

# Foreign Involvement and Firm Productivity-An Analysis for Manufacturing Firms in India

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## Abstract

The increasing internationalisation of manufacturing firms in India through outbound foreign direct investment (OFDI) is of major interest in an emerging markets context as contrary to the predictions of the Neoclassical theory, transferring large amounts of capital abroad by a relatively capital scarce economy appears odd. Using firm-level data for the period 1995 to 2010, based on two methodologies and two specifications of the production function to estimate total factor productivity (TFP) at the firm level, nonparametric methods are used to examine the nature of productivity differentials between firm categories (based on foreign involvement). For this, attempts are also made to refine the criterion for firm classification as OFDI firms, and improve on the measurement of input variables. For firms in the manufacturing sector, cross-sectional associations between foreign involvement and firm productivity suggest that in comparison to firms with purely domestic operations, and those that organise international activities only through exports, OFDI firms (that also export) have higher productivity levels. This link between foreign involvement and firm productivity could however be due to both self-selection and/or learning-by-outward investment. Productivity differentials vary, sometimes considerably, by 2-digit industry/industry groups. The research and development (R&D) intensity distribution for overseas investing firms (that also export) also lies marginally to the right of that for purely export firms, that in turn lies marginally to the right of that for purely domestic firms.

## 1 Introduction

In recent years, there have been important changes in the nature of firms. The dramatic rise in trade, OFDI, offshoring and outsourcing reflect the new way firms organise their activities (Gattai, 2006). Firms are investing abroad in an increasing range of markets, industries and products, experiencing changes in their technology sourcing, contractual patterns and asset structures. Foreign production/activities range from the export substituting kind, horizontal or market-seeking OFDI (Markusen, 1984; Brainard, 1997; Helpman, Melitz and Yeaple, 2004 (below HMY)), to vertical or resource-seeking OFDI (Helpman, 1984), to complex integration strategies (Yeaple, 2003).

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Although there has been an impressive increase in both the *intensive* and *extensive margins* of trade and OFDI,<sup>2</sup> Mayer and Ottaviano (2008), Bernard, Jensen, Redding and Schott (2012) (below BJRS) and Antràs and Yeaple (2013) among others document that micro level empirical studies have shown that international activity is concentrated among a few very large firms that are active in more than one country and in more than one industry.<sup>3</sup>

In explaining the observed *heterogeneity* in the foreign involvement decision of firms, empirical insights from the trade literature (Bernard and Jensen, 1995, 1999, 2004) placed within-industry *heterogeneity* in firm productivity (Baily, Hulten and Campbell, 1992; Bartlesman and Doms, 2000) in a dominant position. Further, within the theoretical constructs of the *new new trade theory* literature (Melitz, 2003; HMY; Melitz and Redding, 2012) firm productivity explains the *self-selection* of firms into foreign markets. Firm productivity has also been taken as an important result of the *learning effects* from foreign contact following Clerides et al. (1998).

Several studies document the increasing internationalisation of Indian firms.<sup>4</sup> Indian FDI outflows have increased considerably from \$ 0.119 billion in 1995, \$ 0.514 billion in 2000, \$2.985 billion in 2005, \$14.285 billion in 2006 to \$14.752 billion in 2011 (3% of Gross Fixed Capital Formation, 2008-2011, annual average). Outward FDI stock has increased from \$0.495 billion in 1995 to \$111.257 billion in 2011 (5.7% of Gross Domestic Product, 2011)<sup>5</sup>. Also, a number of studies, for instance, Mukim (2011), Thomas and Narayanan (2012), and Haidar (2012) for exports; Pradhan (2004), Kumar (2007), Demirbas, Patnaik and Shah (2013), Bhattacharya, Patnaik and Shah (2012) (below BPS), Goldar (2013) and Thomas and Narayanan (2013) for exports and OFDI; and Lancheros and Girma (2010) for OFDI and outsourcing examine if productivity is fundamental to the firm's foreign involvement.

Based on a large sample of Indian manufacturing firm-level data obtained from the CMIE *Prowess* database for 1995-2010, (about 6,068 firms; 57,698 observations), (refer Table A.1 in the Appendix below), this paper seeks to establish if there is a positive link between firm productivity and organisation of international activities through exports and/or OFDI. Exports and OFDI are the only two channels of foreign market access that are being

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<sup>2</sup>*Extensive margin* for exports is the number of firms involved in exports, while *intensive margin* is the average firm-level exports conditional on exporting. Likewise, for OFDI, *extensive margin* is the number of firms involved in OFDI, while *intensive margin* is the average firm-level OFDI flows conditional on doing OFDI.

<sup>3</sup>In support, the present study finds that Indian foreign investment activity is very much concentrated. In 2009 and 2010, of the sampled firms, the top1% outward investors from manufacturing account for 64.5% and 68% of the total investment outside India (*Prowess4* database and own calculations).

<sup>4</sup>For example, Report of the Working Group on Foreign Investment, 2010, Tables 3.5 and 3.6; UNCTAD, 2014.

<sup>5</sup>UNCTAD, 2013, Tables 1and 3.

considered for analysis. Although the positive link could be due to the most productive firms *self-selecting* themselves into foreign markets, it could also reflect *learning effects* through foreign engagements.

This paper begins in Section 2 by reviewing the related theoretical international trade literature on firm productivity and multinational firms. Section 3 highlights the important contributions of the empirical firm productivity, exports and OFDI literature. Section 4 describes panel data and construction of real output and input series required for estimating firm productivity. Section 5 discusses the methodological issues, alternate productivity estimation approaches and the productivity estimation approach followed in this study. Section 6 discusses firm characteristics by categories, and gives inter-industry comparison. Section 7 compares distributions of firm productivity for firms that export as well as invest abroad, pure exporters, and firms that serve the domestic market only for the alternate productivity estimation methodologies/production function specifications, and the alternate definitions of outward orientation. Section 8 summarises and concludes. The Appendix presents additional tables, and provides inter-industry productivity density plots as per internationalisation status of firms.

## 2 Theoretical considerations

Early empirical findings on firm heterogeneity and trade, Bernard and Jensen (1995, 1999) observed that only a *few* firms export, and others in the same industry do not, and exporters are marked by clear defining characteristics in terms of size, productivity, capital intensity, skill and wages. On the theoretical side, this was at odds with Krugman's *new trade theory* where all firms export. Theoretical research on the firm and international trade in the *new new trade theory* framework associated with Melitz (2003) and Bernard, Eaton, Jensen and Kortum (2003) (below BEJK) introduces firm heterogeneity<sup>6</sup> that underlies comparative advantage. The productivity ordering pattern between exporters and purely domestic firms in trade (Melitz) has been extended to outward investing firms (HMY and Head and Ries, 2003 (below HR)).

In HMY, firms face the proximity-concentration trade-off. Self-selection entails the least productive firms to exit from the industry, less productive firms cater only to the domestic market (D), more productive firms choose to export (DX) as they can cover the higher cost of export. At some point, these firms are able to afford the sunk costs of OFDI

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<sup>6</sup>BEJK develop another approach based on the Ricardian model of comparative advantage to explain plant-level export behaviour.

and make the transition to the next level and invest abroad (DI).<sup>7</sup> The model predicts the sorting of firms into different organisational forms based on their productivity draw. The HMY model with its focus on firm heterogeneity can be related to a wider literature on firm-specific advantages and firm-level determinants of OFDI.

Head and Ries (2003) develop an alternate model to get the HMY predictions and consider the empirical complementarity between exports and OFDI to extend the choice from exports or OFDI to exports and OFDI. The prediction of the productivity ordering between D, DX, DXI (export and invest abroad) is closer to the empirical literature in developing economies that suggests that it is exporters that graduate to the next level and invest overseas. In the context of the literature on emerging market MNEs, while the asset-seeking motive may dominate over asset-exploitation, some firm-level capacity to absorb resources is required.

### 3 Related empirical literature

#### *Exports and productivity*

On the empirical side, the bulk of the early studies established the superior performance of exporters of *manufactured goods* over domestic producers using estimated export premia,<sup>8</sup> tested for differences in average productivity, and tested for stochastic dominance of productivity distributions (e.g., Aw and Hwang, 1995; Bernard and Jensen, 1999; Delgado, Farinas and Ruano, 2002; ISGEP, 2008).

#### *Exports, OFDI and productivity*

HMY find support for their model in their analysis of the relationship between the exports to OFDI ratio of 4-digit US manufacturing industries. Regressing log of productivity (taken as value added per worker) on a set of controls, HMY find that an export firm has a productivity advantage of around 39% over non-exporters while an outward investing firm has a productivity advantage of around 15% over an average export firm. The scope of the coverage of the microeconomic evidence on testing the predictions of HMY is wide. Head and Ries (2003) replicate the HMY prediction without imposing CES preferences and

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<sup>7</sup>The nomenclature D, DX, DXI and DI follows Head and Ries (2003) and Demirbas, Patnaik and Shah (2013) among others.

<sup>8</sup>The export premium shows the average percentage difference in productivity/other performance characteristics between exporters and non-exporters in the same industry. A regression of the form:

$\ln X_i = \alpha + \beta \text{Export}_i + \gamma \text{Industry}_i + \varepsilon_i$  is used to estimate the export premium ( $100 * (\exp(\beta) - 1)$ ), where  $X_i$  is log productivity/other performance characteristics,  $\text{Export}_i$  is a dummy for current export status and  $\text{Industry}_i$  is a dummy for industry. The export premium can also be conditional on additional firm characteristics (Bernard and Jensen, 1999).

‘iceberg’ transportation costs. For 1,070 large Japanese firms in 1991, the study shows that there exists a hierarchy in productivity levels of firms investing abroad, exporting firms and purely domestic firms, although the differences tend to be statistically insignificant and there is weak correlation between firm size and productivity.

