policy changes influence the relationship between innovation and market structure. Considering the literature and patent policy change in India, in this paper, we empirically verify the impact of TRIPs on the two-way relationship between patenting and monopoly power in Indian high and medium technology firms. To explore the interdependence between patenting and monopoly power, we utilize the system of two equations, namely patenting equation and monopoly power equation. To analyze the impact of TRIPs, we classify our database into two time periods, 1995–2005 and 2006–2015, as India is fully complied with TRIPs agreement in 2005 by allowing product patent in all fields of technology. We also separately perform the analysis for both high and medium technology firms as sectoral patterns of innovation literature suggest that types of innovation and propensity to innovate vary among industries.

4 Description of Variables

4.1 Endogenous Variables

Both innovation and monopoly power are endogenous variables in this study. We use Lerner index[3] or price cost margin as a measure of monopoly power. PCM also reflects firm-level pricing and cost structure. Following Clerides et al. (2015) and Saraswathy (2018), we calculate the weighted Lerner index (WLI) with market share as the weights. WLI shows the relative position of a firm in a particular industry.

R&D and patenting are some of the major proxies to measure firm-level innovation activities. In the Indian context, studies like Kumar and Saqib (1996), Narayanan (1998), Kathuria (2008), Sasidharan and Kathuria (2011), Basant and Mishra (2014) utilize R&D as a measure of innovation activities which is an input-based measure of innovation. Other studies like Deolalikar and Röller (1989), Chadha (2009), Ambrammal and Sharma (2016), Dhanora et al. (2018), Khachoo et al. (2018), and Dhanora et al. (2019) utilize firm-level patent data to measure innovation activities which is output-based measure of innovation. Patent data is an observer proxy for successful R&D expenditure. Patents acquired by firm are closely associated with newly commercialized technologies. This study utilized patenting as a major proxy of firms' innovation activities.

[3]Koetter et al. (2012) define adjusted Lerner index as: adjusted Lerner = $[(\prod_i + \mathrm{tc}_i - \mathrm{mc}_i q_i)/(\prod_I + \mathrm{tc}_i)]$, where $\prod_i$ is profit, tc_i is total cost, mc_i is marginal cost, andq_i is the output. If we assume that marginal cost is constant, then adjusted Lerner can be defined as: $[(\prod_i/q_i p_i)]$.

4.2 Control Variables

In Sect. 3, we have discussed about the system of two equations, namely innovation and monopoly power equations. We also utilize separate control variables in these equations.

4.2.1 Patenting Equation

With respect to patenting equation, we identify control variables on the basis of literature including size and age of firm, R&D expenditure, exports, embodied and disembodied technologies and advertising. The rationale for introducing these variables is as follows:

Due to availability of finance and economies of scale, large firms do more R&D and patenting activities (Cohen and Levinthal 1989; Sasidharan and Kathuria 2011; Aggarwal 2018). Size (SIZE) and its square term ($SIZE^2$) are important determinants of firms' innovation activities. In knowledge production function, R&D expenditure (RD) determines firms patenting activities (Griliches 1979, 1981; Pakes and Griliches 1980; Crépon et al. 1998). Export-oriented firms are more innovative as they are aware about recent innovations; hence, export intensity (EXPI) positively influence firms patenting (Evenson and Joseph 1999; Ambrammal and Sharma 2014). Technology imports in the form of embodied (EMBD) and disembodied (DISEMBD) also determine firm innovation behavior (Narayanan 1998; Basant and Mishra 2014).[4] Advertisement intensity (ADI) which is a proxy for product differentiation also influences innovation (Basant and Mishra 2014). In differentiated market, firms are more innovative. However, alternative argument is that investment in promotional activities is an alternative strategy to R&D and patenting. We also include age of the firm (AGE) and its nonlinear term (AGE^2) in the patenting equation to explore the possible nonlinear impact of learning by doing (Arrow 1962; Thornhill 2006). In developing country context, patenting performance of multinationals (MNEs) is superior to domestic firms. MNEs have access to technology developed by their parent organization that provides them competitive advantage vis-à-vis domestic firms. Hence, we also incorporate ownership dummy (FOS) in the model. We differentiate between MNEs and domestic firms on the basis of 10% foreign promoters' equity participation (Basant 1997; Ambrammal and Sharma 2014).

[4] Literature on the transaction cost theory (Williamson 1985; Pisano 1990) and absorption capacity building hypothesis (Cohen and Levinthal 1989; Arora and Gambardella 1990; Patel and Pavitt 1997) give detail explanation on the relationship between in-house R&D and technology imports.

4.2.2 Monopoly Power Equation

With respect to monopoly power equation, control variables include export intensity, advertisement intensity, market growth rate, import intensity, ownership, age, and capital intensity of firm. The rationale for introducing these variables is as follows:

Export intensity captures dynamic characteristics of the firm which positively influence firms' monopoly power (Resende 2007; Yoon 2004). Strickland and Weiss (1976) and Yoon (2004) explain that advertisement expenditure increases market concentration. Differentiated firm enjoys more monopoly in the market. More expenditure on promotional strategies also creates high entry barriers which result in high market concentration (Gupta 1983; Resende 2007). Market growth rate (MGR) is also an important control variable in monopoly power equation. MGR is a demand factor which influences firm profits (Gupta 1983). Import intensity (IMPI) enhances the domestic market competition by increasing the efficiency of resource distribution (Yoon 2004). Narayanan (1998) explains that accumulation of technology by learning by doing gives a firm competitive advantage which results in high concentration in the industry. Hence, we also use AGE as a control variable. Capital intensity (CAPITAL) also determines firms' monopoly power. Efficient utilization of capital makes firm more productive (Kambhampati and Parikh 2003). We also incorporate ownership dummy (FOS) in monopoly power equation.

On the basis of above discussion, we have the following system of two equations:

$$\begin{aligned}
\textbf{innovation} &= \mathbf{f}(\textbf{monopoly power}, \textbf{RD}, \textbf{EXPI}, \textbf{DISEMBD}, \textbf{EBMD}, \textbf{ADI},\\
&\qquad \textbf{AGE}, \textbf{AGE}^{\mathbf{2}}, \textbf{SIZE}, \textbf{SIZE}^{\mathbf{2}}, \textbf{FOS})\\
\textbf{monopoly power} &= \mathbf{f}(\textbf{innovation}, \textbf{EXPI}, \textbf{IMPI}, \textbf{ADI}, \textbf{AGE}, \textbf{CAPITAL},\\
&\qquad \textbf{MGR}, \textbf{FOS})
\end{aligned}$$

5 Data

This study utilizes firm-level panel data for Indian high and medium technology industries over 1995–2015. We identify firms in high and medium technology industries on the basis of Organization for Economic Co-operation and Development (OECD) classification and concordance is drawn between International Standard Industrial Classification (ISIC) 2003 Revision 3 and National Industrial Classification (NIC) 2008 via NIC 2004. Major source of data for this study includes Center for Monitoring Indian Economy (CMIE) prowess database and website of Controller General of Patent, Design and Trademark (CGPDT, Government of India). We collected the list of granted patents from monthly publication of CGDTP and Indian Patent Advanced Search System (InPASS).

Dataset for this study include firms which are active in R&D and patenting. Firms which are reporting zero sales are dropped from the sample. After cleaning the data, we are able to collect the information for 686 firms which are active in innovation activities. Out of these 686 firms, 232 (33.81%) firms are high technology and 454 (66.18%) are medium technology firms. We further segregated these firms into domestic- and foreign-owned firms on the basis of 10% foreign promoters' equity participation. Out of 232 high technology firms, 31 (13.36%) firms are foreign firms and 201 (86.63%) are domestic. For medium technology sample, 63 (13.87%) firms are foreign firms and 391 (86.12%) are domestic. Table 2 presents definitions of variables and their data source. Table 3 presents the descriptive statistics of full sample, high and medium technology firms.

Table 4 analyzes R&D and patenting during different patent policy changes. For high technology firms, average R&D intensity (in terms of % of sales) for the period of 1995–1999 is 0.94% which increased to 2.06% over 2006–2015. Average granted

Table 2 Definition of variables and source of data

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

Table 3 Descriptive statistics

Variables	Full sample			High technology			Medium technology		
	1995–2015	1995–2005	2006–2015	1995–2015	1995–2005	2006–2015	1995–2015	1995–2005	2006–2015
WLI	0.00488	0.00458	0.00526	0.00592	0.00521	0.00669	0.00435	0.00425	0.00447
	−0.02	−0.014	−0.025	−0.025	−0.017	−0.032	−0.017	−0.013	−0.021
TOPI	0.50916	0.04598	1.02599	0.72434	0.08424	1.42844	0.3992	0.02643	0.80925
	−4.663	−0.987	−6.664	−5.054	−1.632	−7.055	−4.446	−0.335	−6.409
RD	0.00846	0.00687	0.00958	0.0158	0.01135	0.02069	0.00471	0.00458	0.00484
	−0.033	−0.028	−0.034	−0.054	−0.044	−0.063	−0.011	−0.012	−0.01
EXPI	0.11849	0.103	0.13582	0.15099	0.12554	0.17898	0.10189	0.09149	0.11333
	−0.17	−0.159	−0.179	−0.201	−0.177	−0.222	−0.149	−0.148	−0.148
AGE	3.35638	3.15605	3.57837	3.27939	3.06134	3.51925	3.39573	3.20445	3.60613
	−0.626	−0.689	−0.454	−0.66	−0.728	−0.472	−0.604	−0.664	−0.444
SIZE	6.25424	6.01915	6.52368	6.0768	5.72288	6.46611	6.34492	6.17054	6.53673
	−1.773	−1.736	−1.777	−1.738	−1.695	−1.702	−1.783	−1.737	−1.814
ADI	0.00612	0.0059	0.00637	0.00688	0.00658	0.00721	0.00574	0.00555	0.00594
	−0.017	−0.016	−0.019	−0.018	−0.016	−0.02	−0.017	−0.015	−0.018
CAPITAL	0.56281	0.54821	0.57696	0.56665	0.53484	0.60163	0.56085	0.55504	0.56724
	−0.61	−0.517	−0.696	−0.634	−0.524	−0.734	−0.598	−0.513	−0.679
MGR	12.68256	12.70926	12.64272	13.34845	13.78658	12.8665	12.34228	12.15874	12.54417
	−11.474	−10.637	−12.363	−10.217	−10.351	−10.047	−12.053	−10.739	−13.348
IMPI	0.10319	0.09241	0.11521	0.1174	0.10645	0.12944	0.09593	0.08523	0.1077
	−0.163	−0.149	−0.176	−0.186	−0.149	−0.22	−0.148	−0.149	−0.148

(continued)

Table 3 (continued)

Variables	Full sample			High technology			Medium technology		
	1995–2015	1995–2005	2006–2015	1995–2015	1995–2005	2006–2015	1995–2015	1995–2005	2006–2015
EBMD	0.01085	0.01242	0.009	0.01114	0.01091	0.0114	0.0107	0.0132	0.00795
	−0.071	−0.095	−0.027	−0.061	−0.077	−0.037	−0.076	−0.103	−0.021
DISEMBD	0.002421	0.0024	0.00246	0.00196	0.00164	0.00232	0.00265	0.00278	0.0025
	−0.008	−0.008	−0.009	−0.008	−0.005	−0.01	−0.008	−0.009	−0.007
OBS	14406	7546	6860	4872	2552	2320	9534	4994	4540

Notes Authors' calculations on the basis of information available in CMIE and CGPDT. Standard deviations are shown in parenthesis

Table 4 Average R&D and patenting during different patent policy regime

	Year	Patent granted	R&D intensity
Full sample	1995–1999	0.01107	0.00629
	2000–2002	0.03352	0.00644
	2003–2005	0.11661	0.00828
	2006–2015	1.01865	0.01020
High technology	1995–1999	0.00689	0.00947
	2000–2002	0.04885	0.01005
	2003–2005	0.24856	0.01577
	2006–2015	1.42844	0.02069
Medium technology	1995–1999	0.01321	0.00466
	2000–2002	0.02569	0.00459
	2003–2005	0.04919	0.00440
	2006–2015	0.80925	0.00491

Source Authors' calculations on the basis of information available in CMIE and CGPDT

patent for this industry is 0.006 for 1995–1999 which increased to 1.42 for 2006–2015. For medium technology firms, the average R&D for 1995–1999 is 0.46% which increased to 0.49% over 2006–2015. For the same industry, average granted patent increased from 0.01 to 0.80 from 1995–1999 to 2006–2015. In Table 4, we observe that patent policy change positively influenced R&D and patenting in high technology firms. The average R&D and patenting activities are higher for high technology firms in comparison to medium technology firms.

6 Results of the Model Estimation

Two-stage least square estimation (2SLS) is utilized for empirical estimation (Lunn 1986; Shan et al. 1994; Koeller 1995, 2005). We utilize error component two-stage least square (EC2SLS) for econometric specifications. In simultaneous panel data model, EC2SLS has more instruments than generalized two-stage least square (G2SLS) (Baltagi and Li 1992). Baltagi and Li (1992) explain that in the case of infinite sample, the difference between asymptotic variance of G2SLS and EC2SLS tends to zero; however, in finite sample, EC2SLS is more efficient than G2SLS.

First, we estimate the results for patenting equation for full panel which include both high and medium technology industries and then segregate the panel into high and medium technology firms. We also perform the analysis differently for 1995–2005 and 2006–2015. Similarly, we estimate the results of monopoly power equation. For econometric estimations, all the variables used are in logarithmic scale.

6.1 Innovation Equation

The results of patenting equation are presented in Table 5. Columns I and II present the result of full sample, columns III and IV for high technology, and columns V and VI for medium technology firms. In full-sample estimation, the coefficient of WLI is positive and significant in column II only. This result indicates that firms' monopoly power has positive influence on patenting activities in post-TRIPs era. We also find that this positive relationship is driven by only medium technology firms. For medium technology firms, the coefficient of WLI is positive and significant in columns V and VI. Schumpeter (1942) explains that firms with high market power conduct more innovation activities. This positive relationship is also known as Schumpeterian effect

Table 5 Impact of monopoly power on innovation

	Full sample		High technology		Medium technology	
	I	II	III	IV	V	VI
	1995–2005	2006–2015	1995–2005	2006–2015	1995–2005	2006–2015
WLI	1.86642 (2.51374)	17.62421*** (5.99690)	−3.54014 (2.58065)	0.59001 (4.47396)	4.60537** (1.89046)	31.77513*** (9.15025)
EBMD	−0.00423 (0.01559)	−0.26099 (0.25292)	0.01759 (0.04674)	0.02793 (0.24920)	0.00001 (0.01497)	−0.44993 (0.49849)
DISEMBD	−0.30901 (0.26212)	0.95324 (0.95196)	−0.52740 (1.26182)	0.461742 (0.84840)	0.03770 (0.18501)	1.35272 (2.35017)
EXPI	−0.00035 (0.01354)	−0.09126 (0.06154)	−0.02782 (0.02923)	−0.03872 (0.06374)	−0.00678 (0.01412)	−0.03386 (0.11987)
RD	0.08852* (0.05430)	0.14622 (0.20000)	0.08282 (0.07931)	0.16999 (0.16419)	−0.03961 (0.12742)	1.29417 (1.25098)
ADI	0.64719** (0.16024)	0.75229 (0.67794)	0.28423 (0.28404)	1.09093 (0.72793)	1.14066*** (0.19433)	−0.35192 (1.24753)
AGE	−0.01178 (0.01861)	−0.55095 (0.40342)	0.01300 (0.03179)	−0.75132 (0.53359)	−0.04954** (0.02078)	−0.02048 (0.64976)
AGE^2	0.00178 (0.00329)	0.09642* (0.05840)	−0.00450 (0.00580)	0.12356* (0.07671)	0.00852*** (0.00346)	0.02124 (0.09500)
SIZE	−0.02056 (0.01368)	−0.01850 (0.03064)	−0.07801*** (0.02091)	−0.10096** (0.04005)	0.01102 (0.01101)	−0.00334 (0.04431)
$SIZE^2$	0.00196 (0.00172)	0.00193 (0.00298)	0.00942*** (0.00255)	0.01403*** (0.00381)	−0.00150 (0.00123)	−0.00132 (0.00380)
FOS	0.02714** (0.01286)	0.12354 (0.09374)	0.00253 (0.02549)	0.22679** (0.11187)	0.02419** (0.01053)	0.03237 (0.15918)
CONSTANT	−0.03719 (0.10213)	−0.05194 (0.79205)	0.12595** (0.05008)	1.33690 (0.92288)	−0.14872 (0.07573)	−1.40570 (1.31082)
SLM (AGE)	–	–	–	–	2.27** [0.0116]	–
SLM (SIZE)	–	–	3.58*** [0.00017]	2.51*** [0.00602]	–	–
OBSERVATION	7546	6860	2552	2320	4994	4540

Notes This table presents estimations using EC2SLS technique. Dependent variable is patent grants. Standard errors are shown in parenthesis. Square brackets contain *p*-value. Here ***, **, and * denote that coefficients are statistically significant at 1%, 5%, and 10%, respectively. Time- and industry-specific dummies have been incorporated in the models. SLM test is Sasabuchi–Lind–Mehlum test to verify U-shaped or inverted U-shaped relationship of competition on innovation (Aghion et al. 2005). Larger and dominant firm have more incentive to innovate due to availability of finance, economies of scale, strong patent protections, and other competitive strategies.

We also explore possible nonlinear impact of WLI on patenting.[5] For this purpose, we introduce WLI^2 as a new variable in innovation equation and results for same are reported in Table 6. The basic setup of Table 6 is same as Table 5. In columns II, IV, and VI, we find a significant inverted U-shaped relationship between monopoly power and patenting. Here, we notice that this nonlinearity prevails only in post-TRIPs era. This result suggests that having monopoly power positively influence patenting up to an optimal level only and afterwards patenting goes down with further increase in the monopoly power. We also perform Sasabuchi–Lind–Mehlum (SLM)[6] to verify this nonlinear relationship. In Columns II, IV, and VI, the SLM test statistics also confirm this inverted U-shaped relationship of Table 6.

In Table 5, we find that the coefficient of ADI is positive and significant in columns I and V. For medium technology firm, high product differentiation is a source of innovation; however, ADI becomes insignificant for post-TRIPs regime. In Column V, the coefficient of AGE is negative and AGE^2 is positive and both are significant which indicates a significant U-shaped relationship between age of the firm and patenting. This U-shaped relationship is also supported by SLM test. For high technology firm, the coefficients of SIZE and $SIZE^2$ also suggest a significant U-shaped relationship with patenting. SLM test in columns III and IV of Table 5 also confirms this nonlinear relationship between SIZE and patenting. The coefficient of ownership dummy (FOS) is positive and significant in columns I, IV, and V. For high technology firms, foreign firms are more active in patenting in post-TRIPs regime. In new patent regime, foreign firms are protecting their newly invented products and process by filing more patents in developing countries. For medium technology firms, we find that the coefficient of FOS is positive and significant for 1995–2005 only. In Table 6, we note that coefficients of some of the control variables are sensitive with addition of WLI^2 in the innovation equation. Coefficient of RD is positive and significant in columns I and VI. The coefficient of EBMD is negative, DISEMBD is positive and both are significant in column II. In column II, we also find that the coefficient of EXPI is negative and significant. However, once the sample is segregated into high and medium technology firms, these coefficients do not produce strong impact on patenting activities.

[5]Aghion et al. (2005) follow Schumpeter (1942) and Arrow (1962). According to Arrow (1962), there exists negative effect of monopoly power on innovation. Competition is a source of efficiency and productivity which leads to more innovation activities.

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

Table 6 Nonlinear impact of monopoly power on innovation

	Full sample		High technology		Medium technology	
	I	II	III	IV	V	VI
	1995–2005	2006–2015	1995–2005	2006–2015	1995–2005	2006–2015
WLI	−0.04249 (2.25498)	45.55250*** (8.71013)	−3.55314 (3.00746)	12.11499* (7.48629)	6.81873* (4.18884)	50.60706*** (9.01017)
WLI^2	31.10412 (21.56962)	−48.65505*** (12.06315)	5.45539 (21.87598)	−14.00184** (7.07439)	6.96595 (42.00714)	−55.97990*** (18.52718)
EBMD	−0.02015 (0.02054)	−0.58653** (0.25515)	−0.01544 (0.05366)	−0.14902 (0.28229)	−0.00068 (0.01624)	−0.55042* (0.30512)
DISEMBD	−0.31530 (0.30441)	1.73262* (0.93026)	1.87649 (1.28624)	0.78816 (0.92805)	0.07596 (0.21719)	1.45777 (1.44395)
EXPI	−0.00396 (0.01240)	−0.13089** (0.05948)	−0.04069* (0.02412)	−0.07379 (0.07055)	−0.00269 (0.01715)	−0.04243 (0.07340)
RD	0.20148*** (0.06830)	0.26223 (0.19407)	0.16011* (0.08927)	0.19318 (0.17700)	−0.08812 (0.14212)	1.55015** (0.76964)
ADI	1.35550*** (0.13770)	0.10873 (0.67106)	0.33665 (0.23930)	0.92035 (0.78695)	0.43213 (0.33880)	−0.68683 (0.77097)
AGE	−0.04378** (0.01730)	−0.27165 (0.38845)	0.00067 (0.03289)	−0.69622 (0.57069)	−0.06702** (0.03195)	0.01507 (0.40408)
AGE^2	0.00729*** (0.00280)	0.05591 (0.05588)	−0.00154 (0.00558)	0.11742 (0.08184)	0.01009* (0.00578)	0.01217 (0.05983)
SIZE	−0.00133 (0.01142)	0.04827 (0.03368)	−0.06874*** (0.02099)	−0.06480 (0.04708)	0.01988 (0.01749)	0.05472* (0.03330)
$SIZE^2$	0.00037 (0.00127)	−0.00688* (0.00358)	0.00836*** (0.00237)	0.00883* (0.00491)	−0.00284 (0.00213)	−0.00797** (0.00323)

(continued)

Table 6 (continued)

	Full sample		High technology		Medium technology	
	I	II	III	IV	V	VI
	1995–2005	2006–2015	1995–2005	2006–2015	1995–2005	2006–2015
FOS	0.02483*** (0.00618)	0.10795 (0.08452)	−0.00040 (0.01616)	0.24272** (0.11718)	0.03031 (0.02480)	0.02327 (0.10660)
CONSTANT	−0.10149 (0.06576)	−1.43620* (0.81360)	0.11955*** (0.04380)	1.22054 (0.98819)	−0.19557 (0.15212)	−1.98637 (0.85389)
SLM (WLI)	–	3.06*** [0.00111]	–	1.62* [0.0529]	–	1.88** [0.0303]
SLM (AGE)	2.53*** [0.00571]	–	–	–	1.09 [0.138]	–
SLM (SIZE)	–	–	3.27*** [0.00054]	1.37 [0.0849]	–	1.63* [0.052]
OBSERVATION	7546	6860	2552	2320	4994	4540

Notes This table presents estimations using EC2SLS technique. Dependent variable is patent grants. Standard errors are shown in parenthesis. Square brackets contain p-value. Here ***, **, and * denote that coefficients are statistically significant at 1%, 5%, and 10%, respectively. Time- and industry-specific dummies have been incorporated in the models. SLM test is Sasabuchi–Lind–Mehlum test to verify U-shaped or inverted U-shaped relationship

6.2 Monopoly Power Equation

The results of innovation equation are presented in Table 7. The coefficient of TOPI is positive and significant in all the columns which confirm that there is a feedback effect of innovation on monopoly power. Studies like Gupta (1983), Lunn (1986), Koeller (1995), Delorme et al. (2002) and Yoon (2004) also confirm positive impact of innovation on monopoly power. This significant relationship holds for both pre- and post-TRIPs era. Firms' patenting is a positive source of monopoly power by increasing pricing structure through product differentiation and also by minimizing cost of production (Dhanora et al. 2018).

Following recent studies by Lokshin et al. (2008), Berchicci (2013), Nemlioglu and Mallick (2017), and Dhanora et al. (2018), we explore nonlinear impact of innovation on monopoly power by introducing nonlinear term of patenting ($TOPI^2$) and report the results in Table 8.[7] In columns I, III, and V, we find that the coefficient

Table 7 Impact of innovation on monopoly power

	Full sample		High technology		Medium technology	
	I	II	III	IV	V	VI
	1995–2005	2006–2015	1995–2005	2006–2015	1995–2005	2006–2015
TOPI	0.10559*** (0.01367)	0.02708*** (0.00219)	0.03771*** (0.00885)	0.02734*** (0.00414)	0.08804*** (0.02040)	0.02386*** (0.00296)
IMPI	0.00046 (0.00147)	0.00065 (0.00200)	0.00103 (0.00214)	0.00277 (0.00365)	0.00072 (0.00128)	−0.00139 (0.00242)
EXPI	−0.00033 (0.00181)	0.00122 (0.00235)	0.00060 (0.00225)	0.00271 (0.00420)	−0.00028 (0.00172)	0.00120 (0.00317)
ADI	−0.02564 (0.02193)	−0.04812 (0.02593)	−0.01005 (0.02268)	−0.06182 (0.04981)	−0.00932 (0.02550)	−0.00757 (0.03255)
AGE	0.00311*** (0.00093)	−0.00253** (0.00125)	0.00090 (0.00117)	−0.00143 (0.00315)	0.00467*** (0.00100)	−0.00224 (0.00162)
CAPITAL	−0.00092** (0.00047)	−0.00060 (0.00060)	−0.00073 (0.00062)	−0.00100 (0.00136)	−0.00099** (0.00043)	−0.00057 (0.00068)
MGR	0.00002 (0.00001)	0.00007*** (0.00002)	0.00001 (0.00002)	0.00020** (0.00008)	0.00001 (0.00002)	0.00004** (0.00002)
FOS	−0.00274 (0.00311)	−0.00227 (0.00159)	−0.00051 (0.00485)	−0.00787* (0.00429)	−0.00206 (0.00344)	0.00052 (0.00204)
CONSTANT	0.02871** (0.01377)	0.05082*** (0. 00830)	−0.00189 (0.00380)	−0.00479 (0.01042)	0.02278* (0.01254)	0.04809*** (0.00951)
OBSERVATION	7546	6860	2552	2320	4994	4540

Notes This table presents estimations using EC2SLS technique. Dependent variable is weighted Lerner index. Standard errors are shown in parenthesis. Square brackets contain p-value. Here ***, **, and * denote that coefficients are statistically significant at 1%, 5%, and 10%, respectively. Time- and industry-specific dummies have been incorporated in the models

[7] Lokshin et al. (2008) and Berchicci (2013) explain negative relationship between innovation and firms' performance in terms of diseconomies of scale, high monitoring, and coordination costs associated with high level of innovation activities. Nemlioglu and Mallick (2017) also find inverted U-shaped relationship between innovation and firm performance in the manufacturing firms of the

Table 8 Nonlinear impact of innovation on monopoly power

	Full sample		High technology		Medium technology	
	I	II	III	IV	V	VI
	1995–2005	2006–2015	1995–2005	2006–2015	1995–2005	2006–2015
TOPI	0.51052*** (0.17189)	0.02559** (0.00994)	0.52329*** (0.08626)	0.01130 (0.01417)	0.72356*** (0.19260)	0.02616** (0.01273)
$TOPI^2$	−0.20113** (0.08774)	0.00046 (0.00354)	−0.18116*** (0.03814)	0.00661 (0.00550)	−0.35206*** (0.10574)	−0.00072 (0.00410)
IMPI	−0.00036 (0.00337)	0.00087 (0.00201)	0.00242 (0.00674)	0.00150 (0.00372)	−0.00125 (0.00364)	−0.00150 (0.00253)
EXPI	−0.00108 (0.00389)	0.00173 (0.00244)	−0.00144 (0.00578)	0.00259 (0.00424)	0.00167 (0.00421)	0.00116 (0.00314)
ADI	−0.06620 (0.04812)	−0.04330 (0.02691)	0.03254 (0.05890)	−0.07008 (0.04798)	−0.13510* (0.07833)	−0.01020 (0.03291)
AGE	0.00126 (0.00138)	−0.00241* (0.00138)	0.00117 (0.00136)	−0.00211 (0.00275)	0.00047 (0.00124)	−0.00226 (0.00157)
CAPITAL	−0.00119 (0.00105)	−0.00067 (0.00063)	−0.00030 (0.00189)	−0.00051 (0.00133)	−0.00098 (0.00112)	−0.00057 (0.00068)
MGR	−0.00003 (0.00005)	0.00007*** (0.00002)	−0.00003 (0.00010)	0.00023** (0.00009)	−0.00006 (0.00006)	0.00004** (0.00002)
FOS	−0.00006 (0.00335)	−0.00229 (0.00177)	0.00348 (0.00336)	−0.01002** (0.00407)	−0.00113 (0.00243)	0.00047 (0.00198)
CONSTANT	0.03685*** (0.01405)	0.05028*** (0.00918)	−0.00264 (0.00550)	−0.00264 (0.00925)	0.04068*** (0.01001)	0.04822*** (0.00922)
SLM (TOPI)	2.09** [0.0185]	–	4.23*** [0.00001]	–	3.05*** [0.00116]	–
OBSERVATION	7546	6860	2552	2320	4994	4540

Notes This table presents estimations using EC2SLS technique. Dependent variable is weighted Lerner index. Standard errors are shown in parenthesis. Square brackets contain *p*-value. Here ***, **, and * denote that coefficients are statistically significant at 1%, 5%, and 10%, respectively. Time- and industry-specific dummies have been incorporated in the models. SLM test is Sasabuchi–Lind–Mehlum test to verify U-shaped or inverted U-shaped relationship

of TOPI is positive and $TOPI^2$ is negative and both are significant. These estimations suggest a significant inverted U-shaped relationship between patenting and monopoly power. We also note that this nonlinearity exists only during 1995–2005. During post-TRIPs era, we do not find any nonlinear relationship. In post-TRIPs phase, firms are focusing more on R&D and patenting activities as a source of monopoly power. There are other strategic reasons for increased patenting in post-TRIPs regime like protection against infringement, strengthening competitive advantage, creation of entry barriers, and protection from litigation. Firms' in new patent regime are engaged in efficient production through technological innovations and effective coordination through other non-technological innovations.[8] Contract research and collaborative R&D has also increased among Indian firms. Firms' technological strategies like interaction between in-house innovations and technology imports also sustain the long-term positive relationship between innovation and firms' performance.

UK. Further, Dhanora et al. (2018) also find inverted U-shaped relationship between product and process innovation and firms' monopoly power in Indian pharmaceutical industry.

[8]Non-technological innovations include marketing and organizational innovations.

Table 9 Summary of the results

		Transition phase (1995–2005)		Post-TRIPs phase (2006–2015)	
		High technology	Medium technology	High technology	Medium technology
Impact of market power on innovation	Linear	Insignificant	Positive significant	Insignificant	Positive significant
	Nonlinear	Insignificant	Insignificant	Negative significant	Negative significant
Impact of innovation on market power	Linear	Positive significant	Positive significant	Positive significant	Positive significant
	Nonlinear	Negative significant	Negative significant	Insignificant	Insignificant

In Table 7, the coefficient of AGE is positive and significant in columns I and V which suggest that older and experience firms are enjoying more monopoly power. The coefficient of CAPITAL is negative and significant in columns I and V. Kambhampati and Parikh (2003) also reported same results for Indian manufacturing firms. They explain this negative relationship in terms of under utilization of capital as a factor of production. Market growth rate (MGR) has significant and positive influence on WLI in post-TRIPs regime. In Table 8 also we find that MGR is positively influencing WLI.

7 Conclusion

This study explores the impact of patent policy change on the relationship between innovation and monopoly power spanning from 1995 to 2015. We have classified analysis into two time period as 1995–2005 and 2006–2015. With the third amendment to the Patent Act 1970 which was introduced through the Patents (Amendment) Ordinance, 2004, with effect from January 1, 2005, which was later replaced by the Patents (Amendment) Act 2005, Government of India complied with TRIPs agreement. The period 1995–2005 was the transition phase for patent policy change as three amendments (1999, 2002 and 2005) were made in the Patent Act 1970. For the period 2006–2015, real implications of strengthening patent policies can be realized on R&D, patenting, and monopoly power. We utilized weighted Lerner index as a measure of monopoly power and granted patents to measure firm-level innovation activities.

Empirical analysis based on high and medium technology firms suggest interdependence between innovation and monopoly power; however, this relationship varies with change in patent policy. For high and medium technology firms, there is nonlinear impact of monopoly power on patenting activities in post-TRIPs regime; however, this relationship is insignificant during transition phase of patent policy change. While examining the impact of patenting on monopoly power, we find that patenting has positive and significant impact on firms' monopoly power in both pre- and post-TRIPs regime. While examining nonlinear relationship, we find inverted U-shaped relationship between patenting and monopoly power during 1995–2005 only.

Based on empirical analysis, this study has important policy implications for developing countries like India. In Indian context, this study suggests that in-house innovation activities are also potential source of firms' monopoly power as the causality also runs from innovation to monopoly power. This relationship is stronger in post-TRIPs era as we do not find any nonlinear impact of innovation on monopoly during this period. An innovative firm can dominate the market by conducting more technological innovations.

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Interplay of Technology and Labour Productivity: Emerging Story of Consumer Electronics in India

Bino Paul and Mansi Awasthi

1 Introduction

Over the years, scholars have been unbundling the big word ‘capital’. To one extreme extent, it is a stock over a period, while at the other extreme extent, it is an ensemble of tangible and non-tangibles, such as artefacts, discoveries, innovations and capabilities. Whatever be the view, capital has been an active change agent from diverse vantages, be it socially good or bad. While the chronicle of capital goes in hand with expansion of business or production, there seems to be an organic link between capital and human, in particular the production system as a case in point. Is this connect mutually beneficial or a trade off? This question is evergreen. Maybe this connect is not linear, rather enmeshed in diverse milieus like globalisation and value chains. An interesting case in point that embodies the interesting dynamics of technological change, globalisation and change in business models is the consumer electronics. This industry epitomises the commodification of research and development in consumer electronics to the final consumption stage, for example colour television and electronic home appliances. What makes this industry more interesting is that its growth is more dependent on populous large developing economies such as India, wherein product penetration rates are noticeably lower than that of developed countries.

In the case of consumer electronics industry in India, the supply of commodity tends to emanate from the domestic industry or from the abroad through the import. With the emergence of global value chains, the domestic production facilities tend to source products through imports, and then add value before selling. Alternately, reputed brands may contract manufacturing to a production facility on the basis of factors such as cost advantages, relational comfort and so on. So, this means that the sketching of production and trade in the context of global value chain is not

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so straightforward. Moreover, although trading and manufacturing tend to be more flexible, the market structure in aggregate appears to have been becoming more oligopolistic in nature, particularly colour television as case in point.

This paper explores the dynamics of consumer electronics production in Indian during last one and half decades. We juxtapose the analysis of domestic production with insights emerging from the media content and secondary data that narrate the recent dynamics in Indian consumer electronics industry. First, we set the background for the discussion by drawing cues from the extant literature on capabilities and firms. Second, we bring out the emerging chronicle of consumer electronics industry and business in India, using the meta-content drawn from the media coverage. Third, we resort to descriptive and inferential analysis of factory-level data drawn from Annual Survey of Industries (ASI), examining the relationship between technology and productivity. Fourth, we build a structural model from the data in which we explore the determinants of labour productivity, technology and share of profit in net value added (NVA).

2 Technology as a Capability

Technological advance is long understood as the principle driving force of economic growth. To appreciate the importance of technological contributions, it is important to understand the historical relationships between science and technology. The history of science as a subject sheds light on how scientific knowledge has helped technologies to understand artefacts and processes with which they work and tailored them to new purposes. The colossal contribution of science to the development of new technology, as a by-product of scientific enterprise, was possible in large measures because particular disciplines have been put into place for that purpose (Chandler et al. 2003). For instance, the discipline of metallurgy emerged from material sciences and engineering in the second half of the nineteenth century to meet the requirement of steel industry. On the industry side, firms started their own research laboratories focusing upon the specificities of firm's technological needs in the competitive environment. The universities institutionalised research and development through continuous supply of scientists and engineers, and, in return, these industrial laboratories created prospective markets for their university graduates (Chandler et al. 2003). The interdependence between augmented university curricula that would enhance student's usefulness to industry and emerging industrial research laboratories pushed the growth of knowledge to assure the needs of various industries. Meanwhile, new applied disciplines, performed at several universities, for instance, electrical and chemical engineering, were started emerging during late nineteenth century to meet the requirements of the new emerging industry for process and products development. The science led to the breakthroughs in technology and creation of stock of knowledge in subjects of commercial value to industries. Over the decades, technology became complicated through improvements in old technologies in the similar manner as it has taken directions from science and its applications. More sophisticated industrial scientific research has evolved out of those simple and traditional beginnings, which have helped private industries to capture national and world markets.

This brings us to the next section on growing interest in technological changes and concerns over the prospects for economic growth. The writings on the technology opportunism have highlighted co-evolution of technology, firm performance and industry structure. There is a colossal literature on the contribution of technology in economic growth. While there is no dispute to it, Rosenberg addresses the question on how technological changes come about by looking into the origin and generation of new technologies (Chandler et al. 2003). The technology has not only grown significantly in the last decades but is no longer seen as exogenous element in the stimulation of growth (Rosenberg 1977). A one-dimensional view is being replaced by multifacet complex, encompassing different elements and inherent dynamics within it that goes beyond the traditional information-processing view of technology. The move from the realm of science to technology over centuries invites the economic motives of firm and firm-level technological changes. The firm, discussed here, is the dynamic firm, characterised by the technology it employs, strategies employed, organisational characteristics, concentration of its geographical embeddedness and its role in regional economies (Chandler et al. 2003). It is well understood that a business enterprise creates and uses embedded resources in pursuit to exploit underutilised resources in new markets. This, in turn, generates extra profits in foreign markets, thus giving them greater competitive advantages in global market place. The diverse international environment allows enterprise to develop diverse capabilities, resulting from broader organisational learning opportunities and innovations, which in turn, ensures ongoing growth of the firm. But, what and how well an enterprise develops strategies and organisational capabilities to sustain competitive advantage in a global market place?

