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FDI in Indian Manufacturing: Whither high-tech industries?

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Abstract

One of the core development objectives of the liberalization regime in India was to enhance FDI in the high-technology industries. Although FDI inflows have increased substantively, it seems that the development goal of technology transfer has not been realized. Moreover, weak enforcement and compliance of environmental norms has put the country at risk of a pollution-haven effect. We examine the pattern of FDI in manufacturing industries, differentiated by technology-intensity and pollution-intensity, to discern the nature of industries that have attracted foreign investment. We build a comprehensive dataset using three databases (on external merchandise trade, foreign investment and domestic production), and find that FDI inflows increased substantially in capital-intensive industries, but not in skill-intensive manufacturing. High-tech export-oriented polluting industries gained significantly, suggesting possibility of a pollution-haven effect through export-platform FDI in polluting industries. In our source-country analysis across industry groups, we find evidence of a pollution-haven effect in high-tech pollution-intensive industries.

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FDI in Indian Manufacturing: Whither high-tech industries?

1. Introduction

One of the core objectives of the economic liberalization and privatization policies initiated in India in 1991, was to enhance inward foreign direct investment (FDI) in the manufacturing sector. The development strategy aimed to bring in large private investment and advanced technology, particularly in the priority manufacturing sectors outlined in the Industrial Policy of 1991, - including machine tools, instruments, drugs and pharmaceuticals, chemicals, etc. The increase in FDI was expected to stimulate and technologically upgrade the manufacturing sector,[1] drive innovation and generate employment for a skilled and educated workforce.

Three decades into the reform regime, India's total FDI has indeed grown significantly. In particular, real FDI in manufacturing increased more than ten-fold during 2000-14, indicating that the policy to achieve greater quantum of FDI inflows has been successful. But has FDI grown in the high-technology manufacturing in India, as envisioned in the development policy? The Industrial Policy 2017 of India observed that the benefits of long-term investments and accessing technology have not been realized, and FDI policy needs review to ensure that it can facilitate greater technology transfer - which was one of the key intents of the liberalization strategy. Considering the systematic liberalization pursued through the last twenty-five years, it indicates that investment prospects of other sectors were more attractive (than in the priority sectors) to foreign entrepreneurs. Recent review of investment liberalization noted that the Indian FDI policy has focused on the entry route with complete disregard to the characteristics of the investors' potential for technology transfer (Rao and Dhar 2018 & 2011). A large share of FDI in India continues to be routed from Mauritius, which are investments made by domestic entrepreneurs, using the foreign route to avail of tax and fiscal advantages, (round tripping), and hence not associated with technological advantage. The review also noted that it is important for institutions administering data on investment, industry, trade etc (including the Department of Industrial Policy and Promotion, Central Statistical Organization, Directorate General of Commercial Intelligence and Statistics, RBI) to work together and mine a wealth of information on foreign and domestic investment that would be useful in further analysis (Rao and Dhar 2018: 123). Our study is a step in that direction and builds a comprehensive dataset using three databases, - namely merchandise trade, foreign investment and domestic production - in order to discern the nature of inward foreign direct investment by disaggregated industry characteristics and export-intensity.

A closer look at the FDI inflows in Indian manufacturing also indicates that around 60% of foreign investment has been in polluting industries during the period 2000-14. The institutional capacity to monitor and enforce environmental policies is poor in India and violation of standards is rampant.[2] Given the weak implementation of environmental regulations in India, it does raise the

[1] FDI is allowed upto 100% equity under the automatic route in most industries, and 90% of total FDI inflows occur through the automatic route (DIP 2017).

[2] In August 2018, the State Minister of Environment acknowledged that hundreds of industries are violating environmental norms.

question whether liberalization of FDI attracted investment in polluting manufacturing. It is well-recognized that the benefits from FDI are not automatic, and the host country's regulations on investment (both foreign and domestic) and other areas vis a vis the rest of the world, determine the economic, environmental and social impact of FDI (Echandi et al 2015). Countries with relatively more stringent environmental regulations may invest in pollution-intensive industries in developing countries to lower production cost, a phenomenon known as the pollution haven effect. Polluting industries are typically capital-intensive,[3] and analysis of outbound-FDI from the US into Mexico and Brazil found evidence of pollution haven effect (Cole and Elliott 2005). Similarly, a study of inbound-FDI into Mexico from high-income OECD countries, including the US, also found evidence of pollution offshoring (Waldkirch and Gopinath 2008). The factor determining the flow of FDI in polluting industries is the relative stringency of environmental regulations in the host- versus the source country. Analyses of inbound FDI in polluting industries from the perspective of developing countries in a country like China (Di 2007, Dean et al. 2009) show that foreign investments through equity joint ventures have been significant in polluting industries, and dirtier firms located in less developed provinces with relatively lower regulatory stringency. While India has featured in some of the cross-country studies examining outbound investment of developed countries in polluting industries (Chung 2014; Xing and Kolstad 2002; Poelhekke and Ploeg 2015; Mulatu 2017), there is no in-depth analysis of FDI inflows into India at the level of disaggregated industry by source-country to examine the determinants of inflows into India in manufacturing industries, and differentiating manufacturing industries by technology and pollution-intensity. This study tries to fill that gap in the literature.

Did liberalization and privatization in India attract foreign investment in polluting industries and bypass the priority industries? Controlling for the investment from Mauritius (due to round-tripping), did FDI flow into lower technology polluting industries from more developed countries? What type of Indian manufacturing industries have attracted foreign investment? We address these questions by examining the nature of inward FDI in Indian manufacturing, by technology-intensity and pollution-intensity of industries over a fifteen-year period during 2000-14.