Girma, Gorg and Strobl (2004) for Ireland in 2000, find that while the most productive firms engage in OFDI, no significant differences are discernible between exporters and domestic firms. Kimura and Kiyota (2006) for Japan in 1996-2002, also find similar patterns. Wagner (2006) for Germany in 1995, Bogheas and Gorg (2008) for Ireland<sup>9</sup> and Arnold and Hussinger (2010) for Germany find support for Helpman, Melitz and Yeaple (2004). Damijan, Polanec and Prasnikar (2007) for Slovenia find no statistically significant advantage of firms with foreign affiliates over exporting firms although firms that export and engage in OFDI are twenty percent more productive than firms that serve only domestic markets.<sup>10</sup>

Tian and Yu (2012) for firms in the Zhejiang province<sup>11</sup> of China, find that for 2006-2008, there is positive correlation between firm productivity and OFDI, higher productivity firms are more likely to undertake OFDI (that is, the *extensive margin* of OFDI), and the higher is firm productivity, the greater is OFDI (that is, the *intensive margin* of OFDI). Unlike HR, the study finds no significant effect of host country income on the firm’s decision to undertake OFDI.

Castellani and Zanfei (2007) for Italy find that productivity is highest for firms with manufacturing activities abroad, followed by firms with only non-manufacturing activities abroad (an intermediate category, considered to have a lower commitment to foreign markets), followed by exporters and then the domestic producers. Tomiura (2007) for Japanese manufacturing firms in 1998 sorts productivity by the modes (combination) of foreign activities and finds that firms engaged in OFDI or in multiple globalisation modes are more productive than foreign outsourcers and exporters, that are in turn more productive than domestic firms.

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<sup>9</sup>Bogheas and Gorg (2008) however note that studies that focus on only a couple of the many alternative strategies for global engagement may potentially yield wrong predictions and demonstrate the superiority of capturing a greater variety of organisational forms.

<sup>10</sup>That the HMY prediction does not hold in the comparison between firms with foreign affiliates and exporters is however traced to transition-specific transitory factors related to inherited foreign investments of large inefficient firms. TFP nevertheless has a positive effect on the probability of investing in the first-ever foreign affiliate.

<sup>11</sup>Zhejiang province being the largest province in the number of OFDI firms in 2007 and the largest in OFDI in 2010.

Yeaple (2009) demonstrates that the HMY sorting extends to the scale and scope of multinational enterprises and finds that the most productive US firms invest in a larger number of foreign countries and sell more in each country in which they operate. Aw and Lee (2008) focus on the production location decision of Taiwanese electronic multinationals in 2000 and find that more productive firms engage in OFDI, firms that invest in US have higher productivity than those that invest in China as well as those that have no overseas assets.

Engel and Procher (2012) note that while theoretically the HMY model applies to market-driven OFDI, empirically it is difficult to disentangle between the different motives for OFDI.<sup>12</sup> For a large sample of French firms from all business sectors that include manufacturing and services sectors, with the exception of the construction industry, the HMY model is confirmed, with MNEs exhibiting the highest productivity followed by exporters and domestic companies. Findings support the HR prediction in Europe with more market-driven outward investing firms exhibiting higher productivity than comparatively less market-driven ones. That MNEs with investments in high-wage countries do not outperform MNEs with investments in low-wage countries in firm-productivity is taken as evidence that high-wage countries are also targets of substantial vertical OFDI (for R&D seeking, for instance).

For India, Iyer (2009), using data from *Prowess*, UNCTAD (2004) and India Brand Equity Foundation over 1989-2004, compares the productivity in India of 15 foreign multinationals, 13 Indian multinationals, 53 domestic firms which export (defined as firms that export over the entire sample period) and 31 domestic firms that sell only at home. Indian multinationals are found to have higher export intensity, R&D intensity and import intensity than foreign multinationals in India. Results based on estimated productivity premium (with controls for firm characteristics and sector dummies) suggest that Indian multinationals have higher productivity than foreign multinationals, followed by domestic exporters and domestic non-exporters respectively. Explanations for the above findings are based on the technological adaptation capability of Indian multinationals, as in Lall (1983).

Bhattacharya, Patnaik and Shah (2012) for 2000-2008 find differences between manufacturing and services industries with regard to the productivity ordering between

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<sup>12</sup>Two alternate approaches for classifying firms' foreign investments into resource-driven and market-driven OFDI can however be used to enhance the empirical precision of the HMY hypothesis. The study distinguishes between the *host country approach* of HR whereby low productive firms enter only low-wage but not high-wage countries and the *NACE approach* that requires similar industry affiliation of the parent company and its subsidiary for market-driven OFDI, and vertical subsidiaries active in upstream (or downstream) industries from their parent's industry for resource-driven OFDI.

exporters and OFDI. While the HMY predictions hold for a manufacturing industry, namely chemicals where firms with OFDI are more productive than exporters, a symmetric analysis for the software services industry reverses the predictions with the least productive firms self-selecting themselves to undertake OFDI.

## 4 Data and variable construction

### 4.1 Criteria for firm categorisation

For this study, identification of firms with foreign investments in *Prowess* is done on the basis of the *investment outside India* data field following Narayanan and Bhat (2010), Demirbas, Patnaik, and Shah (2013) and Dougherty (2013) wherein sector classification is done only on the basis of the activity of the investing firm, not its affiliates outside India. Following this definition, in 2008 for instance, the sample of firms with *investment outside India* (that may also export) is 447 out of nearly 4,303 firms in that year. Firms are categorised into D, DX, DXI, DI and DIDXI. D represents firms that only serve the domestic market; DX firms also export. DX thus covers not only the continuing exporters (that is, those firms that export continuously over the sample period) but also firms that switch their export status from domestic to exporter in the current year  $t$ . DXI firms export and invest abroad. DI firms invest abroad but do not export. Further, the DXI and DI categories are also merged to form the outward investing firms' category, henceforth represented by DIDXI. In this study, the DIDXI category is used to define the OFDI firm category.

To make the cross sectional comparisons of estimated productivity distributions for D, DX and DXI category firms, two specifications are used: S1, where DX represents firm-years where the firm's export/sales ratio (*export intensity*) is positive while DXI represents firm-years where the firm's export intensity and investment outside India/total assets ratio (*foreign investment intensity*) is positive and the alternate specification, S2, where a 1% cut off on the firm's export intensity is imposed to define firm-years as DX, while in addition to the 1% cut off on the firm's export intensity a 1% cut off on the firm's foreign investment intensity is required to define firm-years as DXI. Likewise, DI covers non-exporter firms with foreign investment intensity of 1% and above. An attempt is then made to see whether the stricter basis for classifying foreign investors affects the productivity rankings of firm categories. A comparative analysis of the estimates of the productivity distributions for these categories of firms is also undertaken at the two-digit industry/industrial groups.

## 4.2 Data and construction of variables

A panel of 6,068 firms is constructed, after data cleaning. To reduce potential bias due to sample selection, the data or firm coverage is not restricted to large firms alone. Wider industry coverage allows cross-industry heterogeneity. Some modifications are applied towards the construction of real output (gross output, value added) and input series (intermediate inputs, namely, raw materials, energy and services; labour and capital) required for the estimation of firm productivity. The ‘combined’ intermediate input series is formed using separate 3-digit specific price deflators for raw materials, energy and services using IOTT 1993-94 and 2003-04.

Incomplete coverage of the labour input in the database leads to the need for imputation/estimation of the labour input (also see Chawla, 2012). Given the widely noted heterogeneity in wages across firms, the ASI based method of imputing firm employment<sup>13</sup> has been criticized for its implicit assumption of a uniform wage rate among all firms belonging to an industry (Goldar, Renganathan, Banga, 2004; Siddharthan and Lal, 2004; Lancheros and Girma, 2010; among others). The imputed estimates of the labour input following the ‘ASI-based approach’ are thus adjusted for a ‘wage premium’ based on ownership categories. Physical real capital stock is constructed following the Perpetual Income Method (PIM), allowing for disaggregated growth of investment, and is combined with ‘knowledge’ or R&D ‘capital’ stock.

## 5 Estimation of firm productivity

For the gross output specification of the Cobb-Douglas production function (in logs),<sup>14</sup> with output  $y_{it}$  as the dependent variable, log of total factor productivity ( $\omega_{it}$ ) is estimated as the residual from the linear regression:  $\hat{\omega}_{it} = (y_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_m m_{it})$

Alternately, in the value added specification,  $v_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \eta_{it}$

where  $v_{it}$  is log of real value added,<sup>15</sup> log of total factor productivity ( $\omega_{it}$ ) is estimated as the residual from the above linear regression:  $\hat{\omega}_{it} = (v_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it})$

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<sup>13</sup> The ‘ASI-based approach’ involves the computation of an average wage rate (emoluments per employee, at the 2-digit or 3-digit industry level), obtained by dividing Annual Survey of Industries (ASI) data on total emoluments by the total persons engaged. Subsequently, by dividing each firm’s wage bill obtained from the company database by this computed average wage rate, an imputed measure of the employment in the firm is arrived at.

<sup>14</sup>  $k_{it}$  (capital) is a quasi-fixed input;  $l_{it}$  (labour) and  $m_{it}$  (intermediate inputs) are variable inputs.



## 5.1 Methodological issues

This section reviews two of the methodological issues or sources of potential biases in the productivity estimates, namely, *simultaneity bias* and *value-added bias*.