The nature and micro-foundations of dynamic capabilities are necessary to understand firms are able to sustain superior performance. Dynamic capability is the capacity to extract rents from current resources as well as build new competencies (Teece et al. 1997). Deploying dynamic capabilities thus involves both capability exploitation and capability building (Luo 2002). Capability exploitation concerns the extent to which a firm exploits rent-generating resources that are firm specific, difficult to imitate, and able to generate abnormal returns. Capability building involves the extent to which a firm commits to building new capabilities through learning from other organisations, creating new skills or revitalizing existing skills in new situations (Luo 2002). These combining capabilities are the key to major source to exploit advantages, and these advantages are only possible when firms continuously reinvent in building new resources. The ability to combine internal resources and external learning is vital to firm's survival and growth in foreign market. However, all firms or industries do not show equal ability and readiness to undertake innovations for continual growth. This conundrum can be answered though historical dimension of innovative activity of electronics industry of USA and Japan at a different point of time.

Chandler et al. (2009) attribute the reason why the Japan overtook the USA in economic performance in electronics industry to differences in strategy, management and enterprise structure. The organisation of Japanese firms after 1950 was a major factor enabling Japanese post-war growth. He traces the course of successful firms in becoming path definers in consumer electronics and computer industry from 1940s to late twentieth century. The distinctive and dynamic capabilities as the basis of competitive advantage of Japanese enterprises reshaped the world consumer electronic market in 1960s. The first movers and their followers, Sony and Matsushita, built integrated leaning bases that helped them to develop, produce and sell in national economies and followed by world markets (Chandler et al. 2009). They grew their bases through reinvestments and diversified into related higher technology and markets. Another important characteristic was the creation of a supporting nexus of large and small enterprises in commercialising new products, thus forming industry's infrastructure that helped them to commercialise the potential of the modern science based technologies. Mowery and Rosenberg (1989) ascribe power to these dynamic capabilities framework in helping to illuminate the importance of enterprise performance to industrial leadership.

The conceptual underpinnings of dynamic capabilities paradigm can be traced to the new behavioural theory of the firms. This framework has been intertwined with contemporary ideas of technological innovations and evolutionary theory of economic change. The foundation of behavioural theory of the firm was laid in 1950s and 1960s on the ideas on 'bounded rationality', 'opportunistic behaviour' and 'routines'. Building on these foundations, both, transaction cost economics and evolutionary theory, have enriched the theory of firm. The evolutionary work by Nelson and Winter (2002) emphasised on the technological advances and performance, the key element in the competitive struggle in the context of economic change at the organisation and industry level. The essence of all the theories is that competitive success arises from the continuous development, alignment and reconfiguration of firm specific assets (Augier and Teece 2009). It is important to outline specifically how firms create new knowledge, shape new investment opportunities,and then transform themselves in the new environment. This involves understanding both technological and organisational change.

Setting the background of centrality of technological phenomena and dynamic capability framework in pushing the growth, the paper makes a modest attempt to examine and to explain the productivity dynamics with choice of technology, consumer electronics industry in India as a case in point.

3 Consumer Electronics Sector in India

The consumer electronics sector in India has been one of the fastest growing industrial sectors. Indian television and consumer durables market have been growing big, but it is primarily driven by imports. However, with the given macroeconomic factors and government impetus with 'Make in India', India is well positioned to increase its manufacturing base in the consumer durables. The burgeoning consumer electronics market in India presents an attractive opportunity to manufacturers. Most of the global corporations are looking at India as regional hub for manufacturing and sales to cater to not only Indian market, but South Asian Association Regional Cooperation and Middle East and African markets, as well. The size of Indian consumer electronics segment is large, growing and is primarily driven by imports. Indian electronics industry revenue in 2014 was US 32.7 billion dollars in 2014. Of this, consumer electronics accounted for 28%. The consumer electronics is expected to be US 29-billion-dollar market by 2020 from US 10 billion in 2015 (FICCI and EY 2015).

There is a huge opportunity for manufacturing in India. First, the demand for flat televisions, refrigerators, washing machines and air conditioners is on rise with increasing disposable income and urbanisation of consumers. Market for white goods and televisions has been growing at close to 14% and is expected to accelerate in coming years. Second, there has been a rise in imports from low-cost regions, China and South-East Asia to meet the rise in demand. Third, companies are planning to expand their local manufacturing in India to meet rising local demand and make the country an export hub. The Indian consumer durables markets have traditionally been a 'high spend', priority sector. Consumer durables account for more than 40% of end consumer spending in India (FICCI and EY 2015). According to Consumer Electronics and Appliances Manufacturers Association, the sector contributes to more than 5.5% of Index of Industrial Production. Figure 1 shows the growing market for fours items in consumer electronics: television (TV), air conditioner, refrigerator and washing machine.

Of late, exports from India have been on a rise. The compound annual growth rates of exports of air conditioners, washing machines, refrigerators and televisions are 20%, 55%, 8% and 3%, respectively, during 2010–2014 (FICCI and EY 2015). UAE, particularly Dubai is a major import hub for India. India is well positioned

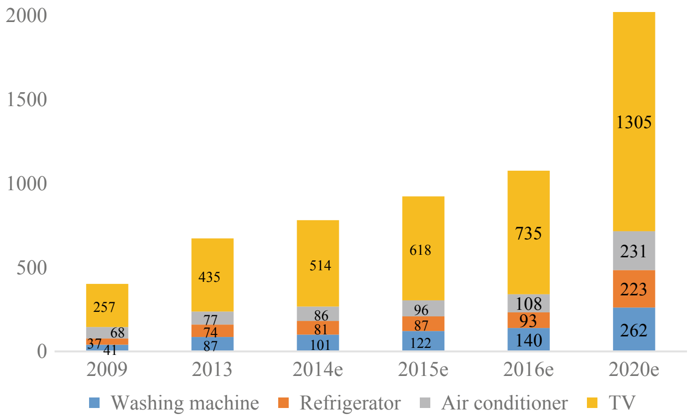

Fig. 1 Indian consumer electronics market size (rupees billions). *Source* FICCI and EY (2015). *Note* '*e*' mean estimate

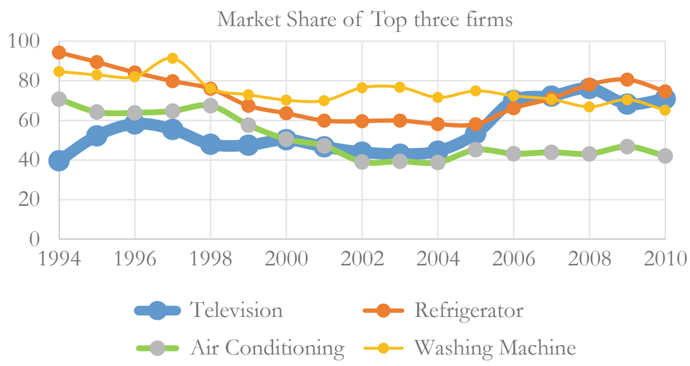

Fig. 2 Market share of top three firms in consumer electronics and home appliances in India. *Source* Industry: Market size and shares, Centre for Monitoring Indian Economy. *Note* Figures are in per cent

to increase its manufacturing base. India is the second-largest population with 0.5 billion in labour force. The 'Make in India' initiative is pushing investments in infrastructure, tax incentive and other policies, facilitating ease of doing business and streamlining exports and imports. But there are some impediments to expanding the local manufacturing base—tax and duty structure, limited scale and quality from domestic suppliers, increasing competition from Chinese and South-East Asian manufacturer, capital intensive nature of business, ease of setting up and running businesses, infrastructure bottlenecks. Also, majority of the parts going into locally manufactured products are imported from China, Japan, Indonesia, Malaysia and Taiwan.

As shown in Fig. 1, across the years, television forms largest share, hovering around two-third, of the consumer electronics market. This makes television industry as a special case in point. During 1994–2010, spanning over fifteen years, share of top three firms in television market increased from 40 to 71% (Fig. 2). Quite important, except for air conditioner, for other products, in 2010, market shares of top three firms account for two-third to three-fourth. This pattern appears to unravel some interesting dynamics. Drawing cues from this trend, it is sensible to posit that the market structure tends to become more oligopolistic while it is moving away from a competitive structure. To have this story, we may connect diverse nods like data points and contents. As an interesting corollary to these dynamics, Fig. 3 depicts that around 2011 value of imported TVs exceeded the domestic production, and this has been continuing, since then. Further, as depicted in Table 1, during 2008–2009 to 2016–2017, East Asian Countries, in particular Malaysia and China, remained as top importers. How we narrate this pattern, further, by using supporting contents? Is this behaviour valid for the whole consumer electronics? To explore these interesting questions, we have created a meta-content of the news from the media, concerning the

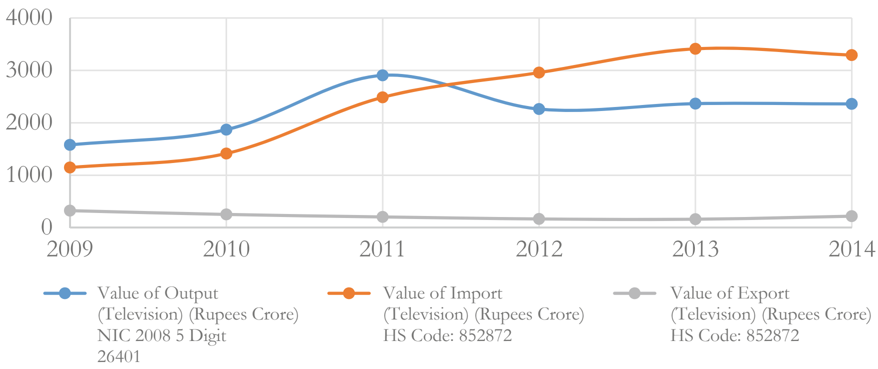

Fig. 3 Domestic production, import and export of television. *Source* Value of output was extracted from Annual Survey of Industries; unit records values of import and export were obtained from http://commerce.nic.in/eidb/default.asp. *Note* Figures are in per cent. NIC = National Industrial Classification, HS = Indian Trade Clarification based on harmonised system of coding

Table 1 Top three TV importing countries to India

Year	Top three TV importing countries to India
2008–09	Malaysia, Thailand, China
2009–10	China, Thailand, Hong Kong
2010–11	Malaysia, China, Hong Kong
2011–12	China, Malaysia, Indonesia
2012–13	Malaysia, China, Thailand
2013–14	Malaysia, China, Thailand
2014–15	Malaysia, China, Indonesia
2015–16	Malaysia, China, Thailand
2016–17	Malaysia, China, Thailand

Source Extracted from http://commerce.nic.in/eidb/default.asp

consumer electronics, by using India Business Insight,[1] capturing the news content during 1995–2017. As given in Appendix 1, we divide the meta-content into three broader segments: value chain, research and development and market. The ensuing discussion is based on the meta-content given in Appendix 1.

[1]India Business Insight is a comprehensive online research tool to Indian business and industry information. The database encompasses daily newspapers, magazines and accesses information disseminated through government sources.

4 Foreign Conglomerates Forays into Indian Consumer Electronics

The relaxation of licensing requirements during mid-1990s effectuated multinational conglomerates into Indian markets of consumer electronics. The onslaught of foreign brands has revamped up their penetration into Indian markets in the last two decades, elbowing out domestic enterprises. The competition from rivals', majorly Korean consumer giants, LG and Samsung, besieged the broken domestic companies—BPL and Onida, most prominent of them in late 1990s. The domestic enterprises did not invest in scale or new technologies during the period of protection, and, as a result, could not adjust to the increased competition from foreign investors who started setting up their local production. Consequently, Indian consumer electronics industry was dominated by multinational corporations such as LG, Samsung and Sony through surpassing in products, features and design.

The broad liberalisation provided ingress to several foreign private conglomerates. In 1995, Samsung invested $1 billion in India. Hyundai electronics made an entry into consumer electronics market in India, through several models of colour televisions in 2004 and later rolled out air conditioners, refrigerators and other consumer electronics by mid-2005. The three consumer electronics giants of China, TCL, Shinco and Aigo made an entry in India as the industry started booming. Shinco tied up with Future Techno Designs (FTD), India, to start product localisation in India by 2008. Aigo, another leading information technology brand, launched its range of digital and self-assembling products in India in 2009. Seagate Technology floated joint ventures to enter Indian market in 2001. Some companies, for instance, Akai made a comeback to Indian markets in partnership with Global Brands in 2010.

Multinationals posted strong growth in sales and profit in their businesses. LG electronics entered Indian market with manufacturing television sets in 1997 and in the next two years, its turnover crossed Rs 1000 crore and topped in the colour television, semi-automatic washing machine, microwave oven, air conditioner and frost-free refrigerator segments of the market by 2002. Similarly, Sony India witnessed sales of Rs 615 crores during 1999–2000, Samsung recorded a sales turnover of Rs 1700 crore during 2002, Panasonic registered sales of Rs 150 crore from its consumer electronics business in 2005–2006, and Videocon achieved sales of Rs 23,000 crore in 2007–2008. The consumer electronics industry in India has been on a high growth path and achieved double-digit sales growth at Rs 26,000 crore in 2008–2009. Multinational companies with superior technology and better-quality control accounted for 70% of the overall market in 2011–2012. Samsung and LG followed the same path into leadership in sale and built commanding lead in the market. Both retained their top spots in the Indian consumer electronics markets in terms of revenue. LG sales grew to Rs 12,958.6 crore in fiscal year 2014–2015, and net profit rose 20% to Rs 761 crore. The Indian consumer electronics market has become more active, exciting and intense with the announcement of investments by foreign private players. However, South Korea-based LG and Samsung duo continued to strengthen their position within Indian market.

The positive numbers of sales have led companies to expand its manufacturing plants all over India. The consumer electronics companies have invested in India to construct new production lines with an extensive focus on domestic manufacturing, following their foray into consumer electronics segment. Over the years, all conglomerates have expanded its portfolio of products to grab market share through attracting local customers with a customised marketing approach. All drew up plans to get more from India by focusing on investments on capacity building, new manufacturing units and new product range on account of rising demand for consumer durables in the region. Philips lined up Rs 200 crore investments to regain double-digit market share in colour television segment during 2003–2004. Hyundai electronics has set up a facility for manufacturing colour televisions (1.2 million per annum) and air conditioners (0.2 million per year) in Uttarakhand for Rs 100 crore. Likewise, Samsung has invested additional Rs 350 crore in its facility in Sriperumbudur to manufacture consumer electronics products and information technology products. LG Electronics has spent Rs 380 crore to create new production lines in 2007 and Rs 1000 crore in setting up new plants for manufacturing 3D appliances in 2013. The consumer electronic companies have invested Rs 3500 crore cumulatively to enhance manufacturing in India through the modified special incentive package scheme. They have put bolstering efforts to expand their presence in India by introducing innovative products and marketing schemes that are specially tailored for Indian consumers.

5 Emerging R&D Destination in India

Indian economy has become a significant recipient of foreign direct investments from the electronic majors. The trends emerging in the market involves convergence of intelligence and smart technologies in appliances to ensure next level user experience. Nearly, all companies have set up their R&D units across the country to develop internal technology focusing on innovative products with intelligent features.

Proliferating their capital expenditure, companies invested into identify consumer insights to incorporate consumer purchase behaviour in product development and marketing strategies. Recent and upcoming technology-ingrained products in the Indian market reiterate the emphasis of product innovation and development to lead the way in future. In a bid to capture market share, companies have changed their strategy by building products specifically to suit Indian needs and by soaring its marketing and R&D expenditure. Samsung and LG earmarked $5 and $9 million, respectively, for R&D during their initial years in India. Subsequently, LG invested Rs 800 crore on new products range, technology platform for manufacturing and India specific R&D. In 2011, Philips developed innovation hub for more locally relevant products in the appliances segment and LG invested Rs 1000 crore for capacity building in the next two years. Panasonic has also set up a R&D centre along their manufacturing plant in Haryana in 2012. Videocon invested Rs 900 crore on R&D for new range of niche products in 2015–2016. Recently, in 2017, Panasonic has set up its R&D unit in Bengaluru.

Technology leadership is the key for the good growth and strengthening the market leadership in consumer durable industry. The development of companies' portfolios of patents and R&D investments parallels their technology development. The electronics makers have continued to invest significantly in R&D and pile up patents and invest higher per cent of sales. Most of the companies have revamped up their research and development spending and started accumulating technology. Samsung has set up consumer laboratory in Indian Institute of Technology, Delhi, to analyse product aspects like aesthetics, ergonomics and user interface. Samsung spends 7–8% of out of revenues each year that gives competitive edge in customizing products for domestic markets like digital signage and edutainment solutions.

6 Production Chain of the Indian Consumer Electronics Industry

Industry-level restructuring in response to trade liberalisation involved consequent changes in the involvement of domestic enterprises. It is important to examine the production chain of the vertically integrated makers of consumer electronics and domestic appliances. The dominant makers outsourced a substantial portion of the parts in its product making, thereby increasing the percentage of local component manufacturing in India. Since their entry into Indian market, foreign private players have entered into contract manufacturing agreements with local partners. LG made pact with Ahmedabad-, Bhopal-, Calcutta-, Chennai- and Nashik-based units for television sets and sought original equipment manufacturers for making refrigerators in South India during 2001–2002. In 2002, Voltas started manufacturing refrigerators for Samsung under contract. Even there is a presence of sub-contracting in case of Haier, Haier has given contract of manufacturing of its products parts to Dixon, which has given sub-contract to Hotline unit in Noida. In 2003, Blue Star outsourced logistics from AFL, and likewise, Anchor electricals started manufacturing consumer durables of Daewoo electronics. These tie-ups with local enterprises in making products locally instead of importing from outside gave solutions to lower costs and saving their crucial time.

The trend to outsource non-core operations is growing along with the vertical integration of core competencies. The need for outsourcing is attributed to rapid technology growth requiring complex manufacturing capabilities and low-cost manufacturing. The outsourcing has created opportunities for companies to locally procure goods and secure suppliers that give competitive advantage. However, designing and engineering processes, the fundamental activities in creating value, are not the areas of partnership with other original equipment manufacturers or local agents.

7 Understanding the Domestic Production System of Consumer Electronics in India

The dynamics narrated above shows that the consumer electronics industry in India has been evolving as globalised activity wherein multinational enterprises consolidate their market share through products embedded by new technologies, global value chains and investing in domestic production systems. More pertinently, television industry as a case in point, the burgeoning domestic demand from India appears to have been met by import during recent times. Is this narrative or set of patterns pointing that firms envisaging more flexible business models that connect domestic production systems and global value chains, while the domestic system destines to be a periphery of operations rather than a source of dynamic capabilities? To examine these questions, we look into the unit records of ASI.

We pool unit records of ASI for the period from 2000–2001 to 2013–2014 for creating database of production units that are engaged in the consumer electronics industry in India. From the database, we got a tally of 3736 factories that were operating during this period. Since we could not ascertain whether units of analysis found repetitive entry in the database, we did not create a panel data. Instead, we pool the data across the years. In order to identify which producing units fall in the category of consumer electronics, we used a concordance table that synchronise National Industrial Classification (NIC) 1998, 2004 and 2008 (Appendix 2). By using the data, we intend to plot three basic relations: (a) net value added per labour and capital labour ratio, (b) share of wage in NVA and share of profit in NVA and (c) capital labour ratio and share of wage or profit in net value added.

Exploring these three relations, we set the context for elucidating narratives and context of dynamic changes in the industry. First, real NVA[2] per person employed (alternately called NVA per labour) appears to be a proxy for average productivity of the system of production, while real capital[3] per person employed (alternately called capital labour ratio), to a greater extent, seems to be an indicator of the type of technology—capital intensive or labour intensive. Since we are concerned about proportionate change rather than absolute change, we transform these variables into natural logarithms. This implies that the slope becomes the ratio of proportionate changes, called elasticity. Second, our concern is about linkage between distributive context and the choice of technology. Needless to say, this is a complex issue, embroiled in plural contexts. Our objective is to get basic intuition about what happens to capital per person when share of wage or profit in NVA changes. Quite important, we simplify the complex concept of technology as capital labour ratio,

[2]Real NVA was computed by discounting nominal NVA by wholesale price deflator for consumer durables.

[3]Real capital computed by discounting nominal value of plant and machinery by machinery and machine tools price deflator.

while net value added per person represents productivity. Moreover, the distributive aspect with respect to net value added is captured by share of wage or profit in NVA.

While Fig. 4 depicts the relation between NVA per labour and capital labour ratio, relation between shares of wage in NVA and profit in NVA is plotted in Fig. 5. Capital labour ratio is plotted with respect to share of profit in NVA and share of wage in NVA, in Figs. 6 and 7, respectively. As shown in Fig. 4, there appears to be a direct relation between NVA per labour and capital labour ratio, tenable across the years. On the other hand, as depicted in Fig. 5, as share of wage in NVA dips, share of profit tends to go up, valid for all the years. Although discernibly scattered patterns, there seems to be a weak direct relation between share of profit in NVA and capital labour ratio (Fig. 6), while there appears be a weak inverse, but pronounced than the former pattern, relation between share of wage in NVA and capital labour ratio (Fig. 7). In brief, plots in Figs. 4, 5, 6 and 7 point to presumably posited relations between technology (capital labour ratio) and productivity (NVA per labour), and relation between technology and distribution of value added to wage and profit, although shrouded in the noises generated by the outliers. Moreover, we disaggregate the whole data with respect to type of organisation. Figure 8 plots capital labour ratio with NVA per labour, segregated for each type of organisation. The relation between capital labour ratio and NVA per labour appears to be markedly steep for two categories—public limited and private limited—than the rest. This points to the impact of governance on technology-productivity relationship.

Fig. 4 Real net value added per person employed and real capita per person employed (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. *N* = 3736 Factories

Fig. 5 Share of profit in net value added and share of wage in net value added (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. $N = 3736$ Factories

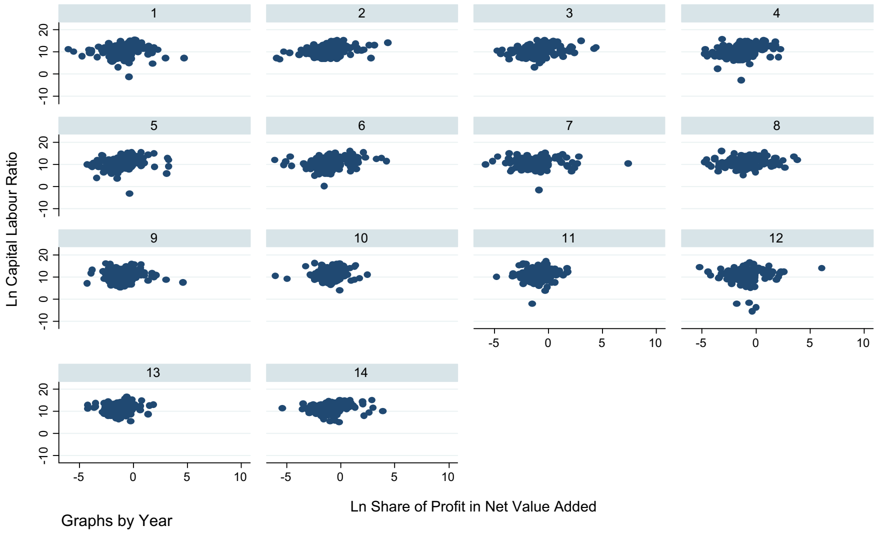

Fig. 6 Share of profit in net value added real capita per person employed (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. $N = 3736$ Factories

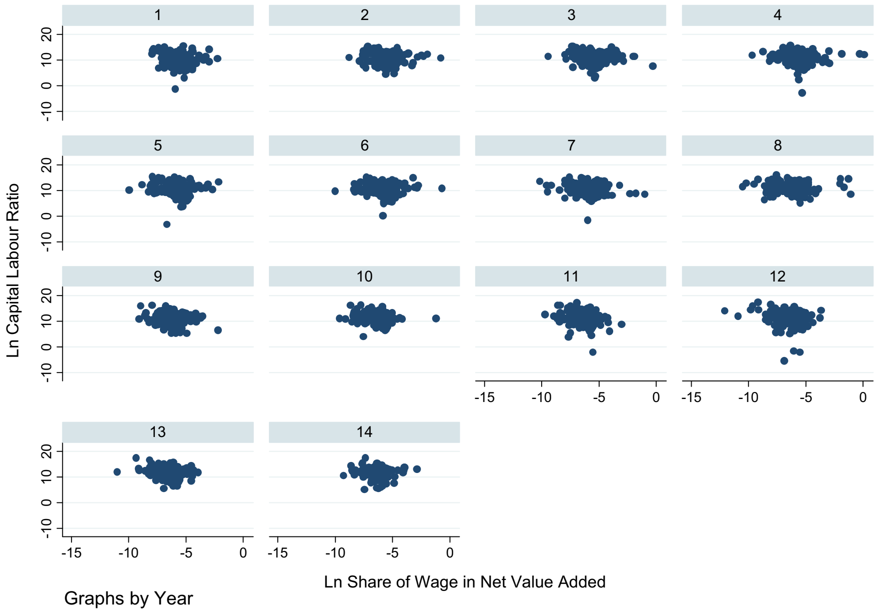

Fig. 7 Share of wage in net value added real capita per person employed (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. $N = 3736$ Factories

As a pooled database, the data are a mix of noise and voice. Not only noise arises from residual part of cross-sectional observations, variation in time also brings a share of noise. On one hand, we may bundle all the observations across the period, or we capture changes in time and identities such as type of organisation and state by using binary coded variables called dummies. In this paper, we use both the options. Moreover, we also let these dummies to interact with explanatory variable; this is to gauge about variance of parameters like slope. Quite interestingly, above-mentioned noises seem to have been combining with the problem of outliers in the data, generating phenomenon like heteroscedasticity that potentially cripples credibility of inferences. In view of this, we use two strategies to gauge estimates. First, we run regression that is subject to robust standard error. Second, we allow central tendency to move from one tail to another by using simultaneous quantile regression, letting us to account for the sensitivity of parameters to lower, middle and upper tail values.

As shown in Table 2, natural log of NVA per labour was regressed on natural log of capital labour ratio, by using five different models. First model is a two-variable ordinary least square regression. Second model is the same except we use the robust regression. Third model has four independent variables—natural log of capital labour ratio and binary-scaled dummies with respect to year, state where the factory is located and type of organisation. Fourth model is the exactly the third

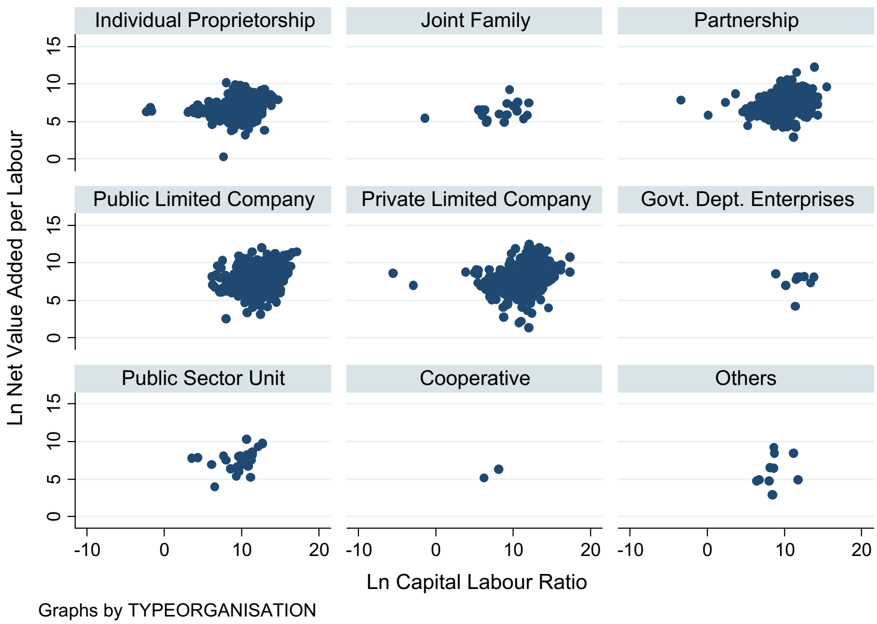

Fig. 8 Real net value added per person employed and real capita per person employed (by type of organisation) (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. $N = 3736$ Factories

model except robust regression. In fifth model, we retain all the variables in third model, while adding three interactive variables—natural log of capital labour ratio multiplied by dummies with respect to year, state and type of organisation. While dummies provide cues about variation emanating from the identities, interactive variables capture if these identities explain change in slope of the relation between NVA per labour and capital per labour. However, for the fifth model, we do have only OLS regression. We refrain from having robust regression since the coefficient with respect to capital labour ratio is statistically insignificant.

As shown in Table 2, across regression models except fifth model, coefficient with respect to capital labour ratio remains statistically significant at one percent. The coefficient across regression models is positive. Since we regressed logarithm of NVA per labour on capital labour ratio, the partial slope or coefficient is the ratio of proportionate changes, called elasticities. The values of elasticity vary in the range of 0.14 (fourth model) to 0.26 (second model). This indicates that, for model 2, with one per cent proportionate change in capital labour ratio, there will be 0.26% proportionate change in NVA per labour. Were this estimate closer to one, we would have concluded that for a unit proportionate change in capital labour ratio, there would be equal proportionate change in NVA per labour. However, our results indicate that none of the coefficients appear to be closer to equiproportionate change. Treating capital labour ratio and NVA per labour as proxies of technology and productivity,

Table 2 Results of regression of Ln real NVA per labour on Ln capital labour ratio of consumer electronics and domestic appliances, 2000–2001 to 2013–2014

Index	Ln real NVA per labour (OLS) Model 1	Ln real NVA per labour (Robust) Model 2	Ln real NVA per labour (OLS) Model 3	Ln real NVA per labour (Robust) Model 4	Ln real NVA per labour (OLS) Model 5
Constant	4.8144***	4.6033***	4.8919***	4.9426***	5.4949***
Ln capital labour ratio	0.2431***	0.2605***	0.1422***	0.1412***	0.0657
Year dummy	No	No	Yes	Yes	Yes
State dummy	No	No	Yes	Yes	Yes
Organisation dummy	No	No	Yes	Yes	Yes
Year dummy * Ln capital labour ratio	No	No	No	No	Yes
State dummy * Ln capital labour ratio	No	No	No	No	Yes
Organisation dummy * Ln capital labour ratio	No	No	No	No	Yes
R^2	0.1668		0.3102		0.3380
N	3736	3736	3735	3735	3735

$p < 0.01$***
N Number of observations
Source Ministry of Statistics and Programme Implementation, unit records of Annual Survey of Industries, 2000–01 to 2013–14

respectively, presumably, inferences from Table 2 point to that productivity does not appear to be discernably sensitive to the change in technology.

To examine the impact of capital labour ratio on distribution of NVA to the factor of production, we regress natural logarithm of share of wage in NVA on natural logarithm of capital labour ratio. We retain five models here, as well. Table 3 provides the results of regression. Except fifth model, coefficients with respect to capital labour ratio are statistically significant at one per cent; all statically significant coefficients are negative, varying in the range of −0.08 (model 4) to −0.71 (model 3). It is important to note that models 1 and 3 suffer from heteroscedasticity. Therefore, we restrict our comparison only to models 2 and 4. For the model 2, the coefficient is −0.1. The result indicates that, while there is an inverse relationship between technology and labour income, the sensitivity of change is of perceptibly lower magnitude. Having been curious about the impact of technology on share of profit in

Table 3 Results of regression Ln wage share on Ln capital labour ratio of industry consumer electronics and domestic appliances, 2000–2001 to 2013–2014

Index	Ln wage share (OLS) Model 1	Ln wage share (Robust) Model 2	Ln wage share (OLS) Model 3	Ln wage share (Robust) Model 4	Ln wage share (OLS) Model 5
Constant	−4.8081***	−4.7262***	−4.7375***	−4.6747***	−4.8827***
Ln capital labour ratio	−0.1036***	−0.1086***	−0.710***	−0.0759***	−0.0439
Year dummy	No	No	Yes	Yes	Yes
State dummy	No	No	Yes	Yes	Yes
Organisation dummy	No	No	Yes	Yes	Yes
Year dummy * Ln capital labour ratio	No	No	No	No	Yes
State dummy * Ln capital labour ratio	No	No	No	No	Yes
Organisation dummy * Ln capital labour ratio	No	No	No	No	Yes
R^2	0.0445		0.2264		0.2473
N	3734	3734	3733	3732	3733

$p < 0.01$***
N Number of observations
Source Ministry of Statistics and Programme Implementation, unit records of Annual Survey of Industries, 2000–01 to 2013–14

NVA, we ran a regression specifying share of profit in NVA on capital labour ratio (not reported in the paper). With respect to this regression, elasticities were positive but of much lower magnitude. So, this means, albeit not so strong, more capital per labour seems to have been generating higher share of profit in NVA. This aspect will be taken up for discussion when we view productivity and technology as a structural system in the later part of the paper.

Now, we go back to Table 2 that brings forth the relation between capital labour ratio and NVA per labour. Postestimation results of models 1 and 3 in Table 2 clearly indicate the presence of heteroscedasticity, rendering estimates not reliable. To obviate this problem, we ran models 3 and 4. We have already discussed the results of these models. Alternately, we may let the central tendency to move from the lower tail to upper tail of the dependent variable. For this, we resort to simultaneous quantile regression that lets regression to be run with respect to 0.2, 0.4, 0.5, 0.6 and

0.8 quantiles. Table 4 reports the results. We ran two models: one without dummies and one with dummies for year, state and type of organisation. Across quantiles and models, there is a direct relation between NVA per labour and capital per labour. Quite important, there appears to be no discernable differences between results in Tables 2 and 4.

8 Productivity, Technology and Relative Factor Prices: A Structural Model

Drawing cues from our previous discussion, in particular Table 2, there appears to be a direct relation between technology and productivity, although this sensitivity is of lower magnitude. An important challenge with this inference is how exogenous is this explanation. Or, this calls for exploring into embedded explanations within the technology. Presumably, technology, while it is complementary to resources in the firm, tends to be swayed by changes in relative prices. For example, change in wage in terms of capital price may directly impact change in technology. Put differently, if the ratio of wage to capital price goes up, capital per labour tends to increase. As shown in Table 3, change in capital labour ratio may weakly impact share of wages in NVA. As elucidated before, corollary to Table 3 is a weak positive relation between capital labour ratio and share of profit in NVA. So, to bring these dimensions together, we envisage a system of three equations in contrast to previous systems of single equations. The structure, we put forth, has three functions. First, we regress NVA per labour on capital labour ratio and share of investment in hardware and software out of total fixed assets. Second, we regress capital labour ratio as a function of ratio of real wages to price of capital. Third, share of profit in NVA is regressed on capital labour ratio. Across these models, we use dummies of time, industry and type of organisation as control variables. In the previous discussion on single equation models, we used industry as the single entity. However, here, we classify them into two: (a) consumer electronics (predominantly colour televisions) and (b) domestic appliances (refrigerators, washing machines and air conditioners). As far as type of organisation is concerned, we prune codes into two: (a) public or private limited and (b) others. In comparison with single-equation models, we dropped state dummies in the structural model, primarily to ease the degree of freedom. Moreover, in single-equation model, results were not sensitive to state dummies. We use three-stage least square (3SLS) multivariate regression model to estimate. Table 5 and Fig. 9 provide the results.