In order to control for industry characteristics, we utilize the data from the Annual Survey of Industries (ASI) at the disaggregated level (National Industrial Classification codes, NIC codes). The ASI 4-digit industries are matched with the FDI sectors defined by Department of Industrial Policy and Promotion (DIPP). Since data on pollution load by industry is not available, we use the Central Pollution Control Board of India (CPCB) classification to distinguish the polluting nature of industries.[4] Several capital-intensive polluting industries, like iron and steel, chemicals, etc., are basic industries that have large domestic markets in a developing country like India. In particular, the large domestic market for chemicals, metal products and transport equipment industries, has been an attraction for foreign investors (Uchikawa 1999; Nagaraj 2003; Balasubramanyam and Sapsford 2007; Wei 2005; Chakraborty and Nunnenkamp 2008). So FDI in such industries are expected to be market-seeking in nature rather than just resource-seeking. On the other hand, the migration of polluting industries under the pollution haven effect would be in the nature of horizontal export-platform FDI (Tang 2015), serving markets other than host country. Thus, we

[3] This is also evident in the Indian industries, as highlighted in the summary statistics of our data in Table A2.

[4] The CPCB has categorized industries into *red*, *orange*, *green* and *white*, based on their pollution index scores, with *red* consisting of the most hazardous industries and *white* consisting of non-polluting industries.

also control for the export-intensity of the industries. We use the UNCOMTRADE data under ISIC Rev.3, since it has direct concordance with India's industrial classification, and allows us to compute the export-intensity at the disaggregated 4-digit industry level.

To the best of our knowledge, this is the first study with a comprehensive analysis for India utilizing information from three databases (external merchandise trade, foreign investment and domestic production) controlling for industry-specific characteristics. We find that although relatively capital-intensive manufacturing industries have received more FDI, the industries are among the less skill-intensive ones. Polluting high-tech industries with greater export-orientation have also attracted FDI, rather than clean high-tech export-oriented industries, suggesting that there may be a pollution-haven effect. We test for the pollution haven effect by examining the source-country pattern of FDI by industry (distinguishing by technology-intensity). In order to control for the FDI due to round-tripping, our country model excludes Mauritius. We find robust evidence of a pollution haven effect for higher technology pollution-intensive industries. The rest of the paper is organized as follows: Section 2 discusses the pattern of FDI inflows in India; Section 3 outlines our empirical model and data sources; Section 4 summarizes our empirical results; and Section 5 concludes the paper.

2. Inward Foreign Direct Investment in India

Liberalization of foreign policies in India has increased FDI inflows, which can be observed systematically beginning 2000.[5] The set of top ten investing countries in India have remained the same over the years, and together contribute to about 85% of total FDI in the manufacturing sectors (see Table 1). The contribution of these top investing countries in highly-polluting industries similarly accounts for 85.6% of total FDI in these industries. Among the top investing countries UK, and Japan, have been the most prominent investors in Indian manufacturing (apart from Mauritius), and in particular, polluting industries.

Table 1: Percentage Share of Top 10 Countries in Manufacturing FDI in India, 2000-2014

Source Country	***Manufacturing Sector***	***Polluting Industries#***
Cyprus	1.6	1.5
France	2.3	2.9
Germany	4.3	4.2
Japan	11.8	14.4
Mauritius	25.2	14.2
Netherlands	7.2	9.2
Singapore	11.5	9.8
United Arab Emirates	0.9	0.9
United Kingdom	14.4	23.1
United States of America	5.5	5.4
Subtotal	**84.7**	**85.6**

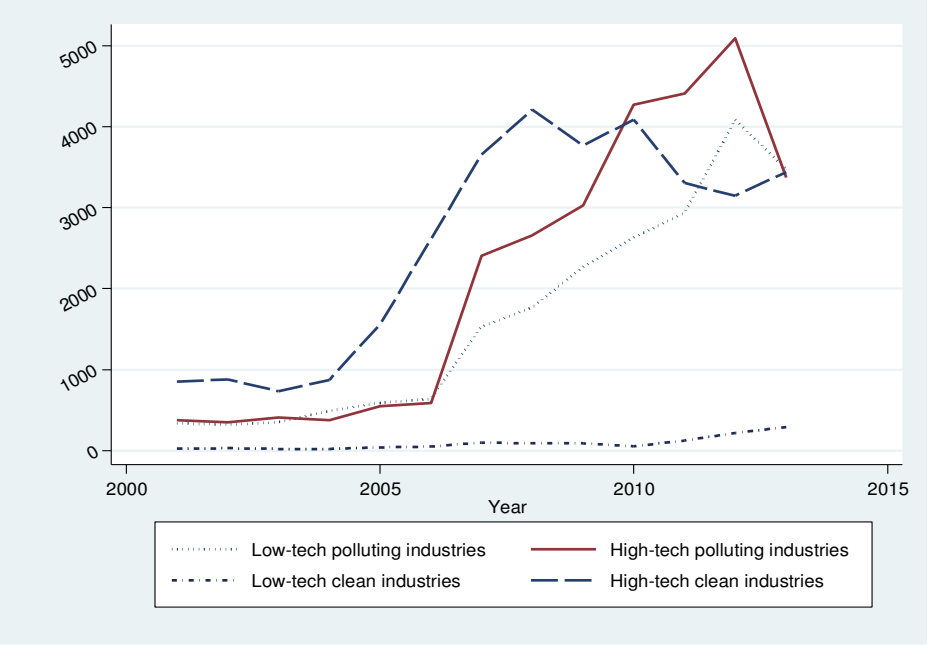
So*urce: Authors' calculation based on FDI Inflows from DIPP data. # includes highly polluting industries*

[5] The FDI reporting system was revised in 2000 to align it with international practices, so investment flows of the last two decades cannot be directly compared with that of the 1990s.