### 5.1.1 Simultaneity problem due to unobserved productivity

Contemporaneous correlation between the observed input levels and unobserved firm-specific productivity process, leads to ‘simultaneity bias’, making OLS estimates of the input coefficients (and productivity) biased and inconsistent.<sup>16</sup> Alternative semi-parametric, *proxy variables approaches* in the literature (Olley and Pakes, 1996, (below O-P); Levinsohn and Petrin, 2003, (below L-P); Akerberg, Caves and Frazer, 2006, (below ACF)) attempt to overcome ‘simultaneity bias’ by taking an observed input decision of the firm, (investment in physical capital in O-P, and intermediate input demand in L-P)<sup>17</sup> as a function of the state variables of the firm (namely, productivity and capital), and show when this demand is strictly positive, and the production technology satisfies the invertibility condition, unobserved productivity can be expressed only as a function of the observable inputs (namely the capital input and the proxy variable,  $\omega_{it} = g_t(k_{it}, m_{it})$ ), and be controlled for in estimation. In L-P, the estimation algorithm in the *first stage* involves the identification of the labour coefficient, while the *second stage* involves the identification of the capital and materials coefficients.

Akerberg, Caves and Frazer (2006), however point out that under the assumption that labour and materials are both chosen simultaneously, they are likely to be functions of the same state variables, namely, productivity and capital ( $m_{it} = m_t(\omega_{it}, k_{it})$ ;  $l_{it} = f_t(\omega_{it}, k_{it})$ ). Under the L-P invertibility condition,  $l_{it} = f_t(g_t(k_{it}, m_{it}), k_{it})$  where  $g_t = m_t^{-1}$ , such that in the first stage, the coefficients on the variable inputs are nonparametrically unidentified due to collinearity with the inverted function. ACF attempt to recover the input coefficients by modifying the timing assumption, wherein, as in L-P, capital  $k_{it}$  is assumed to be chosen at time  $t-1$ , intermediate inputs  $m_{it}$  at time  $t$ , but adjustment time for hiring and firing labour

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<sup>15</sup> Real value added is calculated by deflating the nominal value added (the difference between the value of output and the value of intermediate inputs) by the *double-deflation* method that involves deflating revenue and intermediate inputs with their own deflators.

<sup>16</sup> The problem is more pronounced for inputs that adjust rapidly (Levinsohn and Petrin, 2003).

<sup>17</sup> L-P suggest taking the optimal level of intermediate input demand as the proxy variable instead as investment demand as in O-P as a large fraction of the observed data sets report non-positive investment, and using O-P may thus lead to large truncation of the data.

allows labour to be chosen by the firm at time  $t-b$ , where  $0 < b < 1$  so that it is ‘less variable’ than intermediate inputs, and being determined prior to intermediate inputs enters the set of variables that affect the choice of the intermediate inputs:  $m_{it} = f_t(\omega_{it}, k_{it}, l_{it})$ .

Wooldridge (2009), (below W-LP) modifies the L-P estimator to address the collinearity issues raised above by a joint GMM estimation of the system, such that the first stage of O-P and L-P provides identifying information for parameters on the variable inputs (such as labour), and efficiently accounts for serial correlation and heteroscedasticity in the errors. The contemporaneous state variable,  $k_{it}$ , any lagged inputs, and functions of these are taken as instrumental variables in estimation.

### 5.1.2 Value added bias

Some studies point out that the relative superiority of exporters in comparison to purely domestic firms may result from several sources of potential bias in productivity estimates, also related to the selection of the functional form of the production function, namely, gross output vs. value added, (Gandhi, Navarro and Rivers, 2011, 2013, and Rivers, 2013). The VA production functions require separability of intermediate inputs and primary inputs of (capital and labour),<sup>18</sup> and may lead to identification problem and bias of the productivity measure in that it ignores the role of intermediate inputs (Rivers, 2013). Output heterogeneity among firms thus reflects not only the variation in productivity, but that in excluded inputs (intermediate inputs) as well, since value added only controls for the variation in capital and labour. As intermediate input usage is likely to be correlated with productivity, it could overstate the true degree of productivity heterogeneity. Also, the correlation between intermediate input usage and inputs that are controlled for (capital and labour) may cause biased output elasticity estimates for these inputs.

With empirical value added denoted by  $VA_{it}^E$ , and  $S_{it}$  being the share of intermediate input expenditures in total output:  $VA_{it}^E = Y_{it} (1 - S_{it}) = F(L_{it}, K_{it}, M_{it}) e^{\omega_{it} + \varepsilon_{it}} (1 - S_{it})$  (equation (14) in Gandhi, Navarro and Rivers, 2011),  $x_{it} = (k_{it}, l_{it})'$  and  $\beta = (\alpha_k, \alpha_l)'$  (output elasticities for the primary inputs), upon taking log transformation of the production function, and regressing log value added on primary inputs yields:

$$b = \beta + \underbrace{E[x_{it}x_{it}']^{-1} E[x_{it}\omega_{it}]}_{\text{'transmission bias'}} + \underbrace{E[x_{it}x_{it}']^{-1} E[x_{it}(\alpha_m m_{it} + \ln(1 - S_{it}))]}_{\text{'value-added bias'}} + \underbrace{E[x_{it}x_{it}']^{-1} E[x_{it}\varepsilon_{it}]}_{= 0}$$

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<sup>18</sup>For Indian manufacturing, Pradhan and Barik (1998) find through a statistical test that primary and intermediate inputs are not separable in the production function, thus weakening the option of using value added for the estimation of TFP.

The bias in estimating the coefficients on the primary inputs thus consists of two components. The first term is the ‘transmission bias’, that results from the correlation between productivity and the primary inputs while a second bias identified as the ‘value-added bias’ results from the failure to subtract intermediate inputs from gross output to fully control for the contribution of intermediate inputs to output (Gandhi, Navarro and Rivers, 2011, p. 20).<sup>19</sup>

## **5.2 Empirical specification: production function estimation**

Two sets of input coefficients are estimated in an attempt to explore whether similar concerns are of importance when investigating the relative superiority of OFDI firms (that also export). Estimates of firm-productivity, and relative firm-productivity index (following Pavcnik, 2002) are obtained from applying two alternative specifications of the production function, the gross output (GO) specification based on the Levinsohn and Petrin (2003) approach,<sup>20</sup> and the value added (VA) specification based on Wooldridge (2009) approach,<sup>21</sup> at the 2-digit industry/industry group level. Within each of these two approaches, productivity estimates are also compared for the two alternative classifications of exporters and outward investing firms (specifications S1 and S2 respectively).

For the gross output (revenue) production function parameters estimated using the L-P approach, intermediate inputs have the highest coefficient in all industries, followed generally by labour and capital. All L-P input coefficients are bounded away from zero and the L-P coefficient is lower than that under OLS in 10 of the 14 industries/groups, broadly consistent with the direction predicted by theory (that the OLS coefficients on variable inputs such as labour and materials should be biased upwards, whereas the direction of the bias on the capital coefficient in a multi input framework is ambiguous).

For the value added specification estimated using the W-LP approach, estimated equations correspond to equations 2.10 and 2.11 in Wooldridge (2009), and vectors of the

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<sup>19</sup>Pradhan and Barik (1998) find through a statistical test that primary and intermediate inputs are not separable in the production function, thus weakening the option of using value added for the estimation of TFP in the Indian manufacturing sector.

<sup>20</sup>The L-P approach is implemented using the `levpet` command (as in Petrin, Poi and Levinsohn, 2004).

<sup>21</sup>The W-LP method is implemented using the program available at <http://www.econ.umn.edu/~petrin/programs.html> using `ivreg2.do`. Under `ivreg2`, the estimator option `gmm2s` (that produces the IV/2SLS estimator, standard errors consistent under homoscedasticity) when combined with the `cluster` option, generates two-step efficient GMM (EGMM) estimates (that is statistics robust to heteroscedasticity and clustering at the firm level). `cluster` standard errors are robust to both arbitrary heteroskedasticity and arbitrary intra-group correlation. The `ivreg2` Stata module developed by Baum, Schaffer and Stillman (2012), available at <http://ideas.repec.org/c/boc/bocode/s425401.html> is used for estimation.

exogenous, endogenous, and instrumental variables follow Petrin, White and Reiter (2011). The production function coefficients obtained by W-LP are mostly significant at the 1 % level. Results of the over identification tests of the joint null hypothesis that the instruments are valid that is, they are orthogonal to the error term, and the excluded instruments are correctly excluded from the estimated equation (as given by the  $p$ -values for the Hansen  $J$  statistic test) indicate that for most cases, the validity cannot be rejected at a cut off of 10%. The W-LP procedure yields TFP estimates from 1997 onwards as inputs used during the first two years of the sample period are used as lagged inputs.

## 6 Descriptive statistics

### 6.1 Broad features by firm category

Over the entire sample period, Table 1 shows the classification of firm-year observations as D, DX, DXI, DI and DIDXI (=DXI+DI) following specifications S1 and S2 respectively.

**Table 1: Firm-years (in percentages), by foreign involvement, 1995-2010**

S1					S2				
D	DX	DXI	DI	DIDXI	D	DX	DXI	DI	DIDXI
42.26	51.89	5.49	0.35	5.84	51.27	45.82	2.51	0.39	2.9

Source: *Prowess 4* and own calculations.

As observed in the table, only a small fraction of observations (5.84% S1, 2.9% S2) correspond to foreign investors<sup>22</sup> while a large proportion (51.89% S1, 45.82% S2) correspond to exporters.<sup>23</sup> Also, in 2009/10, the DIDXI category accounted for 53 % of sales of all firms in the sample (by S1) and 19.67% (by S2). The export and foreign investment intensity varies greatly between firms. For instance, in 2009/10, among the 1,771 exporters, about 18.4% export less than 1% of their sales, while another 34.5% export between 1 to 10 percent of their sales, 32.9% export 10-50% of their sales, 7.5% export 50-75% of their sales and 6.5% export 75 to 100% of their sales. Also, among the 444 outward investors in the same year, 48.4% firms have a foreign investment intensity of less than 1%, 35.6 % hold 1 to 10 % assets abroad; another 15% invest between 10 to 50 % assets abroad while 0.006% hold 50-75% assets abroad.