Figure 9 captures statistically significant results reported in Table 5. As shown in Fig. 9, capital labour ratio directly impacts NVA per labour, reporting a partial elasticity of 0.26. Interestingly, this result is not discernably different from result in Table 2. Moreover, share of investment in hardware and software in fixed assets appears to positively impact NVA per labour, although the coefficient is of lower

Table 4 Results of quantile regression Ln real NVA per labour on Ln capital labour ratio for consumer electronics and domestic appliances, 2000–2001 to 2013–2014

Index	Ln real NVA per labour					Ln real NVA per labour				
	0.5	0.2	0.4	0.6	0.8	0.5	0.2	0.4	0.6	0.8
Constant	4.6899***	4.3055***	4.4799***	4.8254***	5.2129***	4.9097***	4.7786***	4.8747***	4.9279***	5.2395***
Ln capital labour ratio	0.2497***	0.2187***	0.2483***	0.2574***	0.2800***	0.1447***	0.1168***	0.1354***	0.1454***	0.1478***
Year dummy	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
State dummy	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Organisation dummy	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.1129	0.079	0.1082	0.1172	0.1122	0.2246	0.1812	0.2153	0.2342	0.2468
N	3736	3736	3736	3736	3736	3735	3735	3735	3735	3735

$p < 0.01$***
N Number of observations
Source Ministry of Statistics and Programme Implementation, unit records of Annual Survey of Industries, 2000–01 to 2013–14

Table 5 3SLS (multivariate) regression

	Ln real NVA per labour	Ln capital labour ratio	Ln profit per NVA
Constant	5.0433***	7.9472***	−2.0393***
Ln capital labour ratio	0.2609***	–	0.0707***
Ln software per fixed asset	0.0602***	–	–
Ln real wages by capital price	–	0.4382***	–
Organisation	0.3098***	0.3083***	−0.0407
Industry	−0.2732***	0.1360*	−0.0522
Year	Yes	Yes	Yes
N	2410	2410	2410
R^2	0.2900	0.2211	0.0251

$p < 0.1$*, $p < 0.01$***
Note Organisation: 1—Public or private limited; 0—Others
Industry: 1—Domestic appliances; 0—Consumer electronics

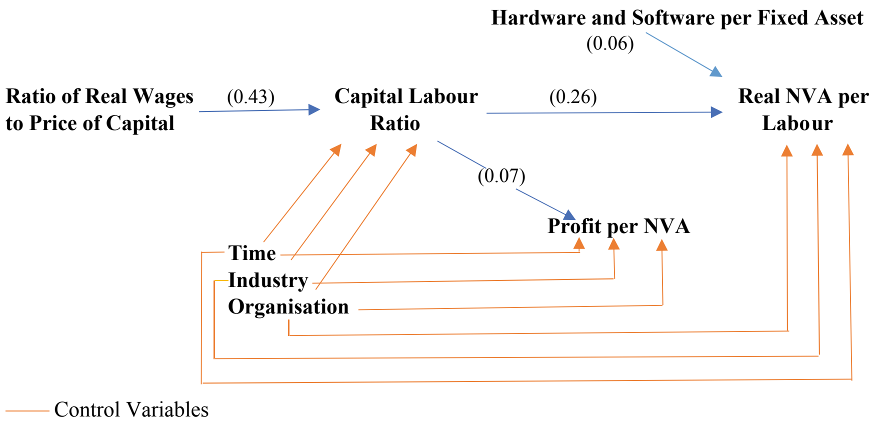

Fig. 9 Productivity, technology and relative factor prices: a structural model. *Source* Based on Table 5. Figures in parenthesis are elasticities

magnitude. Referring to Table 5, if an organisation is public/private limited, the constant of the equation tends to increase by 0.6%. This is an important result that says the governance of organisations has an impact on translating technology to productivity. So, going by this result, changing the type of organisation from something like proprietorship to public private limited enables the firm to transform organisational capacities to payoffs like productivity. Another important result is that the type of industry does impact NVA per labour. If we change the type of industry from consumer electronics to home appliances, the intercept drops by 0.56%. This behaviour seems to have been emanating from the trend of consumer electronics being more globalised than the home appliances (as discussed previously using the meta-content of news in the media during 1995–2017). Quite important, the second model conveys the sensitivity of capital labour ratio to relative factor price, reporting an elasticity of 0.43. The third function is almost identical with the single equation estimates, showing a discernably weak relation between capital labour ratio and share of profit in NVA.

What we gauge from these results is that while the consumer electronics industry in India has been evolving during last two decades from not so globalised to more globalised, amply manifesting in influx of multinational enterprises and renowned brands, it appears the conversion of globalisation process has not yet translated into creation of core capabilities such as creation of new products, generation of innovation and extensive foray into the exports. If we accept factory as the fundamental unit of production and capabilities, drawing cues from descriptive and inferential analysis, we have ample evidence to say that technology in this industry hardly convert to value added per labour. Is this signifying the limits of global capital? Do we see the global capital foraying into populous developing geographies, mainly to tap the bourgeoning market sizes, rather than creating capabilities through innovation and technology transfer? Our results point to these questions while envisaging more constructive research in future on these issues.

9 Conclusion

The consumer electronics industry in India, enveloping colour televisions to home appliances, has been growing exponentially over the years, more pertinently during last one decade. This growth as a milieu is also a chronicle of entry of technology-orientated multinationals, in particular those located in East Asia, to India. They have been using flexible business models and trading arrangements to grow in the market, by consolidating market shares and innovating novel products and so on. What does this mean for domestic production of consumer electronics in India, covering television and home appliances?

We look into the fundamental unit of analysis, i.e. factory for exploring these questions. This paper, by using the factory unit records from Annual Survey of Industries, examines the relation between technology and value added per labour. Our exercise revolved around the pooled data of factories, spanning over 2000–2001 to 2013–2014. Our descriptive and inferential analysis of data conveys that change in technology, measured by capital per labour, has not translated to change in labour productivity, measured by NVA per labour. Interestingly, this result remains more or less same across diverse empirical settings, be it single-equation models with or without dummies and interactive variables or simultaneous equation system. Drawing cues from the meta-content and the analysis of data, the expansion of consumer electronics market in India seems to have been not corresponding to expected growth in shaping of technological and business capabilities of domestic firms, whether they are part of multinational enterprises or not. As evident in the trade data, import has been emerging as the principal source of supply in Indian consumer electronics market, which is shaping as an oligopolistic structure, in particular colour television as a case in point.

From a policy point of view, our conclusion raises interesting options. Perhaps, time is ripe for envisioning a creative innovation structure that fuses the culture of venturing, scientific discoveries, innovative branding, higher order skills in production, globally benchmarking production standards and dynamic governance models. If the current conundrum of progressive accumulation of capital that does not create production capabilities goes on, presumably it tends to create a vicious cycle of exponentially growing markets that plough money towards an ever-expanding capital accumulation, but not much to socially desirable productivity and spillovers.

Appendix 1

Select meta-content on media coverage of value chain, R&D and market share of Indian consumer electronics industry

1. Value chain	
1997	• Thomson Electronics sets up TV plants in Chandigarh with JV Partners of Chennai
	• Daewoo Anchor Electronics plans to source refrigerators from Godrej
1998	• Thomson Consumer Electronics ties up with regional contract manufacturers for colour TVs in Chennai, West Bengal, Punjab and Maharashtra
	• Samsung to source direct cool refrigerators from Videocon's plant at Aurangabad
	• Samsung tie-up with Voltas Limited for contract manufacturing of washing machines
2000	• LG Electronics to source 12 lakh fridges from Voltas Limited; bags order Rs 900 crore
2001	• LG Electronics alliances with Polygenta Technologies, Nashik, for contract manufacturing colour TVs. Polygenta undertakes contract manufacturing for BPL, TCL, Aiwa and Salora too
	• LG plans contract manufacturing of TV sets to local OEMs in Calcutta, Nasik, Bhopal, Chennai and Ahmedabad
2002	• LG seeks OEM pacts with Voltas Limited in Hyderabad for consumer electronics, home appliances and computer peripheral products
	• LG signs contract manufacturing agreements of Rs 10,000 crore with local producers in Gujarat
	• Voltas Limited signs a contract of Rs 900 crore to manufacture refrigerators for Samsung
	• LG Electronics ties up contract manufacture of colour TVs in Guwahati, Patna and Jammu

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2003	• Haier selects BPL and Voltas Limited as OEMs for TVs, refrigerators and air conditioners for Indian market
	• Anchor Electronics manufactures consumer durable products of Daewoo in India
	• Blue Star outsources logistics for finished goods from AFL Logistics
2004	• LG Electronics ties up with West Bengal Electronics Development Corporation to manufacture colour TVs from 2003
	• Haier TVs rolls out of Hotline unit in Noida (Haier has given contract to Noida-based Dixon which has given sub-contract to Hotline to manufacture TVs)
	• Citrix solution helps LG Electronics to optimise operational costs for consumer durables
	• Hyundai Electronics talks with Videocon Group and other local OEMs to roll out consumer electronics products in India
2006	• Shinco Consumers ties up with Future Techno Designs, India, for product localisation an DVD assembly unit in India by 2008
	• Sanyo signs contract manufacturing for refrigerators and other home appliances instead of imports from its plants in Thailand and Vietnam
2009	• LG Electronics opts for contract manufacturing of low-end durables and upgrades its Noida facility to manufacture premium products
2011	• Toshiba invests Rs 450 crore to start contract manufacturing for LCDs, refrigerators and washing machines
2012	• Toshiba sets up facility for exclusive contract manufacturing of TVs and other digital players in Dehradun
2015	• Sony's LED TVs will be contract manufactured in Sriperumbudur
2. Research and development	
1998	• Philips plans corporate R&D centre in India to execute software projects and products
1999	• BPL plans Rs 25 crore R&D centre in Bangalore to design and develop colour TVs to satisfy the desires of Indian costumers
2000	• LG Electronics lines up $20 million for digital R&D and focusses in the areas of multimedia products
	• Samsung sets up $5 million R&D centre in Noida to design and develop TV sets for Indian customers
2001	• LG Electronics sets up an international development centre in Bangalore at an investment cost of $1 million
2002	• Seagate Technology, Singapore, in talks for technology transfer for product development and security solutions alliances with consumer electronics manufacturers in India
	• Samsung earmarks $5 million for R&D and aiming to become largest company in colour TV segment
2003	• Samsung sets up consumer laboratory at IIT Delhi to analyse product aspects and customise products
2004	• Haier sets up R&D centre along with assembly unit in India for colour TVs, entailing an investment of $3–5 million
	• Philips sets up homelabs to test new technology prototypes
2005	• LG plans to invest $30 million for R&D in air conditioners over next five years

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	• Samsung invests $12.5 million to build R&D operations at Noida for developing software for worldwide requirements for colour TVs and local manufacturing of DVDs and audio products instead of importing from Korea
2007	• Sony mulls R&D centre for high definition products, like digital cameras, camcorders and colour television sets, as part of its 'global localisation' plans
	• Samsung invests $5 million in expanding R&D operations for digital media products
2008	• LG Electronics invests $38 million on new technology platform for manufacturing and R&D
	• Samsung invests $13 million for product customisation to focus on mass products; formed separate hardware R&D centre in Noida
	• Philips sets up R&D centre for lighting electronics at Gurgaon; address the needs of not only the Indian market but also of the Asia-Pacific region, Europe and North America
2009	• Videocon spend Rs 300 crore on new technologies as well as for research and development in 2009–2010
	• LG Electronics doubles its spending in R&D at Rs 400 crore during 2009–2010
2010	• LG Electronics invest Rs 1500 crore for capacity expansion and setting up of research and development centre in 2010 to develop export-oriented models
2011	• LG Electronics invests Rs 1000 crore for capacity building during 2012–2013
	• Panasonic sets up R&D centre by 2012 in Haryana
	• Videocon invests Rs 1 billion in R&D and capacity enhancement during 2012–2013
	• Hitachi opens R&D centre in Bangalore as part of its efforts to develop products based on local needs
	• Philips looks at R&D hub to develop locally relevant products in appliances segment
2012	• Samsung spends 7–8% out of revenues in R&D each year
2014	• LG Electronics invests Rs 800 crore on R&D and production in 2014
2015	• Videocon invests Rs 900 crore on R&D for new rage of niche products in 2015–2016
	• LG Electronics invests Rs 1000 crore to boost marketing, research and development and product localisation
2017	• Panasonic–Tata Elxsi sets up an R&D unit in Bengaluru to develop artificial intelligence and robotics for domestic and global markets
3. Market	
3.1 Entry	
1995	• Samsung invests $1 billion in Indian market
1998	• Seagate enters consumer electronics market in the set-up box segment
1999	• LG Electronics makes India its export hub; invests Rs 350 crore to export colour TVs, refrigerators and top-load washing machine
2004	• Hyundai Electronics enters consumer electronics; targeting customers in major cities
2005	• Matsushita builds consumer electronics business through investments and new product range of audio-visual products, colour TVs and industrial components
2006	• INTEX diversifies into consumer electronics, spends Rs 10 crore on marketing initiatives

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2007	• China's TCL sets up manufacturing plant in India to manufacture colour TVs and DVDs in Noida
2009	• China's Aigo launches range of digital and self-assembling products
3.2 Sales	
1998	• Thomson turnover Rs 400 crore during 1997
1999	• LG Electronics crosses Rs 1000 crore; holds 9% in televisions
2000	• Samsung banks on home appliances for Rs 5000 crore turnover
2001	• Samsung records a turnover of Rs 340 crore; sales of TV rose by 8%
2002	• LG Electronics crosses 13.84% share in television; achieved sales of over 9 lakhs sets
	• Samsung records 12% growth; consumer electronics segment contributes 58.5% of its total sales
2003	• LG Electronics records 36% growth in turnover at Rs 4500 crore in 2003
2004	• Philips earns Rs 650 crore from sales in 2003
	• Samsung revenues increases to Rs 5000 crore from sales in 2004
	• LG Electronics posts Rs 205 crore net profit
2005	• Panasonic registers sales of Rs 150 crore from consumer electronics
	• Samsung targets total sales of Rs 6500 crore from consumer appliances export as well as domestic sales
	• Philips's revenue from India to reach Rs 5000 crores by 2008 against current turnover of Rs 3000 crore
	• Hyundai Electronics targets Rs 600 crore turnover; growing at 30%
	• Hitachi earns 10% market share in air conditioners in India
2007	• Sony revenues at $1 bn in 2006–2007, expects $2 billion by 2009–2010
2008	• LG achieves a turnover of Rs 11,500 crore; aims at 20% top-line growth
	• Reliance eyes Rs 15,000 crore from electronics business by 2012
2009	• Samsung eyes $3 billion sales in 2010; aims a growth of 40% over 2009
3.3 Capital expenditure	
3.3.1 Location	
1998	• LG Electronics sets up new air conditioner manufacturing facility in Himachal Pradesh and in southern India
2004	• Hyundai Electronics sets up for manufacturing colour TVs plant, air conditioners and DVD players in Uttarakhand at cost Rs 100 crore
2008	• Videocon lines up Rs 2000 crore project to manufacture electronic products in Tamil Nadu along with its subsidiary VDC Technologies, Italy
2009	• LG Electronics invests Rs 1000 crore in setting new plants for manufacture of 3D appliances to increase its global market share by 12%
2010	• Samsung expands plant at Rs 350 crore to manufacture consumer electronics and information technology products in Sriperumbudur
2016	• Daiken sets up new air conditioners plants in South India to export to Africa
3.3.2 Product diversification	

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1999	• LG Electronics introduces a range of digital products in Indian market; aimed at the upper-end of the market
2005	• Panasonic launches a range of plasma and LCD along with digital cameras
2008	• Samsung shifts focus on premium consumer electronics, flat panel TVs, high-end DVDs and Blue-ray player
2013	• Panasonic increases product lines; launches washing machines to meet growing demand within domestic appliances
2015	• Hitachi re-enters TV segment with strategic partnership with Croma

Source Indian Business Insight, http://indiabusinessinsight.com/ibi/

Appendix 2

Concordance between 3-digit industry classes of NIC 1998, 2004 and 2008

Industry	NIC 1998 3-digit	NIC 2004 3-digit	NIC 2008 3-digit
Consumer electronics	323	323	264
Domestic appliances	293	293	275

There are three different classifications (NIC 1998, NIC 2004 and NIC 2008) in use over the 2000–2001 to 2013–2014. The first step in developing comparable data over time is to prepare a concordance across the different classifications. A concordance for consumer electronics and domestic appliances is done at the three-digit level—as according to NIC 1998 and NIC 2004, consumer electronics has the industrial code of 322 and domestic appliances has industrial code of 293; for NIC 2008, industrial code for consumer electronics is 264 and domestic appliances is 275

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Firm-Specific Determinants of R&D Behaviour of Foreign Affiliates in India

Savita Bhat

1 Introduction

Over the last few decades, owing to the advances in transportation and communication technologies, many firms are distributing their value chains across the globe (Dunning and Lundan 2009). The multinationals are increasingly engaging in vertical foreign direct investments (FDI) and spreading across various locations all over the globe their different activities, including research and development (R&D) activity (Hanson et al. 2005; Guillen and Garcia-Canal 2009).

Thus, internationalization of R&D has become an important research theme for many research articles (Ito and Wakasugi 2007; Kurokawa et al. 2007). It is observed that the multinational firms often evaluate the cost and benefits of undertaking R&D at the potential locations before finalizing the R&D location (Hu 2004). The multinationals have the options to perform their R&D activities either at the headquarters in their home country or at the overseas subsidiaries in the host countries (Caves 1996; Hu 2004). It is believed that the companies that choose to locate R&D in home countries do so to have higher efficiency and scale economies. Others who choose to locate R&D in the overseas subsidiaries often do so to customize their products for local needs and to exploit the resources and incentives provided by the host countries.

Researchers like Hegde and Hicks (2008) have observed paradigm shifts in the constituents of R&D in host countries. During the 1980s, R&D in the host subsidiaries was mainly focused on the development aspect, with the core sophisticated research part still remaining at home. In the late 1980s and early 1990s, it was observed that the foreign subsidiaries engaged in sophisticated applied research and even acquired foreign know-how. More recently, multinationals have been seen engaging in R&D that can expand their home innovation capabilities.

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Further, initially, overseas R&D investments undertaken by multinational firms from developed countries like the USA were located in other developed countries (Veliyath and Sambharya 2011). However, during the 1990s, the pattern changed and increasing shares of outbound R&D from USA were going to countries like Singapore, Israel, and India (Doh et al. 2005). These R&D activities were in different industries including chemicals and computers (Hegde and Hicks 2008).

Researchers have observed that multinational firms from developed countries often invest on frugal innovations in the developing countries to eliminate the non-value adding functions from the original complex product existent in the developed countries (Simula et al. 2015). This type of R&D helps the multinational firms to create a product design with minimal features that is found to be more economical by the consumers of the low-income emerging markets. Subsequently, these innovative products are introduced in the developed countries to cater to the needs of the cost-aware consumers in developed countries. In such instances, the multinational firms can be considered to be setting up R&D centres in the emerging countries like India to acquire and build on locally available knowledge (Vasudeva and Sonderegger 2007). This type of R&D that is undertaken in the emerging economies to create products that are eventually diffused into developed markets is termed as reverse innovation (Immelt et al. 2009; Govindarajan and Ramamurti 2011; Simula et al. 2015).

Thus, the research focus in the area of innovation is now increasingly shifting towards the R&D activities of multinational firms in developing countries like India (Brem and Wolfram 2014). However, although there is an increasing trend in the amount of R&D investments by the multinationals going to the developing countries, a large amount of overseas R&D investments by the multinationals are still located in developed countries (Veliyath and Sambharya 2011).

Given the fact, the objective of this study is to understand the latest trends in in-house R&D investments by foreign affiliates in India. Further, the present study attempts to understand the firm-specific factors that determine the R&D behaviour of foreign affiliates operating in India. Here, foreign affiliates are the firms that are owned by foreigners including foreign government. It should be noted that determinants of in-house R&D by firms is a well-researched topic. However, there are limited studies in the recent past that have examined the factors that affect the in-house R&D activities of foreign affiliates in India. The present study tries to fill this gap in recent literature in the area of innovation.

The following section presents a review of literature on the factors that can determine R&D activities of the firms. After that, the sample and methodology are discussed. Then, the next subsection highlights the patterns in the R&D investments with respect to the foreign affiliates in the present sample. The subsequent section deals with the analysis and results of the econometric models. The final section gives the conclusion and implications of the study.

2 Literature Review on Factors Determining R&D Activities

The following subsections give a review of literature on various factors that determine R&D activities of firms in general. The relevance of these variables to the R&D behaviour of foreign affiliates is particularly focussed. These variables include size of the firm, age of the firm, capital intensity, labour intensity, selling and distribution intensity, outsourcing intensity and import of technology.

2.1 Size of the Firm

Size of the firm has been used in innumerable empirical studies on firm behaviour. It essentially acts as a proxy for the amount of resources available to the firms (Schumpeter 1943). Basant (1997) found a larger firm size to favourably affect the firm's chances of doing R&D. However, others believe that there is decreasing returns to scale in the production of innovations due to loss of managerial control and bureaucratization of innovative activity (Benvignati 1982). Katrak (1989) found that larger enterprises invested proportionately less on R&D in Indian industries. Narayanan and Bhat (2009) observe that there is no consensus regarding the effect of size of the firm on innovative activities. Nevertheless, Kumar and Siddharthan (1997) observed that most of the studies on developing countries have found larger firms to be involved in more formal technological activities compared to the smaller ones.

With regard to the size of foreign affiliates, relatively large sized ones would possibly have more resources and be forced by the host country institutions to incorporate local requirements in their operations (Rottig 2016). Moreover, the multinationals that have successfully introduced products and captured markets in the host developing countries would be interested in investing further on R&D for reverse innovation. Hence, the effect of size of the foreign affiliates (in terms of sales) is hypothesized to have a positive effect on R&D activities of the firms in India.

2.2 Age of the Firm

Age of the firm captures the experiences and learning of the firm. Siddharthan (1992) noted that in the case of Indian firms, the age of the R&D unit would indicate long run and sustained commitments of the units to R&D. The study found that older established firms undertook higher R&D activities. Similar results were found by Narayanan and Bhat (2009) in the case of Indian basic chemical industry.

In the case of foreign affiliates too, the firms that have been operating in the host developing countries for some time and gained knowledge about consumer preferences would be more confident of investing successfully on R&D in those countries. There is evidence that, as time progresses, the small investments in import-and-adapt R&D of foreign firms evolve into more significant investments in local R&D for local product development (Motohashi 2015). Hence, it is hypothesized that the age of the firm has a positive effect on the R&D activities of even the foreign affiliates in India.

2.3 Capital Intensity

Capital intensity, in terms of investment on plants and machinery as a proportion of sales, indicates the extent to which a company prefers automation of its processes. Capital investment may reflect the overall collateral value of the firm (Hottenrott and Peters 2011), which may give confidence to the firms to invest more on risky R&D activities. However, in the case of Indian private corporate sector, Siddharthan (1992) found capital intensity to be unimportant in determining R&D intensity of the firms.

The parents of the foreign affiliates operating in developing countries are generally from advanced countries where capital-intensive automated processes are more popular. Hence, the foreign affiliates are likely to have greater affinity towards adopting capital-intensive techniques for their different activities including R&D. Thus, due to the possibility of higher overall collateral value, the capital-intensive foreign affiliates are hypothesized to undertake more R&D investments.

2.4 Labour Intensity

Higher labour intensity can be a proxy for higher human skills in the firm. Lall (1983) found that technical employee skill has a positive effect on R&D in Indian engineering industry. Tan and Hwang (2002) also found skill to favourably affect the decision of the firms to undertake R&D in electronics industry in Taiwan.

Many of the foreign affiliates are increasingly locating their R&D centres to developing countries like India to exploit the skills of the abundant human capital (Haakonsson and Ujjual 2015). The foreign affiliates that invest higher amounts on the wages and salaries of employees are likely to utilize their capabilities for improving the operations of the company including for in-house R&D activities. Hence, it is postulated that labour intensity as a proxy for skill will have a positive effect on R&D activities of the foreign affiliates.

2.5 Selling and Distribution

According to Porter (1980), access to distribution channels is one of the barriers to entry into any industry. The foreign affiliates may invest large amounts on selling and distribution activities to create this competition barrier for their existing products in the host developing countries. In other words, the foreign affiliates that give high priority to market expansion in the host countries are likely to give less preference to investments on in-house R&D activities in those countries. Hence, it is postulated that selling and distribution intensity of the foreign affiliates may have a negative effect on the in-house R&D activities of the firm.

2.6 Outsourcing

Outsourcing, where all or part of a firm's activity is given to an outside vendor, is often considered to be an important tool to cut costs, improve performance and refocus on the core business (Barthelemy and Adsit 2003). It is well known that many multinationals locate their subsidiaries in developing countries due to cost considerations. Hence, the foreign affiliates that outsource their manufacturing activities may invest more on other activities including in-house R&D in the host developing counties. However, if the outsourcing activity involves sourcing of new technologies from collaborators in India, then most of the R&D activities may be undertaken outside the firm in dedicated R&D centres rather than in-house (Mrinalini and Wakdikar 2008). Due to lack of empirical evidences with regard to the effect of outsourcing on in-house R&D of foreign affiliates in India, it is difficult to postulate the effect of outsourcing on in-house R&D activities of these firms in India.

2.7 Import of Technology

Import of technology can be in the embodied form embedded in imported raw material or imported capital goods or can be in disembodied form like designs, drawings, blueprints and patents against royalty and technical fee payments (Basant 1997). Often firms operating in developing countries like India are observed to be following the import-and-adapt strategy, where the firms import technology and use in-house R&D investments to the local environment (Katrak 1985). It is possible that foreign affiliates may import technology from their parent firms through intra-firm mode. Nevertheless, the firms that do import technology through arms-length purchases may undertake some in-house R&D to adapt the imported technology. Hence, it is hypothesized that import of technology (whether in embodied or disembodied form) has a positive effect on R&D activities of the foreign affiliates.

3 Sample and Methodology

The secondary data for the study is extracted from the Prowess database provided by Centre for Monitoring Indian Economy (CMIE). The present study considers firms that are classified as foreign as per the database. These are the firms that are owned by foreigners including foreign government. After removal of firms with missing data and the outliers, the final balanced sample consists of data on 242 firms for a period from 2011 to 2015. The sample has both manufacturing and services firms. These firms can be classified into different industries based on the two-digit classification (called Division) in 2008 National Industrial Classification (NIC) codes published by the Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India.

To construct the variables, information on various firm characteristics has been extracted from the Prowess database. The definitions of the variables based on this information are presented in Table 1. Except SIZE and AGE variables, all other variables are normalized with respect to size of the firm by considering sales in the denominator. The variable outsourcing intensity (OSRCI), which considers only the manufacturing jobs that are outsourced, may be appropriate mainly for the manufacturing firms. Nevertheless, the variable has been introduced in all the econometric models in this study as some of the services firms (mainly in publishing industry and wholesale industry) are also outsourcing manufacturing jobs.

3.1 Econometric Specifications

In the present study, the data is a panel data consisting of 242 firms (cross sections) and 5 years (time periods) from 2011 to 2015. Since the dependent variable has many zero values, limited dependent data model specifications are considered to be appropriate. Two of the popular limited dependent data models are the Tobit model and the sample selection model (Cameron and Trivedi 2009).

Following Cameron and Trivedi (2009), a random effects Tobit model for *i* cross sections and *t* time periods can be specified as,

$$\mathrm{RDI}^*_{\mathrm{it}} = \mathbf{X}_{\mathrm{it}}\,\boldsymbol{\beta} + \alpha_{\mathrm{i}} + \varepsilon_{\mathrm{it}} \quad (1)$$

where $\mathrm{RDI}^*_{\mathrm{it}}$ is the latent variable that depends on explanatory variables ($\mathbf{X}_{\mathrm{it}}$), an idiosyncratic error ($\varepsilon_{\mathrm{it}}$) and an individual-specific error (α_{i}). If $\mathrm{RDI}_{\mathrm{it}}$ is the observed variable, then

$$\begin{aligned} \mathrm{RDI}_{\mathrm{it}} &= \mathrm{RDI}^*_{\mathrm{it}} \text{ if } \mathrm{RDI}^*_{\mathrm{it}} > 0 \\ &= 0 \quad \text{if } \mathrm{RDI}^*_{\mathrm{it}} \le 0 \end{aligned} \quad (2)$$

Table 1 Definitions of the variables

Sl. No	Variables	Symbol	Definition
1	Decision to invest on in-house R&D	D_{RDI}	$D_{\text{RDI}} = 1$ if Research and development expenses (in Rs. millions) > 0 $D_{\text{RDI}} = 0$ otherwise
2	In-house R&D intensity	RDI	Research and development expenses (in Rs. millions) as a percentage of sales (in Rs. millions)
3	Size of the firm	SIZE	Logarithm of sales (in real terms Rs. millions)
4	Age of the firm	AGE	Year of observation—year of incorporation
5	Capital intensity	CAPI	Net investments on plant and machinery (in Rs. millions) as a percentage of sales (in Rs. millions)
6	Labour intensity	LABI	Investments on salaries, wages, bonus, ex gratia pf & gratuities (in Rs. millions) as a percentage of sales (in Rs. millions)
7	Selling and distribution intensity	SDI	Selling and distribution expenses (in Rs. million) as a percentage of sales (in Rs. million)
8	Outsourcing intensity	OSRCI	Outsourced manufacturing jobs (in Rs. million) as a percentage of sales (in Rs. million)
9	Import of raw materials intensity	IRAWI	Import of raw materials (in Rs. million) as a percentage of sales (in Rs. million)
10	Import of capital goods intensity	ICGI	Import of capital goods (in Rs. million) as a percentage of sales (in Rs. million)
11	Import of disembodied technology intensity	IRTI	Forex spending on royalty/technical know-how (in Rs. million) as a percentage of sales (in Rs. million)

Following Maddala (1983, p. 268), the sample selection model being analysed may be represented as[1]:

$$\text{RDI} = \mathbf{X}\boldsymbol{\beta} + u \tag{3a}$$

$$D^{*}_{\text{RDI}} = \mathbf{Z}\boldsymbol{\gamma} - \varepsilon \tag{3b}$$

[1]The sample is an unbalanced panel data where each observation may be considered as a separate data point. Hence, Eqs. (3a)–(4) should ideally have subscript 'it' for RDI, X, D^{*}_{RDI}, Z and D_{RDI}. However, subscript 'it' has been dropped from the equations for ease of notational representation.

where RDI is the explained variable, **X** and **Z** are vectors of exogenous variables, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are vectors of coefficients on **X** and **Z**, respectively, and u and ε are stochastic error terms.

Equation (3b) represents the selectivity criterion with D^*_{RDI} as the dependent variable that is not observed. Instead D^*_{RDI} has a dichotomous realization D_{RDI} that is related to D^*_{RDI} as follows:

$$\begin{aligned} D_{\mathrm{RDI}} &= 1 \text{ iff } D^*_{\mathrm{RDI}} \geq 0 \\ &= 0 \text{ otherwise} \end{aligned} \tag{4}$$

The dependent variable RDI is conditional on **X**. Furthermore, **Z** has a well-defined marginal distribution. However, RDI is not observed unless $D^*_{\mathrm{RDI}} > 0$. Thus, the observed distribution of RDI is truncated. The parameters can be estimated using the Heckman two-step procedure to ensure consistent estimates for the coefficients (Greene 2002). Further, in order for the model to be identified, it is important to introduce at least one factor that affects the selection variable but not the level variable (Maddala 1983). Furthermore, to ensure that the results are not affected by heteroskedasticity, robust standard errors have been calculated for both random effects Tobit models and Heckman two-step sample selection models through bootstrapping procedure (Horowitz 2001) with 100 replications. All the statistical models have been estimated in STATA (version 10) statistical software.

4 Patterns in in-House R&D Investments by Foreign Affiliates in the Present Study

Figure 1 shows the share of some of the industries in the present study sample of firms with foreign affiliation. The sample has 190 manufacturing firms and 52 services firms. Most of the manufacturing foreign affiliates in this sample belong to the machinery and equipment industry (Division 28), followed by chemical and its products (Division 20). Around 4% firms belong to the pharmaceutical industry (Division 21) and another 4% firms belong to computer, electronic and optical products industry (Division 26). The services firms are spread across various industries including wholesale (Division 46), accommodation (Division 55), telecommunications (Division 61) and computer programming, consultancy and related activities (Division 62).

Figure 2 depicts the trends in the average in-house R&D investment values (in real terms) during 2011 to 2015 for some of the industries in the present study sample. According to Fig. 2, foreign affiliates operating in motor vehicles are investing the highest amount on in-house R&D followed by those in pharmaceutical industries. The average in-house R&D investments undertaken by the multinationals in other industries are less than Rs. 100 million (in real terms).

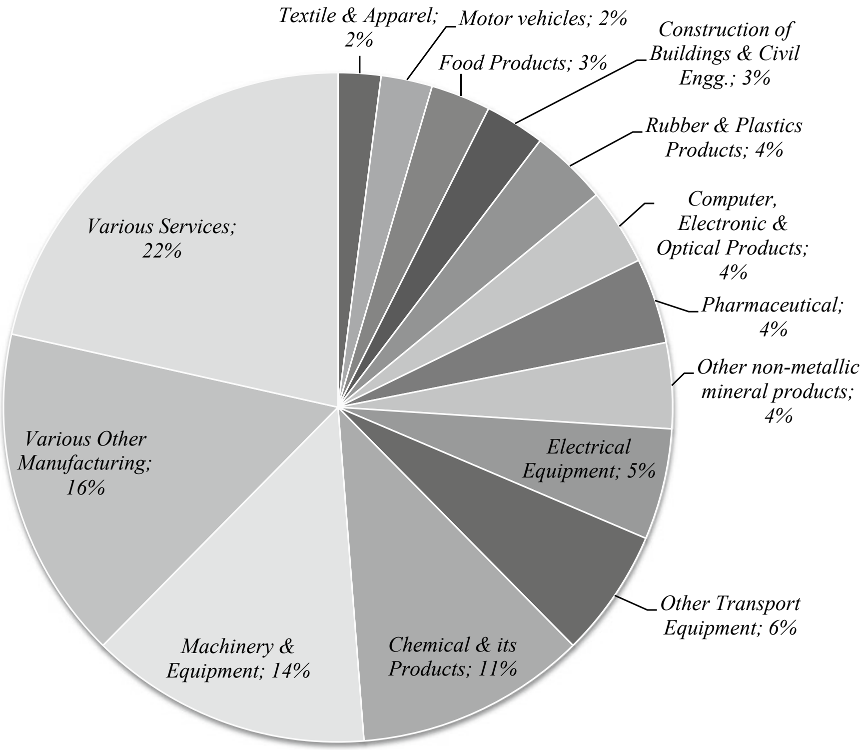

Fig. 1 Pie chart depicting the percentage share of different industries in the study sample

In the motor vehicles industry, the leading firms in terms of real investments on in-house R&D are Maruti Suzuki India Ltd., Ashok Leyland Ltd. and Bosch Ltd. In the last six years, Maruti Suzuki India Ltd. has launched 36 new and refreshed car models.[2] The firm has started a state-of-the-art R&D centre in Rohtak, Haryana, is equipped to design, develop and evaluate vehicles. Ashok Leyland Ltd. is a subsidiary of Hinduja Group that is headquartered in London, UK.[3] The company has a global R&D centre at Chennai which has close to around 1000 engineers engaged in design and development of commercial vehicles and vehicle systems. In India, Bosch Automotive Aftermarket Division of Bosch Ltd. is responsible for the supply, sales and distribution of automotive parts for vehicle servicing; diagnostics equipment for

[2]Information obtained from the website of the company https://www.marutisuzuki.com/technology.aspx (accessed 27 August 2017).

[3]Information obtained from the website of the company http://www.ashokleyland.com/ (accessed 27 August 2017).

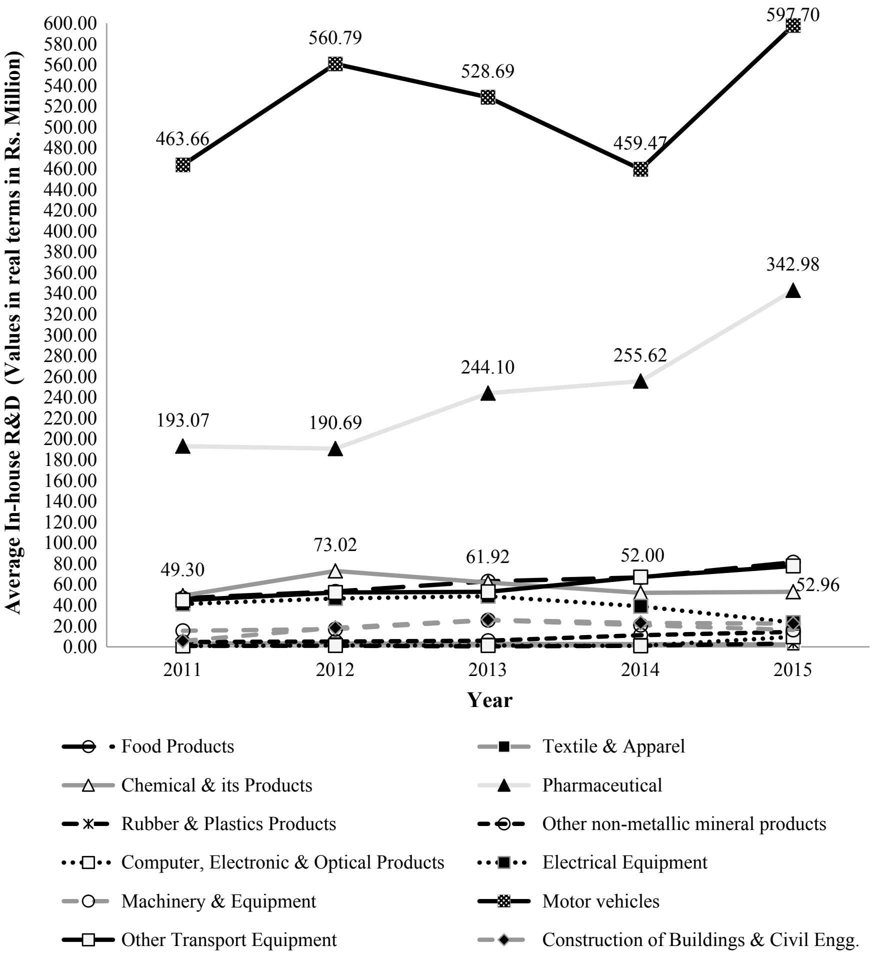

Fig. 2 Trends in the average in-house R&D investments of the foreign affiliates in different industries (*Source* Author's calculations based on data from prowess database)

workshops (i.e. testing equipment), technical information, training and consulting; and technical after-sales service for Bosch automotive products and systems.[4]

In the case of pharmaceutical industry, Mylan Laboratories Ltd., is the leading pharmaceutical firm in terms of R&D investments (in real terms). The firm operates in India in several pharmaceutical segments like critical care, hepatic care, HIV care, oncology care and women's care.[5] The firm claims to have more than 2900 R&D

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[4]Information obtained from the website of the company http://www.boschindia.com/en/in/our_company_5/business_sectors_and_divisions_5/automotive_aftermarket_5/automotive-aftermarket.html (accessed 27 August 2017).