In order to discern the pattern of FDI inflows across industries, we use the disaggregated DIPP data that provides sector-wise country-wise annual FDI into India. We concord the DIPP sectors with the industries at three-digit NIC classification, and distinguish the industries by technology-intensity (high, medium-high, medium-low, and low)[6] and pollution-intensity (polluting and clean).[7] This allows for industries to be classified into eight sub-groups (Table A1 provides the list of manufacturing industries thus classified).

The trends in real FDI (smoothened by considering 3-year moving average real FDI) in Figures 1 and 2, indicate that FDI in Indian manufacturing grew significantly in the polluting medium-high-tech and high-tech industries (like chemicals, automobiles, drugs and pharmaceuticals); as well as in the polluting low-tech industries (like food-processing, metallurgical, and cement).

Figure 1. Manufacturing FDI Inflows by tech-intensity from all countries

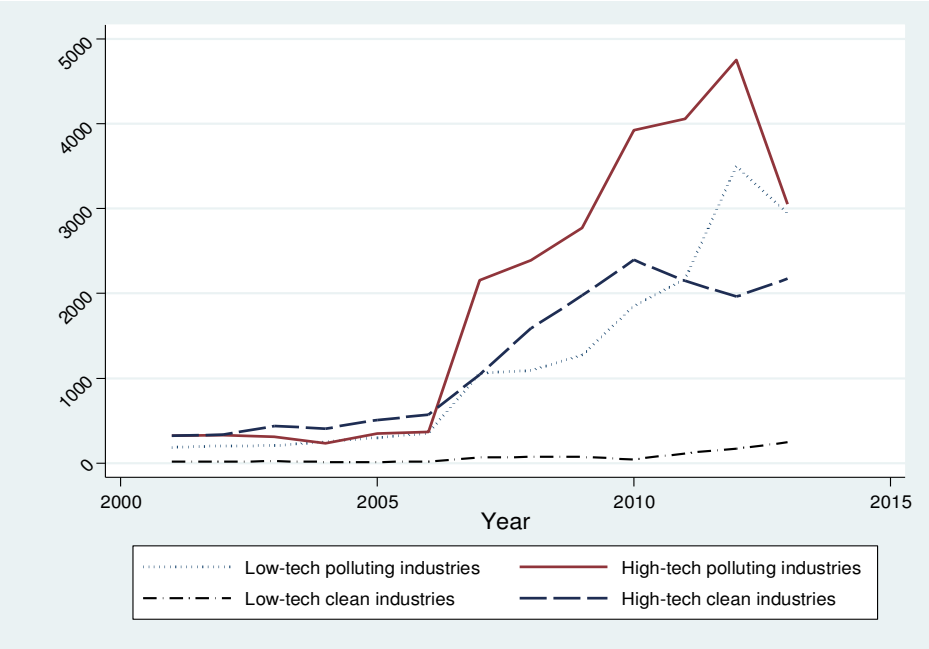


While the FDI from developed countries has grown in clean medium-high tech and high-tech industries including industrial machinery, electrical equipment, computer hardware and software,[8] FDI has been minimal or missed in some of the high-tech priority sectors identified in the liberalization development strategy like machine tools, scientific instruments, medical and surgical appliances. The FDI through Mauritius was largely in the category of higher technology clean industries, as observed in the two graphs. However, since FDI through Mauritius includes round-

[6] Based on the OECD classification of technology-intensity of manufacturing industries.
[7] Based on CPCB's classification of highly polluting industries, which are traditional polluting industries worldwide.
[8] Due to the reporting system of DIPP, we are unable to segregate FDI in computer hardware manufacturing and services. Similarly, FDI in telecommunications equipment and services are not separable in the reported data.

tripping of investment by domestic entrepreneurs, this investment would not represent access to newer technology expected to drive innovation and growth in India.

Figure 2. Manufacturing FDI Inflows by tech-intensity excluding Mauritius



3. Empirical Model

We first examine the nature of Indian industries that have attracted FDI, and then analyze the source (home) country characteristics, including their environmental regulatory stringency. We use FDI inflows to capture the FDI behavior into different industries, and from various source-countries. The FDI inflows provide an indicator of the attractiveness of the different industries. Our model captures the actual FDI flow responses to changes in the industry characteristics through the fifteen-year period in India. Indeed, several studies testing the impact of industry characteristics on FDI inflows have used FDI flows, including Elliott and Shimamotto (2008) and Globerman and Shapiro (2002), as FDI behavior is more comprehensively measured for flows than for stocks.

(a) Industry analysis

We model the FDI inflow in Indian manufacturing sector in industry *i* in year *t*, as a log linear function of the industry characteristics in India (host country), including size of the industry, capital-intensity of its production process, export-orientation of the industry, skill intensity of production, and industrial growth rate:

$$\log(FDI_{it}) = \alpha_i + \beta_1 \log(K/L_{it-1}) + \beta_2 \log(Skill_{it-1}) + \beta_3 \log(Size_{it-1}) + \beta_4 growth_{it-1} + \beta_5 \log(X_{it-1}) + \beta_6 \log(X_{it-1}) * Tech + \log(X_{it-1}) * Tech * Clean + y_t + \varepsilon_{it} \quad (1)$$

Where FDI_{it}, is the real FDI inflow in industry *i* in year *t* in India, K/L_{t-1} is the lagged capital-labour intensity of the industry, $Skill_{t-1}$ is the lagged skilled-labour intensity in production, $Size_{t-1}$ is the average manufacturing plant size of the industry, $growth_{t-1}$ is the growth rate of the industry experienced in the previous period, X_{t-1} is the lagged export orientation of the industry. We compute industry characteristics using Annual Survey of Industries data (concorded with FDI sectors). *Tech* is a discrete variable, ranging from 0 to 3, where 0 signifies low-tech, 1 medium-low tech, 2 medium-high tech, and 3 high-tech industry. *Clean* is a dummy for less-polluting industries, 0 for polluting and 1 for clean industry.