<sup>22</sup>Following S2 however may cause a firm's classification to change to a non-exporter and/or a non-overseas investor firm if a change in exports (and/or investment outside India) and/or in sales/total assets causes these ratios to fall below 1% (as for *Videocon Industries* in 2006) among others, instead of an actual change in the firm's trajectory between export and/or overseas investment and the domestic market over any given period.

<sup>23</sup>Unlike the empirical findings wherein *few* firms export, (e.g. Bernard et al., 2007 for US, where exporters represent only 18% of the total population), the relatively large share of exporting firms in the sample reflects the oversampling of the relatively large and medium firms in the data base.

Several empirical studies have shown that the exporting and foreign investing firms are generally larger in size (usually identified by employment status as in Bernard et al., 2007 or by sales and/or assets). The size regularity is also found in the present data. Firm size (measured by sales) is positively related with the percentage of firms participating in overseas investment. Table 2 shows the broad features of the structure of firms with foreign operations as compared to those that do not. The left-hand panel is for specification S1 and the right-hand panel is for specification S2.

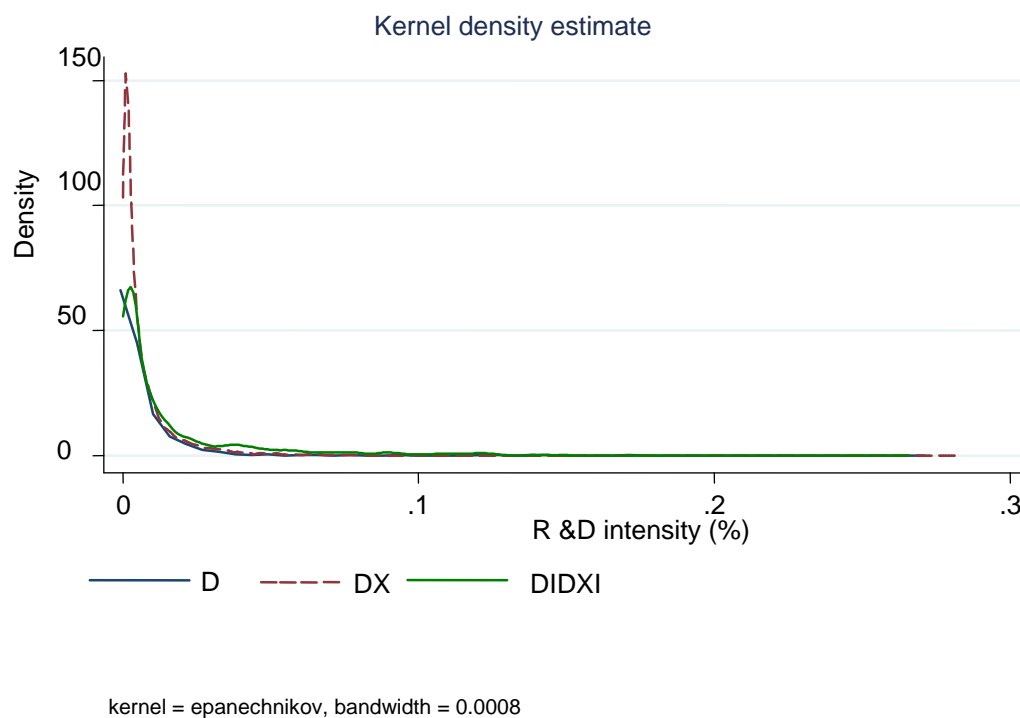
**Table 2: Descriptive statistics by foreign involvement (after data cleaning), 1995-2010**

Variable	S1						S2									
	D	DX	DI	DXI	D	DX	DI	DXI	D	DX	DI	DXI				
	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range		
<b>Ln TFP index</b>	-.028	- .189/.139	.0005	-.151/.166	.068	-.078/.294	.061	-.114/.227	-.018	-.176/.150	-.0004	-.155/.165	.150	-.051/.360	.042	-.149/.189
<b>Ln TFP</b>	.170	-.04/.43	.249	.027/.489	.259	.048/.473	.306	.06/.541	.181	-.029/.443	.257	.029/.496	.343	.063/.543	.255	.049/.474
<b>Sales (in Rs. cr)</b>	21	7/ 55	65	24/173	117	30/772	385	133/1027	26	9/74	69	25/191	212	41/961	408	121/1137
<b>Total assets (in Rs. cr)</b>	18	8/44	60	24/166	143	41/610	414	145/1183	22	9/61	64	25/189	189	50/731	541	141/1421
<b>R&amp;D expenditure (in Rs. cr)</b>	.1	.04/.4	.4	.1/1.4	1	.2/3	2.7	.7/13	.2	.1/.7	.5	.1/2	3	.44/8	4	.8/23
<b>Export intensity (in %)</b>	-	-	8.5	2/28	-	-	17.6	6/42	0	0/0	13	5/35	0	0/4	22	9/48
<b>Foreign investment intensity (in %)</b>	-	-	-	-	1	.4/4	.9	.1/4	.2	0/5	.1	0/4	3	1/8	4.4	2/10
<b>Output (in 1999/00 rupees)</b>	19	7/49	59	23/157	103	25.4/560	314	112/810	24	8/65	62	23/171	198	31/773	325	100/888
<b>Value added (in 1999/00 rupees)</b>	5	2/13	17	6/52	33	8.5/15	111	37/307	6	2/19	18	6/57	52	15/297	122	34/336
<b>R and D stock (in 1999/00 rupees)</b>	0	0/0	0	0/3	0	0/1	.4	0/5	0	0/0	0	0/3	0	0/9	.4	0/8
<b>Number of employees (imputed)</b>	127	46/381	450	171/1227	529	216/1569	2074.5	776/5105	165	56/498	484	176/135	704	243/300	2031	744/5593
<b>No. of observations</b>	24,383		29,940		206		3,169		29,580		26,440		227		1,451	

Source: *Prowess 4* and own calculations.

Table 2 shows that for both specifications S1 and S2, the median firm in the outward investing firms' categories (DI and DXI respectively) is more productive than firms that are not engaged in OFDI (DX and D categories respectively), while the median DX firm is more productive than the D firm. The median firm in the D sample is smaller (in sales/total assets/number of employees) than firms in the DX sample, while DXI firms are much larger.<sup>24</sup> The median DX or DI/DXI firm produces more output and has higher value added than the D firm. DXI firms have higher export intensity than DX firms (reflecting market-seeking export behaviour, and interdependencies across the modes of internationalisation). DXI firms also spend more on R&D, indicating creation of 'knowledge' capital (Figure 1).

**Figure 1: R&D intensity distributions for D, DX and DIDXI category firms (with positive R&D intensity)**



Source: *Prowess 4* and own calculations.

This evidence is consistent with Narayanan and Bhat (2010) who find that over 2000-2005, multinational firms from the information technology (IT) industry have higher export intensity and make more technological effort than other IT firms in the sample. There is also a slight difference in DXI and DI categories qualitatively (for both specifications S1 and S2) as regards the overall characteristics of firm categories. Also, Table A.2 in the Appendix

<sup>24</sup>Following Hall and Mairesse (1995), descriptive statistics are presented in terms of median and inter quartile range.

shows that the DXI category has slightly lower capital-output ratio, combined material, raw material and energy intensity although their services intensity is slightly higher than the D category.

Further, it is examined whether there is any change in the mean productivity of OFDI firms over time, that is, in comparing the pre-and post-OFDI time periods. For this, using productivity estimates for the gross output specification (based on Levinsohn and Petrin, 2003 approach), for S1 specification, if  $t = 0$  is the year in which a firm  $i$  switches into becoming an OFDI firm by investing abroad for the first time, for 599 OFDI entries over various years of the sample period, Table 3 shows the mean productivity  $\ln$  TFP index of DIDXI firms at time  $t \pm s$ , where  $s = 1, 2, 3$ , that is,  $s$  years pre- and post- OFDI entry respectively.

**Table 3: Mean productivity ( $\ln$  TFP index) of OFDI firms, pre-and post-OFDI**

<b>(a)</b>							
<b>Time periods</b>	$t-3$	$t-2$	$t-1$	$t0$	$t+1$	$t+2$	$t+3$
<b><math>\ln</math> TFP index</b>	.0323	.0545	.0557	.0659	.0718	.0725	.0731
<b>(b)</b>							
	Pre-OFDI (merging time periods $t-3, t-2, t-1$ )			Post-OFDI (merging time periods $t+1, t+2, t+3$ )			$t$ -test Post>Pre ( $p$ -value)
<b>Mean <math>\ln</math> TFP index</b>	.0477			.0724			0.0143
<b>(No. of obs.)</b>	$(n = 1520)$			$(n = 1560)$			

Source: *Prowess 4* and own calculations.

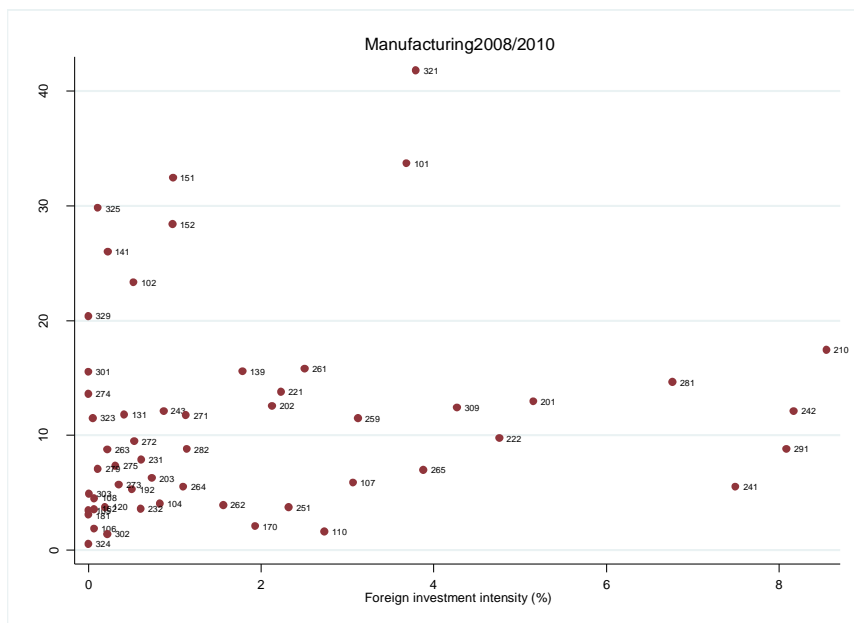
Merging the pre-and post-OFDI time periods ( $t-3, t-2, t-1$ ) and ( $t+1, t+2, t+3$ ) respectively, the mean productivity for the post-OFDI time period is significantly higher (at the 5% level) for the one sided  $t$ -test that the average of the post-OFDI time period is higher than that for the pre-OFDI time period.