[5]Information obtained from the website of the company http://www.mylan.in/ (accessed 27 August 2017).

and regulatory experts who work collaboratively across 10 different centres around the world. Further, about half of the scientific affairs workforce is based in India working at the firm's global R&D centre of excellence in Hyderabad and other R&D centres in Bangalore and Ahmedabad.

5 Analysis and Results

Table 2 presents the mean and standard deviation for the different variables in this sample. The table also indicates a number of observations that are undertaking R&D (represented by the dummy variable D_{RDI}). It is clear that hardly any foreign services firms claim that they undertake in-house R&D. In fact, in the present sample, the 12 non-zero observations on D_{RDI} for services is due to four firms undertaking R&D in various years. These four firms are Carrier Airconditioning & Refrigeration Ltd., Aimil Ltd., Kernex Microsystems (India) Ltd. and Lakeshore Hospital & Research Centre Ltd. It is visible that foreign manufacturing firms are having higher average in-house R&D intensity (0.33%) compared to foreign services firms (0.02%). The average age of the firms in the sample is around 35 years. With regard to embodied technology imports, the average raw material import intensity is higher for manufacturing firms at around 12% and the average capital goods import intensity is higher for services firms. Manufacturing firms on an average invest more on sales and distribution as a ratio of sales compared to the services firms. Foreign services firms have higher average labour intensity (19.45%) compared to the manufacturing firms

Table 2 Descriptive statistics

Sl. No.	Variables	Full sample	Manufacturing	Services
1	D_{RDI}	Value of 1= 483 Value of 0 = 727	Value of 1 = 471 Value of 0 = 479	Value of 1 = 12 Value of 0 = 248
2	RDI	0.26 (0.79)	0.33 (0.87)	0.02 (0.13)
3	SIZE	7.75 (1.91)	8.01 (1.78)	6.78 (2.06)
4	AGE	35.50 (21.22)	38.7 (20.86)	23.83 (18.25)
5	CAPI	19.84 (36.66)	18.03 (32.13)	26.46 (49.34)
6	LABI	11.41 (10.88)	9.22 (6.57)	19.45 (17.67)
7	SDI	4.88 (5.51)	5.44 (5.74)	2.84 (3.93)
8	OSRCI	1.24 (3.30)	1.46 (3.48)	0.45 (2.38)
9	IRAWI	9.84 (12.59)	12.06 (12.91)	1.70 (6.67)
10	ICGI	1.87 (21.21)	1.21 (3.06)	4.29 (45.37)
11	IRTI	0.57 (1.03)	0.66 (1.10)	0.22 (0.64)
Number of observations		1210	950	260

Mean with standard deviation in parenthesis for the variables from Sl. No. 2 to 11

(9.22%). Interestingly, both manufacturing and services firms are outsourcing manufacturing jobs. In the case of manufacturing, high OSRCI values are present mainly in construction industry and machinery and equipment industry. As mentioned earlier, in the case of services, high OSRCI values are present mainly in publishing industry and wholesale industry.

Although foreign affiliates in motor vehicles industry are leading in terms of average real investments on in-house R&D (Fig. 1), the trends for the average in-house R&D intensities (Fig. 3) are different. The highest R&D intensity is observed in the case of the high-tech industry, pharmaceuticals. Interestingly, the next highest

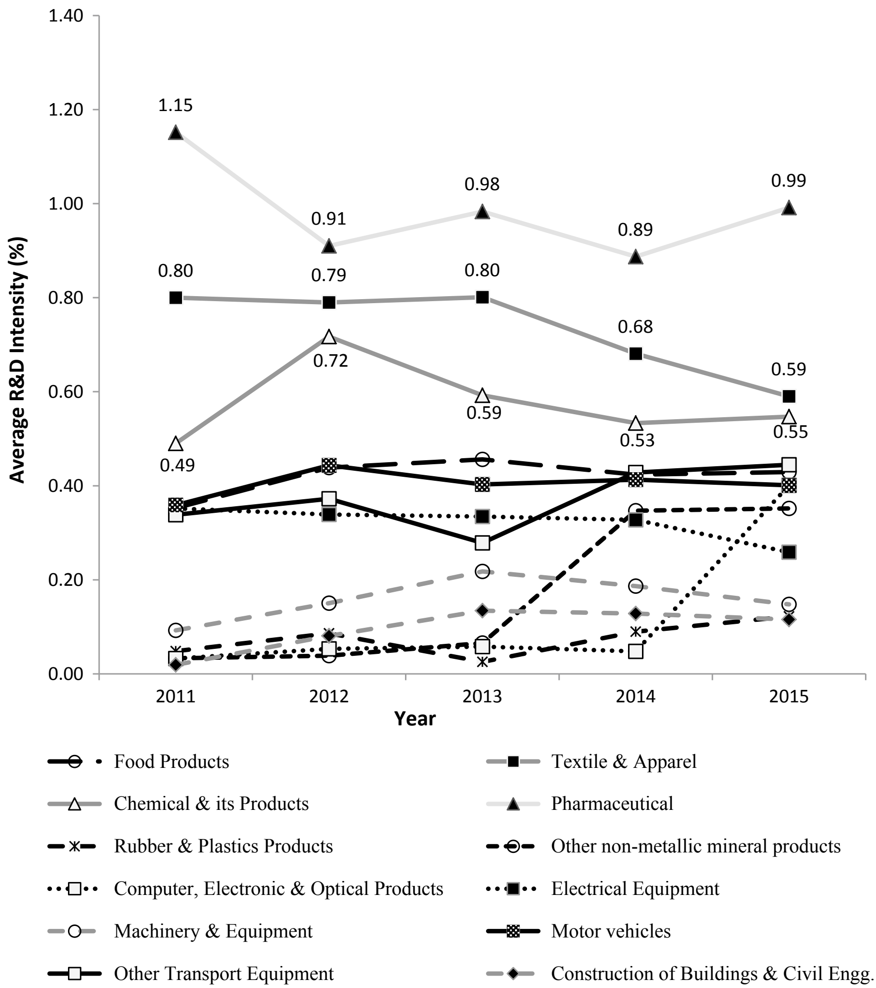

Fig. 3 Trends in the average in-house R&D intensity of the foreign affiliates in different manufacturing industries (*Source* Author's calculations based on data from prowess database)

R&D intensity is found in the firms belonging to relatively lower technology group, namely textile and apparel, followed by those belonging to chemical and its products.

In the present sample, Voith Paper Fabrics India Ltd. is the firm in the textile and apparel industry with high R&D intensity. The firm is a subsidiary of VP Auslandsbeteiligungen GmbH, which belongs to the Voith Group of Companies, Germany.[6] The firm's focus is on paper machine clothing (PMC), fibre-cement sheet making felts and hi-tech textile processing felts. The firm undertakes research and development activities for improving the quality of its products to meet the expectations of customer and for developing indigenous resources for import substitution. Another firm, Indian Card Clothing Co. Ltd., is into manufacturing of metallic yarn. The firm is promoted by Mauritius-based Multi Act Industrial Enterprises Limited (MAIL). The firm undertakes in-house R&D to improve its products and processes in the area of metallic card clothing and card wire. It has ISO 9001:2008 certification.[7]

Surprisingly, in another high-tech industry, namely computer, electronic and optical products, the average in-house R&D investments (Fig. 2) as well as average in-house R&D intensity (Fig. 3) of the foreign affiliates are relatively low. In this industry, the average R&D intensity improved to around 0.4% in 2015 from 0.05% in 2011 (Fig. 3) mainly due to relatively high investments on in-house R&D during the year by Panasonic A V C Networks India Co. Ltd.

Tables 3 and 4 present the correlation matrix for the variables for the full sample and for the manufacturing firms, respectively. The variables SIZE, AGE, IRAWI and IRTI are positively correlated with RDI. However, the magnitude of correlation coefficient is low in all the cases. The magnitudes of the correlation coefficients between all other variables are also low in both Tables 3 and 4. Hence, there are less chances of multicollinearity problem in the present study.

5.1 *Results of Random Effects Tobit Econometric Models*

The results of the random effects Tobit econometric models for the full sample and the manufacturing firms are presented in Table 5. To explore industry-specific effects on R&D, additional dummy variables (D_{pharma}, D_{textile}, and D_{chem}) have been introduced in the econometric Model 2 and Model 4 to represent the firms belonging to the top three industries in terms of average R&D intensity in the present sample (Fig. 3). Size of the firm and age of the firm is statistically significant with positive sign in all the four econometric models. This implies that the older and larger foreign affiliates are likely to undertake more R&D. None of the other variables are statistically significant.

[6]Information obtained from the website of the company https://voith.com/vpf-india-en/ (accessed 27 August 2017). Felt is a textile material that is produced by matting, condensing and pressing fibres together.

[7]Information obtained from the annual report of the company present in Bombay Stock Exchange website http://www.bseindia.com/bseplus/AnnualReport/509692/5096920313.pdf (accessed 27 August 2017) and ICRA report https://www.icra.in/Rationale/GetRationaleFile/27861 (accessed 27 August 2017).

Table 3 Correlation matrix for full sample

Variables	RDI	SIZE	AGE	CAPI	LABI	SDI	OSRCI	IRAWI	ICGI	IRTI
RDI	1.00									
SIZE	0.15*	1.00								
AGE	0.10*	0.30*	1.00							
CAPI	−0.06	−0.21*	−0.11*	1.00						
LABI	−0.05	−0.35*	−0.08*	0.02	1.00					
SDI	0.01	0.29*	0.25*	−0.08*	−0.20*	1.00				
OSRCI	0.03	−0.03	−0.02	−0.06*	−0.04	−0.03	1.00			
IRAWI	0.15*	0.12*	−0.04	−0.16*	−0.22*	−0.10*	−0.04	1.00		
ICGI	−0.01	−0.03	−0.05	0.01	−0.03	−0.03	−0.01	−0.01	1.00	
IRTI	0.15*	0.30*	0.09*	−0.11*	−0.17*	0.15*	−0.02	0.17*	0.07*	1.00

*Statistical significance at 5% level

Table 4 Correlation matrix for manufacturing firms

Variables	RDI	SIZE	AGE	CAPI	LABI	SDI	OSRCI	IRAWI	ICGI	IRTI
RDI	1.00									
SIZE	0.13*	1.00								
AGE	0.06*	0.32*	1.00							
CAPI	−0.05	−0.16*	−0.13*	1.00						
LABI	0.02	−0.40*	0.08*	−0.04	1.00					
SDI	−0.02	0.31*	0.22*	−0.04	−0.17*	1.00				
OSRCI	0.01	−0.08*	−0.04	−0.04	−0.004	−0.06*	1.00			
IRAWI	0.11*	0.03	−0.17*	−0.16*	−0.14*	−0.21*	−0.10*	1.00		
ICGI	0.02	0.04	−0.04	0.09*	−0.07*	−0.01	0.06	0.11*	1.00	
IRTI	0.13*	0.33*	0.05	−0.12*	−0.16*	0.13*	−0.09*	0.11*	0.07*	1.00

*Statistical significance at 5% level

Table 5 Results of random effects Tobit econometrics models with in-house R&D intensity (RDI) as explained variable

	Model 1	Model 2	Model 3	Model 4
	Full sample	Full sample	Manufacturing firms	Manufacturing firms
Constant	−2.59 (−4.06)[a]	−2.60 (−4.36)[a]	−2.36 (−3.24)[a]	−2.40 (−3.54)[a]
SIZE	0.13 (2.43)[b]	0.14 (2.70)[a]	0.14 (2.01)[b]	0.15 (2.41)[b]
AGE	0.02 (4.96)[a]	0.02 (3.98)[a]	0.02 (3.31)[a]	0.02 (3.50)[a]
CAPI	−0.002 (−0.69)	−0.001 (−0.44)	−0.001 (−0.30)	−0.001 (−0.26)
LABI	−0.01 (−1.57)	−0.01 (−1.32)	0.002 (0.23)	0.002 (0.14)
SDI	−0.002 (−0.20)	−0.01 (−0.81)	−0.01 (−0.89)	−0.02 (1.18)
OSRCI	−0.01 (−0.64)	−0.01 (−0.47)	−0.02 (−0.84)	−0.01 (−0.79)
IRAWI	0.01 (1.12)	0.01 (0.99)	0.003 (0.51)	0.003 (0.46)
ICGI	−0.005 (−0.57)	−0.005 (−0.76)	−0.003 (−0.43)	−0.003 (−0.58)
IRTI	0.03 (0.62)	0.04 (0.81)	0.04 (0.69)	0.04 (0.77)
D_{pharma}	–	1.42 (1.48)	–	1.23 (1.38)
D_{textile}	–	1.48 (0.23)	–	1.13 (0.13)
D_{chem}	–	0.59 (1.34)	–	0.50 (1.06)
Wald Chi^2	33.93[a]	33.21[a]	28.16[a]	36.67[a]
Log likelihood	−616.18	−608.33	−575.97	−570.09
No. of Obs.	242 × 5 = 1210	242 × 5 = 1210	190 × 5 = 950	190 × 5 = 950

Robust standard errors have been calculated using bootstrapping procedure with 100 replications
[a,b,c]Indicate statistical significance at 1%, 5% and 10% respectively. z-statistics in parenthesis

This may be because the factors that affect the decision to undertake R&D may be different from the factors that affect in-house R&D intensity.

5.2 *Results of Heckman Two-Step Econometric Models*

In the present study, Heckman two-step estimation models that can incorporate differing effects of the factors on decision and level parts have also been estimated. Tables 6 and 7 present the results for the same. While Table 6 (Models 1–4) gives the results for full sample, Table 7 (Models 1–4) gives the results for manufacturing firms. As mentioned earlier, for the Heckman two-step econometric models to be identified, it is important to introduce at least one factor that affects the selection variable but not the level variable (Maddala 1983). Hence, industry dummy variables (D_{pharma}, D_{textile}, and D_{chem}), which represent the firms belonging to the top three industries with respect to average R&D intensity in the present sample (Fig. 3), have been introduced in only the selection part of Model 1 in Tables 6 and 7.

Table 6 Results of Heckman two-step model with decision to undertake in-house R&D (D_{RDI}) and in-house R&D intensity (RDI) as explained variables for full sample

	Model 1	Model 2	Model 3	Model 4
	Full sample	Full sample	Full sample	Full sample
	Selection	Selection	Selection	Selection
Constant	−3.20 (−13.15)[a]	−3.20 (−11.14)[a]	−3.08 (−12.69)[a]	−3.20 (−11.54)[a]
SIZE	0.21 (7.51)[a]	0.21 (7.37)[a]	0.20 (7.46)[a]	0.21 (8.14)[a]
AGE	0.03 (13.65)[a]	0.03 (12.35)[a]	0.03 (13.02)[a]	0.03 (11.75)[a]
CAPI	−0.002 (−1.44)	−0.002 (−1.47)	−0.002 (−1.53)	−0.002 (−1.38)
LABI	−0.01 (−2.00)[b]	−0.01 (−2.08)[b]	−0.01 (−1.62)[c]	−0.01 (−1.86)[c]
SDI	−0.004 (−0.48)	−0.004 (−0.49)	0.003 (0.33)	−0.004 (−0.47)
OSRCI	−0.01 (−1.13)	−0.01 (−1.10)	−0.02 (−1.42)	−0.01 (−0.98)
IRAWI	0.01 (4.52)[a]	0.01 (4.29)[a]	0.02 (5.71)[a]	0.01 (4.45)[a]
ICGI	−0.001 (−0.05)	−0.001 (−0.08)	−0.0003 (−0.04)	−0.001 (−0.06)
IRTI	0.11 (2.90)[a]	0.11 (2.42)[b]	0.09 (2.01)[b]	0.11 (2.66)[a]
D_{pharma}	1.05 (3.95)[a]	1.05 (4.00)[a]	–	1.05 (4.42)[a]
$D_{textile}$	1.34 (3.79)[a]	1.34 (5.27)[a]	–	1.34 (4.36)[a]
D_{chem}	0.18 (1.24)	0.18 (1.24)	–	0.18 (1.45)
	Level	**Level**	**Level**	**Level**
Constant	2.84 (2.87)[a]	2.73 (3.72)[a]	1.87 (2.72)[a]	1.82 (2.54)[a]
SIZE	−0.04 (−0.94)	−0.03 (−0.81)	0.004 (0.09)	0.02 (0.37)
AGE	−0.03 (−3.30)[a]	−0.03 (−3.75)[a]	−0.02 (−3.04)[a]	−0.02 (−3.79)[a]
CAPI	0.004 (1.06)	0.002 (0.87)	0.001 (0.27)	0.003 (0.78)
LABI	0.03 (3.08)[a]	0.03 (2.66)[a]	0.03 (2.58)[a]	0.04 (2.74)[a]
SDI	−0.02 (−2.25)[b]	−0.02 (−2.15)[b]	−0.02 (−2.30)[b]	−0.03 (−3.12)[a]
OSRCI	0.12 (3.49)[a]	0.12 (3.12)[a]	0.12 (2.77)[a]	0.11 (3.81)[a]
IRAWI	−0.0005 (−0.09)	–	–	–
ICGI	−0.02 (−1.16)	–	–	–
IRTI	0.02 (0.25)	–	–	–
D_{pharma}	–	–	–	0.43 (1.30)
$D_{textile}$	–	–	–	0.10 (0.26)
D_{chem}	–	–	–	0.48 (2.45)[b]
Wald Chi^2	23.57[a]	17.88[a]	18.91[a]	33.49[a]
Mills λ	−1.29[a]	−1.25[a]	−0.79[b]	−0.91[a]
No. of Obs.	1210	1210	1210	1210

Robust standard errors have been calculated using bootstrapping procedure with 100 replications
[a,b,c]Indicate statistical significance at 1%, 5% and 10% respectively. z-statistics in parenthesis

Table 7 Results of Heckman two-step model with decision to undertake in-house R&D (D_{RDI}) and in-house R&D intensity (RDI) as explained variables for manufacturing firms

	Model 1	Model 2	Model 3	Model 4
	Manufacturing firms	Manufacturing firms	Manufacturing firms	Manufacturing firms
	Selection	Selection	Selection	Selection
Constant	−3.16 (−9.22)[a]	−3.16 (−9.06)[a]	−3.08 (−10.95)[a]	−3.16 (−10.17)[a]
SIZE	0.24 (6.39)[a]	0.24 (5.81)[a]	0.23 (8.07)[a]	0.24 (7.37)[a]
AGE	0.03 (9.21)[a]	0.03 (10.41)[a]	0.03 (11.57)[a]	0.03 (10.42)[a]
CAPI	−0.002 (−1.43)	−0.002 (−1.49)	−0.002 (−1.37)	−0.002 (−1.43)
LABI	0.02 (0.22)	0.002 (0.21)	0.01 (1.05)	0.002 (0.21)
SDI	−0.01 (−1.63)[c]	−0.01 (−1.64)[c]	−0.01 (−0.99)	−0.01 (−1.57)
OSRCI	−0.03 (−2.51)[b]	−0.03 (−2.88)[a]	−0.04 (−3.12)[a]	−0.03 (−2.73)[a]
IRAWI	0.01 (1.56)	0.01 (1.66)[c]	0.01 (1.97)[b]	0.01 (1.57)
ICGI	0.02 (0.93)	0.02 (1.03)	0.02 (0.93)	0.02 (0.94)
IRTI	0.08 (1.76)[c]	0.08 (1.48)	0.06 (1.18)	0.08 (1.68)[c]
D_{pharma}	0.86 (3.11)[a]	0.86 (3.68)[a]	–	0.86 (3.53)[a]
$D_{textile}$	1.05 (3.43)[a]	1.05 (3.12)[a]	–	1.05 (3.73)[a]
D_{chem}	0.16 (1.28)	0.16 (1.13)	–	0.16 (1.05)
	Level	**Level**	**Level**	**Level**
Constant	3.23 (3.17)[a]	3.45 (3.62)[a]	1.67 (1.76)[c]	2.00 (2.09)[b]
SIZE	−0.07 (−1.35)	−0.08 (−1.66)[c]	0.01 (0.19)	0.005 (0.08)
AGE	−0.03 (−3.50)[a]	−0.03 (−3.25)[a]	−0.02 (−2.98)[a]	−0.02 (−3.44)[a]
CAPI	0.004 (1.04)	0.001 (0.30)	−0.001 (−0.23)	0.002 (0.48)
LABI	0.02 (2.03)[b]	0.02 (1.94)[c]	0.02 (2.28)[b]	0.03 (2.10)[b]
SDI	−0.01 (−1.31)	−0.01 (−1.58)	−0.02 (−2.05)[b]	−0.03 (−2.69)[a]
OSRCI	0.14 (3.35)[a]	0.14 (3.38)[a]	0.12 (3.18)[a]	0.13 (3.39)[a]
IRAWI	0.006 (0.99)	–	–	–
ICGI	−0.03 (−1.37)	–	–	–
IRTI	0.03 (0.38)	–	–	–
D_{pharma}	–	–	–	0.50 (1.39)
$D_{textile}$	–	–	–	0.22 (0.55)
D_{chem}	–	–	–	0.50 (2.07)[b]
Wald Chi^2	24.97[a]	21.86[a]	18.21[a]	26.20[a]
Mills λ	−1.54[a]	−1.56[a]	−0.68[c]	−0.99[b]
No. of Obs.	950	950	950	950

Robust standard errors have been calculated using bootstrapping procedure with 100 replications
[a,b,c]Indicate statistical significance at 1%, 5% and 10%, respectively. z-statistics in parenthesis

It is clear from the results of Model 1 in Tables 6 and 7 that the variables representing technology imports (IRAWI, ICGI and IRTI) are not statistically significant in the level parts. Hence, the variables representing import of technology in embodied (IRAWI and ICGI) and disembodied (IRTI) forms are introduced only in the selection models in the other three econometric models in both these tables. The assumption for doing so is that any technology that is imported may require some amount of R&D to adapt it to local conditions. Hence, the firms importing technology are likely to undertake R&D. However, imported technology intensities may not affect R&D intensity of the firms if the foreign affiliates are engaging in explorative R&D activities or reverse innovation, which focuses on utilizing locally available technologies. Since technology imports are not statistically significant in the level part of the Heckman two-step model, there is a possibility that foreign affiliates in India are engaging in R&D investments for reverse innovation.

As is clear from the results of the econometric models (Tables 6 and 7), the factors that determine the decision to invest on R&D are quite different from the factors that determine the R&D intensity of the foreign affiliates. Further, the results of Heckman two-step models (Tables 6 and 7) differ from those of random effects Tobit models (Table 5). Thus, the results of the Heckman two-step econometric models (Tables 6 and 7) may be more relevant in giving useful insights in the present study. Furthermore, as per Wald Chi^2 statistics, the best of the four models is Model 4 in both the tables. This is the case where the technology import variables (IRAWI, ICGI and IRTI) are introduced only in the selection part and the three industry dummy variables are introduced in both the selection and level parts.

In both Tables 6 and 7 (except Model 2 of Table 7), the coefficient of size of the firm is statistically significant with positive sign only in the selection step. This implies that in the case of foreign affiliates, larger firms are more likely to undertake in-house R&D activity. However, size of the firm may not matter in determining the level of R&D intensity of these firms. Interestingly, sign on the coefficient of AGE is different in selection step (where it is positive) and level step (where it is negative) in all the results. Thus, more experienced foreign affiliates are more likely to undertake in-house R&D. However, younger firms rather than the older ones invest more amounts (as a proportion of sales) on R&D activities.

The coefficient of the variable LABI is statistically significant with a negative sign in the selection part in Table 6, suggesting that foreign affiliates with high labour intensity do not invest in R&D activities. However, this negative coefficient on LABI is present only in the case of full sample (Table 6) and not in the case of manufacturing firms (Table 7), where the coefficient is statistically insignificant. The full sample includes those software and services firms that have high LABI values but low (and even zero) values on in-house R&D activities, which may be influencing the results. However, as is clear from the level results in all the four econometric models in both the tables, higher labour intensities favourably affect in-house R&D intensities. In other words, higher investments in skilled labour are required to undertake more rigorous R&D activities.

The coefficient of the variable SDI is negative when it is statistically significant in the econometric models. Thus, as hypothesized, sales and distribution intensity

(SDI) and in-house R&D activities seem to be substitutes of each other. In other words, the firms that invest more on sales and distribution in a given year are more interested in capturing markets rather than spending on innovative efforts.

The results with regard to another variable, outsourcing of manufacturing jobs (OSRCI) is interesting. In the case of full sample (Table 6), the coefficient of OSRCI is not statistically significant in the selection part. However, in the case of manufacturing firms (Table 7), the coefficient of OSRCI is negative and statistically significant in the selection part. This implies that the manufacturing firms that outsource are not undertaking R&D activities. In the sub-sample of manufacturing firms, there are firms like Coretec Engineering India Pvt. Ltd. (produces industrial machinery), Sobha Ltd. (operates in real estate construction), I T D Cementation India Ltd. (operates in other infrastructure construction) and Toyo Engineering India Pvt. Ltd. (involved in construction of other industrial plants) that operate in engineering and construction industry and outsource a large portion of their operations. These firms hardly undertake any in-house R&D activities. However, the level estimates in all the econometric models of Tables 6 and 7 indicate higher outsourcing intensities favourably affect in-house R&D intensities. The manufacturing firms that undertake R&D and also outsource manufacturing jobs belong to different industries. For example, Nalco Water India Ltd. is based in Pune and is a subsidiary of Nalco Holding Co. that produces specialty chemicals including water treatment chemicals.[8] The Pune facility serves as headquarters for sales, marketing and supply chain for the company and also has a state-of-the-art technology and innovation centre. Another firm G M M Pfaudler Ltd. is an Indian subsidiary of Pfaudler Inc of USA and is a leading supplier of engineered equipment and systems for critical applications in the global chemical and pharmaceutical markets and works closely with its customers to provide solutions.[9] Mylan Laboratories Ltd., the leading pharmaceutical firm in terms of R&D investments, also has high outsourcing intensity. Such firms with high outsourcing intensities seem to be subcontracting the routine tasks in their production processes to focus on more challenging design and innovative activities.

With regard to import of technology, the results of the present study are not reliable. In the case of full sample (Table 6 all four econometric models), the firms that import raw materials and the firms that import disembodied technologies are more likely to invest on R&D activities. However, in the case of sample with only manufacturing firms, the two technology import variables (IRAWI and IRTI) are statistically significant with positive sign in only some models. Further, in line with the findings of Siddharthan (1992) in the context of private corporate sector in India, capital intensity (CAPI) is not important in determining in-house R&D even in the case of foreign affiliates operating in India.

With regard to industry dummy variables, the firms belonging to pharmaceutical industry and textile & apparel industry are more likely to undertake R&D as compared

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[8]Information obtained from the website of the company http://www.nalco.com/aboutnalco/india.htm (accessed 27 August 2017).

[9]Information obtained from the website of the company http://www.gmmpfaudler.com/index.php (accessed 27 August 2017).

to other industry firms. However, the firms that belong to chemical industry are more likely to be R&D intensive compared to firms that belong to other industries. As environmental regulations across the world are becoming more stringent (TSMG 2014), perhaps the firms in the chemical industry are investing rigorously on in-house R&D to create new products that conform to these regulations.

6 Conclusion and Implications

The present study attempted to understand the latest trends in the in-house R&D investments by foreign affiliates in India. Further, it tried to explore the factors that explain the inter-firm differences in R&D activities of these firms in India. The study used random effects Tobit model and Heckman two-step technique for a sample of 242 firms for the period of five years from 2011 to 2015.

With regards to the latest trends motor vehicles and pharmaceuticals are the leading industries in terms of average R&D investments by foreign affiliates. These foreign affiliates have also set up R&D centres in India. With regard to trends in average R&D intensities of foreign affiliates, pharmaceutical industry was on the top followed by textile and apparel industry, and chemical and related products industry, respectively.

The econometric analysis indicates that even in foreign affiliates, size of firm and experience of the firm are essential for the firms to be confident enough to invest on in-house R&D activities in India. However, it is the relatively younger firms that are willing to undertake higher intensities of in-house R&D. The Government of India can try to bring in policies wherein the recently established foreign affiliates are encouraged to undertake joint R&D activities with other Indian firms or Indian research centres to create innovative products of global standards through mutual sharing of knowledge.

In the case of foreign affiliates, higher labour intensities have a positive effect on in-house R&D intensities. By paying high salaries and wages to their employees, these firms are likely to attract the cream of the talent, who may contribute manyfolds to the intellectual property creation for the multinational firms. An in-depth comparative study on the corporate culture of leading corporate firms in India and the multinationals may be required to shed a light on the factors other than high salaries and wages that attract the skilled workforce of India to work for multinational firms.

In the foreign affiliates, import of technology through arms-length purchases is hardly important in determining in-house R&D intensity. However, outsourcing of manufacturing jobs is favourable for in-house R&D intensity. Further, the firms that are outsourcing as well as doing in-house R&D have dedicated R&D centres in India. Thus, one can presume that the foreign affiliates in India are indeed engaged in explorative R&D activities or reverse R&D where they would like to source and build on locally available knowledge to provide innovative products for their home market. An in-depth study on the intention of R&D activities of foreign affiliates in India can confirm this.

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Push Factors of Outward FDI—A Cross-Country Analysis of Developed and Developing Countries

Indrajit Roy and K. Narayanan

1 Introduction

Numerous theories attempted to explain the determinants of outward foreign direct investment (OFDI). MNEs spread out their activities in overseas locations for multiple reasons such as the exploitation of economies of scale/scope; the use of firm-specific advantages (Hymer 1960) often due to a life-cycle pattern of their products (Vernon 1966) to avoid contracting problems and associated transactions costs (Coase 1937; Teece 1986). Companies prefer internal transaction rather than arm's length market transactions, i.e. internalisation advantages (Dunning 1981) for these reasons. Literature also suggests various institutional factors such as macroeconomic economic factors of a country or push factors that cause OFDI. The main motives behind FDI decision of enterprise (Behrman 1972; Dunning and Lundan 2008) are market-seeking, resource-seeking, efficiency-seeking and strategic asset-seeking.

Several empirical studies (Barry et al. 2003; Kimino et al. 2007; Kumar 2007; Kyrkilis and Pantelidis 2003; Tolentino 2008) have examined push factors of OFDI in a panel data set-up using ordinary least square (OLS) method of regression. These factors may influence OFDI of varied magnitude depending on whether reference country is developed or developing countries. Also, there are issues when effects are estimated based on OLS model. OLS-based model focuses on the average/mean as a measure of location of the distribution; therefore, information about the tails and other parts of the distribution are ignored. Additionally, OLS is sensitive to extreme values (outliers), which can at times significantly distort the results. As a result, sometimes macroeconomic variables, based on OLS regression which is considered

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having significant (positive/negative) influence on OFDI, may not necessarily be true as the effects may be insignificant or very different (intensity and direction) for some segments (e.g. higher/lower strata) of FDI distribution. Quantile regression technique on the other hand attempts to explain the complete description of the conditional distribution (rather than only conditional mean analysis as in OLS), i.e. how the median, or may be 25th or 75th percentile of the dependent variable, are affected by explanatory variables.

This paper examines the association of select macroeconomic variables with the aggregate outward FDI of a country (i.e. 'home country'[1] determinants or 'push factors'[2] for OFDI) based on country-level panel data comprising a set of 'developed economies'[3] (G7[4] and other developed countries[5]) and 'emerging market economies' or developing economies[6] (BRICS[7] and other EME[8]s) using quantile regression. Specifically, the study aims to analyse the set of determinants for inter-country differences in OFDI. This study uses time series data of annual frequency for 36 developed and developing countries (which account for around 85% of total OFDI and 75% of total IFDI) for the period 1996–2013. The data are drawn from IMF, World Bank and UNCTAD databases.

Brief literature survey on FDI and push factors are discussed in Sect. 2. Methodology and empirical model specifications are discussed in Sect. 3. Empirical results are presented in Sect. 4, and finally a summary of findings is presented in Sect. 5.

2 Survey of Literature

Hymer (1960) observed that many enterprises invest as well as borrow from abroad and there are substantial cross movements of resources internationally within few selected industries. Also, capital was mostly transferred from developed countries to

[1] 'Home country' refers to parent or originating country of a company who have initiated outward FDI, whereas 'host country' refers to country of destination.

[2] 'Push factors' refers to domestic factors or determinants from Home country's perspective.

[3] 'Developed economies' refers to set of countries with high GDP, low inflation, high per capita income, higher life expectancy, high level of literacy and skilled manpower.

[4] G7 refers to front runners among the developed economies, viz. Canada, France, Germany, Italy. Japan, UK and USA.

[5] Other_Dev is set of developed countries (excluding G7 countries), viz. Australia, Austria, Belgium, Denmark, Finland, Ireland, New Zealand, Norway, Spain, Sweden and Switzerland).

[6] 'Emerging market economies' (EMEs) refer to set of countries with roughly 80% world population and constitute 20% world economies and which are progressing towards becoming advanced with faster GDP growth, low or middle per capita income, with lower level of literacy as well as skilled manpower. EMEs are in between of developed economies and frontier or least developed economies.

[7] BRICS refers to Brazil, Russia, India, China and South Africa which are front runner among the EMEs.

[8] Other_EMEs: Mexico, Thailand, Bangladesh, Bulgaria, Colombia, Ghana, Indonesia, Malaysia, Pakistan, Philippines, Sri Lanka, Turkey and Uruguay.

developed countries and not to less developed countries—these phenomena could not be explained by capital arbitrage theory. Hymer (1960) argues that firms engaging in international operations must possess ownership advantages (such as lower-cost factors; know-how skills; distributional and marketing advantages; expertise in product differentiation, etc.), which is sufficient to offset the disadvantages (i.e. 'liability of foreignness' due to information costs; exchange rate risks; and government restriction on type of activities and discrimination against foreigners including risk of expropriation of assets) they faced in competing with local firms in the host country. Hymer's hypothesis forms the basis of other explanations for determinants of FDI such as transactions costs and internalisation theories.

Johanson and Vahline (1977) followed behavioural theory and introduced Uppsala model which focuses on gradual internationalisation of firms through different stages. The model explains how firms gradually increase their activities in foreign markets which begin with occasional exports orders that are followed by regular exports and subsequently by foreign production. The model focuses on the gradual acquisition of knowledge about foreign markets and operations, and thereby gradually increases their commitments to foreign markets. By way of incremental learning, firms gain experience and expand their business into markets with greater 'psychic distance' (idiosyncratic differences), including geographical distance (Hashai and Almor 2004). Therefore, the internationalisation progresses are stepwise process and at a relatively slow pace because of local market regulations and organisational learning. At the same time, the level of commitment to foreign market may also decrease or even end, if the performance and prospect are not sufficiently met. While the Uppsala model posits that the internationalisation process of a firm is based on incremental learning, recent studies have shown that new firms especially from the emerging markets with little experience on foreign markets quickly penetrate and integrate with other foreign markets (these firms are termed as 'Born global' into the literature (Hashai and Almor 2004).

The eclectic paradigm, also known as OLI paradigm, was developed by Dunning (1988, 2001). OLI paradigm is a combination of three factors, i.e. ownership (O) advantage (industrial organisation theory), location (L) advantages (international immobility of some factors of production) and internalisation (I) advantage (transaction cost economics) which explain different types of FDI. A firm should possess some sort of comparative advantage over other firms in the host country, and the firm believes that it would gain immensely by internalisation of these assets. This implies that an internal expansion is preferred instead of depending on market (e.g. license agreement with another firm). The ownership advantage of the firm can be better exploited when it is combined with the favourable factor inputs located in the host country. OLI theory postulates FDI as a means for companies to leverage ownership, in attractive locations, by way of internalizing assets to gain competitive advantage which would imply that firms to invest abroad at the same or lower level of development to reap the benefit (i.e. AE to AE, AE to DE, DE to DE). Therefore, OLI theory has been criticised as it is based on the MNEs from developed countries and fails to explain the new wave of OFDI especially the cases when EM MNEs, which do not have those 'O' advantages are not waiting to gain experience or assets but undertake OFDI activities to the developed markets and taking aggressive steps (such as M&As) to gain those advantages (Rugman and Li 2007).

Dunning (1981, 1988) and Dunning and Narula (1996) developed investment development path (IDP) hypothesis which argues that a country's net outward direct investment position is systematically related to its level of economic development. According to IDP model, countries evolve through five stages of investment development. Stage-1 of IDP is related to pre-industrialisation period and characterised by insufficient location advantages or attractiveness for foreign capitals (small domestic markets, inadequate infrastructure, scarcity of skilled labour force and underdeveloped legal frameworks). Domestic companies are not competent enough to internationalise their activities. In this phase of development, inward and outward FDI flows to the country are almost non-existent. In stage-2 of IDP, government policies facilitate the development of certain location-specific advantages, which in turn attract inward foreign direct investment. But as domestic firms lack ownership advantages, very little outward investment may be possible at this stage of development. As a result, net investment position will become increasingly negative. Domestic companies will take time to accumulate the firm-specific assets which will eventually enable them for OFDI (Caves 1971; Dunning 1988). In stage-3 of IDP, inward FDI diminishes, however, over the time, 'learning-by-doing' will help in improving competitiveness of domestic companies and outward FDI will emerge. As a result, net FDI stock position will start improving, although continue to be in the negative region. Stronger domestic companies will be more competitive in the home market and may engage in market/strategic asset-seeking investment in developed countries, whereas resource-seeking OFDI will be destined to the developing countries. In stage-4 of IDP, OFDI increases further and eventually turn countries into net outward investors. In stage-5 (added subsequently, Dunning and Narula 1996), the net investment position of such countries will revolve around zero depending on the short-term evolution of exchange rates and economic cycles. IDP curve may vary widely across individual countries due to specific economic structures (market size, availability of natural resources), the type of FDI undertaken and government policies.