In equation (1) we incorporate industry fixed effects (α_i) to control for unobserved heterogeneity across industries and year fixed effects (y_t) to capture economy wide changes that affect decision to invest in India within the manufacturing sector. We use one-period lag values of all industry characteristics as we assume investment in current period is based on characteristics of industries in previous period.

We measure capital-labour intensity of industries as the ratio of real net fixed assets to the number of workers, which captures the essential infrastructure required for production in that industry in India. The definition of capital intensity of industries is consistent with Waldkirch and Gopinath (2008). We expect FDI in India to come into capital-intensive industries. However, it is important to recall that the highly polluting industries being typically capital-intensive in nature, are not as foot-loose, hence these industries may not re-locate to developing countries despite the stringent environment regulations in the developed countries (Copeland and Taylor 2003). Skill-intensity of industries is measured as the share of skilled personnel (supervisors and managers) to total persons engaged in the manufacturing industry *i* in year *t-1*. The use of higher technology in the production process would entail higher skill-intensity of labour, and we use this as a continuous variable to control for nature of the production process of an industry. Our summary statistics indicates that higher-technology industries are relatively more skill-intensive, and polluting industries are relatively more capital-intensive compared to polluting industries (see Table A2).

In order to distinguish between market-seeking FDI versus export-platform FDI in the Indian industries, we control for the export-orientation of industrial production. The interaction of export-orientation with *Tech* and *Clean* is included to discern differential the elasticity of FDI in high-technology and high-tech clean industries (omitted category being low-tech polluting industries). As the Indian NIC 2004 classification is concorded with the ISIC Rev. 3 classification, we utilize the export data from UNCOMTRADE Stats defined by ISIC Rev. 3 to calculate the export-intensity (total volume of exports to total output) of the industries. Since our industries are defined at the 4-digit industrial classification, we expect it is broad enough to capture export-orientation upstream and downstream production.[9] We also control for growth in the output of an industry, as it provides a signal to a potential investor on the economic prospects of the industry. Following

[9] Foreign investment of multinational corporations can track the vertical motive of FDI (Helpman 1984), whereby subsidiaries of firms in developed countries are set up in unskilled labor-abundant countries while head-quarter services (skilled-labour intensive) continue in the parent country. The subsidiaries export back either intermediate product for further processing or finished products to serve market of parent country or third country. In our analysis at the industry-level, although vertical-motive cannot be isolated we consider the exports at the 3-digit industry which can capture the processed products in the same broad industrial category.

Elliott and Shimamoto (2008), we measure industrial growth of output of host country in a period over the previous period. Since we take one-year lag, industrial growth in our model is measured by output of industry *i* in year *t-1* over period *t-2*.

(b) Country analysis

We next analyze the source-country characteristics of FDI into India. Resource endowments of the FDI source-countries are important determinants of the investment abroad, including capital, skilled-labour, etc., thus while testing for the pollution haven effect in FDI, environmental stringency of the parent country is considered as a determining factor (Waldkirch and Gopinath 2008, Chung 2014). We model FDI from source country *j* in year *t* as follows:

$$\log(FDI_{jt}) = \alpha_j + \beta_1 \log(K/L_{jt-1}) + \beta_2 \log(Skill_{jt-1}) + \beta_3 \log(GDP_{jt-1}) + \beta_4 Open_{jt-1} + \beta_5 \log(ES_{jt-1}) + y_t + \varepsilon_{it} \quad (2)$$

Where FDI_{jt} is the real FDI inflow in Indian manufacturing industry (classified by technology and pollution-intensity) from source country *j* in year *t*, with $K/L_{j,t-1}$ being the capital-labour endowment ratio of source-country *j*, $Skill_j$ the relative of skilled labour endowment in the source-country, GDP_j its gross domestic product, $Open_j$ is the relative integration of the source-country with the global market, and ES_j is the environmental stringency of country *j*. We also incorporate country dummies α_j to control for unobserved but fixed factors of countries affecting FDI behavior, and year dummies y_t to capture the time-varying economy-wide changes that affect decision to invest in the Indian manufacturing sector (e.g. investment easing policies in India). We take one-period lag value of all explanatory variables assuming that foreign investment in current period is based on previous period's determining factors.

Since FDI inflows from Mauritius represent round-tripping for financial gains, we estimate our model (2) excluding Mauritius. Distinguishing between the technology-intensity of clean and polluting industries, we estimate equation (2) separately for these categories of industries in order to discern the country characteristics associated with different industry categories.

Capital abundance of the countries is measured as real capital stock per total labour force (number of persons engaged) in the home country. The measure of capital abundance of countries is consistent with Chung (2014), and Waldkirch and Gopinath (2008). We expect the coefficient β_1 to be positive as we expect that capital-rich countries to be investing more.

The size of the source country is measured by its real GDP, and we expect larger countries to be the source of greater FDI inflow. We also expect more open economies to be investing more abroad (and importing back processed manufactures in case of resource-seeking FDI), and this is captured in the model through the measure of openness of the home country (export *plus* import as ratio of GDP).

The source-country skill abundance is measured as the ratio of highly skilled workers in total workforce of that country. Skilled workers in firms of the home country generate services including Research and Development, managerial activities, etc. (often termed as 'Headquarter Services'), and may choose to invest in India to seek markets or cheaper resources while retaining

skilled services in the parent firms. The definition of skilled labor is consistent with Waldkirch and Gopinath (2008). We expect that the FDI in high-tech manufacturing industries from source-countries relatively rich in skilled workforce would be of greater value in terms of bringing in state-of-the art technology into India.