## 6.2 Inter industry comparison

Figure 2 shows the scatter plot of the outward orientation of industries as measured by the average industry export and foreign investment intensity over 2008-2010 and is indicative of considerable heterogeneity at the 3-digit industry level. Industry specific effects, partly attributable to the nature of products produced are suggestive of the outward orientation of firms belonging to the industry groups.



**Figure 2: Scatter plots: average export and foreign investment intensity by 3-digit industry, for S1, 2008-2010**



Notes: NIC191 and NIC103 are excluded as the number of outward investing firms is below five.  
Source: *ProWess* 4 and own calculations.

## 7. Productivity comparisons

For each year in the sample period, the nonparametric test of first-order stochastic dominance (Kolmogorov-Smirnov test) is used to test whether foreign involvement is associated with firm productivity. In section 7.2 below we first graphically compare productivity trends and distributions of the three firm categories, namely DIDXI, DX and D, followed by Kolmogorov-Smirnov test (K-S test) as discussed below.

### 7.1 Testing procedure: Kolmogorov-Smirnov test (K-S test)

To assess if there are any significant differences between the distributions of productivities of firms based on their foreign engagements, that is for the three categories of firms, namely, DX and D; DIDXI and DX; and DIDXI and D respectively, following Delgado et al. (2002) and Girma, Gorg and Strobl (2004) among others, section 7.2 employs the non-parametric K-S test that makes no assumption about the sample distribution,<sup>25</sup> and tests for differences in all moments of the productivity distribution. Differences in marginal moments such as the mean and standard deviation do not reflect the entire distribution of productivities. Following Girma, Gorg and Strobl (2004), Engel and Procher (2012), and Wakasugi and Natsuhara

<sup>25</sup>The test is more robust than the *t*-test that requires the normality assumption.

(2012) among others, these are comparisons of unconditional distributions, that is, are not controlled for other covariates such as size, age, innovation, group and industry fixed effects.

The hypothesis to be tested is that if productivity differences between firms at any point in time reflect *self selection* and/or *learning effects*, the productivity distribution of the outward investing firms (that may export as well) should dominate that of the pure exporting firms that should in turn dominate the productivity distribution of the purely domestic firms.<sup>26</sup> Robustness checks using productivity estimates obtained from the VA specification (based on W-LP) rather than the GO specification (based on L-P) are also performed.

With the cumulative distribution functions of productivity corresponding to the two categories of firms say the outward investors and the pure exporters denoted by  $F_{DIDXI}$  and  $F_{DX}$  respectively, first order stochastic dominance (FOSD) of the distribution function  $F_{DIDXI}$  relative to  $F_{DX}$  requires:  $F_{DIDXI} - F_{DX} \leq 0$  uniformly in  $z \in \mathbb{R}$ , with strict inequality for some  $z$ .<sup>27</sup> The test requires that the null hypothesis of the *two-sided* test:

$H_0: F_{DIDXI}(z) - F_{DX}(z) = 0$  for all  $z \in \mathbb{R}$  vs.  $H_1: F_{DIDXI}(z) - F_{DX}(z) \neq 0$  for some  $z \in \mathbb{R}$  can be rejected while that of the *one-sided* test:

$H_0: F_{DIDXI}(z) - F_{DX}(z) \leq 0$  for all  $z \in \mathbb{R}$  vs.  $H_1: F_{DIDXI}(z) - F_{DX}(z) > 0$  for some  $z \in \mathbb{R}$  cannot be rejected.

This allows us to conclude (1) that the two distributions are not identical and (2) that one distribution dominates the other. Graphically,  $F_{DIDXI}$  is to the right of  $F_{DX}$ , that is, is on the higher productivity side or that overseas investors' productivity distribution stochastically dominates that of the exporters. Further, to maintain the independence assumption, the hypothesis is tested separately for each year of the sample period. The *D-statistic* and the *p*-value (the probability that the two distributions are the same) are reported in Tables A.3 and A.4.<sup>28</sup>

<sup>26</sup>As Girma et al. (2004, p. 319) note, 'although these tests encompass the possibility that firms of the same productivity level may choose different forms of commerce, the degree of uncertainty in behaviour cannot be too large such that the structure of commerce and firm heterogeneity are no longer meaningfully related.'

<sup>27</sup>The random sample of productivity corresponding to the first group of firms (with sample size  $n$ ) and distribution function  $F_{DIDXI}$  is taken as independent of the random sample of productivity (of sample size  $m$ ) corresponding to the second group of firms with distribution function  $F_{DX}$ .

<sup>28</sup>The directional hypotheses are evaluated with the statistics:

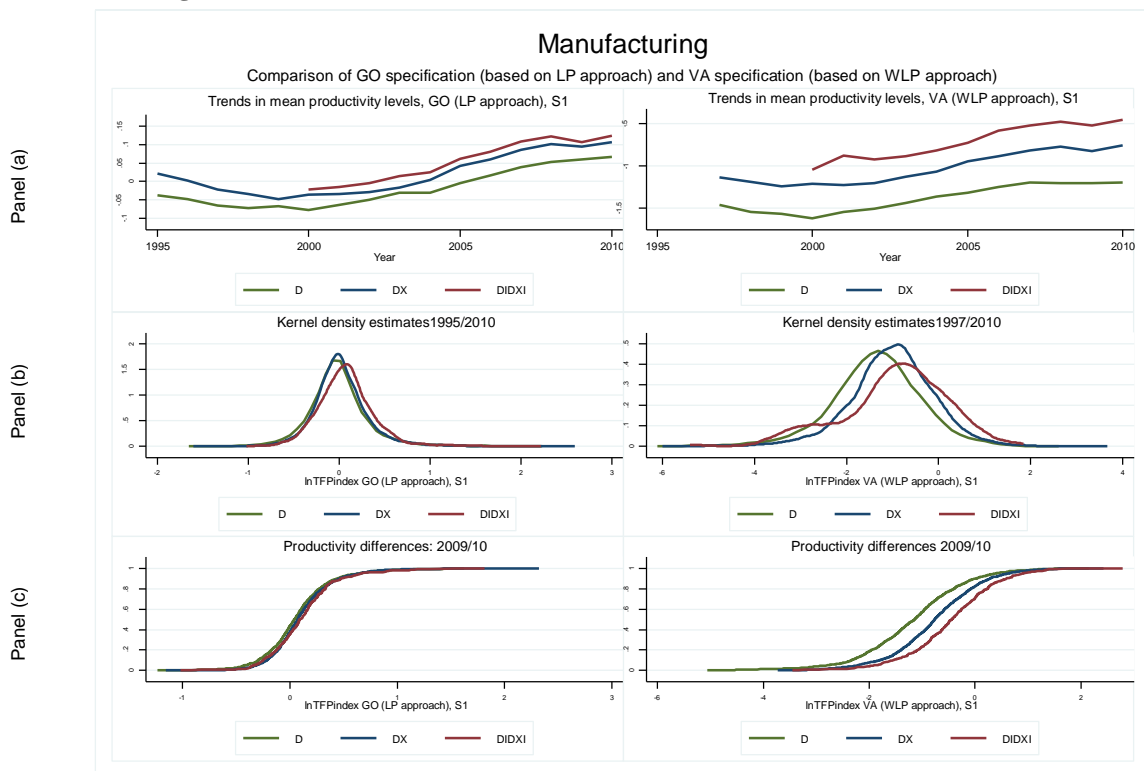
$D^+ = \max_x \{F(z) - G(z)\}$ ,  $D^- = \max_x \{G(z) - F(z)\}$  where  $F(x)$  and  $G(x)$  are the empirical distribution functions for the samples being compared. The combined statistic is:

$D = \max(|D^+|, |D^-|)$  which identifies the maximum vertical difference between the two empirical cumulative distribution functions. The *p*-value for this statistic may be obtained by evaluating the asymptotic limiting distributions. If  $m$  is the sample size for the first distribution, and  $n$  is the sample size for the second sample, Smirnov (1939) shows that  $\lim_{m,n \rightarrow \infty} Pr\{\sqrt{mn/(m+n)}D_{m,n} \leq z\} = 1 - 2 \sum_{i=1}^{\infty} (-1)^{i-1} \exp(-2i^2 z^2)$ . The first five terms form the approximation  $P_a$  used by *Stata*. A corrected *p*-value is obtained by modifying the asymptotic *p*-value using the numerical approximation technique.

## 7.2 Results

Figure 3 compares the productivity differences among the three firm types for the two alternate productivity measures for specification S1. Column (1) depicts the GO specification (based on L-P approach) for 1995-2010, while column (2) depicts the VA specification (based on W-LP approach) for 1997-2010.

**Figure 3: Differences among firm types (DIDXI, DX, D), based on TFP estimates, comparing methods, manufacturing, S1, 1995-2010**



Source: *Prowess 4* and own calculations.