3 Push Factors of OFDI

Various determinants examined in this study and associated hypotheses are described below:

3.1 Home Country—Market Conditions

Market size of a country is reflected in its gross domestic products (GDP). Incidentally, at times, even country with smaller GDP may enjoy advantage of a larger market because of their membership to customs union like EU. Generally, a high level of GDP is indicative of large market size and companies by way of serving to a large market (economies of scale) develop certain competence (ownership advantage) which they can use to their advantage for overseas expansion. Therefore, a company with large home market is likely to undertake investment at overseas locations. Therefore, a positive relationship between GDP and outward FDI is expected. Market demand or buying capacity of the consumer is reflected in per capita GDP of a country. In home country with low market demand condition, companies may not reap benefits of economies of scale and may initiate OFDI (Dunning 1981; Taylor 2002; Kyrkilis and Pantelidis 2003; Deng 2004; Buckley et al. 2007). Therefore, a negative relationship is expected between per capita GDP and OFDI. Share of services and manufacturing sector in overall GDP is also indicative of level of economic development of home country. Therefore, share of non-agriculture GDP (i.e. services GDP and manufacturing GDP combined) in overall GDP influences the quantum of OFDI.

3.2 Policy Variables

FDI openness of the home country is expected to have positive influence on OFDI. A more liberal and open FDI policy would induce domestic companies to shift investment abroad and thereby lead to a greater outward FDI (Dunning 1981; Buckley et al. 2007). Inward FDI (IFDI) stock of a country is also indicative of liberal policy as well as technology advancement (direct and spill over) of a country and may influence OFDI. Therefore, a positive relationship is expected between IFDI and OFDI. Trade openness of home country is generally measured as trade (exports + import) to GDP ratio. Empirical studies suggest that expansion of trade activities enables domestic firms to acquire knowledge about foreign markets and therefore develop certain expertise for foreign operations and marketing of their products and thereby facilitate them to establish operations abroad (Johanson and Vahlne 1977; Buckley et al. 2007; Goh and Wong 2011; Kyrkilis and Pantelidis 2003). Therefore, positive relationship is expected between trade openness of home country and its OFDI.

3.3 Economic Variables

Interest rate in home country is also assumed to influence OFDI. Low interest rate implies abundance of capital, and therefore, opportunity cost of capital reduces. As a result, firms with abundant capital may look for more profitable avenues in foreign countries, especially in capital-intensive sector (Krykilis and Pantelidis 2003). Therefore, negative relationship is expected between interest rate of home country and its OFDI. Exchange rate of home country if it appreciates (strengthen), foreign currency denominated assets at host becomes cheaper for firms’ from home country’s perspective. Therefore, appreciation of exchange rate of home country with respect to host country lowers the capital requirements (in domestic currency) of MNEs for foreign investment therefore encourage OFDI (Blonigen 1997; Buckley et al. 2007). Moreover, an appreciation in exchange rate makes exported goods more expensive to foreign buyers, therefore makes exports less competitive. As a result, appreciation in exchange rate makes OFDI a relatively cheaper option to domestic companies for servicing foreign market.

3.4 Production Factors

Technological capability of a company provides ownership advantages, and the company can capitalise it by investing to other countries (Lall 1980; Clegg 1987; Grubaugh 1987; Pearce 1989; Kogut and Chang 1991; Dunning 1993). Therefore, efforts and policy towards capacity building of technology absorption/diffusion is important, and also certain technology obtained from developed countries may not be suitable in the emerging economies and thereby necessitate indigenous innovations (Lall 2001; Girma 2005; Li 2011; The World Bank 2008; Fu et al. 2011). This suggests that developing countries that put greater efforts in indigenous technological innovation are more likely to benefit out of international technological diffusion thus facilitate a greater level of internationalisation through OFDI. Research and development expenditure (% of GDP) is considered as a proxy for the technology capability of the home country, and a positive relationship is expected with OFDI.

3.5 Governance, Corruption and Outward FDI

In general, MNEs are corruption averse and the least corrupt countries may attract more FDI because they provide a more favourable climate for investors. Castro and Nunes (2013) investigate the impact of corruption on FDI inflows in 73 countries, over the period 1998–2008, and observed that countries where corruption is lower, the FDI inflows are greater. Hence, perception of heightened corruption and various other weak governance indicators at home also drive investment out of home country, especially in developing economies.

Based on the worldwide survey on governance, where respondents are public, private, and NGO sector experts, Worldwide Governance Indicators (WGI) project presents cross-country measure of the Control of Corruption index (captures perceptions of corruption including both petty and grand forms of corruption), political stability and absence of violence (measures perceptions of likelihood of social unrest, terrorism, violent demonstrations and security risk rating, etc.), the Government Effectiveness index (captures the quality of bureaucracy, the competency of civil servants and government's commitment to policies), the rule of law index (captures enforceability of contracts and the effectiveness of judiciary), the regulatory

Table 1 WGI Governance—correlation coefficients among sub-indicators

Correlation (2016)	Voice and accountability	Political stability and absence of violence	Government effectiveness	Regulatory quality	Rule of law	Control of corruption
Voice and accountability	1.00	0.69	0.69	0.93	0.92	0.95
Political stability and absence of violence		1.00	0.69	0.65	0.76	0.74
Government effectiveness			1.00	0.93	0.94	0.91
Regulatory quality				1.00	0.95	0.87
Rule of law					1.00	0.95
Control of corruption						1.00

quality index (measures price controls, inadequate bank supervision and perceptions of burdens imposed by excessive regulations such as foreign trade, business development, etc.) and voice and accountability (captures different aspects of political process, civil liberties and independence of the media.). The units of aggregate governance indicators follow standard normal distribution with zero mean and unit standard deviation, ranging from −2.5 (weak) to 2.5(strong). These six indicators are highly related (Table 1).

3.6 *Ease of Doing Business*

World Bank's ease of doing business ranks countries according to the costs that firms face when operating in a country. A high ease of doing business ranking indicates the regulatory environment is more favourable to the starting and operation of a local firm. Ease of doing business is based on composed index of ten topics, viz. Starting a Business, Dealing with Construction Permits, Getting Electricity, Registering Property, Getting Credit, Protecting Minority Investors, Paying Taxes, Trading across Borders, Enforcing Contracts and Resolving Insolvency. These indicators are closely related (Table 2).

Table 2 Ease of doing business—subcomponents: correlation coefficients

Correlations	Starting a business	Dealing with construction permits	Getting electricity	Registering property	Getting credit	Protecting minority investors	Paying taxes	Trading across borders	Enforcing contracts	Resolving insolvency
Starting a business	1.00	0.54	0.47	0.53	0.39	0.56	0.52	0.47	0.51	0.56
Dealing with construction permits		1.00	0.55	0.52	0.31	0.43	0.55	0.49	0.50	0.40
Getting electricity			1.00	0.58	0.41	0.52	0.55	0.59	0.59	0.58
Registering property				1.00	0.49	0.54	0.62	0.60	0.61	0.54
Getting credit					1.00	0.56	0.35	0.40	0.35	0.50
Protecting minority investors						1.00	0.49	0.45	0.52	0.63
Paying taxes							1.00	0.57	0.57	0.51
Trading across borders								1.00	0.54	0.62
Enforcing contracts									1.00	0.48
Resolving insolvency										1.00

4 Methodology

4.1 Empirical Model Specification and Data Description

This study uses time series data of annual frequency of 36 developed and developing countries (which account for around 85% of total OFDI and 75% of IFDI) for the period 1996–2013. The data are drawn from IMF, World Bank and UNCTAD databases.

Hypothesis 1 Outward FDI of a country is positively associated with its market size.

Hypothesis 2 Outward FDI is negatively associated with the market demand as measured by per capita GDP of home country.

Hypothesis 3 Outward FDI is positively associated with economic development of home country.

Hypothesis 4 Outward FDI is positively associated with degree of trade openness of home country.

Hypothesis 5 Outward FDI of a country is positively associated with its inward FDI.

Hypothesis 6 Outward FDI is negatively associated with real interest rate of home country.

Hypothesis 7 Outward FDI is positively associated with real effective exchange rate of home country.

Hypothesis 8 Outward FDI is positively associated with home country's technological efforts (share of R&D expenditure in GDP)

Hypothesis 9 Outward FDI is positively associated with share of ores and metals import in overall imports.

Hypothesis 10 Outward FDI is positively associated with ICT goods imports (% total goods imports).

4.2 The Basic Panel Regression Model

$$Y_{it} = \sum_{j=1}^{k} b_j Z_{it}^{j} + a_i + e_{it} \tag{1}$$

where Y_{it} represents OFDI of *i*th country for the '*t*'th year; $Z_{it}^{j} (j = 1 \ldots k)$ is the selected (*j*th) macroeconomic determinants pertaining to '*i*'th country for '*t*'th year; a_i is the unobserved effects due to country heterogeneity; b_i is unknown coefficient; and e_{it}'s are independently (over time '*t*' as well as across country indexed on '*i*') and identically normally distributed error process with mean zero and variance σ_e^2.

A special case of model (1) would be obtained if group heterogeneity was zero or negligible. In such case, a_i's, (for all *i*) are equal and the model would be estimated by pooled regression as

$$Y_{it} = \sum_{j=1}^{k} b_j Z_{it}^{j} + a + e_{it} \tag{2}$$

Generally, model (1) would give a better fit over model (2), which can be tested by the usual F-statistics on exclusion principle. Least square dummy variables (LSDV) technique is used to estimate group heterogeneity in model (1).

The LSDV model with *k* countries can be estimated as

$$Y_{it} = \sum_{j=1}^{k} b_j\, Z_{it}^{j} + \eta + \eta_2\, D_{2t} + \eta_3\, D_{3t} + \cdots + \eta_k\, D_{kt} + e_{it} \tag{3}$$

where D_{it} assumes a value 1 for all observations pertaining to *i*th country and assumes a value 0 for all other country, $i = 2, 3,\ldots, n$.

Model (3) is the re-expression of model (1) by assuming $a_1 = \eta$ and $a_i = (a_1 + \eta_i)$, $i = 2,3, \ldots, n$. Thus, model (3) considers first country as the base country with effect $a_1 = \eta$ on Y_{it}, and η_i represents the incremental effect of *i*th country over the base country, $i = 2, 3,\ldots, n$. In the absence of any country-level heterogeneity, $\eta_2 = \eta_3 = \cdots = \eta_n = 0$. This hypothesis can be tested in model (3) using F-statistics based on exclusion principle/restrictions.

We investigate determinants of OFDI using quantile regression model (similar to LSDV model). Further, it is unlikely that the drivers of outward FDI are the same across all developing countries—the panel estimation helps us to overcome this limitation as it accommodates for country and time effects separately. Here, instead of using all individual countries as dummies, we group the countries based on level of economic development and use these groups as dummies, viz. seven highly industrialised countries (G7); other advanced countries (other_developed); among developing economies five countries which are progressing at relatively faster pace, i.e. BRICS countries—Brazil (BRA), Russia (RUS), India (IND), China (CHN) and South Africa (ZAF); and other developing counties (eme_others). Also, we use time trend dummies (Trend). We test statistical significance of ten OFDI determinants for 36 countries during 1996–2013. Data for certain variables are missing for some country/year combination, and as a result, if all variables are included in the same regression equation, number of observations become less than half as compared to the average number of observations available when we test the significance of an individual determinant. Further, as determinants are correlated of various degrees, multicollinearity poses a problem. Therefore, we first test the significance of each determinant individually and thereafter test the effect of all determinants together on OFDI.

$$\begin{aligned} \text{LOFDI}_{it} = \alpha &+ \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} \\ &+ \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} \\ &+ \beta_9 * \text{Factor}^k_{it} \end{aligned} \quad (4)$$

$$\begin{aligned} \text{LOFDI}_{it} = \alpha &+ \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRICS} + \beta_3 * \text{DEV}_t + \beta_4 * \text{LGDP} \\ &+ \beta_5 * \text{LGDP\_PC} + \beta_6 * \text{LNAGDP} + \beta_7 * \text{LIFDI} \\ &+ \beta_8 * \text{LRDG} + \beta_9 * \text{LOMI} + \beta_{10} * \text{Lint\_rate} \end{aligned} \quad (5)$$

where 'i' denotes country, and 't' denotes year. The dependent variable LOFDI_{it} is log of Outward FDI (USD, million, current prices) of 'i'th country in 't'th year. Selected factors (all are log transformed). α: intercept; Trend: time trend (year); BRA: dummy variable for Brazil (i.e. 1 for record pertaining to Brazil and 0 for others). RUS, CHN, IND, ZAF, G7, BRICS, Dev and Other_Dev are also dummy variables pertaining to Russia, China, India, South Africa, G7 group of countries, BRICS countries, developed countries and other developed countries. LGDP: Log of nominal GDP; LGDPPC: Log of GDP per capita; LTrade: Log of Trade; LREER: Log of REER; LRDG: Log of R&D growth; LICI: Log of ICI; LOMI: Log of OMI; LIFDI: Log of Inward FDI; LNAGDP: Log of non-agriculture GDP of the country corresponding to log of OFDI stock (as dependent variable) of country concern (Table 3).

Table 3 Push factors (determinants) of outward foreign direct investment

Push factors/determinants	Symbol
Nominal GDP (USD, million)	LGDP
GDP per capita, PPP (constant 2011 international $)	LGDP_PC
Inward FDI (USD, million, current prices)	LIFDI
Non-agriculture GDP (share of services and manufacturing GDP)	LNAGDP
Real effective exchange rate	LREER
Trade (% of GDP)	LTRADE
Nominal interest rate (%)	LINT_rate
ICT goods imports (% total goods imports)	LICT
Research and development expenditure (% of GDP)	LRDG
Ores and metals imports (% of merchandise imports)	LOMI

Model (4) is to test the individual determinants without taking into consideration of other determinants. Model (5) takes into consideration of all identified determinants together.

$$\text{Model 1}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{Nominal GDP})_{it}$$

$$\text{Model 2}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{GDP per capita})_{it}$$

$$\text{Model 3}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{Trade})_{it}$$

$$\text{Model 4}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{REER})_{it}$$

$$\text{Model 5}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{Intrate})_{it}$$

$$\text{Model 6}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{RDG})_{it}$$

$$\text{Model 7}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{ICI})_{it}$$

$$\text{Model 8}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{OMI})_{it}$$

$$\text{Model 9}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{IFDI})_{it}$$

$$\text{Model 10}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRA} + \beta_3 * \text{RUS} + \beta_4 * \text{IND} + \beta_5 * \text{CHN} + \beta_6 * \text{ZAF}_t + \beta_7 * G^7_{it} + \beta_8 * \text{Other\_developed}_{it} + \beta_9 * \log(\text{NAGDP})_{it}$$

$$\text{Model 11}: \text{LOFDI}_{it} = \alpha + \beta_1 * \text{Trend}_{it} + \beta_2 * \text{BRICS} + \beta_3 * \text{DEV}_t + \beta_4 * \text{LGDP} + \beta_5 * \text{LGDP\_PC} + \beta_6 * \text{LNAGDP} + \beta_7 * \text{LIFDI} + \beta_8 * \text{LRDG} + \beta_9 * \text{LOMI} + \beta_{10} * \text{Lint\_rate}$$

4.3 Quantile Regression

Quantile τ (ranging from 0 to 1) refers to a specified proportion of an ordered sample of a population, e.g. $\tau(0.5)$ is the median value. Distribution function $F_Y(y)$ of Y can determine the probability (τ) of occurrence of $Y = y$, whereas quantiles define exactly the opposite; i.e., for a given probability τ, it provides the corresponding value $y_\tau = F_Y^{-1}(\tau)$ of the sample data/distribution. The entire conditional distribution of the dependent variable Y can be characterised through different values of τ. For a given $X_i = x_i$, if the cumulative density function (CDF) for a conditional dependent variable Y is $F_{x_i}(y)$, then apart from mean $\mu_{x_i}(y)$, different quantiles $F_{x_i}^{-1}(\tau)$ of y can also be computed. OLS regression basically connects $\mu_{x_i}(y)$ across different values of X_i, whereas quantile regression for a given τ connects $F_{x_i}^{-1}(\tau)$, across different values of X_i, thereby it focuses on the interrelationship between the explanatory variable X_i and the dependent variable Y for different quantiles (Koenker 2005).

In OLS by focusing on the mean as a measure of location of the distribution, information about the tails and other parts of a distribution are ignored. Moreover, OLS is sensitive to extreme values (outliers) that can distort the results significantly. Sometimes, OLS estimates can even be misleading about the correct association between an explanatory and a dependent variable as it may be very different for different subsections (quantile) of the sample. Quantile regression explains complete description of the conditional distribution (rather than only conditional mean analysis as in OLS), e.g. how the median, or perhaps the 25th or 75th percentile of the dependent variable, are affected by the explanatory variables. There may be instances when a macroeconomic variable considered having positive influence on OFDI based on OLS-based regression; may not be the true for some segments (higher/lower strata) of OFDI distribution which may have, on the contrary, insignificant or even opposite effect.

5 Empirical Findings and Discussion

The correlation matrix of the variables used in this study is given in Table 4. Scatter plot is given in appendix. The regression results are given in Tables 5, 6, 7 and 8.

5.1 *Examining Push Factors in a Univariate Setup*

As discussed above, due to data issue (missing data for some determinants on some country/year and for other determinants data are missing for different set of country/year combination), and also to avoid multicollinearity issue, individual determinants are first tested for their significance using both OLS method and quantile regression technique with country/regions dummies (Eq. 4), and thereafter, all determinates are tested together (Eq. 5). Accordingly, using Eq. (4), ten determinants are tested (named as Model 1 to Model 10) and results are presented in Tables 5, 6, 7 and 8.

Model 1 regresses log of OFDI to country/region dummies and log of nominal **GDP**, and OLS estimates suggest that GDP is positively related to OFDI. Individual country-/region-specific differences are found to be significant. Intercept for base-level region (i.e. other EMEs except BRICS) is negative. Intercept for other countries/regions are also negative (intercept for base group added to individual country/region coefficient), and for India, intercept is lowest. Negative intercept in log–log model implies very small positive number. Therefore, Model 1 also reveals that in general for all countries under study, OFDI to GDP shares of all of the economies were low in the initial period and increased over time (as trend coefficient is positive) and initial value of OFDI to GDP (intercept term) is lowest for India followed by China. Quantile estimates also reveal similar relationship across different quantiles. The result supports Hypothesis 1 indicating that OFDI of a country is positively associated with its GDP.

Model 2 regresses log of OFDI to country/region dummies and log of 'GDP per capita'. OLS estimates suggest that 'GDP per capita' is positively related to OFDI. Individual country/region dummies are also found to be significant and higher for the emerging economies as compared to developed economies. Quantile regressions also indicate positive and significant relationship. However, for lower quartile (first quartile or 25th percentile), we observe estimated coefficient for log of per capita GDP (i.e. LGDPPC) is 3.48 which is lower than the coefficient observed for median (5.0) and third quartile (5.44). This implies that effect of per capita GDP on OFDI is not uniform, but it increases with OFDI volume. The result indicates that OFDI is positively associated with the market demand as measured by per capita GDP of home country and defies Hypothesis 2.

Model 3 investigates the relationship between OFDI with **trade openness**, and OLS estimate is positive and significant. Also, individual country-/region-specific dummies are positive and significant. Intercept for India is found to be lower than

Table 4 Correlation coefficient OFDI and determinants

	LOFDISTO	LNGDP	LGDPPC	LNAGDP	LTRADI	LIFDI	LINT_RATE	LREER	LRDG	LOMI	LICI
LOFDISTO	1										
LNGDP	0.83	1									
LGDPPC	0.65	0.30	1								
LNAGDP	0.51	0.36	0.53	1							
LTRADE	−0.14	−0.49	0.06	−0.10	1						
LIFDI	0.89	0.79	0.44	0.38	−0.07	1					
LINT_RATE	−0.57	−0.52	−0.45	−0.40	0.07	−0.40	1				
LREER	0.44	0.46	0.31	0.28	−0.15	0.43	−0.34	1			
LRDG	0.75	0.56	0.70	0.54	−0.06	0.53	−0.60	0.31	1		
LOMI	0.30	0.39	0.01	−0.07	0.02	0.12	−0.44	0.19	0.35	1	0.115701
LICI	−0.04	0.09	−0.24	−0.12	0.14	−0.02	−0.18	0.04	−0.09	0.12	1

Table 5 Results of LSDV Eq. (4) for 10 determinants: OLS regression for mean: coefficient (t-statistics)

Mean Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
C	−8.69*** (−18.03)	−11.98*** (−12.03)	3.58*** (6.54)	−11.4*** (−4.79)	8.54*** (19.62)	7.11*** (28.92)	2.35*** (6.77)	5.54*** (30.07)	−4.33*** (−17.13)	24.28*** (−7.33)
TREND	0.05*** (6.02)	0.1*** (10.92)	0.14*** (12.21)	0.11*** (8.85)	0.1*** (7.01)	0.15*** (11.54)	0.2*** (13.58)	0.14*** (12.34)	−0.02*** (−2.66)	0.14*** (12.88)
BRA	1.02*** (4.17)	3.18*** (10.89)	4.66*** (12.41)		5.19*** (12.5)	2.82*** (6.87)	3.83*** (10.8)	3.87*** (11.2)	1.11*** (5.77)	3.03*** (8.77)
RUS	1.44*** (6.1)	2.39*** (7.95)	4.02*** (11.41)		4.2*** (11.54)	2.74*** (7.49)	4.73*** (13.27)	4.12*** (11.8)	1.76*** (9.46)	4.12*** (10.21)
IND	−0.81*** (−3.39)	3.72*** (12.19)	2.25*** (6.25)		1.82*** (5.03)	0.78*** (2.22)	2.77*** (7.78)	1.39*** (3.91)	0.69*** (3.82)	2.41*** (7.07)
CHN	−0.31 (−1.18)	4.65*** (15.96)	4.03*** (11.41)		3.29*** (8.82)	2.67*** (7.25)	2.69*** (7.32)	3.17*** (8.65)	0.48*** (2.46)	3.84*** (11.52)
ZAF	2.31*** (10.29)	2.53*** (8.69)	3.28*** (9.3)		3.2*** (8.86)	2.07*** (4.81)	2.95*** (8.3)	3.4*** (9.72)	1.64*** (8.99)	2.2*** (6.39)
G7	1.83*** (10.64)	2.97*** (13.62)	6.32*** (38.11)		5.18*** (22.19)	4.71*** (15.23)	5.92*** (36.73)	5.94*** (37.07)	2.28*** (18.68)	4.7*** (21.5)
OTHER_DEV	2.95*** (29.63)	0.99*** (4.59)	4.16*** (28.85)		3.61*** (17.33)	2.85*** (9.59)	4.37*** (30.64)	4.18*** (29.85)	1.94*** (21.36)	3.09*** (17.36)
BRICS				3.65*** (15.38)						
DEV				4.56*** (29.89)						
LNOM_GDP	1.35*** (31.12)									

(continued)

Table 5 (continued)

Mean Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
LGDPPC		4.72*** (18.22)								
LTRADE			0.61*** (4.65)							
LREER				3.96*** (7.48)						
Lint_Rate					−0.84*** (−6.32)					
LRDG						0.5*** (3.56)				
LICI							1.4*** (12.85)			
LOMI								0.62*** (5.22)		
LIFDI									1.21*** (42.89)	
LNAGDP										7.08*** (9.22)
Adj R-squared	0.90	0.83	0.75	0.69	0.74	0.77	0.79	0.75	0.94	0.77
F-statistics	622.51	344.86	209.59	289.48	160.03	169.10	209.35	208.11	1002.52	210.13

Note C: intercept; Trend: time trend (year); BRA: dummy variable for Brazil (i.e. 1 for record pertaining to Brazil and 0 for others). RUS, CHN, IND, ZAF, G7, BRICS, DEV and Other_Dev are also dummy variables pertaining to Russia, China, India, South Africa, G7 group of countries, BRICS countries, developed countries and other developed countries. Other_EME is dummy variable for other EME countries used as base line and not included in the models; LGDP: Log of nominal GDP; LGDPPC: Log of GDP per capita; LTrade: Log of Trade; LREER: Log of REER; LRDG: Log of R&D growth; LICI: Log of ICI; LOMI: Log of OMI; LIFDI: Log of Inward FDI; LNAGDP: Log of non-agriculture GDP of the country corresponding to log of OFDI stock (as dependent variable) of country concern. T-statistics is given in parenthesis ()

$***p < 0.01$, $**p < 0.05$, $*p < 0.10$

Table 6 Results of LSDV Eq. (4) for 10 determinants: quantile regression for median coefficient (t-statistics)

Median Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
C	−7.15*** (−12.45)	−12.3*** (−12.35)	4.39*** (5.65)	−6.03 (−1.67)	7.72*** (11.21)	7.7*** (31.04)	1.68*** (3.37)	5.97*** (12.85)	−3.67*** (−12.75)	33.31*** (−3.62)
TREND	0.06*** (6.61)	0.09*** (8.44)	0.13*** (8.53)	0.13*** (7.53)	0.13*** (6.19)	0.16*** (11.96)	0.2*** (14.81)	0.15*** (10.64)	−0.01 (−0.89)	0.13*** (10.31)
BRA	1.32*** (6.76)	2.45*** (16.85)	4.51*** (12.66)		4.65*** (13.86)	2.09*** (8.8)	3.73*** (16.46)	3.7*** (9.77)	1.26*** (8.6)	2.5*** (10.44)
RUS	1.9*** (7.83)	1.9*** (9.1)	4.32*** (11.21)		4.18*** (11.7)	2.39*** (8.53)	4.79*** (20.22)	4.06*** (9.4)	1.84*** (15)	3.95*** (16.76)
IND	−0.69 (−1.96)	3.03*** (6.84)	1.87*** (3.27)		1.44*** (2.29)	−0.06 (−0.13)	3.24*** (8.43)	1.26 (1.9)	0.7*** (2.69)	1.89*** (3.92)
CHN	0.1 (0.46)	3.79*** (21.75)	3.81*** (11.06)		3.3*** (7.93)	1.97*** (7.83)	2.45*** (7.61)	3.31*** (7.28)	0.34 (1.86)	3.63*** (15.07)
ZAF	2.26*** (13.41)	1.78*** (11.22)	3.26*** (9.71)		2.95*** (8.63)	1.22*** (5.18)	2.97*** (13.19)	2.98*** (7.45)	1.61*** (11.3)	1.66*** (6.73)
G7	2.27*** (10.06)	2.16*** (9.68)	6.18*** (19.49)		5.06*** (11.27)	3.96*** (12.42)	5.9*** (28.58)	5.76*** (15.28)	2.32*** (14.75)	3.94*** (11.28)
OTHER_DEV	3.1*** (23.51)	0.03 (0.1)	4.25*** (12.67)		4.04*** (10.41)	2.11*** (6.84)	4.3*** (21.18)	4.17*** (11.16)	2.16*** (17.5)	2.46*** (6.52)
BRICS				3.42*** (7.87)						
DEV				4.91*** (11.42)						
LNOM_GDP	1.21*** (23.58)									

(continued)

Table 6 (continued)

Median Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
LGDPPC		5*** (19.01)								
Ltrade			0.42*** (2.13)							
REER				2.74*** (3.32)						
LlntRate					−0.59*** (−3.47)					
LRDG						0.42*** (2.8)				
LICI							1.68*** (10.14)			
LOMI								0.25 (0.95)		
LIFDI									1.14*** (33.32)	
LNAGDP										9.29*** (4.37)
Pseudo R-squared	0.70	0.62	0.52	0.43	0.50	0.55	0.56	0.52	0.77	0.55
Adjusted R-squared	0.70	0.62	0.52	0.42	0.49	0.54	0.55	0.51	0.77	0.55

Note C: intercept; Trend: time trend (Year); BRA: dummy variable for Brazil (i.e. 1 for record pertaining to Brazil and 0 for others). RUS, CHN, IND, ZAF, G7, BRICS, DEV and Other_Dev are also dummy variables pertaining to Russia, China, India, South Africa, G7 group of countries, BRICS countries, developed countries and other developed countries. Other_EME is dummy variable for other EME countries used as base line and not included in the models; LGDP: Log of nominal GDP; LGDPPC: Log of GDP per capita; LTrade: Log of Trade; LREER: Log of REER; LRDG: Log of R&D growth; LICI: Log of ICI; LOMI: Log of OMI; LIFDI: Log of Inward FDI; LNAGDP: Log of non-agriculture GDP of the country corresponding to log of OFDI stock (as dependent variable) of country concern. T-statistics is given in parenthesis ()

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 7 Results of LSDV Eq. (4) for 10 determinants: quantile regression for 1st quartile coefficient (t-statistics)

First quartile: Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
C	−7.99*** (−15.97)	−9.05*** (−4.64)	2.87*** (3.61)	11.63*** (−3.12)	4.93*** (9.35)	5.44*** (12.79)	1.73*** (5.56)	3.76*** (21.32)	−4.51*** (−8.59)	23.87*** (−3.03)
TREND	0.04*** (4.74)	0.12*** (10.92)	0.15*** (13.48)	0.13*** (9.72)	0.12*** (7.03)	0.14*** (9.16)	0.18*** (12.59)	0.14*** (12.21)	−0.02 (−1.14)	0.14*** (11.34)
BRA	1.82*** (8.39)	4.97*** (17.76)	6.33*** (27.6)		6.59*** (25.03)	4.5*** (12.29)	5.25*** (23.13)	5.92*** (24.43)	1.76*** (5.9)	4.95*** (8.49)
RUS	2.08*** (6.54)	4.03*** (7.03)	5.37*** (7)		5.57*** (10.84)	3.76*** (4.59)	6.06*** (30.05)	5.14*** (8.17)	2.42*** (9.45)	5.94*** (13.15)
IND	−0.78 (−1.84)	4.16*** (9.87)	3.25*** (7.19)		2.9*** (6.31)	1.57*** (2.96)	3.25*** (10.48)	2.67*** (5.19)	0.81*** (2.87)	3.44*** (10.68)
CHN	0.65*** (2.74)	5.89*** (28.52)	5.78*** (28.8)		5.41*** (18.46)	4.12*** (10.47)	4.01*** (11.92)	5.37*** (16.58)	0.71*** (2.02)	5.44*** (14.39)
ZAF	2.96*** (19.53)	4.15*** (15.12)	5.13*** (26.12)		5.15*** (23.75)	3.6*** (9.97)	4.33*** (19.38)	5.04*** (23.46)	2.01*** (7.86)	3.97*** (6.69)
G7	2.46*** (9)	4.93*** (10.03)	7.78*** (47.58)		7.07*** (22.69)	5.78*** (13.42)	6.89*** (34.3)	7.43*** (28.82)	2.72*** (7.59)	6.18*** (8.65)
OTHER_DEV	3.29*** (20.27)	2.93*** (5.43)	5.92*** (30.82)		5.67*** (19.04)	4.08*** (8.53)	5.28*** (24.42)	5.71*** (21.09)	2.42*** (7.47)	4.52*** (6.52)
BRICS				4.67*** (23.62)						
DEV				5.14*** (26.56)						
LNOM_GDP	1.23*** (24.64)									

(continued)

Table 7 (continued)

First quartile: Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
LGDPPC		3.48*** (6.52)								
Ltrate			0.22 (1.13)							
REER				3.65*** (4.43)						
LINT_Rate					−0.36*** (−2.38)					
LRDG						0.43* (1.94)				
LICI							1.07*** (7.9)			
LOMI								0.25 (1.74)		
LIFDI									1.16*** (16.15)	
LNAGDP										6.53*** (3.45)
Pseudo-R-squared	0.74	0.64	0.60	0.53	0.59	0.61	0.64	0.59	0.79	0.60
Adjusted R-squared	0.74	0.63	0.59	0.52	0.58	0.60	0.63	0.59	0.79	0.60

Note C: intercept; Trend: time trend (year); BRA: dummy variable for Brazil (i.e. 1 for record pertaining to Brazil and 0 for others). RUS, CHN, IND, ZAF, G7, BRICS, DEV and Other_Dev are also dummy variables pertaining to Russia, China, India, South Africa, G7 group of countries, BRICS countries, developed countries and other developed countries. Other_EME is dummy variable for other EME countries used as base line and not included in the models; LGDP: Log of nominal GDP; LGDPPC: Log of GDP per capita; LTrade: Log of Trade; LREER: Log of REER; LRDG: Log of R&D growth; LICI: Log of ICI; LOMI: Log of OMI; LIFDI: Log of Inward FDI; LNAGDP: Log of non-agriculture GDP of the country corresponding to log of OFDI stock (as dependent variable) of country concern. T-statistics is given in parenthesis ()

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

Table 8 Results of LSDV Eq. (4) for 10 determinants: quantile regression for third quartile

Third quartile: Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
C	−7.89*** (−8.18)	−13.48*** (−16.34)	6.02*** (12.86)	−7.48*** (−3.47)	9.61*** (10.46)	8.82*** (19.6)	5.49*** (6.85)	7.38*** (27.01)	−2.59*** (−4.24)	−14.4*** (−5.99)
TREND	0.04*** (3.81)	0.09*** (9.84)	0.15*** (12.97)	0.12*** (7.86)	0.13*** (7.02)	0.15*** (10.13)	0.19*** (11.14)	0.15*** (12.75)	0 (0.07)	0.16*** (16.88)
BRA	0.61*** (3.13)	1.91*** (15.58)	2.83*** (14.23)		3.27*** (6.19)	1.15*** (2.87)	2.31*** (10.71)	2.51*** (15.16)	0.78*** (6.28)	1.92*** (10.83)
RUS	1.2*** (6.54)	1.33*** (7.89)	2.78*** (13.26)		2.69*** (9.94)	1.55*** (3.64)	2.96*** (10.91)	3.04*** (10.46)	1.35*** (13.93)	2.8*** (13.93)
IND	−0.66*** (−3.04)	3.62*** (17.4)	1.45*** (5.44)		1.37*** (3.81)	0.25 (0.56)	1.71*** (4.94)	1.39*** (5.38)	0.69*** (5.3)	1.84*** (6.56)
CHN	−0.88*** (−3.84)	3.9*** (11.97)	2.69*** (10.34)		2.13*** (6)	1.19*** (2.78)	2*** (6.61)	2.44*** (9.46)	0.69*** (4.05)	2.69*** (12.53)
ZAF	1.84*** (9.73)	1.49*** (9.26)	1.84*** (7.44)		1.77*** (6.35)	0.4 (1.08)	1.38*** (6.26)	2.01*** (6.85)	1.08*** (8.05)	1.27*** (5.47)
G7	1.73*** (9.72)	1.84*** (8.7)	5.02*** (27.15)		4.46*** (13.68)	3.44*** (6.22)	4.84*** (22.98)	5.05*** (27.82)	2.01*** (13.41)	4.18*** (21.69)
OTHER_DEV	2.69*** (24.48)	0.04 (0.16)	3.3*** (21.8)		2.93*** (8.74)	1.85*** (3.85)	3.61*** (12.73)	3.5*** (20.89)	1.75*** (22.37)	2.78*** (17.26)
BRICS				2.31*** (7.34)						
DEV				3.71*** (16.81)						
LNOM_GDP	1.35*** (16.42)									

(continued)

Table 8 (continued)

Third quartile: Eqn.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
LGDPPC		5.44*** (23.59)								
Ltrate			0.41*** (3.6)							
REER				3.47*** (7.34)						
LIntRate					−0.69*** (−2.17)					
LRDG						0.66*** (3.2)				
LICI							0.79*** (3.07)			
LOMI								0.19 (1.21)		
LIFDI									1.09*** (17.14)	
LNAGDP										5.1*** (9.38)
Pseudo R-squared	0.67	0.63	0.50	0.39	0.49	0.52	0.49	0.49	0.73	0.54
Adjusted R-squared	0.66	0.63	0.49	0.38	0.48	0.51	0.48	0.49	0.72	0.53

Note C: intercept; Trend: time trend (year); BRA: dummy variable for Brazil (i.e. 1 for record pertaining to Brazil and 0 for others). RUS, CHN, IND, ZAF, G7, BRICS, DEV and Other_Dev are also dummy variables pertaining to Russia, China, India, South Africa, G7 group of countries, BRICS countries, developed countries and other developed countries. Other_EME is dummy variable for other EME countries used as base line and not included in the models; LGDP: Log of nominal GDP; LGDPPC: Log of GDP per capita; LTrade: Log of Trade; LREER: Log of REER; LRDG: Log of R&D growth; LICI: Log of ICI; LOMI: Log of OMI; LIFDI: Log of Inward FDI; LNAGDP: Log of non-agriculture GDP of the country corresponding to log of OFDI stock (as dependent variable) of country concern. T-statistics is given in parenthesis ()

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$

other BRICS countries and also than the developed countries but higher than other emerging economies. However, quartile regression reveals positive and significant association of trade and OFDI for median and upper (third) quartile and insignificant for first quartile. Therefore, effect of trade openness is not felt in countries with small size of OFDI; however, significant relationship exist for all others.

Model 4: Hypothesis of positive relationship of **REER** with OFDI is tested in Model 4, and OLS estimate supports the hypothesis. Quantile regressions also indicate similar results with marginally lower effect for median class.