In order to control for the environmental stringency in the source country, we use carbon intensity of production as a proxy as countries with strict environment regulations have relatively lower emissions as compared to the countries with lax environment regulations.[10] This is measured as carbon emissions in kgs per real GDP (constant US$). In tracking the pollution-haven effect, one typically needs to control for the endogeneity problem, in order to obtain consistent estimates. Since India still remains a small economy in terms of share of FDI received from the developed countries, we do not expect endogeneity to be present when tracking inflows from different countries.[11]

4. Empirical Results

The estimation results of equation (1) are summarized in Table 2. We examine the industry characteristics that attracted FDI inflows through the years, using fixed effects regression to control for unobserved industry heterogeneity. We find that foreign investment in India has indeed come into the relatively capital-intensive industries. However, after controlling for capital-intensity, we find that growth of foreign investment was significantly higher in the less skilled-intensive industries, and export-intensive high-tech polluting industries.

Considering the real FDI across the entire set of manufacturing industries, we find that FDI inflows grew significantly in capital-intensive industries (in all specifications R1-R5, Table 2), though those less skill-intensive. On average, the plant-size of industries receiving FDI have been larger, indicating higher scale of production in these sectors.

While FDI in clean industries are concentrated into less export-oriented industries, inflows of foreign direct investment in polluting industries grew significantly more in export-oriented industries (interaction terms with export-intensity in R3 and R4). This suggests that there may be a pollution haven effect through export-platform FDI in the group of high-technology polluting industries. In order to confirm this effect, we turn to our source-country analysis.

The estimation results of equation (2) is summarized in Tables 3, and excludes Mauritius, (since it is a routing country for tax benefits, FDI sourced from it cannot be truly attributed to Mauritius). In the country analysis, we report the fixed effects regression, controlling for country

[10] Although studies have used indices to measure stringency of environmental regulations of countries, including index of environmental stringency and enforcement of laws in Global Competitiveness Reports (available only until 2008-09); Environmental Performance Index (available from 2002); and Environmental Policy Stringency Index (available for OECD countries), data is limited, and not available for 1999 through 2013 as required in our analysis, nor available for all concerned FDI source-countries of India.

[11] To control for endogeneity of the environmental proxy, we also instrumented carbon intensity of output with the abatement in nitrous oxides (since 1990) which is associated with the carbon intensity (but independent of the error in FDI) and estimated by 2SLS. Even if environmental stringency measure is not exogenous, the 2SLS estimates would be consistent. We found the 2SLS-IV estimates (not reported) to be qualitatively same as the FE estimations.

heterogeneity. We estimate the model for technology-intensity industry groups separately, to discern the difference across the diverse categories of industries.

We find that larger countries have been the source of greater FDI in most industries: in the low-tech, medium-high and high-tech *polluting* industries (R1, R3, R4) as well as in medium-low, medium-high, and high-tech *clean* industries (R6-R8). Capital-rich countries have also been significant in FDI in low-tech *polluting* and high-tech *polluting* industries (R1, R4) but not so in high-tech clean industries (R8).

We also find that skill-rich countries have invested significantly in high-tech and low-tech *polluting* industries (where elasticity is greater in high-tech polluting compared to low-tech polluting industries, R5 and R8, Table 3), but not in high-tech *clean* industries. The highly significant negative elasticity coefficient of carbon-intensity, our environmental stringency proxy, for higher tech polluting industries (R4, Table 3) confirms the presence of a pollution haven effect in FDI inflows. i.e. Investors from countries with higher environmental stringency have invested significantly in polluting high-tech industries in India.

Table 2. Industry Analysis of FDI inflow in India

Dependent variable is log(real FDI*it*) in industry *i* in year *t.*

	All manufacturing			*Polluting*	*Clean*
	(R1)	(R2)	(R3)	(R4)	(R5)
log(Capital-labour ratio$_{it}$)	0.343***	0.338***	0.395***	0.413**	0.356**
	(0.118)	(0.121)	(0.121)	(0.196)	(0.157)
log(Skill-intensity$_{it}$)	-0.307***	-0.329***	-0.393***	-0.632***	-0.391***
	(0.111)	(0.107)	(0.108)	(0.220)	(0.127)
log(average plant size $_{it}$)	0.468***	0.487***	0.628***	0.855***	0.708***
	(0.154)	(0.156)	(0.162)	(0.260)	(0.217)
Industrial growth rate $_{it}$	-0.034	-0.0293	-0.0401	-0.0868	0.019
	(0.122)	(0.121)	(0.121)	(0.198)	(0.170)
log(Export-intensity $_{it}$)	-0.004	0.077	-0.002	-0.0078	0.032
	(0.077)	(0.0919)	(0.0730)	(0.080)	(0.190)
log(Export-intensity $_{it}$)*$Tech_i$		-0.0551	0.183***	0.176***	-0.071
		(0.0632)	(0.065)	(0.067)	(0.106)
log(Export-intensity $_{it}$)*$Tech_i$*$Clean_i$			-0.256***		
			(0.066)		
Observations	570	570	570	315	255
Industry dummy	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year dummy	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.737	0.738	0.745	0.738	0.777
F statistic	14.34	13.43	14.64	12.13	5.129
Prob>F	0.00	0.00	0.00	0.00	0.00

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Source-Country Analysis FDI in manufacturing industries by technology-group and pollution-intensity (excluding Mauritius)

Dependent variable is log (real FDI_{jt}) from country *j* in year *t* in the industry group indicated.