A comparison of the graphs in panel (a) for the trend in mean productivity ( $\ln(\text{TFP index})$ )<sup>29</sup> for the three firm types (DIDXI, DX, and D) displays stronger differences across firm types under the VA rather than the GO specification.<sup>30</sup> Panel (b) shows that the kernel density estimates<sup>31</sup> of the productivity distribution for the foreign investors (DIDXI) lies to

$$Z = \Phi^{-1}(P_a) + 1.04/\min(m, n) + 2.09/\max(m, n) - 1.35/\sqrt{mn/(m+n)}$$

$p\text{-value} = \Phi(Z)$  where  $\Phi(Z)$  is the cumulative normal distribution' (*Stata Base Reference Manual Vol.2, Release 10, p.109*).

<sup>29</sup>The mean productivity for the sample DIDXI is not shown for 1995-1999, as due to the small number of firms in this time period, the mean values are subject to larger variations.

<sup>30</sup>Both columns however show that the impact of the negative demand shock for Indian firms in 2008 (Q2) to 2009 (Q2) has been more so for firms with foreign engagements than purely domestic firms.

<sup>31</sup>Epanechnikov kernel, with varying bandwidth.

the right of the distribution of exporters (DX) and even further to the right from the distribution for the purely domestic firms (D) consistent with the HMY (and HR) prediction.<sup>32</sup> For 2009/10, panel (c) shows that the cumulative distribution function of firm productivity for the DIDXI firms lies to the right of the DX firms and more so for the D firms indicating FOSD. Productivity rankings thus favour DIDXI over DX, DX over D and DIDXI over D (which also follows by transitivity) respectively. Firms that invest abroad have higher productivity than firms that export only or that only operate domestically.

The differences across firms are however more pronounced for the VA specification indicating a ‘value added bias’ that remains even after controlling for the ‘transmission bias’ with the W-LP productivity estimation technique that is robust to the ACF (2006) criticism (Gandhi, Navarro and Rivers, 2013; Rivers, 2013).

The density plots of the estimated productivity at the 2-digit level/combined groups are shown in Figure F.1 in the Appendix below. These indicate that the relationship between firm productivity and foreign involvement is stronger in some industries, for instance, in textiles (NIC 13), coke and refined petroleum products, chemicals (NIC 19, 20), pharmaceuticals (NIC 21), basic metal and fabricated metal (NIC 24, 25), and machinery and equipment n.e.c. (NIC 28) than in the rest.

Table A.3 in the Appendix presents the number of firms by each firm type for each year of the sample period, in columns (2) to (4)<sup>33</sup> with mean values of productivity ( $\ln$  TFP index) in columns (5) to (7). K-S test statistics of productivity differentials are presented for exporters and non-exporters (DX vs. D), in columns (8) to (10); outward investors and exporters (DIDXI vs. DX) in columns (11) to (13); (DXI vs. DX) presented only for the GO specification (based on L-P approach) in columns (14) to (16), and outward investors and domestic firms (DIDXI vs. D) in columns (17) to (19) respectively for the GO specification. The rest of the columns correspond to the VA specification (based on W-LP approach) for corresponding comparisons. Tests are applied separately to each category for every year of the sample period.

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<sup>32</sup>As the HMY model deals with horizontal FDI alone, and although a large fraction of FDI by Indian firms goes to the developed countries for market-access (RBI *Bulletins*), it seems reasonable to test the HMY predictions. Nunnenkamp et al. (2012) also find that the location choice of Indian direct investors is dominated by the motive of market-related factors, much less so for access to raw materials or for superior technologies. In so far as OFDI is also guided by vertical or complex integration strategies, also related to the internationalisation of R&D, in the absence of the fraction of OFDI directed by the underlying motives, testing the HMY predictions may however yield partial insights.

<sup>33</sup>The number of observations is reported for the GO specification (based on L-P approach). Under the WLP approach, as noted above, the overall sample size is smaller.

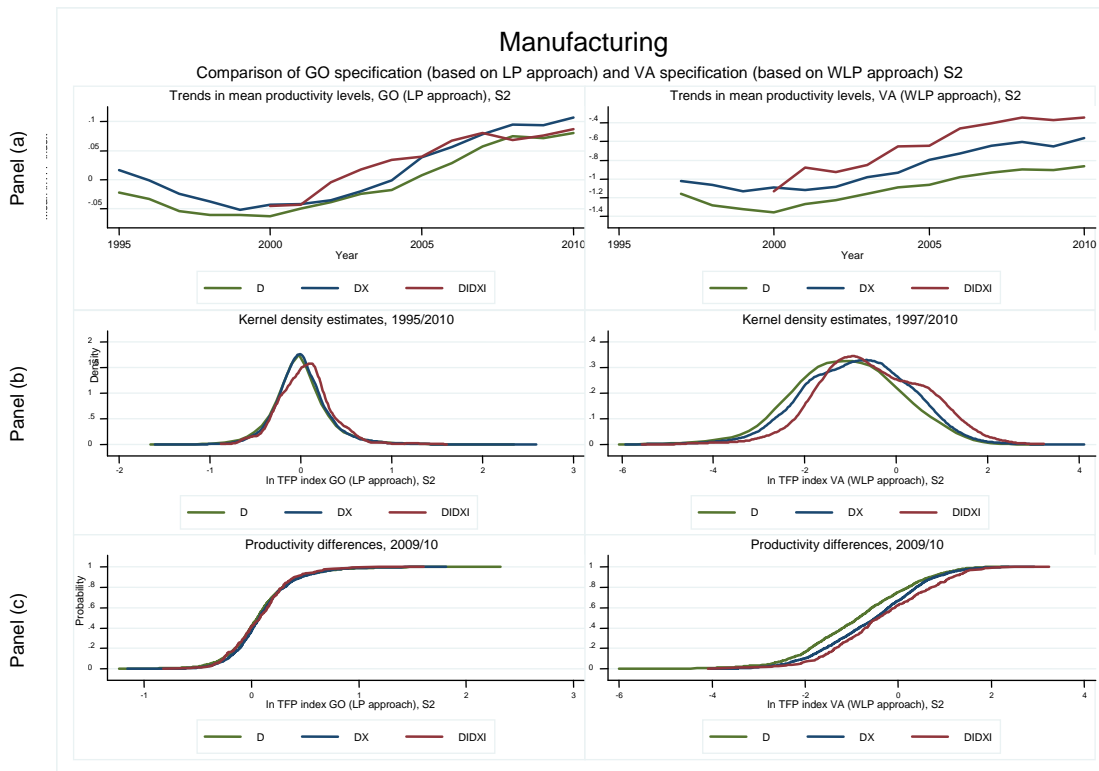
**DX vs. D:** First, for the category DX and D, the null hypothesis of equality between both distributions can be rejected at the 1% level for several years (mainly after the year 2000). The null hypothesis, that the direction of the difference is as expected, that is, DX have greater productivity than D cannot be rejected at any reasonable significance level for most years. **DIDXI vs. DX:** Second, for the category DIDXI and DX the equality of both productivity distributions cannot be rejected at any reasonable significance level in the earlier years of the sample period 1995-2000. Although productivity differences between DIDXI and DX are rather modest in the GO specification, it is only after 2001 that they favour DIDXI over DX as suggested by the test statistics for the one-sided test, column (12).<sup>34</sup> Qualitatively similar results obtain in comparing the DXI with the DX firms i.e.  $DXI > DX$ , columns (14) and (15). **DIDXI vs. D:** Thirdly, for 2001 onwards, the DIDXI category stochastically dominates the D category in manufacturing.

Figure 4 and Table A.4 in the Appendix evaluate for any effects that limiting the lower bound for qualifying as an exporter and foreign investing firm (as in specification S2), may have on the validity of the HMY (and HR) hypothesis. The K-S test results lend support to the HMY (and HR) models for most but not all years of the sample period. Graphically, differences in firm categories are however less pronounced for S2 than for S1.

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<sup>34</sup>The year 2001 onwards has also witnessed a significant increase in the number of outward investing firms.

**Figure 4: Differences among firm types (DIDXI, DX, D), based on TFP estimates, comparing methods, manufacturing, S2, 1995-2010**



Source: *Prowess 4* and own calculations.

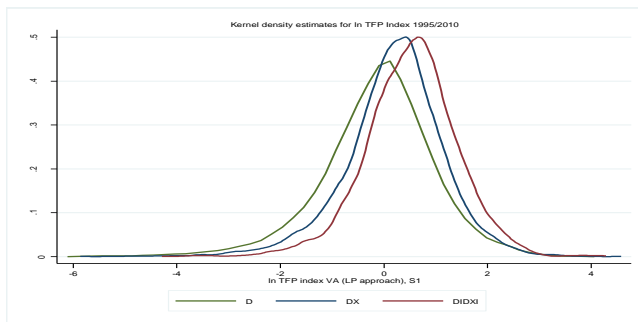
### 7.3 Robustness analysis

This section performs robustness analysis in terms of examining what results are sensitive to the choice of data set, choice of TFP measure (gross output *vs.* value added) and choice of methodology of production function estimation respectively. First, examining the choice of data set in terms of comparing specifications S1 and S2, it is observed that irrespective of whether the L-P approach (comparing the left-hand panel of Figures 3 and 4 respectively) or the W-LP approach (comparing the right-hand panel of Figures 3 and 4 respectively) are employed, the same pattern of productivity rankings obtains. The results are thus robust to covering the data set that includes firms with small overseas positions.

Second, in examining the choice of TFP measure, even for the same methodology of production function estimation (say, L-P approach), comparing distributions based on GO specification (Figure 3, left-hand panel) and VA specification (Figure 5 below) respectively shows that the ‘pecking order’ as in HMY obtains for both specifications of the production function though VA based distributions suggest stronger differences among firm categories. The results are thus robust to the choice of TFP measure (gross output *vs.* value added).