Model 5: Hypothesis of negative relationship of **Interest rate** with OFDI is tested by Model 5, and OLS estimate supports the hypothesis. Significant individual country/region differences are also observed. Intercept for India is found to be lower than other BRICS countries as well as developed countries, however higher than other emerging economies. Quantile regressions also indicate negative and significant relationship and support hypothesis 6. However, estimated coefficient for real interest rates for first quartile is (−) 0.36 which is lower (intensity, ignoring the sign) than other two quartiles (−0.59 for median and −0.69 for third quartile) as well as OLS estimate of (−) 0.84 suggesting that effect is weaker for lower quartile. This implies that negative effect of interest rate on OFDI is not uniform, but it increases with the OFDI volume.

Model 6: Hypothesis of positive relationship of **RDG** with OFDI is tested in Model 6, and OLS estimate supports the hypothesis. Significant individual country/region differences are also observed. Intercept for India is found to be lower than other BRICS countries, developed countries as well as other emerging economies. Quantile regressions also indicate positive and significant relationship for all three quartiles but highest for upper quartile.

Model 7: Hypothesis of positive relationship of **ICI** with OFDI is tested in Model 7, and OLS estimate supports the hypothesis. Quantile regressions also indicate similar results with higher effect for median class than the first quartile as well as third quartile.

Model 8: Although, **OMI** and OFDI are found to be positively associated in OLS regression (Hypothesis 8), no significant association observed for first, second and third quartile.

Model 9: OFDI is found to be strongly associated with **IFDI** (Hypothesis 5). Effect of IFDI on OFDI is by and large uniform across countries.

Model 10: Economic development may also get reflected in the share of non-agriculture GDP (**NAGDP**), i.e. share of services and manufacturing sector in overall GDP, and is found to be positively related with OFDI (Hypothesis 3). Effect of NAGDP on OFDI is strongest for the median (9.3) and weakest for the upper quartile (5.1); OLS estimate of coefficient is 7.1. All of these indicate positive but large inequality of influence of NAGDP on different segments of OFDI distribution.

5.2 *Examining Push Factors in a Multivariate Setup*

Seven determinants, out of ten determinants which were tested individually in 5.1, are found to be significant when all were tested together in Model 11 using Eq. (5) (Table 9).

Model 11 reveals that outward FDI rises with GDPPC, NAGDP, GDP, IFDI, RDG, OMI and OFDI falls with interest rate. Effect of GDP on OFDI is found to be significant across all quartiles, however, found to be relatively stronger for the lower quartile as compared to the upper quartile. Similarly, per capita GDP (LGDPPC) is also observed to be positively influence OFDI, and effect varies considerably across quartiles with strongest effect observed for the first quartile and weakest effect observed for the third quartile. Share of non-agriculture GDP in overall GDP may be considered as economic development was also found to be positively associated with OFDI. The effect of NAGDP varies considerably across quartiles with strongest effect observed for the first quartile and weakest effect observed for the third quartile. IFDI stock was also found to be positively associated with OFDI for all quartiles as well as for the mean. However, the effects are different across quartiles, and strongest effect is observed for the upper quartile. Effect of IFDI is most prominent for countries which have very high level of OFDI. RDG is also found to be a significant factor for OFDI, and effect is relatively stronger for lower quartile than that of mean, median class as well as upper quartile. Nominal interest rate is found to have negative effects on OFDI for the mean, median and upper quartile. However, no significant effects were observed for lower quartile. OMI has positive effects on OFDI only for the first quartile and mean. No significant effect was observed for the median and upper quartile.

Table 9 Determinants of OFDI: significant (at 5% and above level) coefficients for different quartiles

	Model 11			
	25%	Median	75%	Mean
C	−20.33	−18.15	−16.52	−16.91
TREND	–	–	−0.01	0.01
BRICS	0.45	0.68	–	0.48
DEV	−0.45	–	–	–
LGDP	0.41	0.34	0.33	0.37
LNAGDP	1.91	1.89	1.80	1.48
LGDPPC	2.63	2.20	1.83	2.18
LIFDI	0.52	0.59	0.70	0.62
LRDG	0.46	0.27	0.34	0.32
LINT_RATE	–	−0.15	−0.15	−0.13
LOMI	0.12	–	–	0.15

5.3 *Governance, Control of Corruption and Ease of Doing Business*

Perception of corruption is much less in developed countries than developing countries. Also, effectiveness of governance structures in existence in developed countries is also perceived to be superior than that of developing countries. For G7 countries, all six sub-indices pertaining to governance and control of corruption are many folds higher than BRICS countries. In 2016, average score for voice and accountability was 1.2 for G7 countries as compared to -0.3 for BRICS countries; average score for political stability and absence of violence was 0.6 for G7 countries vis a vis −0.6 for BRICS countries; similarly, average score on government effectiveness for G7 countries was 1.5, and for BRICS countries, it is 0.1; perception on regulatory quality, rule of law and control of corruption are identical at 1.4 in G7 countries, whereas the scores are −0.2, −0.2 and −0.4 for BRICS countries. Perception on political stability, control of corruption, regulatory quality, rule of law are negative (in a scale of −2.5 (weak) to 2.5(strong)) and much lower than G7 countries (Table 10).

Table 10 Perception on control of corruption and other governance parameters: G7 versus BRICS

	Voice accountability	Political stability	Government effectiveness	Regulatory quality	Rule of law	Control of corruption
G7 countries (2016)						
Canada	1.4	1.2	1.8	1.7	1.8	2.0
Germany	1.3	0.8	1.7	1.8	1.6	1.8
France	1.1	−0.1	1.4	1.1	1.4	1.4
United Kingdom	1.2	0.4	1.6	1.8	1.6	1.9
Italy	1.0	0.4	0.5	0.7	0.3	0.0
Japan	1.0	1.0	1.8	1.4	1.4	1.5
United States	1.1	0.4	1.5	1.5	1.7	1.3
G7-average:2016	1.2	0.6	1.5	1.4	1.4	1.4
BRICS countries (2016)						
Brazil	0.5	-0.4	−0.2	−0.2	−0.1	−0.4
China	−1.6	−0.5	0.4	−0.3	−0.2	−0.3
India	0.4	−1.0	0.1	−0.3	−0.1	−0.3
Russian Federation	−1.2	−0.9	−0.2	−0.4	−0.8	−0.9
South Africa	0.6	−0.1	0.3	0.2	0.1	0.0
BRICS-Average:2016	−0.3	−0.6	0.1	−0.2	−0.2	−0.4

*value range −2.5 (weak) to 2.5 (strong); *Data Source* The World Bank

5.4 *Ease of Doing Business*

Average rank for ease of doing business in G7 countries is much favourable at 23 out of 192 countries, whereas average rank for BRICS countries is 84. In particular, India is at 100th position in terms of ease of doing business ranking. On some of the sub-components which constitute ease of doing business composite index, situation in India is exceedingly better than G7 countries. India ranked fourth on 'Protecting Minority Investors' parameter (average rank is 40 for G7 countries), ranked 29th on 'Getting Electricity' (average rank is 34 for G7 countries) and also ranked 29th on 'Getting Credit' parameter (average rank is 51 for G7 countries). However, India ranked worst at 181st in terms of 'Dealing with Construction Permits', 164th on 'Enforcing Contracts', 156th on 'Starting a Business', 154th on 'Registering Property', 146th on 'Trading across borders', 119th on 'Paying Taxes' and 103rd on 'Resolving Insolvency' (Table 11).

6 Summary and Conclusions

Literature identifies many macroeconomic push factors of OFDI. However, whether these push factors vary across countries and whether association of push factors with OFDI is of nonlinear in nature are studied here in a cross-country framework. We observed that the degree of economic development, level of global integration, technological development of 'home country' have a positive influence on outward FDI, whereas interest rate is found to be negatively associated with the OFDI. Also, the effects of these determinants are of varying magnitude across different segments (lower, median and upper strata) of the distribution of OFDI.

Previous studies (Al-Sadig 2013; Banga 2007; Bhasin and Jain 2013) also found that most of these macroeconomic variables are be important determinants of OFDI. However, they did not analyse the varying role of these determinants on the magnitude of effects across different segments of OFDI. In a cross-country setup this study empirically verified ten different macroeconomic push factors of OFDI, viz. (a) whether OFDI of a country is positively associated with its market size, (b) whether outward FDI is negatively associated with the market demand as measured by per capita GDP of home country, (c) whether OFDI is positively associated with economic development of home country, (d) whether OFDI is positively associated with degree of trade openness of home country, (e) whether OFDI of a country is positively associated with its Inward FDI, (f) whether OFDI is negatively associated with real interest rate of home country, (g) whether OFDI is positively associated with real effective exchange rate of home country, (h) whether OFDI is positively associated with home country's technological efforts (share of R&D expenditure in GDP), (i) whether OFDI is positively associated with share of ores and metals import in overall imports and (j) whether OFDI is positively associated with ICT goods imports (% total goods imports).

Table 11 Perception on ease of doing business: G7 versus BRICS

	Ease of doing business rank	Starting a business	Dealing with construction permits	Getting electricity	Registering property	Getting Credit	Protecting minority investors	Paying taxes	Trading across borders	Enforcing contracts	Resolving insolvency
G7 countries (2017)											
United States	6	49	36	49	37	2	42	36	36	16	3
United Kingdom	7	14	14	9	47	29	10	23	28	31	14
Canada	18	2	54	105	33	12	8	16	46	114	11
Germany	20	113	24	5	77	42	62	41	39	22	4
France	31	25	18	26	100	90	33	54	1	15	28
Japan	34	106	50	17	52	77	62	68	51	51	1
Italy	46	66	96	28	23	105	62	112	1	108	24
Average: G7	23	54	42	34	53	51	40	50	29	51	12
BRICS countries (2017)											
Russian Federation	35	28	115	10	12	29	51	52	100	18	54
China	78	93	172	98	41	68	119	130	97	5	56
South Africa	82	136	94	112	107	68	24	46	147	115	55
India	100	156	181	29	154	29	4	119	146	164	103

(continued)

Table 11 (continued)

	Ease of doing business rank	Starting a business	Dealing with construction permits	Getting electricity	Registering property	Getting Credit	Protecting minority investors	Paying taxes	Trading across borders	Enforcing contracts	Resolving insolvency
Brazil	125	176	170	45	131	105	43	184	139	47	80
Average: BRICS	84	118	146	59	89	60	48	106	126	70	70

**Data Source* The World Bank

Based on a quantile panel regression, it is observed that the level of nominal GDP, GDP per capita, shares of services and manufacturing sector in overall GDP, inward FDI stock, share of R&D expenditure in GDP and interest rate of a country, are significantly associated (push factors or home country factors) with outward FDI. In particular, OFDI rises with all those parameters. However, the magnitude of effects of these determinants varies across quartiles; i.e., effects are asymmetric. Countries with high level of OFDI have a different level of association with these determinants, compared to countries with lower level of OFDI. Stronger effects of per capita GDP, nominal GDP, R&D and interest rate are observed for the higher quartile of OFDI distribution (i.e. large OFDI countries). No significant association between trade openness and OFDI was observed in countries with relatively small OFDI.

Weak perceptions about India on political stability, control of corruption, regulatory quality, rule of law as well as perceptions on various impediments in doing business such as dealing with construction permits, enforcing contracts, starting a business, registering property, trading across borders, paying taxes and resolving insolvency, etc., might also act as the push factors of OFDI from developing countries in general and India in particular.

To sum up, this study observes that macroeconomic factors which are associated with country-level OFDI are similar in nature across advanced countries and developing countries. However, intensity of these macroeconomic push factors varies considerably across different groups of countries, when they are grouped in terms of size of OFDI. Moreover, apart from various macroeconomic indicators for which hard data are available, perception-based indicators on control of corruption, governance aspects and climate of ease of doing business which are much weaker in developing economies than that of advanced economies also act as push factors of OFDI from developing countries.

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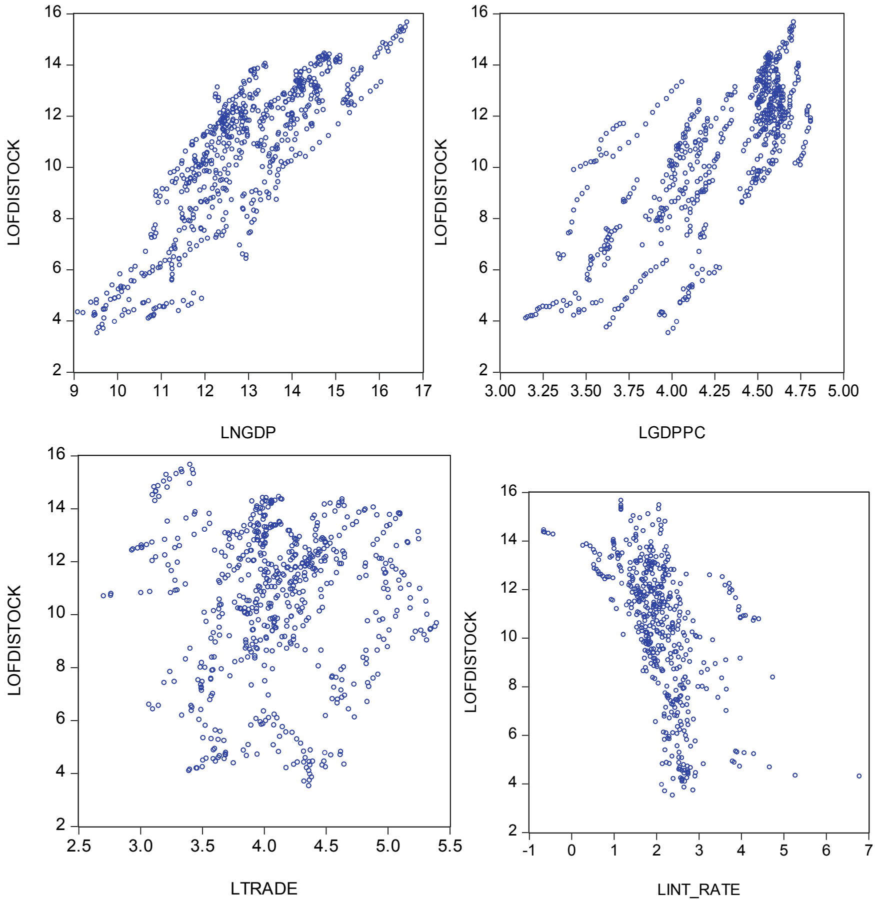
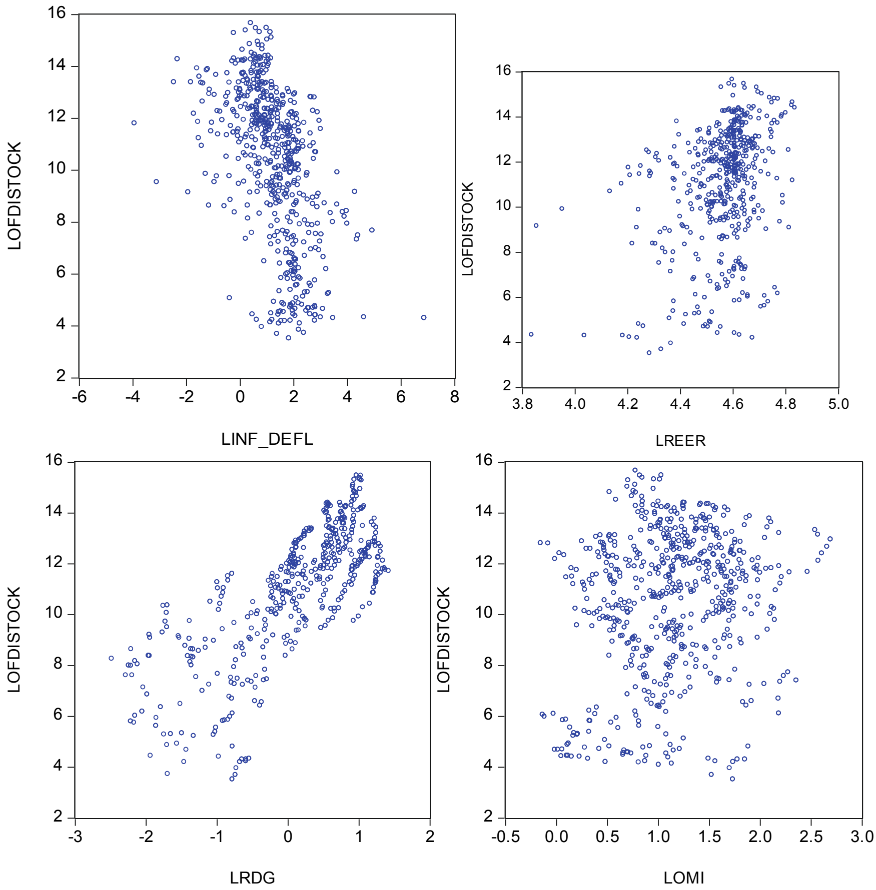
Appendix

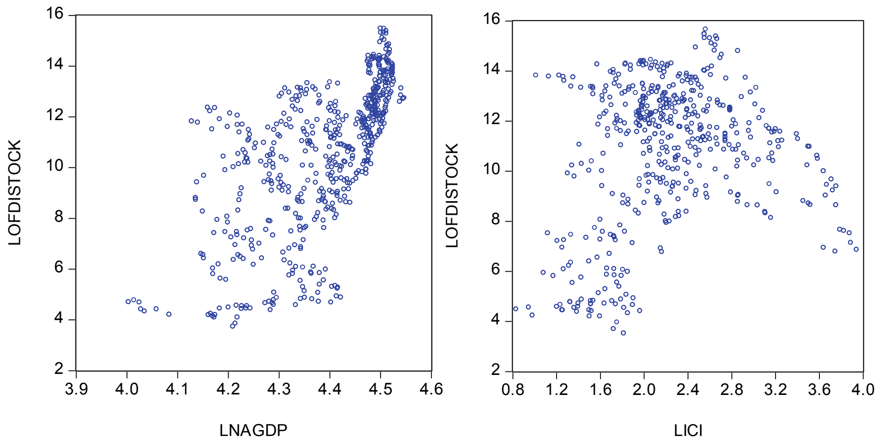
Scatter plots of OFDI and determinants (push factors) of selected home countries (Related to Chapter "Patent Policy and Relationship Between Innovation and Monopoly Power: Evidence from Indian High and Medium Technology Industries")



LOFDISTOCK: Logarithm of OFDI stock of a country; **LGDPPC**: logarithm of GDP per capita of a country; **LTRADE**: Log of Trade; **LINT_Rate**: Log of Interest rate.



LOFDISTOCK: Logarithm of OFDI stock of a country; **LOMI**: Logarithm of Ores and Minerals import of a country; **LREER**: Logarithm of real effective exchange rate; **LINFL_Defl**: Logarithm of Inflation (GDP deflator); **LRDG**: Logarithm of investment in R&D.



Data Source: IMF, World Economic Outlook

LOFDISTOCK: Logarithm of OFDI stock of a country; **LNAGDP**: Log of non-agriculture GDP of a country; **LICI**: Logarithm of ICT goods imports (% of total goods imports).

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Foreign Direct Investments and Environmental Policies: A Meta-Analysis

Santosh Kumar Sahu and Unmesh Patnaik

1 Introduction

Over recent times, policy makers are more concerned about the negative effects of ecosystem and the environment as the interdependency between economies have increased in terms of foreign direct investments (FDI) and international trade. Recent advancements in research with regards to international trade have shifted the comparative trade analysis from economics of trade to environmental regulation and trade. Therefore, environmental regulations may become one of the influencing factors in comparative advantage if barrier of trade will fall.

Most of the research hence is in the line of understanding FDI and environmental externalities both at academic and policy levels. Mostly, results between FDI and environmental externalities are contradictory to each other. In examining the relationship between FDI and environmental regulations, three major contributions are made, firstly that flows a pollution haven hypothesis (PHH). This holds two main issues, first inward FDI worsens environmental conditions and second FDI can be a factor of production. In this line of a result, environmental indicators such as energy intensity, emission, trade openness and economic growth have mostly been considered. If inter-jurisdictional differences in the degrees of regulatory stringency are assumed, the PHH suggests that pollution-intensive production activities move to economies that have laxity in environmental rules and regulations through FDI or by increasing market shares of exporting firms. Therefore, it is clear that tougher environmental rulers and regulations will add to the cost of production not only at firm

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level but also at aggregate level. This might bring the locational disadvantage to firms that are investing in the economies that have harder rules related to environmental standards in short run but will be beneficial at a long run in terms of sustainable business environment and sustainable ecosystem. Such costs may be in line of process or product design, R&D or technological shifts. In the absence of these firm characteristics, the decision to invest/locate/relocate the production activities depends solely on the firm to choose between higher/lesser stringent environmental regulations. Therefore, the decisions to reallocate remain one of the important strategies at firm level. The interaction of both country characteristics and firm decision makes the FDI decision to one of the countries either with stronger environmental rules and regulations or otherwise. The number of empirical studies of PHH has expanded steadily since the beginning of the 2000s. The economic rationale of PHH is well established with alternative analysis with the empirical standpoint related to the PHH, hence not reaching to any robust conclusions to establish the relationship between FDI and environmental regulations. As a matter of fact, these arguments have not been tested for a developing countries perspective to our knowledge and particular for the Indian case.

The second area of research brings the concept of pollution halo hypothesis (PhaH), which concludes that FDI results in deteriorating environmental quality in host country. These sets of studies imply that FDI inflows can lead to rapid improvement in energy efficiency and hence result in reducing carbon dioxide emissions. In the case of PhaH, it is important to notice that foreign-funded firms also facilitate development of better technologies for the environmental externalities in the host countries either by technology transfers or by R&D. In this connection, FDI has been presented to be conductive to promoting environmental quality.

One of the reasons for not arriving at a general conclusion on the impact of FDI on environment is classified as differences in research objectives, ideas, methods and timeline. On the one hand, most of the scientific approach of understanding environmental problem is to look at sulphur dioxide, carbon dioxide and other pollution emissions or to look at wastewater, waste dust and soot. Most of the research has focused on pollution instead of waste. Therefore, the effect of FDI on particular pollutants remains identified and these pollutions have strong spatial linkage and higher concentration of the pollutants will have higher spatial correlation with the presence of FDI.

In terms of techniques used, traditional panel data has overlooked the impact of spatial correlation and find out partial or biased estimate in establishing relationship between FDI and environmental consequences. However, the general conclusion on role of FDI is turned out to be an important effect on the host economy in terms of boosting economic activity, major source of external finance/capital and minimising the gap between targeted investment and domestic saving. Further, in the economic development front, FDI helps in reducing gap between foreign exchange requirements and net exports earnings. General conclusions also include direct capital financing, positive externalities for economic development and stimulating economic growth through spillover and technology transfers, productivity gains, and introduction of new process, product and managerial benefits.

These said positive benefits of FDI come at the cost of environment. This is mostly due to laxity in environmental rules and regulations of developing economies and weaker government interventions. These are termed as pollution haven hypothesis (Copeland and Taylor 1994). In this context, industrial flight hypothesis states that firms are more likely to shift production to countries with less stringent environmental regulations to reduce production cost. On the contrary, foreign firms employ better management practices and technology that helps in the production process in terms of reduced environmental hazards. This argument is related to pollution halo hypothesis that does not support the general industrial flight hypothesis but claims that weaker environmental regulations are helpful to firms in locational choice related to resources availability. Particularly, for the energy-intensive sectors, a technological base is tested for this hypothesis in Blackman and Wu (1998).

The literature on looking at the Environmental Kuznets Curve (EKC) hypothesis concludes that FDI has a positive impact on the growth of an economy and hence on higher energy consumption. If foreign firms adopt advanced technology in production, it can help in reducing energy demand. The existing empirical studies also correlate the increase in per capita income or energy demand due to FDI with CO_2 emissions (Omri and Kahouli 2014). Romer (1993) stated that FDI could be an important source for technology transfer and transfer of business knowledge to the host economy with substantial positive spillover effects. However, according to Boyd and Smith (1992), the domestic regulations also hamper allocation of resources. However, the EKC literature on FDI and environmental regulation explains that initially environmental pollution increases, and after threshold levels, it starts decreasing theoretically (Grossman and Krueger 1995). Researches in line with the EKC hypothesis are being conducted for the environmental regulations, emissions at aggregate and disaggregate levels on various pollutants such as the CO_2 (Stern 2004).

This debate brings out two broad perspectives: One that goes in line with comparative advantage in trade literature, and second deals with neo-technological trade literature. In the first sets of literature, environmental resources as considered as a factor of production and therefore countries with strict environmental regulations will be relatively high cost of production. Hence, these economies cannot have comparative advantage in producing polluting goods that restricts them in not specialising. On the second perspective, if laxity in environmental rules and regulations are followed, it will populate dirty industries in the economy, which is being identified as the technology gap of the economy. Therefore, one the hand, FDI has a positive impact in the environment by transferring knowledge, learning and machine from the developed to the developing economy, and on the other hand, the neo-technology perspective of trade can be analysed by the Porter hypothesis.[1] Few authors such as Palmer et al. (1995) criticise Porter hypothesis as this approach ignores the cost-benefit analysis.

[1]The "Porter hypothesis" states that stringent environmental policies encourage producers to innovate and create new environment-friendly technologies and to become net exporters of these new technologies. This is derived from the concept of offsets whether in the form of product or process offsets. Although stringent environmental laws may increase compliance costs, the benefits of environment-friendly, innovative techniques can offset the cost of compliance (Mihci et al. 2005).

In various ways, we can classify the FDI literature from the empirical viewpoint. For example, there are studies that are related to FDI and economic growth; FDI and environment; FDI, economic growth and environment. These studies can also be classified in terms of data in use, for example, either country level and/or cross-country level and/or state level with either cross section/time series or panel data. This paper tries to understand FDI and environmental regulations through a standard literature review, using quantitative techniques such as the meta-analysis to conclude if earlier findings are sensitive to models used, and hence, identifying possible policy implications.

In arriving at better policy implications in economic studies, application of meta-regression/analysis is often used after the seminal work published by Stanley and Jarrell (1989). This paper is similar in the spirit of Mulatu et al. (2004) and Jeppesen et al. (2002)[2] but departs in terms of focussing empirical literature related to environmental regulations, pollution, ecology and FDI. Nearly, 700 estimates, from 29 studies (list of studies are presented in the appendix) those conducted from 1994 to 2019, are considered as the sample of this work. The sample has firms that are engaged in FDI from various countries including the USA, the UK, France, Germany, Japan, India, other developed economies and the emerging economies. The result of this study suggests that certain aspects of research design are important for the significant of these studies. We further conclude that government environmental expenditure generates higher probability in supporting PHH. This result has similarity in terms of country context either for developing or for the developed economies. In one of the recent studies, it is also found that environmental policies in general and energy and emission efficiencies are found to be stabilizing agent for business cycle synchronisation (Patnaik and Sahu 2017). From both factor endowment and the PHH, it is likely that the capital flow in case of the pollution-intensive industries undergoes diverging experiences. This distinguishes between the market-seeking and efficiency-seeking FDIs. Many of the previous studies are unable to differentiate between these two categories. Therefore, we strongly recommend that future works on FDI should make use of disaggregate FDI and bilateral trade data along with the environmental indicators. In sum previous studies are weakly able to differentiate between market-seeking and efficiency-seeking FDIs in the context of environmental regulations. Therefore, we believe the future studied should focus on disaggregate FDI and bilateral trade data in analysing relationship between FDI, environmental regulations and nature of FDI.

The paper is organised as follows. Section 2 of the paper discusses estimation strategies and selection of important variable related to this study. Section 3 explains the findings from the meta-regression with the final Sect. 4 presenting the conclusions of this study with the possible policy implications.

[2]Relationship between environmental regulations and trade flow among economies is analysed by using meta-analysis in the former study. Whereas, the latter uses a similar approach with 11 studies and analyse relationship between environmental regulations and firm definition (new) for the USA.

2 Estimation Strategies and Selection of Variables

The previous section of this study indicates that most of the earlier studies have looked at if stringency of regulations in the context of better environmental indicators affects flow of FDI across jurisdictions in the context of PHH. The most common empirical specification is to model the equation related to the determinants of FDI using standard regression equation. Given the variety in hypothesis in arriving at the determinants of FDI, it is quite difficult to conclude from the standard approach, the existence of either PHH or PhaH. This paper explains the variations in existing estimates on how stringency of environmental regulations, are related/influenced FDI inflows. Information is gathered from earlier literate (without changing the model types) and used in the meta-analysis. In this process, we are not necessarily changing the model type, but able to model the error characteristics in the regression equations. Deviating from a single-estimate-per-study, we adopt multi-approach framework and adopt multiple-estimate-per-study approach for the following reasons:

(i) Ideally, it is better to use most of the information presented in the earlier paper as against discarding them,
(ii) In the literature of meta-regression/analysis, there is no clear rule on selecting estimate; and,
(iii) Recent researches on meta-analysis focus more on addressing issues in multiple-estimate-per-study in meta-analyses.[3]

Therefore, once the sample of estimates from various studies is gathered, we start understanding the meta-regression by estimating a probit model first. This limited dependent model will explain if results favour PHH both in sign and statistically significant. For the probit model, the definition of the dependent variable is quite important and tricky. This definition varies based on the research question on the one hand. In this case, we will confirm if PHH is validated with FDI inflows, and thereby, we create the dependent variable that takes value one if estimate is statistically significant, zero otherwise.

Further, this is followed by an intercept. The role of this intercept is quite important as these are estimated as the response coefficients that account for the differences between within studies. In general, inter-study comparisons can be made using these coefficients. Hence, these coefficients or factors affect the likelihood of supporting the PHH. On this setup, we can further classify our study based on multiple stages. We bring three major variants of our analysis. These variants are arrived at again from the earlier literature that is discussed in the introduction of this study. The first extension of the analysis is for the estimates that support PHH. The second extension is for those studies that do not validate the PHH and statistically insignificant. One further classification can also be done using the Porter (1991) hypothesis that encourages using a categorical effect size indicator as a dependent variable. Having different types of dependent variables, we can use an ordered probit model as the second models. This is general applied in meta-analysis that has categorical effect size with

[3]See, Rosenberger and Loomis (2000), Nelson and Kennedy (2009) for detail.

more than two ordered dependent variable. Looking at the results of both probit and ordered probit regressions, we explain that the estimates show direction of change in effect of one of the categories, and hence, only arriving regression coefficients are not enough for a better understanding in this context of research problem, and hence, we have estimated marginal effects.[4]

For the empirical analysis, we use Lipsey and Wilson (2001) as the benchmark study. Following this study, we also obtain the maximum statistical efficiency of the meta-regression. This is done using a weight of inverse of variance. The understanding is that estimates that have smaller degrees of variances are more assumed to be more reliable, and therefore, they should have more weight in the regression, which becomes the rationale of this procedure. In most of the cases, the empirical research papers do not necessarily report a variance; hence, this restricts us not to use variance, and hence, we weight each observation with its sample size.[5] Further, stratification is done in order to account for the pseudo-panel characteristics of the sample according to each study. Econometrically, we have also computed the adjusted and the robust standard errors of estimates for robustness of the empirical estimations.

As our data is from the earlier literature on FDI and environmental policies, we have collected papers that are published in English language from SIC/Scopus listed journal. In addition to this, these papers are also listed in EconLit. For the papers that are based on Indian economy, we have got papers from international conferences that include papers presented in Forum for Global Knowledge Sharing.[6] A number of research papers considered in this analysis are 29 that directly deal with FDI and PHH literature with focus on environmental policies. Out of 29 papers, 21 papers are published in academic journals, seven working papers and conference papers and one book chapter published by Springer publication. Six papers of this study focus on the US economy that deals with FDI and PHH, which refers to the behaviour of the developed economy. Other studies relatively look at the similar context of emerging and low/medium income economies. Such studies are concentrated on the African and Asian economics. In the context of the developed economies, we have also selected papers that are related to the European economies or any group economies. In the emerging economy context, we have also selected papers that are related to the Indian economy. When we classify papers based on the data in use, we can see that papers that are published relatively early in this area use cross-sectional data and the recent ones use data that is classified as panel structure. Out of 29 papers, one paper has used Bayesian analysis along with 3SLS estimates.

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[4]Based on the multiple estimates from single study, precision of meta-analysis may not be arrived at due to the reason that change in the variance will create a comparative relation across study.

[5]Meta-analysis studies in environmental economics that have used this approach include Brons et al. (2005) and Van Houtven et al. (2007).

[6]Forum for Global Knowledge Sharing (Knowledge Forum) is a specialised, interdisciplinary global forum. It deals with science, technology and economy interface. It aims at providing a platform for scholars belonging to different institutions, universities, countries and disciplines to interact, exchange their research findings and undertake joint research studies. It is designed for persons who have been contributing to R&D and publishing their' research findings in professional journals. Detail of this forum can be found at http://fgks.in.

From the sample of studies, it is evident that most of the studies (18) have looked at the first stand of testing of the hypothesis, namely examining role of stringent jurisdictions in attracting higher FDI. On the second issue of concern, some studies also look at if pollution-intensive industries/firms are more likely to decide for outward FDI. This is where we are able to classify the FDI behaviour in the context of environmental rules and regulation with inward and outward FDI. There are four such studies that look at the pollution-intensive firms/industries in the contest of outward FDI. One study is focused on productivity and emission at aggregate country level. Interestingly, six studies accommodated buy the stands. Looking at the proxies used for the analysis of environmental regulations, most of the studies selected in this paper focus on using one proxy, few of them use more than one proxy. The combination of all such studies and estimates we arrive at 700 estimates, of which 248 support the PHH. A clear look at the estimate gives us the understanding that 452 reject PHH; however, only 68 out of 452 accept the Porter hypothesis. The conclusion of such 68 estimates concludes that higher degree of environmental rules and regulations attract higher FDI. From the sample of estimates, 435 estimates were obtained from regression analysis employing a proxy for environmental regulations and one through Bayesian method of analysis. Next step on the analysis front is to generate the independent variable of interest. As these studies can be further subgrouped, we created eight dimensions from the sample studies. They are described in Table 1. For one of the groups identified in Table 1, we further represent them in Table 2 in detail.

3 Results and Discussion

Consistencies in approach across studies are arrived from the result of our study. In all cases, the prediction capability of the model has turned out significant for the select variable. In this case, a positive result indicates the correctness of the model used and selection of the variable is robust. We present the definition of variables in Table 3.

The empirical estimation and results are presented in Table 4. This includes results obtained by probit and ordered probit estimations. As evidenced by the results presented in Table 4, if studies have used establishment definition of new firms, they arraign results in support of PHH. This result is also because of the use of panel data as against cross-sectional data and reducing other control variables. It should be noted that these set of studies have also used government environmental spending as a proxy to represent stringency of environmental regulations.

Results from both probit and ordered probit explain that studies that have used either pollution intensity or firm-level environmental spending have barely significant effect(s) on supporting PHH. However, use of government expenditure on environmental-related measures gives result in favour of PHH. Hence, macro-level interventions on environment-related issues are more important as compared to the

Table 1 Design parameters: eight dimensions

Sl. No.	Variable	Issues
1	Stringency of environmental regulations	More generalised classification of this variable is presented in Table 2. This is one of the critical variables as many times it is unclear from the researcher viewpoint in defining this variable
2	Number of proxies uses	An unclear but accepted argument, in this case, is higher the number of proxies used better the results in explaining the PHH in the context of FDI inflow
3	Definition of FDI	1. New plant establishment[a] 2. We have also used capital flow/capital stock/employment to explain the FDI definition apart from the first definition in terms of new firm[b]
4	Level of pollution at firm level	Aggregation versus disaggregation
5	Host country's level of development	1. International monetary fund 2. The World Bank
6	Data type	We look at data both at cross section and panel structure
7	Endogeneity	FDI and pollution(s) may be determined simultaneously[c]
8	Other controls	Other control variables used include wage rates, tax or the effect of agglomeration

[a]Friedman et al. (1992) and List (2001) have used this definition
[b]Recent studies have used this definition(s)
[c]Endogeneity problem may also exist if environmental regulations are set strategically to attract inflows of FDI (Fredriksson et al. 2003; Cole and Fredriksson 2009)

micro-level interventions at firm/industry level. Therefore, policies related to environmental suitability and FDI should be top-down approach. Levinson and Taylor (2008) explain that level of data aggregation is quite relevant to the PHH literature. In this work, we find that studies that use new plant establishment as a definition of FDI have a favourable result for PHH as against those used capital flow definition. One possible explanation of this result is that as effect of the environmental rules and regulations on FDI is mostly a microeconomic phenomenon at firm level, studies that use unit-level/firm-level information are able to support the argument in favour of PHH compared to those use aggregate and country-level data in validating PHH. This finding also correlates with the earlier finding of environmental regulations must be top-down approach.