	Polluting manufacturing industries				Clean manufacturing industries			
	Low tech	*Medium-low*	*Medium-high*	*High tech*	*Low tech*	*Medium-low*	*Medium-high*	*High tech*
	(R1)	(R2)	(R3)	(R4)	(R5)	(R6)	(R7)	(R8)
$Log(GDP_{jt})$	2.526**	3.350	3.615***	3.551*	3.245	5.203**	2.221*	3.431***
	(1.013)	(2.701)	(1.220)	(1.836)	-2.35	-2.384	-1.242	-0.95
$Log(K/L_{jt})$	3.124**	0.191	1.468	7.923***	1.892	1.117	1.601	2.023*
	(1.444)	(2.652)	(1.577)	(2.214)	-2.565	-2.787	-1.375	-1.024
$Log(skill\ share_{jt})$	6.106**	-6.818	-3.342	13.72***	6.403	-5.053	-0.934	-3.216
	(3.019)	(5.389)	(2.809)	(3.698)	-5.387	-4.757	-2.544	-2.143
$Log(Openness_{jt})$	0.619	-0.960	3.146*	4.764**	-0.218	-0.338	1.494	2.390*
	(1.499)	(3.801)	(1.829)	(2.364)	-3.31	-3.17	-1.715	-1.364
$Log(CO_2\_intensity_{jt})$	0.107	-3.161	-2.063	-4.604**	-0.484	-0.0515	0.0182	-0.306
	(0.945)	(2.610)	(1.485)	(1.946)	-1.931	-1.303	-1.398	-0.926
No. of countries	9	9	9	9	9	9	9	9
Observations	132	112	124	104	89	76	124	133
Country dummy	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year dummy	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared	0.621	0.303	0.630	0.525	0.433	0.569	0.654	0.707
F statistic	10.29	1.468	8.865	4.181	1.137	.	7.061	6.749
Prob>F	0.00	0.119	0.00	0.00	0.341	.	0	0

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

Our study examined the pattern of FDI into Indian manufacturing to check whether one of the key goals of the liberalization regime to enhance foreign investment in high-technology industries has been realized. We find that although FDI inflows have increased substantially in capital-intensive industries, the investment has not been significant in skill-intensive manufacturing. Further, FDI has been significant in high-tech export-oriented *polluting* industries, which suggests the possibility of export-platform FDI in pollution-intensive industries. This is rather disconcerting since India's environmental performance has been poor, and the environmental Ministry acknowledges rampant violation of pollution norms. The poor environmental stringency puts India at risk of being a pollution-haven.

Our source-country analysis of India's inward FDI across industry groups, classified by tech-intensity and pollution-intensity, shows that FDI in low-tech and high-tech *polluting* industries are sourced from large, capital-abundant and skill-abundant countries (more developed countries). In high-tech pollution-intensive industries we find significant evidence of a pollution haven effect. Our results show that investors from capital-rich and skill-rich countries have been attracted towards low-tech polluting and high-tech *polluting* industries, rather than high-tech clean industries that are more skill-intensive and could have helped in the achievement of India's development goal.

References

Balasubramanyam, V. N. and David Sapsford (2007) "Does India Need a Lot More FDI?" *Economic and Political Weekly* 42: 1549-1555.

Chakraborty, C. and P. Nunnenkamp (2008) "Economic Reforms, FDI and Economic Growth in India: A Sector Level Analysis", *World Development* 36: 1192-1212.

Chung, S (2014) "Environmental Regulation and Foreign Direct Investment: Evidence from South Korea", *Journal of Development Economics 108: 222-236.*

Cole, M. A. and Robert J. R. Elliott (2005) "FDI and the Capital Intensity of "Dirty" Sectors: A Missing Piece of the Pollution Haven Puzzle", *Review of Development Economics* 9: 530-548.

Copeland, B. R. and M.S. Taylor (2003) *Trade and the environment: Theory and evidence*. Princeton University Press, Princeton.

Dean, J. M., M. E. Lovely and Hua Wang (2009) "Are Foreign Investors attracted to Weak Environmental Regulations? Evaluating the Evidence from China", *Journal of Development Economics* 90: 1-13.

Di,W. (2007) "Pollution abatement cost savings and FDI inflows to polluting sectors in China", *Environment and Development Economics* 12(6): 775-798

DIPP (2017) *Industrial Policy – 2017*, Discussion Paper, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India.

Echandi, Roberto, J. Krajcovicova and C. Zhenwei Qiang (2015) "The Impact of Investment Policy in a Changing Global Economy: A Review of the Literature", *Policy Research Working Paper 7437*, Trade and Competitiveness Global Practice Group, World Bank.

Elliott, Robert J.R. and K. Shimamoto (2008) "Are ASEAN Countries Havens for Japanese Pollution-Intensive Industry?", *The World Economy* 31: 236-254.

Eskeland, Gunar S. and Ann E. Harrison (2003) "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis" *Journal of Development Economics* 70: 1-23.

Garsous, G. and T. Kozluk (2017) "Foreign Direct Investment and the Pollution Haven Hypothesis: Evidence from Listed Firms", OECD Economics Department Working Paper 1379.

Globerman, S. and D. Shapiro (2002) "Global Foreign Direct Investment Flows: The Role of Governance Infrastructure", *World Development* 30 (11): 1899-1919.

Helpman, E (1984) "A Simple Theory of International Trade with Multinational Corporations", *Journal of Political Economy* 92: 451-71.

Manderson E, and R. Kneller (2012) "Environmental Regulations, Outward FDI and Heterogeneous Firms: Are Countries Used as Pollution Havens", *Environmental and Resource Economics* 51: 317-352.

Mulatu, A. (2017) "The Structure of UK Outbound FDI and Environmental Regulations", *Environmental and Resource Economics*. 68(2):1-32.

Nagaraj, R. (2003) "Foreign Direct Investment in India in the 1990s: Trends and Issues", *Economic and Political Weekly* 38: 1701-1712.

NCAER (2010) "FDI in India and its Growth Linkages", National Council for Applied Economics Research, Sponsored by Department of Industrial Policy and Promotion, Ministry of Commerce & Industry, Government of India.