Third, for the same productivity measure (say, value added) and specification (say, S1) comparing distributions based on L-P and W-LP approaches (Figure 5 and Figure 4, right-hand panel) respectively, confirms that the results are robust to choice of method for production function estimation. This is consistent with results obtained previously. For instance, comparing their results across productivity measurement methods, Galushak and Lizal (2012) show that in general, except for two industries, rubber and plastic products; other manufacturing, (without assuming measurement error in capital), production function estimates using the L-P method are not significantly different from those using Wooldridge (2009). Both methods yield quantitatively similar results.

**Figure 5: Kernel density estimates for  $\ln$  TFP index, VA specification (based on L-P approach), S1, 1995-2010**



Source: *Prowess 4* and own calculations.

## 8 Summary and conclusions

Descriptive statistics for various firm categories show that the median firm in the D sample is smaller than firms in the DX sample, while DXI firms are much larger, have higher export intensity than DX firms (reflecting market-seeking export behaviour, and interdependencies across the modes of internationalisation) and also spend more on R&D. Further, while the DXI category has slightly lower capital-output ratio, combined material, raw material and energy intensity, their services intensity is slightly higher than the D category. The *inter-industry* comparison showed considerable heterogeneity in the export and foreign investment intensity at the 3-digit industry level suggesting that the nature of products produced at a disaggregated industry level may affect the outward orientation of firms. At the 2-digit level, the chemicals/pharmaceuticals industries are more strongly involved in OFDI than the rest.

On the productivity measurement side, this paper is based on production inputs that include the services input, a labour measure that is adjusted for a ‘wage premium’ based on ownership groups, a measure of physical capital that allows for disaggregated growth of

investment, and a capital stock measure that combines physical and ‘knowledge’ or R&D ‘capital’ stock. Comparisons of two production function estimation approaches that control for the ‘transmission bias’, are presented for two alternate specifications of the industry level production functions. The Kolmogorov-Smirnov test was used to establish first order stochastic dominance (FOSD) of the cumulative distribution functions (CDF) of firm productivity for various firm categories. These productivity comparisons are not controlled for size, age, innovation, group and industry fixed effects. Overseas investing firms (DIDXI) are found to be more productive than the other firm categories, while pure export firms (DX) have intermediate productivity levels. These results are in agreement with such results from similar studies for several countries including Tian and Yu (2012) for China who also find a positive correlation between firm productivity and OFDI.

Although DIDXI and DX categories dominate over the purely domestic firms (D) for both production function specifications, the gross output (GO) specification (based on L-P approach) suggests quantitatively smaller differences in productivity between firm categories. The value added (VA) specification (based on W-LP approach) thus validates the HMY (and HR) hypothesis more strongly than the GO specification (based on L-P approach). These results compare with Gandhi, Navarro and Rivers (2013) and Rivers (2013) that show that accounting for intermediate inputs using the GO specification, substantially reduces the estimated productivity advantage of exporters over non-exporters. This suggests that controlling the ‘*value added bias*’ is important and it is not sufficient to control only for the ‘*transmission bias*’.

Further, productivity differentials vary, sometimes considerably by 2-digit industry/industry groups. In manufacturing, the HMY (and HR) pattern obtains, more so in textiles (NIC 13), coke and refined petroleum products, chemicals (NIC 19, 20), pharmaceuticals (NIC 21), basic metal and fabricated metal (NIC 24, 25), and machinery and equipment n.e.c. (NIC 28) than in the rest. Also, although similar patterns obtain, yet graphically, differences in firm categories are less pronounced for S2 than for S1. The study thus finds qualified support for the HMY (and HR) models. At the 2 digit/industry level, graphically, the predicted relationship is more obvious in several but not in all industries.



## Appendix

Table A.1: Number of firms in the sample, 1994/95 to 2009/10

Panel 1a: By Year		Panel 1b: By Industry							
Year	Count	2-Digit NIC Code	NIC-2008 Description	No. of 3-Digit Industries	Firms		Firm-Year Count**	Firm-Year Count (DXI)***	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	S1	S2
			<b>Manufacturing*</b>				(All)		
1995	2,503	10	Food products	8	695	11.45	6,408	200	90
1996	2,758	11	Beverages	1	124	2.04	1,068	20	4
1997	2,925	12	Tobacco products	1	08	.13	105	14	-
1998	3,054	13	Textiles	2	696	11.47	6,527	265	87
1999	3,253	14	Wearing apparels	1	107	1.76	844	42	16
2000	3,371	15	Leather and related products	2	64	1.05	558	62	24
2001	3,402	16	Wood and products of wood and cork, except furniture	1	32	.52	318	07	-
2002	3,486	17	Paper and paper products	1	228	3.75	2,057	18	07
2003	3,842	18	Printing and reproduction of recorded media	2	23	.37	164	03	02
2004	4,035	19	Coke and refined petroleum products	2	41	.67	292	22	04
2005	4,222	20	Chemicals and chemical products	3	802	13.21	7,934	478	211
2006	4,353	21	Pharmaceuticals, medicinal chemical and botanical products	1	437	7.20	4,267	471	298
2007	4,378	22	Rubber and plastics products	2	362	5.96	3,550	265	124
2008	4,303	23	Other non-metallic mineral products	2	225	3.70	2,312	143	52
2009	4,106	24	Basic metals	3	695	11.45	6,427	232	94
2010	3,707	25	Fabricated metal products, except machinery and equipment	2	195	3.21	1,767	67	40
	<b>57,698</b>	26	Computer, electronic and optical products	5	224	3.69	1,937	159	82
		27	Electrical equipment	6	299	4.92	2,884	115	39
		28	Machinery and equipment n.e.c.	2	360	5.93	3,692	222	81
		29	Motor vehicles, trailers and semi-trailers	1	15	.24	159	37	13
		30	Other transport equipment	4	335	5.52	3,558	203	111

32	Other manufacturing	5	101	1.69	870	124	72
		<b>57</b>	<b>6,068</b>	<b>100</b>	<b>57,698</b>	<b>3,169</b>	<b>1,451</b>

Notes:\*Excluding NIC-31 (Manufacture of furniture), NIC-33 (Repair and installation of machinery and equipment).

\*\*Firm-year count (number of observations) at each 2-digit level is based on the sample for which Levinsohn and Petrin (2003) estimates are obtained (section 5 above).

\*\*\*Firm-year count is for firms that export and invest abroad (DXI).

Source: *Prowess 4* and own calculations.

**Table A.2: Descriptive statistics by foreign involvement (after data cleaning), additional variables, 1995-2010**

Variable	S1								S2							
	D		DX		DI		DXI		D		DX		DI		DXI	
	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range	Median	IQ range
<b>Capital output ratio</b>	.5	.3/1	.5	.3/.8	.4	.2/.8	.5	.3/.7	.5	.3/1	.5	.3/.9	.4	.2/.7	.5	.3/.8
<b>Capital labour ratio</b>	.1	.03/.2	.1	.03/.1	.1	.03/.2	.1	.03/.1	.1	.03/.2	.1	.03/.1	.1	.03/.2	.1	.04/.1
<b>Material output ratio</b>	.7	.6/.8	.7	.6/.8	.6	.5/.8	.6	.5/.7	.7	.6/.8	.7	.6/.8	.6	.5/.8	.6	.5/.7
<b>Raw material intensity (raw material /output)</b>	.5	.4/.7	.5	.4/.6	.5	.3/.6	.5	.3/.5	.5	.4/.6	.5	.4/.6	.4	.3/.6	.4	.3/.5
<b>Energy intensity (energy /output)</b>	.03	.01/.1	.03	.01/.1	.01	.003/.03	.02	.008/.04	.03	.01/.1	.02	.01/.1	.01	.00/.03	.01	.0/.03
<b>Services intensity (services /output)</b>	.1	.1/.2	.1	.1/.2	.1	.1/.2	.1	.1/.2	.1	.1/.2	.1	.1/.2	.1	.1/.2	.1	.1/.2
<b>No. of observations</b>	24,383		29,940		206		3,169		29,580		26,440		227		1,451	

Source: *Prowess 4* and own calculations.

**Table A.3: Productivity level differences between outward investors, exporters and domestic firms; hypotheses test statistics, manufacturing, S1, 1995-2010**