Data availability and a structured panel type increase the understanding of the estimates and the direction of FDI and pollution. A research on select industry type may not possibly increase the results in support of PHH. Hence, for a policy analysis, researchers/policy makers must use data of a panel type. One more important

Table 2 Five subcategories for proxies used

Sl. No.	Category	Example(s)	Deficiency
1	Pollution abatement spending at firm level	In general, few firms invest in acquiring environment-friendly equipment and technologies that help firm in upgrading their production technology; however, these spending are considered as additional environmental tax expenses at firm level	One of the problems of this category is for all economies, researcher may not get data annually
2	Environmental spending of the government	In enforcing the environmental regulations, economics spend on pollution abatement or on the enforcing agencies	It may ignore the economies of scale of the regulators
3	Pollution intensity	At firm level, this indicator uses information on level of particular matter such as CO_2, NO_x, SO_x. for air pollution of BoD/CoD for the water pollution	Data at firm level may not be directly observed
4	Index	Categories identified above can be clubbed in an index number that defines are combination of one or more activities at firm or at economy level	Information may not be available for every country
5	Opinion survey by competent authorities	For example, Global Competitiveness Report measures overall stringency of environmental regulations using a scale from 1 to 7. In this case, 1 stands for the economies that have most laxity in environmental rules and regulation and higher than 1 have stricter regulation related to environmental issues[a]	Sample selection and bias in survey may be one of the concerns

[a]This *construct* is used by Wagner and Timmins (2009)

Table 3 Definitions of explanatory variables

Sl. No.	Variable	Definition
1	Data type	1. 1 if panel data is used; 0 if otherwise
2	Aggregation	1. In this case, we have created a variable for the dirty industry, value one is assigned if the study is carried out for a dirty industry, else this variable takes value zero
		2. Similarly, for the clean industries, value takes one if study is attempted for the clean industries else zero
3	Stringency of environmental regulations	1. If a firm spends on environmental expenditure, the value is assigned as one, else zero
		2. For the second case, if government spending is reported, this variable takes a value one, else zero
		3. For the third case, if pollution intensity is used as a variable, this takes one, else zero
		4. In the fourth case, if the study has used an index, this value of the variable is one, else zero
4	Level of development in the recipient country	1. This case, we classify studies based on economic development, and value one is assigned if the study is undertaken for a developed economy, else zero
		2. Similarly, the other definition is if study is undertaken for a developing economy, the variable value takes one, else zero
5	The definition of FDI	1. If new plant definition in terms of establishment is considered, the value takes one, else zero
		2. If capital flow is used in defining FDI, the value of this variable takes value one else zero
6	Other variables	1. 1 if endogeneity of environmental regulation is taken into account; 0 if otherwise
		2. 1 if study includes a variable on wage, else 0
		3. 1 if study has taken agglomeration effect, else 0
		4. 1 if study has used tax as one of the variable, else 0
		5. 1 if study has used bilateral data for FDI and emissions, else 0

Table 4 Marginal effects from probit and ordered probit regression

Category	Variable	Probit model estimates	Ordered probit model estimates		
		(1)	(2)	(3)	(4)
			$M = -1$	$M = 0$	$M = 1$
Data	*Panel data*	0.28*** (0.05)	−0.25** (0.11)	−0.25*** (0.07)	0.11*** (0.05)
Aggregation	*Dirty firms*	0.19 (0.25)	−0.04** (0.02)	−0.29** (0.15)	0.27** (0.15)
	Clean firms	−0.16 (0.16)	0.01 (0.05)	0.02 (0.05)	−0.05 (0.05)
Development level of the recipient country	*Developed*	−0.56** (0.25)	0.11 (0.06)	0.18* (0.10)	−0.36* (0.21)
	Developing	−0.89** (0.26)	−0.05 (0.25)	−0.05 (0.08)	0.09* (0.05)
Proxy of stringency of environmental regulation	*Government spending*	0.84** (0.24)	−0.48** (0.25)	−0.55** (0.28)	0.63** (0.33)
	Firm spending	0.59** (0.21)	−0.11* (0.06)	−0.15 (0.09)	0.31 (0.21)
	Pollution intensity	0.21** (0.11)	−0.07 (0.06)	−0.017 (0.09)	0.28 (0.26)
The definition of FDI	*Establishment definition*	0.58*** (0.18)	−0.3*** (0.04)	−0.67*** (0.11)	0.79*** (0.18)
	Capital flow definition	0.01 (0.25)	−0.04 (0.03)	−0.09 (0.18)	0.19 (0.14)
Other variables	Endogeneity	−0.25 (0.22)	0.01 (0.05)	0.01 (0.04)	−0.02 (0.06)
	Wage	−0.17 (0.12)	0.08** (0.03)	0.17* (0.09)	−0.22** (0.12)
	Agglomeration	0.02 (0.12)	0.09 (0.06)	0.03* (0.02)	−0.20 (0.15)
	Tax	0.29*** (0.11)	−0.14 (0.09)	−0.41* (0.22)	0.27** (0.16)
	Sample size	0.05 (0.25)	0.01 (0.01)	0.01 (0.01)	0.01 (0.12)
	Bilateral trade data	−0.25 (0.18)	0.01 (0.01)	0.01 (0.01)	0.01 (0.18)
Observations		476	476	476	476
Studies		29	29	29	29

Notes *, **, ***Refers to statistical significance at 0.1, 0.05 and 0.01 levels of significant, respectively. Standard errors are presented in the parentheses. Marginal effects are estimated at sample mean of the respective independent variables. For the model that uses ordered probit, evidence of PHH is given in column 4, under $Y = 1$. All regressions are estimated with cluster robust estimates by study econometric issue that comes is using more than one proxy that explains stringency in environmental policy does not influence the likelihood in favour of PHH. A closer look at the economies that are developed explains that these economies are capital-abundant typically, and hence, they specialise in capital-intensive industries, and in the absence of better technological support either from the production or energy demand, they turnout to be emission/pollution intensives too. Therefore, in such cases, PHH predicts that these economies will relocate to economies with lesser regulated economies on environment where they can possibly maximise profit. These two arguments do not converge, and hence, they may cancel out as competing pressures in the regression estimations. The result that we have arrived at further indicates that endogeneity does not change the probability of supporting PHH; rather, this is one of the standard econometric analyses for academic gains in understanding data and methods, not necessarily for the policy analysis.

Now, discussing the issues related to the multinational corporation related to the PHH, we must understand that these corporations undertake market-seeking FDI or more specifically horizontal FDIs. This allows the multinational corporations to gain advantage in supplying to the local or the domestic market. In other lines of research, the vertical FDI mostly happens between dissimilar economies for gaining in factor-price differences at the time when cost of trade is low. Hence, the sensitivity of FDI to host economies will vary according to the locational choice or the destination of production. Going by the theory of comparative advantage, both from the theory and empirical viewpoint, PHH is relevant in the context of FDI that is vertical in nature. Our study, however, made no attempt to distinguish between these two types of FDI. Except one study in our sample, others do not explain this classification of FDI. Therefore, we are not been able to capture this phenomenon in the meta-regression. Also, only one of the papers used in this analysis uses bilateral FDI and pollution data; hence, it is not possible to come up with robust policy related to FDI and pollution. This is one of such areas of research that researcher has to pay more attention. The understanding from the results of the meta-analysis as presented in this paper is one of the rare attempts to understand the empirical stand between FDI and environmental policies. Our results are encouraging enough in pushing for a better climate negotiation policy, if it is believed that FDI generates externalities in terms of pollution and waste. From the understanding of carbon footprint and carbon tax evidence are there in the context of a developed economy. However, such initiatives are rare in the context of an emerging economy. When most of the developing and emerging depend on FDI for positive spillover either in terms of employment or technology support in production and participation in export market, understanding ecosystem and cleaner production remains a challenge. In parallel to the above objectives in attracting FDIs, if emerging economies can design appropriate carbon tax at both local and regional scale, this will increase global welfare and target for sustainable development.

4 Conclusion

From the empirical literature on FDI, it is quite accepted argument that FDI can fuel economic development with positive spillovers from technology development to labour management. However, if the environmental rules and regulations are not stricter from the host country viewpoint that would result in inefficient and irreversible environmental destruction, there is a possibility that it may decline the welfare of the host economy. Hence, it is very important for the host country viewpoint in selecting the FDI in specific sector where it is likely to create environmental problems both at short and long run. The findings from meta-regression can be summarised in the following points along with international best practices for better environmental policies and FDI.

While going for a solution to the impacts of FDI, policy makers must look at the costs and benefits of such projects. These solutions in terms of policies should be focused on institution with the capacity to change in the short run before environmental damage happens. Therefore, building capacity in the host economies governments to manage FDI and maintain environmental standard is equally important and hence can be considered as longer-term process. In the short to medium-term solutions, standards must be raised through other policy instruments such as involvement of civil society, non-governmental organisations and conduct of the investors. With the support of the international agreements, these mechanisms will build capacity in the host economy especially for lesser developed/remote/conflict areas. In using voluntary codes for environmental safety and regulations, different sectors such as the forestry, fisheries and tourism sectors can be identified where eco-labelling can be made mandatory. There is equally a need to reform the existing and the planned investors' protection agreements so that they do not undermine the environmental rules and regulations. If international coordination and regulations can be built in ensuring FDI, it will promote sustainable development by preventing destructive competition, increasing economic benefits to host economies and protecting the rights of local communities and domestic industries.

To arrive at the maximum contribution of FDI in minimising negative impact, it is important to have practical solutions at all institutional levels including national/regional and international levels. However, in promoting higher environmental quality and sustainable use of natural resources, it is also important to have voluntary, market based and regulatory components as well. In fact, as there is no magic bullet in ensuring sustainability in a globalised economy, a diverse set of complementary approach is required to balance between growing economic pressure and sustainable development. Table 5 summarises the available and modified policy linkages that can foster FDI and sustainable development through environmental regulations and policies.

These regulatory policies can be implemented through various institutions at national or regional or international levels. Or the governments can also choose a balance evolution of these instruments to get the maximum benefit from FDI on the sustainable development.

Table 5 Summary of specific policy linkages

Sl. No.	Policy	Advantage
1	Eco-labelling	Importance should be given to consumer-sensitive natural resource sectors
2	International agreements	Focus should be on the national sovereignty and international regulations
3	Investor protection and promotion agreements	Subordinates investor rights to legitimate national sovereignty and the achievement of sustainable development
4	Detailed agreements on environmental standards	Importance should be given to minerals, fossil fuels, basic agricultural commodities and bulk chemicals
5	No-lowering of standards	Ensure revenue collections from natural resources
6	Support environmental best practice	Minimise or eliminate costly and inefficient competition based on lowering or freezing environmental standards

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Appendix: Select Studies for Meta Analysis

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FDI, Labor Market and Welfare: How Inequality Navigates Welfare Loss?

Arfat Ahmad Sofi and Subash Sasidharan

1 Introduction

Globalization being the prominent driver of modern economic growth significantly influences the global growth through foreign direct investment (FDI) and international trade. FDI being one of the key components of globalization made rapid growth during the previous two decades resulting in prominent changes in labor markets in the countries. Many times, FDI is seen a panacea for many economic problems like improving the standard of living. FDI is expected to generate higher income and strong positive effects in the labor markets through a monotonic decrease in unemployment. It is argued that FDI drives capital and technology, therefore, enhances the productivity to the targeted firms, industries and the country as a whole. The external effects arising from the diffusion of skill-based technology not only aim to boost productivity but also improve the employment conditions and thus the wages. However, the higher demand for skilled labor by foreign firms may create wage inequality leading to loss of welfare (Crescenzi et al. 2015).

The reason for tracing the transmission channels of FDI on labor markets is reasonably straightforward. The most prominent is outsourcing manufacturing jobs to the locations with lower labor costs. The outcome of shifting jobs generally backfires on the parent economies by altering their labor market consequences domestically. However, from the perspective of host country, inward FDI alters the labor market

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setting in the form of higher employment (Makino et al. 2004). In the long run, FDI leads to deterioration of labor market outcomes due to negative scale shift toward outsourced low-skilled and low-wage employment. On the other hand, the inward FDI improves the capacity of the labor market of the country by higher employment in low and medium skills. In most of the cases, low-wage host countries embolden FDI through the efficiency route which affects the employment structure especially in industry and services (Sethi et al. 2003; Karlsson et al. 2009; Waldkirch et al. 2009).

It may be recalled that the deterioration of the labor markets in European and other advanced countries during the 1980s and 1990s was evident probably due to shifting of labor scale and outsourcing of low-skilled labor (Gaston and Nelson 2004). This evidence contradicts to the usual convention of positive effects of FDI. Similarly, Wei (2013) rejects the notion of a positive relationship between FDI and labor market outcomes in China. Therefore, it may be argued that FDI may improve as well as dampen the condition of labor market outcomes. The positive effects may last in short run and medium run though not in long run; however, these effects may not be a regular feature (Feenstra and Hanson 1997; Bhagwati and Blinder 2009). More recently, a new phenomenon observed where the employment outcomes affect the distribution of the labor market by altering the low-skilled sectors (Acemoglu and Autor 2010). This led to a surge in many interpretations of the theoretical models and a wide array of empirical investigations. These investigations emphasize that the FDI–labor markets nexus can be of varied nature across the countries depending upon the country's macroeconomics features, development conditions and specific forms of investment (Gaston and Nelson 2004).[1] With regard to the developing economies, a major challenge is to shift the labor force from the traditional agricultural sector to reduce poverty, and FDI is expected to fairly lubricate the process (Karlsson et al. 2009). In addition, low-cost labor force drives the FDI (Dunning and Lundan 2008), thus affecting the labor market outcomes with a shift from agriculture to the services in developing economies.

With regard to the welfare aspect, a pertinent question arises regarding how FDI intrudes into the dynamics of social welfare of the host countries. This may be viewed through the prism of enhancing the various macroeconomic conditions, viz. income, wages, skill and competitiveness of the domestic market during the dynamic growth process (Klein et al. 2001; Gohou and Soumare 2012; Lehnert et al. 2013). And may arise the welfare dampening conditions by shifting the employment scale to high-skilled labors with high-end technologies, offshoring complements and sustainability (Kosack and Tobin 2006; Chintrakarn at. al. 2012). Due to this interpretation, a growing concern among the researchers is to analyze how FDI influences the distribution of incomes and labor markets of host countries. An extensive survey of studies highlights a near consensus on the complementarity between FDI and economic growth (De Mello 1997). Using a sample of more than a hundred countries, Choi (2006) found escalating inequality due to inward FDI to host countries leading to welfare loss due

[1] A comprehensive survey on the FDI–labor markets nexus through host countries perspective can be traced in Hale and Xu (2016).

to the unequal distribution of the benefits of FDI. Therefore, FDI may not always be considered as an instrument for enhancing the welfare because of the market imperfections generated that hampers welfare gains (Campos and Kinoshita 2002a, b; Blomström and Kokko 2003). Similarly, there is evidence of increased inequality as an outcome of FDI-growth nexus varies across the geographical regions in Asian economies (Tsai 1995). The differences in welfare dimensions across the economies are always a difficult task to examine, and it becomes more complicated when considered in a heterogeneous economies setup. Failing to account for this dimension poses serious challenges for the statistical inference, hypothesis testing and policy-making (Ravallion 1996). Therefore, analyzing the welfare dynamics using a comprehensive approach is vital.

Based on the above discussion, it is clear that there needs to be a comprehensive understanding of the welfare aspect of FDI in host countries. The broader question addressed here is how FDI leads to the improved social welfare of the countries. Even though the literature highlights issues of the labor market and welfare aspects of FDI, the empirical evidence remains thin on the dynamics of the interface between them. Therefore, this chapter aims at examining the relationship between inward FDI and labor market outcomes and subsequent countrywise welfare implications of FDI for a panel of 64 countries over the period 1991–92 to 2014–15. We draw special attention to the case of Asian economies in the empirical analysis given the crucial role of FDI in the Asian region. The analysis is derived to understand the conventional perspective of the positive impact of inward FDI on the labor market and to examine the welfare gains for the host countries. To estimate the models, we follow a static general equilibrium system using an instrumental variable and welfarist approaches. The novelty of the present study in contributing to the existing literature is of two-fold. *First*, the study considers a crucial aspect of the FDI and labor market relationship, where we examine the broader perspective of the nexus between the two using a comprehensive approach. The main argument analyzed is to revisit the theoretical foundations of impact inward FDI on macroeconomic conditions of the host country. *Second*, we evaluate the welfare aspect by estimating the loss exerted due to heterogeneous effects of inward FDI to the host countries. The insights gained from such an exercise would open avenues for further research.

The remaining paper is organized in the following way. Section 2 presents a detailed methodology and empirical strategy. In Sect. 3, description of the data and variables is presented. Section 4 covers the preliminary analysis of the FDI, labor market and inequality interface. In this Sect. 5, a detailed discussion on the empirical results is provided, and the final section concludes the paper.

2 Methodological Framework

2.1 The Model

A standard competitive general equilibrium approach is followed to study the labor market implications of FDI in a cross-country framework augmented through the production function approach (Helpman 1984; Ethier 1986; Jones and Kierzkowski 2001). Following the standard practice, we assume a Cobb–Douglas production function framework augmented with FDI:

$$Y_t = f(K, L, \mathrm{FDI}) \tag{1}$$

where Y is output, K is capital, L is labor, and FDI is foreign direct investment inflows to the host country. FDI is assumed to transmit into production function and alters it through the changes in labor market outcomes assuming a profit-maximizing setting for country i at time t subject to constraint to technology. Similar to Greenaway et al. (1999) and Jude and Silaghi (2017), the augmented production function with FDI influencing the technical efficiency parameter A can be present in the following way:

$$Y_{i,t} = A^{\gamma} K_{i,t}^{\alpha} L_{i,t}^{\beta} \tag{2}$$

where α and β represent the elasticities pertaining to capital and labor, respectively. A, representing technical progress, with the coefficient γ allows the factors to change the efficiency parameter of the production function that can be traced through the influence of FDI (Greenaway et al. 1999) such that $A^{\gamma} = e^{\delta_0 T_i}\mathrm{FDI}_{i,t}^{\delta_1}$. FDI is the stock of inward foreign direct investment in country i at the time t, T is the time trend and $\delta_0, \delta_1 > 0$. By a general rule, it is imperative that a profit-maximizing firm employs the inputs so that their marginal productivities are equal such that real returns of labor (w) are equal to the marginal productivity of labor and real returns to capital are traced through marginal product of capital (c). By eliminating capital from Eq. (2), we solve the system simultaneously.

$$Y_{i,t} = A^{\gamma}\left(\frac{\alpha}{\beta}\acute{L}_{i,t} * \frac{w_{i,t}}{C_{i,t}}\right)^{\alpha} L_{i,t}^{\beta} \tag{3}$$

$\acute{L}$ represents the employment level. Taking the logarithm of the Eq. (3) and solving for L, we obtain

$$\ln L_{i,t} = \rho + \varphi_1 \ln Y_{i,t} + \varphi_2 \ln \frac{w_{i,t}}{C_{i,t}} + \varphi_3 \ln \mathrm{FDI}_{i,t} + \varphi_4 \ln T \tag{4}$$

where $\rho = \left(\alpha - \ln\alpha - \alpha\ln\beta\right)\big/(\alpha+\beta)$; $\varphi_1 = 1/(\alpha+\beta)$; $\varphi_2 = -\alpha/(\alpha+\beta)$; $\varphi_3 = \theta\delta_1$; $\varphi_4 = \theta\delta_0$ and $\theta = -\gamma/(\alpha+\beta)$.

The above specification assumes the time-varying cost of capital so as to maintain the reliability of the data on capital cost (Milner and Wright 1998; Onaran 2008; Jude and Silaghi 2017). This simple theoretical simplification allows us to include time dummies into the empirical model to capture the variation over time. We expect that the level of employment has a positive correlation with output. However, FDI employment may follow either positive (Jenkins 2006) or negative relationship (Holland et al. 2000; Girma et al. 2002; Conyon et al. 2002). Therefore, it necessitates the use of a suitable empirical strategy to analyze the nexus between inward FDI and the labor markets. To test the labor market effects of FDI, we adopt econometric models with suitable instruments as explained in the subsequent section.

Further, to explore the welfare implications of FDI on the labor market, we augment the welfarist approach (Atkinson 1970; Antràs et al. 2017) in a panel set up to estimate the loss function. This approach, for evaluating the policy decisions, is estimated through the instrumented social welfare function for mapping the series of vectors to a finite number. It is usually presented as the function through the integration of the concave transformation of actual and disposable income of the agents (I) in consideration. Such that,

$$V = \int u\left(r_{\varphi}^{d}\right) dI_{\varphi} \tag{5}$$

where $u' > 0$ and $u'' \leq 0$, r_{φ}^{d} represents rate the of return. The distribution of φ in the population is measured through cumulative aggregation considering a constant elasticity function:

$$u\left(r_{\varphi}^{d}\right) = \frac{\left(r_{\varphi}^{d}\right)^{1-\rho} - 1}{1-\rho} \tag{6}$$

where $\rho \geq 0$ reflects a constant degree of aversion for inequality in a well-behaved social planner by the agents in the central position. Therefore, we consider a simple monotonic transformation of the social welfare function of the Eq. 5 to evaluate the changes in social welfare transmitted to the labor market in the following way:

$$W = [1 + (1-\rho)V]^{1/(1-\rho)} \tag{7}$$

This transformation enables us to express social welfare as an arithmetic function that is separated from aggregate real income M and a term Δ, which is assumed to be inversely related to inequality in the distribution of disposable income:

$$W = \Delta \times M, \tag{8}$$

where $\Delta = \Delta\left(F_r^d, \rho\right) = \frac{\left[E\left(\left(r_{\varphi}^{d}\right)^{1-\rho}\right)\right]^{1/(1-\rho)}}{Er_{\varphi}^{d}}$. The term Δ refers to the correction in inequality through welfarist approach is supposed to be one minus the Atkinson

(1970) index. By Jensen's inequality[2] we have $\Delta \leq 1$, and $\Delta = 1$ if and only if $\rho = 0$ (representing no inequality aversion) or if the distribution of disposable income F_r^d is fully egalitarian (has zero dispersion).[3]

2.2 Empirical Strategy

To unravel the empirical nexus between FDI and labor market outcomes, we derive a labor demand function from the Eq. (4) and estimate the same using a panel data approach.

$$\text{LMO}_{i,t} = \alpha + \lambda_1 \text{FDI}_{i,t} + \lambda_2 \text{INQ}_{i,t} + \lambda_3 Y_{i,t} + \gamma \sum_{i=1}^{N} X_{i,t} + \mu_{i,t} + \nu_{i,t} + \varepsilon_{i,t} \quad (9)$$

where LMO represents the Labor market outcomes consisting of total and sectoral employment across the 64 countries for the period of 1991–92 to 2014–15. $\text{FDI}_{i,t}$ represents the inward FDI as a percentage of GDP, $\text{INQ}_{i,t}$ is the income inequality, $Y_{i,t}$ is the real per capita income, $X_{i,t}$ is the various macroeconomic conditions across countries, $\mu_{i,t}$ is country fixed effects, $\nu_{i,t}$ represent the time effects, and $\varepsilon_{i,t}$ is the standard error term.

The above equation can be estimated using the ordinary least squares (OLS). However, due to the endogeneity problem, OLS estimates are not reliable due to: (i) high risk of internal conflicts, foreign investors avoid investing in those countries since there might be a high level of regional inequality which may put their investment under risk (Lucas 1990; Janeba 2002); and (ii) foreign investors may concentrate on countries with high inequality to be part of their long-run economic growth and to improve their competitiveness. To mitigate this issue, we rely on the instrumental variable (IV) panel data approach. We use educational level, the lag of FDI and regionwise income as the instruments. We undertake a standard tests to validate the suitability of the instruments employed.

3 Data Sources and Variable Description

The data for this study are obtained from various sources including Standardized World Income Inequality Database (SWIID 6.0), World Bank, Pen World Table (PWT), International Labor Organization (ILO) and Global Financial Development Database. As mentioned, we consider period from 1991–92 to 2014–15 for a sample

[2]Jensen's inequality measure relates the value of a convex function of an integral to the integral of the convex function. It is central in the derivation of the expectation–maximization algorithm and thereby proof of consistency for the maximum likelihood estimators.

[3]For further explanation, refer Antràs et al. (2017).

of 64 countries (see Appendix: Table 8 for the details). To measure the labor market outcomes, we employ three variables, viz. employment (total and sectoral with gender classification), FDI (percentage of GDP), per capita income and measure of income inequality (Table 1).

In the empirical analysis, we include a set of control variables following the existing studies. Each control variable has been standardized and used in real terms. As echoed by previous studies, a particular geographical region does affect the inward

Table 1 Variable description

Variable	Description	Source
Main variables of interest		
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank, UNCTAD
Employment	Number of persons employed (in millions) to the total workforce	World Bank, ILO
Inequality	Inequality estimates based on income	SWIID 6.0 (2017)
GDP per capita	Real GDP per capita at constant 2011 national prices (in mil. 2011US$)	World Bank, PWT
Other explanatory variables		
Human capital index	Human capital index	World Bank
Welfare adjusted total factor productivity	TFP at constant national prices (2011 = 1)	PWT
Agglomeration index	Population in urban agglomerations of more than 1 million (% of total population)	World Bank, OECD database
Financial institutional index	Financial institutional index	Global financial development database, 2017
Agricultural value added	Agriculture, value added (% of GDP)	World Bank
Industrial value added	Industrial, value added (% of GDP)	World Bank
Services value added	Services, value added (% of GDP)	World Bank
Capital output ratio	Ratio of gross capital formation to total output	World Bank
Price level of household consumption	Price level of household consumption, price level of USA GDP in 2011 = 1	PWT
Price level of capital formation	Price level of capital formation, price level of USA GDP in 2011 = 1	PWT

FDI and the per capita income distribution, therefore, leading to a strong case for differential welfare implication. Sectoral decomposition does define the growth perspective of a country which in turn facilitates the penetration of FDI toward the comparative advantageous sector. Differential sectoral contribution to the overall economy plays an important role in the development perspective of an economy, and therefore, for a suitable estimation of heterogeneous economies, we need to account for such differences. Toward this end, we include a control variable, country-specific sectoral value added as a percentage of GDP. Other controls include welfare adjusted total factor productivity (TFP), human capital index, agglomeration index, financial institutional index, capital output ratio, price level of household consumption and price level of capital formation.

4 FDI, Labor Market and Inequality: A Preliminary Analysis

FDI and labor market outcomes are assumed to follow a positive relationship. However, it is argued that FDI does not necessarily affect the labor market in similar ways. One strand of literature states that FDI promotes higher employment nevertheless it has a differential impact on sectoral employment for developed and developing countries. FDI may improve the employability of the industrial sector in developing countries at the cost of the agricultural sector. It affects the employment scenario of developed countries toward high-end services and retains the employment opportunities in another sector unaffected. This situation leads to the differential interpretations where FDI on the one hand improves the employment and on the other hand shifts the employment toward more advanced sectors. In both the cases, there are possibilities of inequality and discrimination in general and toward gender-based employment in particular which is severe across countries.

Before undertaking econometric analysis, we present the trends and patterns aspect of FDI, labor market and inequality across the countries. From Figs. 1 and 2, it is observed that the kernel density function shows a skewed behavior of FDI

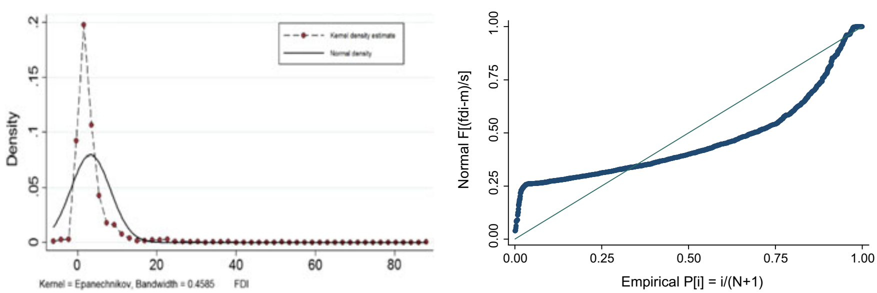

Fig. 1 Kernel density estimates and probability distribution: FDI

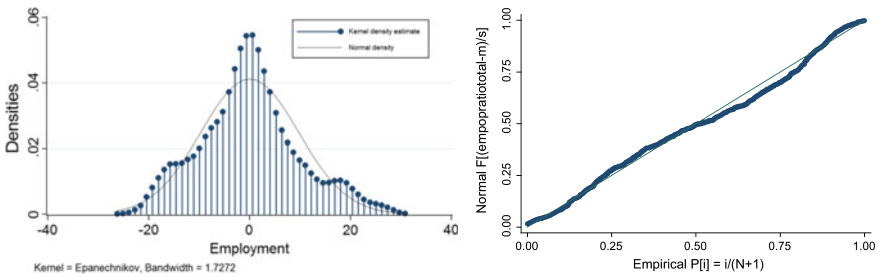

Fig. 2 Kernel density estimates and probability distribution: employment

across the countries, while employment shows a normal distributive nature among them. It may be argued that the FDI is concentrated in the countries of lower capita income. Presumably, the kernel distribution reflects that most of the FDI is hosted by lower and middle-income countries. However, the employment pattern behaves homogeneously across the sample countries. Further, to understand the true nature of a nonlinear pattern of FDI and employment, the probability densities are plotted (Fig. 3).

To trace out the distributional pattern of the relationship between FDI, labor market and inequality, we present the diagnosis graphically. Figures 4 and 5 present the linear patterns of FDI, GDP and employment. The predictions indicate that increased GDP and employment is associated with the prognostic increase in inward FDI over the study period. It may be noted that predictive graphical analysis depicts that labor market outcomes are a linear function of increase in FDI and GDP. Nevertheless, an inverted U-shaped pattern is observed in the case of inequality–FDI relationship reflecting a reduction in inequality since the 2007–08 financial crisis (Fig. 6). The graphical representation shows that the linear prediction of FDI, GDP and employment accepts the usual theoretical convention through which increasing GDP growth attracts the FDI which results to an outcome of inverted U pattern of inequality

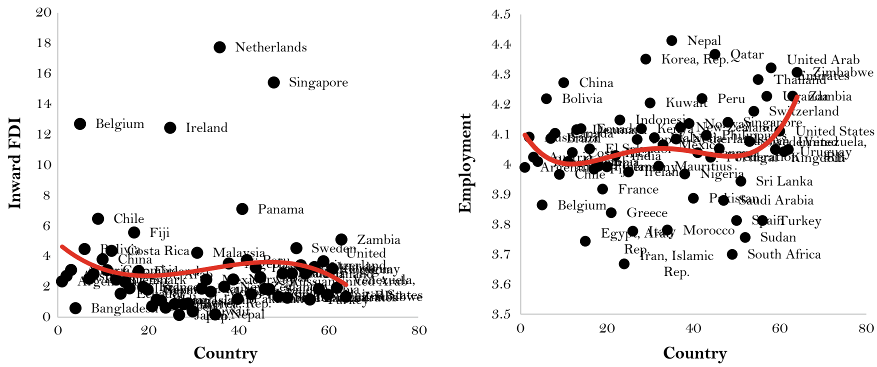

Fig. 3 Distribution according to the inward FDI and employment

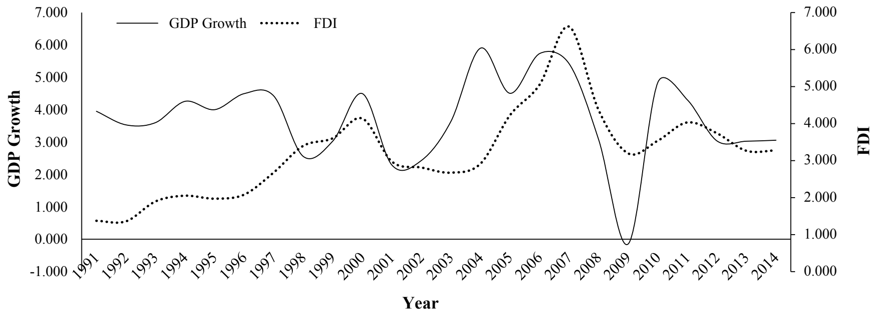

Fig. 4 Pattern of FDI and GDP per capita income

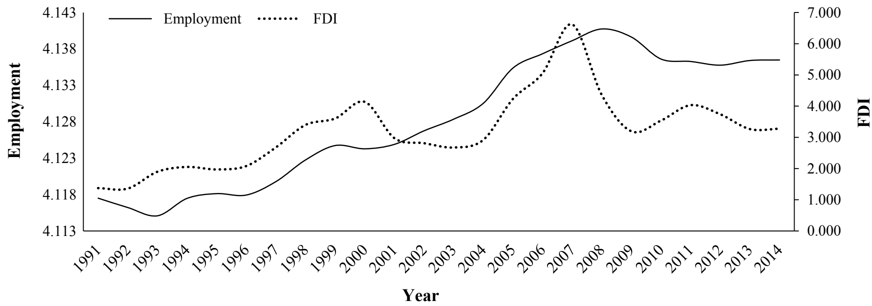

Fig. 5 Pattern of FDI and employment

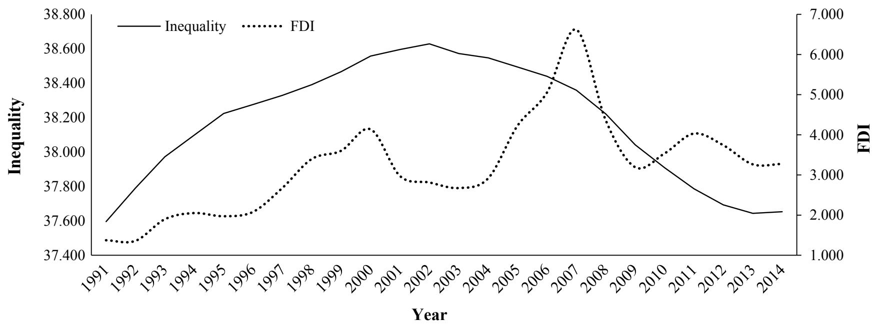

Fig. 6 Pattern of FDI and inequality

among the countries. It means that as economies grow, they attract more and more FDI for stimulating their growth process, nevertheless with a threshold where the economy attains higher per capita income growth explores the possible avenues for outward FDI for their counterparts. This transitional dynamic pattern and structural shift of macroeconomic conditions provide an incentive to test whether the declining inequality has any impact on the welfare horizon obtained in the labor market of the host country. The graphical analysis predicts improvement in labor market outcomes albeit with mixed forces generated by inequality that might outweigh the positive effects and decline the overall welfare. It may be an important introspection concerning the relationship between FDI and labor market outcome showing a specific pattern across the countries, yet the acceptance of this prediction is subject to a rigorous empirical analysis which is taken up subsequently.

5 Empirical Results and Discussion

5.1 Global Perspective

In this section, the empirical results are presented which are obtained through regression analysis and loss function. We use IV regression analysis to estimate the labor market implications of FDI across the countries. While implementing a panel data model, it is necessary to control for fixed and other effects. To arrive at the suitable model specification, we perform diagnostic tests using the Hausman test. The test favors fixed effects specification to examine the FDI and labor market nexus.

The broader perspective of foreign investment is to ease out the process of improvement for the standard of living and the country's welfare gain. However, it is observed that FDI has a heterogeneous impact on the income, employment and other macroeconomic indicators depending upon the development scenario of the host country. In the present study, our focus is to see whether or not FDI leads to improvement in labor market outcomes and to trace out the transmitting process of the welfare gain from the FDI. To verify the degree by which labor market outcomes of the countries are being influenced by inward FDI and to facilitate the empirical analysis, we follow an empirical strategy examining the labor market effects of FDI and its welfare implications across the countries. The results reveal that labor market outcomes are positively affected by FDI for both developed and developing countries. However, there are significant differences in the long-run effects of FDI on the sectoral labor market measures leading to unequal outcomes. (Table 2, column 2, 4 and 6). Interestingly, we observe that FDI improves female labor market more than the male labor market with the significant marginal difference between the two. The results are in line with the existing literature which predicts a positive impact of FDI on employment and wages. However, the major concern is whether this improvement is strictly improving welfare or not. By welfare implication we mean, does inward FDI is harmonious and equally affecting the male–female labor markets in a country and across the markets of the countries. The main argument follows that whether the FDI equally imparts the welfare among the labor markets. The control variables are significant and are in line with the expected signs. The important one, viz. income

Table 2 FDI and labor market outcomes: IV regression

Explanatory variables	Employment—aggregate		Employment—male		Employment—female	
	Fixed effects	(2SLS) estimation	Fixed effects	(2SLS) estimation	Fixed effects	(2SLS) estimation
	(1)	(2)	(3)	(4)	(5)	(6)
FDI	0.257*** (0.034)	0.257*** (0.034)	0.072** (0.027)	0.072** (0.027)	0.437*** (0.049)	0.437*** (0.049)
Income inequality	−0.112*** (0.036)	−0.112*** (0.036)	−0.077*** (0.028)	−0.077*** (0.028)	−0.143*** (0.051)	−0.143*** (0.051)
GDP per capita growth	0.892*** (0.366)	0.892*** (0.364)	0.447* (0.216)	0.447* (0.216)	1.527*** (0.523)	1.527*** (0.523)
Human capita index	2.616*** (0.553)	2.616*** (0.551)	−1.971*** (0.432)	−1.971*** (0.432)	7.249*** (0.791)	7.249*** (0.791)
Welfare adjusted total factor productivity	−1.771*** (0.710)	−1.771*** (0.706)	0.223 (0.554)	0.223 (0.554)	−3.913*** (1.014)	−3.913*** (1.014)
Agglomeration index	−0.124*** (0.038)	−0.124*** (0.037)	−0.077*** (0.029)	−0.077*** (0.029)	−0.137*** (0.054)	−0.137*** (0.054)
Financial institutional index	2.088* (1.122)	2.088 (1.117)	−4.522*** (0.877)	−4.522*** (0.877)	8.192*** (1.603)	8.192*** (1.603)
Agricultural value added	−0.032 (0.025)	−0.032 (0.025)	−0.034 (0.019)	−0.034 (0.019)	−0.004 (0.035)	−0.004 (0.035)
Industrial value added	−0.017*** (0.008)	−0.017** (0.008)	0.011 (0.007)	0.011 (0.007)	−0.014 (0.012)	−0.014 (0.012)
Services value added	−0.138*** (0.016)	−0.138*** (0.016)	−0.154*** (0.012)	−0.154*** (0.012)	−0.099*** (0.023)	−0.099*** (0.023)
Capital output ratio	−0.003** (0.001)	−0.003*** (0.001)	−0.002*** (0.000)	−0.002*** (0.000)	−0.005*** (0.001)	−0.005*** (0.001)
Price level of household consumption	0.734* (0.352)	0.734* (0.350)	−1.183*** (0.392)	−1.183*** (0.392)	2.343*** (0.718)	2.343*** (0.718)
Price level of capital formation	1.330*** (0.365)	1.330*** (0.363)	1.382*** (0.285)	1.382*** (0.285)	1.327*** (0.522)	1.327*** (0.522)
Constant	62.761*** (3.511)	–	92.532*** (2.743)	–	27.285*** (5.040)	–
Overidentification test *(Sargan Statistic)*		87.356		84.324		99.115
Underidentification test *(Anderson Canon LM statistic)*		321.493***		321.493***		321.493***
Observations (*N*)	1536	1536	1536	1536	1536	1536

Note Values in parenthesis report standard errors, and [***], [**] and [*] represent the significance level at $p < 0.01$, $p < 0.05$ and $p < 0.1$, respectively inequality, has negative sign throughout the models indicating that inequality deteriorates the labor market outcomes. This remains the major worry since it indicates that though FDI does affect positively labor market, inequality outweighs this effect in some countries resulting in loss of welfare obtained through the improved labor market situation. Other controls variables like interaction term of FDI and GDP per capita income, human capital index, welfare adjusted total factor productivity, income inequality, GDP per capita, urbanization, agricultural value added, industrial value added, services value added and capital output ratio, price level of household consumption, price level of capital formation are found to be significant.