Poelhekke, S. and F.V. Ploeg (2015) "Green Havens and Pollution Havens", *The World Economy*. 38(7): 1159-1178.

Rao, K.S. Chalapati, and Biswajit Dhar (2018) *India's Recent Inward Foreign Direct Investment: An Assessment*, Institute for Studies in Industrial Development, New Delhi.

Rao, K.S. Chalapati, and Biswajit Dhar (2011) "India's FDI Inflows: Trends and Concepts", *Working Paper 2011/01*, Institute for Studies in Industrial Development, New Delhi

Tang, J. (2015) "Testing the Pollution Haven Effect: Does the Type of FDI Matter?", *Environmental and Resource Economics*, 60: 549–578.

Uchikawa, S. (1999) Economic Reforms and Foreign Trade Policies: Case Study of Apparel and Machine Tools Industries. *Economic and Political Weekly*:138-148.

Waldkirch, A. and G. Munisamy (2008) "Pollution Control and Foreign Direct Investment in Mexico: An Industry-Level Analysis", *Environmental and Resource Economics* 41: 289-313.

Wei, W (2005) "China and India: Any Difference in their FDI Performances", *Journal of Asian Economics*, 16: 719-736.

Xing, Y. and C.D. Kolstad (2002) "Do lax Environmental Regulations Attract Foreign Investment?" *Environmental and Resource Economics*, 21: 1-22.

Data Appendix

The data on inflow of FDI by industrial sectors was provided by the Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce, Government of India. The data represents sector-wise FDI equity inflows from the top 10 investing countries in India for the 15-year period January 2000 through December 2014 and covers FDI through the automatic route[12]/Acquisition of shares/Foreign Investment Promotion Board. The top 10 countries investing include Cyprus, France, Germany, Japan, Mauritius, Netherland, Singapore, United Kingdom, United Arab Emirates and the United States. These countries together contribute around 85% of total FDI in manufacturing sector in India during the period 2000 to 2014. The foreign equity inflows by sector follows the industry classification of DIPP based on the Industrial (Development and Regulation) Act, 1951.

[12] Under automatic route, foreign investor can invest in any industry upto the ceiling allowed without any prior notice to the Reserve Bank of India.

The data on the characteristics of Indian industries is taken from the Annual Survey of Industries (ASI) defined at 4-digit National Industrial Classification (NIC). As the data spans fifteen years, the ASI data corresponds to NIC 1998, NIC 2004 and NIC 2008 classifications. Our ASI industry data covers the period 1999-00 to 2013-14 (lagged by a year), and we use the data on net book value of fixed assets, number of workers, value of output, number of supervisors and managers, number of total persons engaged, to measure different industry characteristics. While we utilized the NCAER (2010) study broadly – that provided the concordance of the DIPP sectors to 3-digit NIC codes, we make the concordance at the 4-digit NIC codes to further disaggregation for a better match.

Since the FDI data is provided by DIPP sector, the latter defines the unit of our industry analysis. While concording the 4-digit NIC codes with the DIPP industry groups, we find that a single DIPP sector sometimes mapped onto multiple NIC codes, and we included all these industry codes corresponding to a single DIPP sector. On the other hand, when a single 4-digit NIC-code mapped to more than one DIPP sector, we clubbed the latter in order to ensure unique matching between the DIPP sector with NIC codes. Although FDI at the DIPP sector-level includes both investment in both services as well as manufacturing, say in "Computer hardware and software", "Telecommunications", etc, we are unable to segregate services versus manufacturing in the data. Our final analysis has 38 sectors mapping to NIC codes. Table A3 summarizes the concordance between the DIPP sectors and disaggregated NIC codes (NIC 2004 and NIC 2008).

The data on exports by industry is obtained from World Integrated Trade System (WITS), using the ISIC (Rev.3) 4-digit industry classification. We use the ISIC Rev.3 trade classification as it conforms with NIC-1998 and NIC-2004. Thus, in our final sample we match the trade data with industry characteristics to the FDI data by DIPP industry classification to get a comprehensive database.

The country data is obtained from the World Bank database, the International Labor Organization, and the Penn World Tables 8.0. Data on carbon emissions, manufacturing exports, imports, GDP are obtained from the World Development Indicators. Data on skilled labor force is taken from the International Labor Organization. The ILO categorizes skilled labor force on the basis of occupation. We use data on highly skilled labor, defined in the categories of 'skill level 3 and 4', and total labor force. Data on real capital stock[13] and number of workers is obtained from the Penn World Table 8.0 for all top 10 investing countries in India.

[13] Capital stock in a country for a given year includes the initial capital stock of that year (adjusted for depreciation) and investment made during the year.

Table A1. Pollution and Technology classification of FDI industry sectors

Pollution category	Industry sector (DIPP classification)	Technology category
Clean	Computer hardware and software	High
	Electronics	High
	Mathematical, surveying, and drawing instruments	High
	Medical and surgical appliances	High
	Scientific instruments	High
	Agricultural machinery	Medium high
	Commercial, office and household equipment	Medium high
	Earth-moving machinery	Medium high
	Electrical equipment	Medium high
	Industrial instruments	Medium high
	Industrial machinery	Medium high
	Machine tools	Medium high
	Miscellaneous mechanical and engineering industries	Medium high
	Prime mover (other than electrical generators)	Medium high
	Rubber goods	Medium-low
	Coir	Low
	Diamond and gold ornaments	Low
	Tea and coffee	Low
	Timber products	Low
Polluting	Drugs and pharmaceuticals	High
	Automobile industry	Medium high
	Chemicals (other than fertilizers)	Medium high
	Dye stuffs	Medium high
	Fertilizers	Medium high
	Glue and gelatin	Medium high
	Photographic raw film and paper	Medium high
	Soaps, cosmetics and toilet preparations	Medium high
	Railway related components	Medium high
	Cement and gypsum products	Medium-low
	Ceramics	Medium-low
	Glass	Medium-low
	Petroleum and natural gas	Medium-low
	Fermentation industries	Low
	Food processing industries	Low
	Leather and leather goods	Low
	Metallurgical industries	Low
	Paper and pulp (including paper products)	Low
	Printing of books (including litho printing industry)	Low
	Sugar	Low
	Textiles (including dyed, printed)	Low
	Vegetable oils & Vanaspati	Low

Table A2. Summary statistics of skill-intensity capital-intensity of Indian manufacturing, classified by tech-intensity and pollution-intensity of industries

Variable		Mean	Std. Dev.	Min	Max	Observations	
Clean medium-high and high-tech industries							
skill	Overall	0.271645	0.591387	0.096388	8.726326	N =	210
	Between		0.176395	0.148831	0.864083	n =	14
	Within		0.56631	-0.36079	8.133888	T =	15
real_kl	Overall	0.091058	0.056594	0.02507	0.56662	N =	210
	Between		0.039153	0.039721	0.165025	n =	14
	Within		0.042103	-0.01569	0.502754	T =	15
Clean low and medium-low tech industries							
skill	Overall	0.101923	0.037431	0.036085	0.149242	N =	60
	Between		0.041912	0.041815	0.133082	n =	4
	Within		0.00783	0.085203	0.118083	T =	15
real_kl	Overall	0.040678	0.029392	0.0093	0.120404	N =	60
	Between		0.029094	0.017529	0.082449	n =	4
	Within		0.014775	0.019334	0.078633	T =	15
Polluting medium-high and high-tech industries							
skill	Overall	0.205495	0.100735	0.079392	0.982396	N =	120
	Between		0.078233	0.107209	0.304326	n =	8
	Within		0.068899	0.104358	0.883565	T =	15
real_kl	Overall	0.168028	0.145735	0.018771	0.554218	N =	120
	Between		0.151866	0.040182	0.462427	n =	8
	Within		0.029815	0.075745	0.269579	T =	15
Polluting low and medium-low tech industries							
skill	Overall	0.121604	0.042603	0.04605	0.30888	N =	210
	Between		0.040137	0.07087	0.223226	n =	14
	Within		0.017662	0.042005	0.207259	T =	15
real_kl	Overall	0.218538	0.43214	0.015005	2.756158	N =	210
	Between		0.417409	0.020437	1.647953	n =	14
	within		0.155518	-0.59118	1.326743	T =	15

Table A3. Concordance between DIPP sector and 4-digit NIC codes (NIC-2004 and NIC 2008)

DIPP Codes	DIPP Sector Description	NIC 2004 codes	NIC 2008 codes
0100	Metallurgical Industries	2711-2720, 2731-32, 2811-13, 2891-93, 2899	2410, 2420, 2431, 2432, 2511-2513, 2591-2593, 2599
0202	Petroleum and natural gas	2320	1920
0400 and 1200	Prime Mover (other than electrical generators) + Misc. Mechanical & engineering industries	2911-15, 2919	2811-16, 2819
0501	Electrical Equipment	3110, 3120, 3130, 3140, 3150, 3190	2710, 2720, 2731-33, 2740, 2790
0503	Electronics	3210	2610
0504	Computer hardware and software	3000	2620
0600	Telecommunications	3220, 3230	2630, 2640
0701	Automobile industry	3410, 3420, 3430, 3591-92, 3599	2910, 2920, 2930, 3091, 3092, 3099
0706	Railway related component	3520	3020
0800	Industrial Machinery	2923, 2925-26, 2929	2823, 2825-26, 2829
0900	Machine Tools	2922	2822
1000	Agriculture Machinery	2921	2821
1100	Earth Moving machinery	2924	2824
1300	Commercial, Office and Household equipment	2930	2750
1400	Medical and surgical appliances	3311	3250, 2660
1500 and 1700	Industrial Instruments. + Mathematical Surveying instruments	3312-13	2651
1600	Scientific Instruments	3320, 3330	2652, 2670
1800	Fertilizers	2412	2012
1900	Chemicals (other than fertilizers)	2411, 2413, 2421-22, 2429	2011, 2013, 2021-22, 2029
2000 and 3200	Photographic raw film and paper. + Glue and gelatin	2429	2029
2100	Dye-Stuffs	24114	20114
2200	Drugs and Pharmaceuticals	2423	2100
2300 and 4210	Textiles (including dyed, printed). + Coir	1711-14, 1722-23, 1725, 1730	1311-13, 1391, 1993-94
2400	Paper and Pulp (Including paper products)	2101-02, 2109	1701-02, 1709

2500	Sugar	1542	1072
2600	Fermentation Industries	1551-53	1101-03
2700	Food processing Industries	1511-13, 1520, 1531-33, 1541, 1543-44	1010, 1020, 1030, 1050, 1062-62, 1071, 1073-74, 1080
2800	Vegetable oil and Vanaspati	1514	1040
2900	Soaps, cosmetics and toilet preparations	2424	2023
3000	Rubber goods	2511, 2519	2211, 2219
3100	Leather and Leather Goods	1911-12, 1920	1511-12, 1520
3300	Glass	2610	2310
3400	Ceramics	2691-3	2391-93
3500	Cement and gypsum products	2694-95	2394-95
3600	Timber products	2010, 2021-23, 2029	1610, 1621-23, 1629
4205	Diamond, gold ornaments	3691	3211
4207	Tea and coffee (processing and warehousing coffee and rubber)	1549	1079
4209	Printing of books (including litho-printing industry)	2221-22	1811-12