On the sectoral analysis, it has been observed that there is a positive impact of FDI on the agriculture and service sectors (Table 3). Nevertheless, it affects industrial sector negatively. The estimates of second stage IV regression reflect a negative impact on the industrial sector that outweighs the positive effects on agriculture and service sectors. Further, it may be seen that the female labor market is affected negatively in the industrial and service sector though there is a positive implication in the agricultural sector. The main argument lies to the fact that due to improved labor market situations in industrial and service sectors, it drives the female population out of the market. That may be because of a gender-biased skill gap between the male

Table 3 FDI and sectoral labor market outcomes: IV regression—full sample

Labor market outcome (employment)	Explanatory variable—FDI	
	Fixed effects	(2SLS) estimation
Agricultural sector		
Total	0.077 (0.102)	0.010 (0.043)
Male	−0.018 (0.043)	−0.018 (0.043)
Female	0.105 (0.064)	0.105 (0.064)
Industrial sector		
Total	−0.182*** (0.039)	−0.182*** (0.039)
Male	0.147*** (0.050)	0.147*** (0.050)
Female	−0.143*** (0.041)	−0.143*** (0.041)
Service sector		
Total	0.172*** (0.050)	0.172*** (0.050)
Male	0.120*** (0.052)	0.120*** (0.052)
Female	0.038 (0.058)	0.038 (0.058)
Controls used	Yes	Yes
Observations (*N*)	1536	1536

Note Values in parenthesis report standard errors, and [***], [**] and [*] represents the significance level at $p < 0.01$, $p < 0.05$ and $p < 0.1$, respectively and female labor markets. It gives rise to an important aspect of welfare loss due to unequal and gender-specific FDI effects of labor markets across the countries.

With regard to the tracing out the transmission of welfare loss, we alter the specification to find out the impact of FDI on the employment differentials estimated. The employment differential refers to the differences in the employment status of a country with respect to the other countries. It acts as an important indicator for tracing out how FDI affects the variation in employment status across countries. Following the earlier estimates, we observe that FDI has a positive impact on employment, albeit with a differential magnitude between male and female. Now, the question arises whether this positive sign does really improve welfare. To trace these effects, we estimated the augmented model with employment differential. The positive sign indicates that FDI widens the differences in employment across the nation, reflecting the fact that the benefits of foreign investment have not been materialized for the welfare gain (Table 4). The female labor market happens to be the worst affected. Even though FDI seems to be prominent to improve the female labor market outcome, nevertheless it severely deteriorates the same by increasing the variation, therefore, leading to declining overall welfare gain. These results are in line with Gaston and Nelson (2004), Makino et al. (2004) and Wei (2013) among others. These estimates refute the conventional argument where FDI is supposed to improve the labor market outcomes so as welfare. This, in turn, instigates to estimate the extent of welfare loss incurred by the inward FDI to the host country. The exercise involves estimating the welfare effect for each cross-sectional unit (country).

To explore on to the multidimensional nature of the welfare effects of FDI through the labor market, the framework augmented in the present study relaxes the linear assumption pertaining to the nexus between FDI and economic welfare. This implies that the FDI may affect the economic welfare in a random pattern. Hence, quashing

Table 4 FDI and labor market outcome: IV regression—full sample

Explanatory variable	Employment differential (aggregate)		Employment differential (male)		Employment differential (female)	
	OLS	(2SLS) estimation	OLS	(2SLS) estimation	OLS	(2SLS) Estimation
	(1)	(2)	(3)	(4)	(5)	(6)
FDI	0.104*** (0.039)	0.203*** (0.038)	0.055 (0.036)	0.119*** (0.036)	0.146*** (0.061)	0.279*** (0.049)
Overidentification test *(Sargan statistic)*		87.833		118.659		72.391
Underidentification test *(Anderson Canon LM statistic)*		329.434***		329.434***		329.434***
Controls used	Yes	Yes	Yes	Yes	Yes	Yes
N	1536	1536	1536	1536	1536	1536

the linear assumption will capture the underlying true dynamics. In order to estimate the welfare loss, we augmented the welfarist approach of Atkinson (1970) in a panel set up to estimate the loss function (see Sect. 3 for explanation). On estimating the loss function, we observe a substantial loss of welfare in income and labor market outcomes with higher magnitude in the total and agricultural sector (Table 5). With respect to the total and male labor markets, it has been observed that the highest welfare loss has been reported in high-income countries. In connection with the sectoral welfare implications, it may be noted that the highest welfare loss is observed in high-income countries and the industrial and service sector face the highest loss in low-income countries. The results show that female labor market has significant welfare loss due to skewed inward FDI to the host countries. Therefore, differential impacts of FDI on labor market trigger inequality among the nations which lead to overall welfare loss and are more severe in low-income countries. This navigation of welfare loss through inequality has stringent negative effects on industrial sector labor market outcomes. These results refute the usual convention of positive effects of FDI with welfare gain. Hence, it is imperative to consider the welfarist aspect while analyzing the effects of FDI on any macroeconomic condition, especially for host countries. As an alternative measure, we estimate different measures of inward FDI to check the robustness of our results. The results are quantitatively similar to our previous results.

It may be concluded from the above analysis that FDI does affect the labor markets but with a significant difference in the long-run outcomes and a substantial welfare loss among the male and female markets. It is noteworthy to reflect the peculiar nature FDI where literature suggests an unequal implication on labor markets of the host countries. These results highlight a very important aspect where it shows on one

Table 5 Welfare loss: employment—World Bank classification

Labor market outcome	Full sample	High income	Middle income	Low income
Total	0.933	0.989	0.911	0.623
Total (male)	0.649	0.789	0.528	0.585
Total (female)	4.176	3.746	4.883	0.789
Agricultural—total	3.253	4.988	1.969	0.170
Agricultural—(male)	2.855	4.331	1.757	0.298
Agricultural—(female)	4.832	6.820	3.473	0.112
Industrial—total	0.690	0.675	0.489	2.979
Industrial—(male)	0.562	0.425	0.487	2.689
Industrial—(female)	2.055	2.185	1.578	5.886
Service—total	0.506	0.212	0.719	1.065
Service—(male)	0.443	0.259	0.548	1.106
Service—(female)	1.044	0.127	1.830	1.520

Note Welfare loss estimated is the average of the sample period (1991–92 to 2014–15) hand FDI improves labor market outcomes while on the other hand it deteriorates the overall welfare due to its unequal nature of the distribution of the outcomes.

5.2 A Case of Asian Economies

Asian region comprises a mix of advanced and emerging market economies. It hosts the world fastest growing economies like China, India. Over the years, the region became a magnet for the FDI. It led to improved benefits for many countries in the region with high economic growth and increasing per capita incomes. As per the Asian Economic Integration Report, there is an increasing trend of inward FDI to Asian countries. Asia accounts for 30% of global FDI in 2016 which increased from 20% in 2000–05. The main recipients include China (Hong Kong and China), Singapore and India. During the same time, more opportunities were created through the better financial sources and improved structural changes in the production process which lead major Asian firms to invest abroad particularly targeting the regional countries. This improved capacity of the country to absorb FDI has led increasing per capita incomes in this region.

However, some of the studies which analyzed FDI employment relationship in Asian countries find no clear conclusive evidence of a significant relationship. Unlike these studies, we aim at analyzing the impact of FDI on labor market outcomes in a comprehensive way and estimate the welfare loss (gain) due to inward FDI. At first, we estimate the effects of FDI on labor market outcomes followed by calculation of welfare loss function. The results reported in Table 6 show no significant sign of any labor market effects of FDI in the aggregate and industrial sector. However, the positive effect in the agricultural sector is offset by the negative effect in services sectors. An interesting fact is observed in these estimates, where female employment is affected positively in agriculture sector, whereas a significant negative impact in the tertiary sector leaves us with a positive overall impact. There was no significant impact seen with respect to male labor market outcomes. The reason could be that the inward FDI triggers increased labor demand from the home country due to skill differences. This possibility is traced out through the positive relationship between real per capita income growth and FDI. Nevertheless, these results may be interpreted with a caution.

This paradoxical situation necessitates to examine the welfare aspect of FDI to host countries. On estimating the loss function, we observe that there is a significant loss of welfare due to the inward FDI in Asian countries (Table 7). The highest loss is reported in the case of China followed by India. The estimates show the gender-biased impact of FDI on welfare. The most vulnerable female labor market is in Pakistan followed by India and Bangladesh. With respect to the sectoral labor markets, the results show a significant loss of welfare in all the sectors, agriculture being the worst affected.

Table 6 FDI and sectoral labor market outcomes: IV regression—Asian countries

Labor market outcome (employment)	Explanatory variable—FDI	
	Fixed effects	(2SLS) estimation
Aggregate		
Total	0.103 (0.080)	0.103 (0.079)
Male	−0.111 (0.069)	−0.111 (0.068)
Female	0.324*** (0.128)	0.324*** (0.125)
Agricultural sector		
Total	0.375*** (0.164)	0.375*** (0.161)
Male	0.272 (0.157)	0.272 (0.154)
Female	0.478*** (0.229)	0.478*** (0.225)
Industrial sector		
Total	−0.024 (0.141)	−0.024 (0.138)
Male	−0.137 (0.144)	−0.137 (0.141)
Female	0.244 (0.170)	0.244 (0.167)
Service sector		
Total	−0.351*** (0.169)	−0.351*** (0.166)
Male	−0.136 (0.155)	−0.136 (0.152)
Female	−0.722*** (0.237)	−0.722*** (0.233)
Controls used	Yes	Yes
Observations (N)	336	336

Note Values in parenthesis report standard errors, and [***], [**] and [*] represents the significance level at $p < 0.01$, $p < 0.05$ and $p < 0.1$, respectively

6 Conclusion

This chapter aims at exploring the welfare implications of FDI on labor market exclusively for countries hosting the FDI. For a panel of 64 countries during the period of 1991–92 to 2014–15, we estimated the FDI effects on labor market outcomes and welfare loss due to inequality in labor markets by augmenting the welfarist approach in a panel set up to estimate the loss function. The results reveal that FDI affects the labor market positively for both developed and developing countries. However, we observe a significant difference in the effects of FDI among sectoral labor markets leading to unequal outcomes during the long run. On estimating the loss function, we observe a substantial loss of welfare in income and labor market outcomes with higher magnitude in middle and high-income countries. With respect to Asian economies, no significant effects of FDI have been found. The worst affected are the female labor markets. Nevertheless, there has been a significant welfare loss across the countries. The main policy direction is to harmonize the FDI toward growth-enhancing sectors of the host countries. It will lubricate the labor market outcome by shifting the scale

Table 7 Welfare loss: employment—Asian countries

Country	Total	Total (male)	Total (female)	Agricultural total	Agricultural (male)	Agricultural (female)	Industrial total	Industrial (male)	Industrial (female)	Service total	Service (male)	Service (female)
Bangladesh	0.029	0.375	3.219	1.286	2.553	2.755	1.132	1.651	6.166	2.339	18.758	2.307
China	0.925	0.601	1.418	4.167	0.043	5.020	3.181	5.189	0.363	0.509	9.664	2.831
Fiji	0.668	0.812	0.611	0.309	0.126	0.294	0.357	0.287	0.096	0.158	0.359	0.255
India	0.779	0.157	5.101	0.504	1.442	0.446	0.315	0.547	1.525	1.333	1.637	0.246
Indonesia	0.055	0.022	0.232	0.675	0.479	0.421	0.854	0.584	0.211	0.737	0.824	0.238
Japan	0.584	0.902	0.286	1.390	0.589	0.195	2.922	0.629	2.404	0.191	0.295	0.111
Korea Rep.	0.058	0.125	0.039	4.269	0.815	0.571	5.541	3.433	2.726	0.368	0.709	0.448
Malaysia	0.127	0.064	0.606	2.035	0.219	0.389	5.021	1.298	1.399	0.146	0.935	0.164
Nepal	0.071	0.157	0.040	0.130	6.728	0.971	0.096	0.243	11.388	6.633	1.088	1.382
Pakistan	0.597	0.065	30.528	0.150	0.368	0.081	0.120	0.566	1.498	0.556	1.512	0.180
Philippines	0.011	0.057	0.181	0.722	0.064	0.561	1.095	0.568	0.637	0.077	0.327	0.783
Singapore	0.373	0.234	2.073	21.613	2.182	0.251	30.191	20.404	3.596	1.693	0.259	0.288
Sri Lanka	0.333	0.245	1.425	0.764	0.367	0.388	0.752	0.833	0.412	0.546	0.993	0.253
Thailand	0.107	0.109	0.128	1.097	0.211	1.696	1.565	0.796	0.140	0.354	2.451	1.113

Note The welfare loss reported is standardised actual numbers and can be interpreted in standard way of labor demand function which in turn will lead to enhanced welfare across the economy.

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Appendix

See Table 8.

Table 8 List of sample countries

Argentina	Mexico
Australia	Morocco
Austria	Nepal
Bangladesh	Netherlands
Belgium	New Zealand
Bolivia	Nigeria
Brazil	Norway
Canada	Pakistan
Chile	Panama
China	Peru
Colombia	Philippines
Costa Rica	Portugal
Denmark	Qatar
Ecuador	Russian Federation
Egypt, Arab Rep.	Saudi Arabia
El Salvador	Singapore
Fiji	South Africa
Finland	Spain
France	Sri Lanka
Germany	Sudan
Greece	Sweden
India	Switzerland
Indonesia	Thailand
Iran, Islamic Rep.	Turkey

(continued)

Table 8 (continued)

Ireland	Uganda
Italy	United Arab Emirates
Japan	United Kingdom
Kenya	United States
Korea, Rep.	Uruguay
Kuwait	Venezuela, RB
Malaysia	Zambia
Mauritius	Zimbabwe

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Aggregate Fluctuations and Technological Shocks: The Indian Case

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1 Introduction

Identification of the sources of fluctuations in aggregate output is very important both from modelling and policy perspective. These fluctuations can be due to demand and supply shocks. Some of the theoretical models like real business cycle (RBC) models attribute random variations in technology as the main source of business cycle and emphasizes the role of aggregate supply shocks, whereas the new Keynesian models give prominence to aggregate demand shocks propagated through price stickiness and imperfect competition. The effectiveness of any policy is conditional on the nature of shocks to aggregate output (Lucas 1977). The demand stabilisation policies will be effective if the demand shocks explain most of the variations in business cycles as predicted by Keynesian models, but it becomes counterproductive if technological shocks are important. Therefore, it is important to empirically examine the importance of different shocks on aggregate fluctuations.

Economic reforms initiated in the early 1990s and the increased international integration of Indian economy brought a high growth rate. A move away from regulated and closed economy to a market-determined and more integrated one does have implications for business cycle facts. Indian economy has also grown from an agrarian economy to a service-oriented and industrial economy over the period of time. The stylised facts of Indian business cycles are very different from pre-reform period as documented by Ghate et al. (2013). In the post-reform period, output becomes less volatile and it is strongly correlated with investment. Imports become pro-cyclical,

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and exports and exchange rates are counter-cyclical in the post-reform period compared to acyclical nature of these variables in the pre-reform period. In this regard, examining the business cycle facts and its driving forces are very much relevant from an emerging economy perspective.

There are significant advancements in the methods and tools used to understand business cycles and its driving forces following the works of Kydland and Prescott (1982) and Long and Plosser (1983). Particularly, the dynamic stochastic general equilibrium models become an inevitable tool for analysing business cycles' facts. There are some attempts to examine the driving forces using vector autoregressive (VAR) models developed by Sims (1980). Later, the structural VAR models developed by Blanchard and Quah (1988) and its extensions were used to understand business cycle fluctuation with minimum required assumptions. In few other studies, structural VAR models are often used. Following this strand of the literature, this study attempts to investigate the main source of macroeconomic fluctuations in India and relate with the total factor productivity (TFP) and technical efficiency.

2 Technological Shocks as a Source of Business Cycles

The idea that technological innovations propagate growth and business cycles dates back to Schumpeter (2010). According to Schumpeter, business cycle happens mainly due to fluctuations in technological innovations and emphasised cyclical nature of economic growth. He distinguished four phases of economic fluctuations: prosperity, recession, depression and recovery. He characterised the cyclical fluctuation into different categories depending on the length of the waves: short-term 3–5 year Kitchin cycles, medium-run Juglar cycles and long-run Kondratieff cycles (Schumpeter 1939). In all these cycles, innovations play a crucial role. The spurt of innovations at particular periods of time known as "neighbourhoods of equilibrium" leads to cycles in the aggregate growth.

The Schumpeterian idea of stochastic technological innovations as the main propagation mechanism came into focus again with the work of Kydland and Prescott (1982) and Long and Plosser (1983) on real balance cycle (RBC).[1] The RBC models were built on frictionless neoclassical framework with optimising agents. They argued that the technological shocks often defined as random variations around the productivity cause aggregate output to fluctuate around the long-term trend. Thus, the real business cycle attributes substantial amount of aggregate fluctuations to technological shocks. Following the work of Kydland and Prescott (1982), many studies have emphasised this fact.[2] The RBC models popularised dynamic stochastic

[1]Technological shocks are assumed to be exogenous in RBC, but it is not so in Schumpeterian models. Please see Akcigit and Kerr (2018), Acemoglu et al. (2012) and Aghion and Jaravel (2015), for modern interpretations of Schumpeterian growth models.

[2]See for example Cooley and Prescott (1995), King and Rebelo (1999).

general equilibrium (DSGE) models which incorporate the preferences and optimising behaviour of producers and other economic agents. These models were later extended to incorporate other features including but not limited to the new Keynesian assumptions.

Apart from DSGE approach, empirical studies have also used structural VAR models to test the predictions of standard RBC models. For example, Shapiro and Watson (1988) used a structural vector autoregressive model (SVAR) to capture the share of demand and technology shocks. They find that one-third of the output variations can be explained by technological shocks. Similarly, Cochrane (1994) examined the importance of transitory (demand shocks) and permanent shocks (technology or productivity shocks) in explaining short-run dynamics of business cycles. They have used weak exogeneity of the variable in a co-integrated system to identify the permanent and transitory components. They find that substantial amount of variations in GNP growth, and stock returns are explained by transitory shocks. It was Blanchard and Quah (1988) who developed a comprehensive approach to decompose demand and supply shocks using a two-variable structural system. They considered supply shocks to have permanent effect while demand shocks are assumed to be transitory in nature. Their approach was generalised to incorporate more variables and allowing for co-integration.

Following Blanchard and Quah (1988) approach, Gali (1999) tried to examine the explanatory power of technology shocks in explaining business cycle fluctuations as predicted by real business cycle models. He employed two SVAR models (i) a bivariate model with labour productivity and labour hours (ii) a five-variable model with labour productivity, labour hours, real money balances, real interest rates and the inflation rate. More specifically, using the five-variable SVAR, the paper identified permanent shocks (technology shocks and labour supply shocks) and transitory shocks interpreted as demand shocks. They refute the predictions of RBC models and show that the technological shocks are unrelated to business cycles. Moreover, the results indicate that the technology shock induces a negative co-movement between productivity and employment.[3] Another important issue is related to the measurement of technological innovations. Previous studies have used many proxies for technological innovations including an aggregate measure of total factor productivity (TFP). These measures are often constructed using aggregate data. These measures often ignore the heterogeneous nature of technological innovations.[4] An index constructed using firm-level TFP would be a better measure of technological innovations, and this study tries to construct the TFP using firm-level data.

There are few studies in Indian context, and most of them focus on extracting business cycles and try to analyse the co-movements of various aggregates variables (see

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[3]Similarly, Basu et al. (2006) constructed a measure of aggregate technology change and argued that sticky-price models fit the data well compared to RBC models. Some studies stressed other important shocks that affect aggregate fluctuations like "fundamental disturbance to the functioning of financial sector" (Justiniano et al. 2010), investment-specific technology shocks (Greenwood et al. 1997; Fisher 2006) and news shocks (Beaudry and Portier 2006).

[4]Many studies have highlighted the importance of idiosyncratic firm-level shocks to aggregate fluctuations (Gabaix 2011)

for e.g., Dua and Banerji 2012; Chitre 1982). Some of the recent studies attempted to analyse the features of business cycles using DSGE framework. For instance, Bhattacharya et al. (2013) examined how terms of trade affect business cycles. Similarly, Ghate et al. (2016) examined the role of fiscal policy in the business cycles of emerging markets. In another study, Banerjee and Basu (2017) developed a small open economy new Keynesian DSGE model for India to understand the importance of two technology shocks, Hicks-neutral total factor productivity (TFP) shock and investment-specific technology (IST) shock for an emerging market economy like India. The results indicated that output correlates positively with TFP but negatively with IST and are important factors in explaining aggregate fluctuation in India. Similarly, the importance of IST has increased after the post-reform period.

In this context, this study tries to examine the role of aggregate fluctuations in a SVECM framework. We also try to construct the productivity measure using highly disaggregated data at the firm level. There are very few studies in Indian context that tries to examine the nature of aggregate fluctuations using measures constructed with microlevel data.

3 Data and Methods

Data for this paper is derived from both at firm-level and macrolevel. The firm-level data is collected from the Prowess database of the Centre for Monitoring Indian Economy (CMIE), and macroeconomic data is collected from various government databases of macroeconomic indicators. The macroeconomic indicators include quarterly data on log of real GDP (LRY) and real money supply (LRM) constructed as the difference between the log of M3 and log of consumer price index. From the firm-level data on inputs and output, we compute total factor productivity (TFP) and technical efficiency (TE) and assume to be the proxies of technological innovations at firm level. Since quarterly data on GDP was available from 1996 Q2, the sample period is chosen as 1996 Q2 to 2017 Q2.

The first part of the method employed in this paper is to calculate TFP and TE. Here, we use a stochastic frontier production function to estimate the technical efficiency, which can be expressed as follows:

$$Y_{it} = f(X_{it}, t; \beta)\mathrm{e}^{v_{it} - u_{it}} \tag{1}$$

where Y_{it} is the output of the ith firm ($i = 1, \ldots, N$) in period $t = 1, \ldots, T$; $f(X_{it}, t; \beta)$ represents the production technology; X_{it} is a $(1 \times K)$ vector of inputs and other factors influencing production associated with the ith firm in period t; β is a $(K \times 1)$ vector of unknown parameters to be estimated; v_{it} is a vector of random errors that are assumed to be iid $N\left(0, \sigma_v^2\right)$; and $\mathrm{u_{it}}$ is a vector of independently distributed and non-negative random disturbances that are associated with output-oriented technical inefficiency. Specifically, u_{it} measures the extent to which actual production falls short of maximum attainable output. If the firm is efficient, the actual output is equal to potential output. Thus, $Y_{it} - Y_{it}^{*} = u_{it}$, where, u_{it} = inefficiency. The technical efficiency of a producer at a certain point in time can be expressed as the ratio of actual output to the maximum potential output, and the technical efficiency can be calculated as.

$$\mathrm{TE}_{it} = \frac{Q_{it}}{f(X_{it}, t; \beta)\mathrm{e}^{-u_{it}}} = \mathrm{e}^{-u_{it}} \tag{2}$$

The error term representing technical inefficiency is specified as: $u_{it} = \exp(-\eta (t - T)u_i)$. Under this specification, inefficiencies in periods prior to T depend on the parameter η. As t tends to T, u_{it} approaches $u_{T.}$ Inefficiency prior to period T is the product of the terminal year's inefficiency and exp $(-\eta\ (t - T))$. If η is positive, then exp $(-\eta\ (t - T))$ = exp $(\eta\ (t - T))$, and it is always greater than 1 and increases with the distance of period t from the last period T. The positive value of η indicates inefficiencies fall overtime, whereas negative value of η indicates inefficiencies increase overtime.

The above model can be estimated by the maximum likelihood estimates (MLE). Restricting $\mu = 0$ in the model, it reduces the model to the traditional half-normal distribution. If μ is not restricted, then µ follows truncated normal distribution. If $\eta = 0$, then technical efficiency is time-invariant, i.e., firms never improve their efficiency. The value of $\gamma = \sigma_u^2/\sigma^2$ $\left(\text{where } \sigma^2 = \sigma_u^2 + \sigma_v^2\right)$ will lie between 0 and 1. If u_{it} equals zero (which indicates full technical efficiency), then γ equals zero, and deviations from the frontier are entirely due to noise v_{it}. If γ equals one, all deviations from the frontier are due to technical inefficiency.

Besides the above rationality, the following Cobb-Douglas specification of functional form is employed to specify the parameters of the model to estimate the efficiency since it is widely used one in efficiency studies. The functional form in the present case is:

$$\ln Q_{it} = \beta_{1t} + \beta_2 \ln C_{it} + \beta_3 \ln L_{it} + \beta_4 \ln M_{it} + \beta_5 \ln E_{it} + v_{it} - \eta_{it} u_{it} \tag{3}$$

where Q = output; C = capital; L = labour; M = material; and E = energy

The parameters of the stochastic frontier model, defined in Eq. (3), are estimated using Coelli (1996) method. The total factor productivity is also estimated using the ACF production function,[5] which is widely used in recent estimates of TFP. For estimating TFP and TE, we used data drawn from the CMIE. In this study, gross output at constant prices is used as a measure of real output. Prowess reports gross output data in value terms (Rs. lakh). Nominal values of gross output are deflated by the wholesale price indices for industrial goods. Wages and salaries of employees are considered for the labour input. Unlike other factors of production, capital is used beyond a single accounting period, and measuring capital stock input is rather problematic. For capital stock, we have followed perpetual inventory method (PIM) as followed in Goldar et al. (2004) and many other studies on Indian manufacturing

[5] For detail methodology, please see Ackerberg et al. (2015).

sector. Once, both TFP and TE are calculated at firm level for each year, they are converted to quarterly TFP and TE based on NIC-2008 classifications of two-digit industrial classifications.

The second part of the empirical analysis is to employ structural vector error correction (SVEC) model to understand the importance of technological shocks in explaining the aggregate fluctuations. We have considered a three-variable VEC model expressed as:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + B\varepsilon_t, \tag{4}$$

where X_t is a vector of K variables, $B\varepsilon_t = u_t$ and $\varepsilon_t \sim N(0, I_K)$

Following Lütkepohl (2005), equation above can be decomposed into permanent and transitory components using a multivariate Beveridge–Nelson representation as:

$$X_t = \Xi \sum_{i=1}^{t} u_i + \sum_{j=0}^{\infty} \Xi_j^* u_{t-j} + X_0^*, \tag{5}$$

where $\Xi = \beta_\perp \left(\alpha'_\perp \left(I_K - \sum_{i=1}^{p-1} \Gamma_i \right) \beta_\perp \right)^{-1} \alpha'_\perp$ and Ξ has a reduced rank equal to $K - r$. Thus, first term in the right-hand side (RHS) of the equation is integrated of order one, and the middle term is stationary and Ξ_j^* converges to zero as $j \to \infty$. The third term in the equation has all the initial values. Since Ξ is a reduced rank matrix, we have r shocks that are transitory and $k^* = K - r$ common trends in the system. Replacing u_t with $B\varepsilon_t$ we can recover the orthogonalised short-run impulse response using $\Xi_j^* B$ as in the case of structural VAR, and the long-run effect of the structural shocks is given by ΞB. Hence, the elements in B matrix can be interpreted as contemporaneous effects of the structural innovations. The long-run impact matrix ΞB can have at most r columns of zeros. Thus, as mentioned earlier, there are r shocks with transitory effects and k^* shocks with permanent effects.

4 Results and Discussions

The measures of plots of the technical efficacy and total factor productivity are shown in Figs. 1 and 2. The figures show an increasing both technical efficacy and total factor productivity which started increasing since 2002 and a slight decline after 2014. The minimum value of total factor productivity for the sample period is 2.68 and maximum is 3.30, it is 0.58 and 0.61 for technical efficiency. Before estimating the structural system, the variable under consideration was examined for its time-series properties. The results of unit root test are given in Table 1.

Standard unit root tests such as augmented Dicky–Fuller (ADF) and Phillips–Perron (PP) are used to test the stationary properties of the variables. The tests

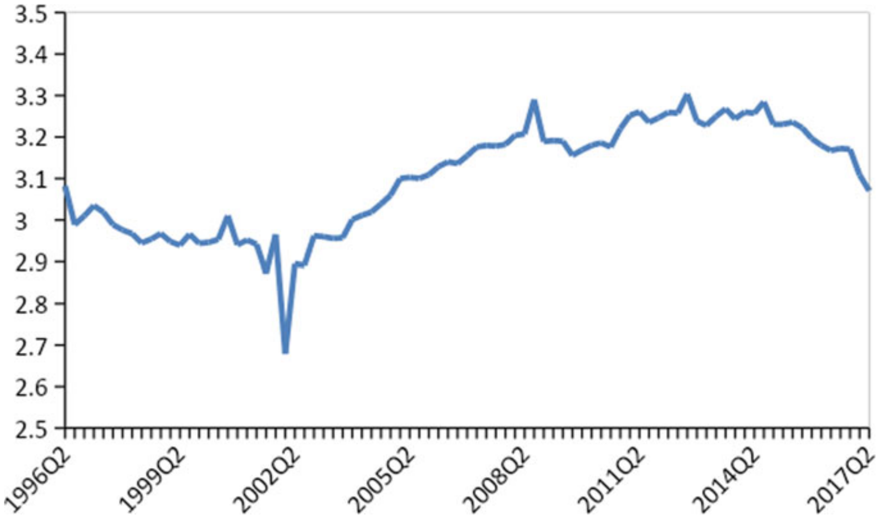

Fig. 1 Measures of total factor productivity (1996 Q2–2014 Q2)

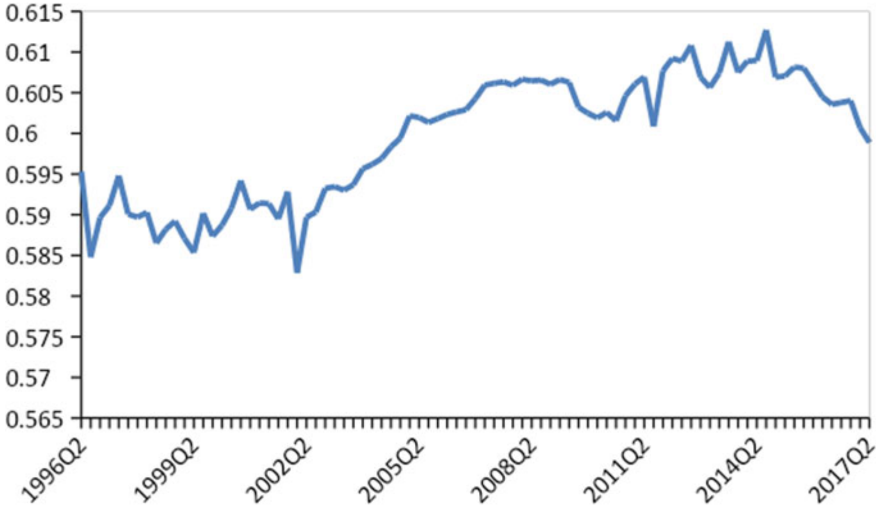

Fig. 2 Measures of technical efficiency (1996 Q2–2014 Q2)

indicate that all the variables under consideration are integrated of order one. As all the variable are $I(1)$, we have proceeded to test co-integration before estimating the structural VECM.

We have considered two different specifications for the Johansen test of co-integration. The first model includes a vector of three variables $X_t = \{\text{LRY}_t, \text{LRM}_t, \text{TFP}_t\}$. The TFP is then substituted by the alternative measure TE.

Table 1 Unit root tests

Variables	ADF test statistic	PP test statistic
LRM	−2.53 (0.11)	−2.816 (0.06)
ΔLRM	−4.4505 (0.00)	−10.009 (0.00)
LRY	−2.5958 (0.28)	−2.560 (0.26)
ΔLRY	−8.898 (0.00)	−8.925 (0.00)
TE	−1.64 (0.456)	−1.54 (0.52)
ΔTE	−14.46 (0.00)	−15.18 (0.00)
TFP	−1.40 (0.57)	−1.100 (0.71)
ΔTFP	−15.96 (0.00)	−15.87 (0.00)

Note Figures in parenthesis are *p*-values

The results of the co-integration test are given in Table 2. The results indicate one co-integrating relation among these variables for both specifications.[6] This implies that we can decompose the structural system into two permanent and one transitory components by appropriately restricting the long-run impact matrix and short-run contemporaneous relationship.

Two shocks with permanent effect and one with transitory effect are identified. The long-run impact matrix is a reduced rank matrix since there is one co-integrating vector as suggested by Johansen test. Accordingly, we have restricted the first column of the long-run matrix to zero. Thus, in the presence of co-integration, we need only two more additional restrictions. The first two elements in the last row can be restricted to zero assuming constant returns to scale.

Table 2 Results of co-integration tests

Variables	Hypothesis	Eigenvalue	λ_{TRACE} statistic	Max-eigen statistic
LRY, LRM, TFP	$r = 0$	0.244	39.19*	23.01*
	$r \leq 1$	0.108	16.18	9.45
	$r \leq 2$	0.079	6.74	6.73
LRY, LRM, TE	$r = 0$	0.234	37.19*	23.32*
	$r \leq 1$	0.102	13.87	8.83
	$r \leq 2$	0.059	5.15	5.05

*Indicates significance level at 5%

[6]VECM was estimated with two lags as suggested by AIC information critera.

$$\Xi B = \begin{bmatrix} 0 * * 0 * * 0 0 * \end{bmatrix} \tag{6}$$

One more restriction is required for the identification of structural innovations. This can be obtained by assuming that the real money shock has no contemporaneous impact on productivity. Thus, the B matrix can be written as

$$B = [* * * * * 0 * * *] \tag{7}$$

The structural system is exactly identified with these restrictions. The variance decomposition is recovered with these restrictions which are given in Tables 3 and 4.[7]

The results of variance decompositions of real output due to technology shocks with TFP are given in Table 3. The results clearly indicate that the percentage of variance explained by aggregate demand shocks is larger at lower lag and decreasing

Table 3 Variance decomposition of real output using total factor productivity

Variance decomposition of	Forecast horizon (Qtrs)	Due to		
		ε_{LRY}	ε_{LRM}	E_{TFP}
LRY	1	0.458	0.401	0.132
	4	0.459	0.403	0.136
	8	0.490	0.354	0.154
	12	0.521	0.304	0.174
	18	0.558	0.236	0.204
	24	0.580	0.188	0.231
	30	0.577	0.168	0.251
	36	0.558	0.179	0.262

Table 4 Variance decomposition of real output using technical efficiency

Variance decomposition of	Forecast horizon (Qtrs)	Due to		
		ε_{LRY}	ε_{LRM}	E_{TFP}
LRY	1	0.430	0.474	0.095
	4	0.434	0.472	0.099
	8	0.466	0.465	0.068
	12	0.497	0.451	0.050
	18	0.539	0.419	0.056
	24	0.553	0.373	0.073
	30	0.546	0.318	0.135
	36	0.517	0.261	0.226

[7]Only the results of variance decomposition of output due to output, TFP/TE and real money supply are represented in the tables. The results of other variables are available upon request.

over the period. There was 40% at lag one and decreased to 18% by lag 36. However, the share of technology shock shows an increasing trend over the period of time. The share of technology shock was just 13% at first lag abut increased to 26%. The results are similar when we substitute TPF with TE. However, the share of TE is very negligible till the lag 24 (below 10%). But, it starts increasing after lag 30. The results in general indicate the transitory nature of aggregate demand shocks compared to technology shocks. The technology shocks explain the forecast error variance of real output at longer lags.

5 Conclusion

This study is one of the rarest attempts to empirically establish a relationship between microdata and macrodata for the Indian economy in general and industrial data and macroeconomics data for the Indian economy in particular. For the Indian economy, there are many studies that have looked at the estimation of TFP and TE and their determinants. Similarly, studies have identified business cycle co-movements, movements in GDP and other macroeconomic indicators. This study, however, links the aggregate fluctuations with TFP and TE for the Indian economy. In doing so, we gather firm-level data from the CMIE Prowess and macroeconomic indicators of Indian economy. The results clearly indicate that the percentage of variance explained by aggregate demand shocks is larger at lower lag and decreasing. However, the share of technology shock shows an increasing trend over the period of time. Therefore, the aggregate demand shock and the technology shock are inversely related in this case. The results are similar when we substitute TPF with TE. The results in general indicate the transitory nature of aggregate demand shocks compared to technology shocks.

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