Year	No. of observations	GO specification (based on L-P approach), S1																	
		DIDXI	DX	D	DIDXI	DX	D	DX vs. D			DIDXI vs. DX			DXI vs. DX			DIDXI vs. D		
					Mean (SD)	Mean (SD)	Mean (SD)	Two-way	DX >D	D >DX	Two-way	DIDXI >DX	DX >DIDXI	Two-way	DXI >DX	DX >DXI	Two-way	DIDXI >D	D >DIDXI
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	
1995	11	1483	1009	-.060 (.212)	.021 (.275)	-.038 (.281)	.107 (.000)	.003 (.989)	-.107 (.000)	.184 (.768)	.184 (.476)	-.099 (.807)	.184 (.768)	.184 (.476)	-.099 (.807)	.189 (.738)	.119 (.734)	-.189 (.457)	
1996	7	1657	1094	-.057 (.077)	.002 (.277)	-.047 (.277)	.103 (.000)	.005 (.960)	-.103 (.000)	.336 (.278)	.336 (.207)	-.252 (.412)	.336 (.278)	.336 (.207)	-.252 (.412)	.330 (.300)	.255 (.402)	-.330 (.220)	
1997	12	1744	1169	.009 (.196)	-.022 (.268)	-.065 (.287)	.102 (.000)	.003 (.978)	-.102 (.000)	.242 (.367)	.130 (.668)	-.242 (.247)	.242 (.368)	.129 (.669)	-.242 (.247)	.317 (.114)	.070 (.888)	-.317 (.092)	
1998	20	1773	1261	-.064 (.195)	-.034 (.284)	-.071 (.288)	.057 (.014)	-.057 (1.000)	-.057 (.008)	.125 (.868)	.125 (.536)	-.082 (.764)	.125 (.868)	.125 (.536)	-.082 (.764)	.119 (.905)	.089 (.729)	-.119 (.569)	
1999	19	1850	1384	-.127 (.248)	-.047 (.287)	-.067 (.296)	.048 (.044)	.002 (.994)	-.048 (.024)	.261 (.100)	.261 (.076)	-.064 (.853)	.246 (.204)	.246 (.146)	-.057 (.899)	.230 (.194)	.230 (.136)	-.073 (.817)	
2000	57	1816	1498	-.022 (.322)	-.036 (.290)	-.077 (.287)	.071 (.000)	.002 (.993)	-.071 (.000)	.100 (.572)	.084 (.457)	-.100 (.329)	.112 (.503)	.106 (.333)	-.112 (.293)	.121 (.334)	.058 (.684)	-.121 (.199)	
2001	160	1771	1471	-.015 (.278)	-.034 (.295)	-.063 (.298)	.042 (.099)	.000 (.999)	-.042 (.054)	.075 (.337)	.022 (.865)	-.075 (.189)	.069 (.496)	.020 (.891)	-.069 (.275)	.109 (.052)	.010 (.968)	-.109 (.032)	
2002	206	1772	1508	-.004 (.274)	-.029 (.288)	-.049 (.304)	.031 (.386)	.003 (.983)	-.031 (.203)	.101 (.037)	.011 (.950)	-.101 (.023)	.100 (.054)	.012 (.951)	-.100 (.033)	.105 (.030)	.011 (.951)	-.105 (.018)	
2003	228	1950	1664	.015 (.293)	-.016 (.284)	-.031 (.305)	.036 (.176)	.022 (.416)	-.036 (.094)	.086 (.078)	.019 (.855)	-.086 (.046)	.088 (.089)	.020 (.859)	-.088 (.053)	.114 (.011)	.009 (.966)	-.114 (.007)	
2004	245	2039	1751	.025 (.295)	.005 (.291)	-.030 (.332)	.066 (.000)	.005 (.941)	-.066 (.000)	.081 (.097)	.031 (.652)	-.081 (.056)	.084 (.085)	.032 (.649)	-.085 (.050)	.121 (.003)	.009 (.962)	-.121 (.002)	
2005	275	2067	1880	.061 (.306)	.043 (.286)	-.004 (.325)	.079 (.000)	.007 (.907)	.079 (.000)	.074 (.114)	.041 (.426)	-.079 (.065)	.077 (.113)	.047 (.353)	-.077 (.065)	.134 (.000)	.004 (.989)	-.134 (.000)	
2006	342	2108	1903	.080 (.294)	.060 (.300)	.016 (.327)	.081 (.000)	.011 (.776)	-.081 (.000)	.069 (.101)	.008 (.956)	-.069 (.059)	.067 (.130)	.010 (.936)	-.067 (.074)	.135 (.000)	.011 (.931)	.135 (.000)	
2007	403	2093	1882	.108 (.282)	.086 (.299)	.039 (.330)	.099 (.000)	.010 (.821)	-.099 (.000)	.066 (.089)	.015 (.857)	-.066 (.050)	.063 (.126)	.017 (.829)	-.063 (.071)	.147 (.000)	.024 (.669)	-.147 (.000)	
2008	447	2064	1792	.122 (.312)	.102 (.305)	.052 (.347)	.096 (.000)	.013 (.701)	-.096 (.000)	.063 (.092)	.019 (.747)	-.063 (.052)	.051 (.280)	.026 (.614)	-.051 (.153)	.131 (.000)	.021 (.715)	-.131 (.000)	
2009	471	1983	1652	.107 (.325)	-.095 (.318)	.060 (.345)	.061 (.002)	.012 (.770)	-.061 (.001)	.065 (.067)	.021 (.711)	.065 (.038)	.067 (.063)	.019 (.760)	-.067 (.036)	.097 (.002)	.013 (.870)	-.097 (.001)	
2010	472	1771	1464	.124 (.333)	.107 (.307)	.066 (.330)	.065 (.002)	.006 (.926)	-.065 (.001)	.065 (.069)	.033 (.442)	-.065 (.039)	.060 (.136)	.030 (.525)	-.060 (.076)	.107 (.000)	.001 (.998)	-.107 (.000)	

**Table A.3...continued**

Year	VA specification (based on W-LP approach), S1											
	DIDXI	DX	D	DX vs. D			DIDXI vs. DX			DIDXI vs. D		
	Mean	Mean	Mean	Two	DX	D	Two	DIDXI	DX	Two	DIDXI	D
	(SD)	(SD)	(SD)	-way	>D	>DX	-way	>DX	>DIDXI	-way	>D	>DIDXI
			<i>D-Statistic (p-value)</i>			<i>D-Statistic (p-value)</i>			<i>D-Statistic (p-value)</i>			
(1)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)
1997	-854 (.617)	-1.133 (.920)	-1.459 (.944)	.180 (.000)	.000 (.999)	-.180 (.000)	.264 (.499)	.124 (.783)	-.264 (.329)	.417 (.069)	.064 (.937)	-.417 (.064)
1998	-1.195 (.633)	-1.187 (.934)	-1.542 (1.02)	.179 (.000)	.000 (.999)	-.179 (.000)	.180 (.541)	.180 (.335)	-.129 (.568)	.283 (.088)	.054 (.905)	-.283 (.069)
1999	-1.570 (1.00)	-1.242 (.946)	-1.570 (.930)	.191 (.000)	.002 (.993)	-.191 (.000)	.277 (.135)	.277 (.102)	-.053 (.918)	.171 (.691)	.171 (.422)	-.168 (.432)
2000	-1.048 (.978)	-1.213 (.881)	-1.623 (.993)	.220 (.000)	.001 (.998)	-.220 (.000)	.181 (.088)	.058 (.744)	-.181 (.060)	.329 (.000)	.002 (1.00)	-.329 (.000)
2001	-.881 (.742)	-1.226 (.917)	-1.545 (.954)	.152 (.000)	.000 (1)	-.152 (.000)	.209 (.000)	.004 (.995)	-.209 (.000)	.358 (.000)	.000 (1.00)	-.358 (.000)
2002	-.924 (.816)	-1.206 (.900)	-1.509 (.956)	.170 (.000)	.000 (.999)	-.170 (.000)	.193 (.000)	.003 (.996)	-.193 (.000)	.329 (.000)	.001 (.999)	-.329 (.000)
2003	-.883 (.971)	-1.129 (.870)	-1.437 (.915)	.165 (.000)	.002 (.991)	-.165 (.000)	.208 (.000)	.011 (.949)	-.208 (.000)	.316 (.000)	.010 (.963)	-.316 (.000)
2004	-.821 (.945)	-1.071 (.948)	-1.366 (.946)	.155 (.000)	.003 (.988)	-.155 (.000)	.156 (.000)	.009 (.968)	-.156 (.000)	.292 (.000)	.006 (.983)	-.292 (.000)
2005	-.727 (.975)	-.944 (.914)	-1.316 (1.00)	.179 (.000)	.000 (1)	-.179 (.000)	.139 (.000)	.009 (.957)	-.139 (.000)	.316 (.000)	.003 (.993)	-.316 (.000)
2006	-.581 (.855)	-.888 (.902)	-1.249 (1.04)	.178 (.000)	.001 (.995)	-.178 (.000)	.158 (.000)	.000 (1.00)	-.158 (.000)	.327 (.000)	.000 (1.00)	-.327 (.000)
2007	-.519 (.839)	-.817 (.924)	-1.199 (.955)	.208 (.000)	.000 (.999)	-.208 (.000)	.166 (.000)	.000 (1.00)	-.166 (.000)	.361 (.000)	.000 (1.00)	-.361 (.000)
2008	-.476 (.885)	-.773 (.911)	-1.207 (1.01)	.224 (.000)	.000 (.999)	-.224 (.000)	.173 (.000)	.001 (.998)	-.173 (.000)	.379 (.000)	.000 (.999)	-.379 (.000)
2009	-.519 (.857)	-.828 (.935)	-1.207 (1.02)	.186 (.000)	.002 (.992)	-.186 (.000)	.165 (.000)	.000 (1.00)	-.165 (.000)	.329 (.000)	.000 (1.00)	-.329 (.000)
2010	-.455 (.865)	-.758 (.855)	-1.195 (1.02)	.210 (.000)	.000 (1)	-.210 (.000)	.186 (.000)	.003 (.994)	.186 (.000)	.362 (.000)	.000 (1.00)	-.362 (.000)

Notes: GO specification (based on L-P approach): TFP estimates obtained from a gross output specification of the production function, using Levinsohn and Petrin (2003) approach.

VA specification (based on W-LP approach): TFP estimates obtained from a value added specification of the production function, using Wooldridge (2009) approach.

D: purely domestic firm, DX: pure export firms that also serve the domestic market, DXI: firms that export and invest overseas, DIDXI: outward investing firms (includes DXI: firms that export and invest overseas, and DI: firms that invest overseas but do not export).

S1: DX if export intensity is positive, DIDXI if export intensity is positive and foreign investment intensity is positive.

Corrected *p*-values in parentheses. Two-way stands for combined K-S.

Source: *Prowess 4* and own calculations.

**Table A.4: Productivity level differences between outward investors, exporters and domestic firms; hypotheses test statistics, manufacturing, S2, 1995-2010**

Year	GO specification (based on L-P approach), S2																	
	DIDXI	DX	D	DIDXI	DX	D	DX vs. D			DIDXI vs. DX			DXI vs. DX			DIDXI vs. D		
	No. of observations			Mean (SD)	Mean (SD)	Mean (SD)	Two-way	DX >D	D >DX	Two-way	DIDXI >DX	DX >DIDXI	Two-way	DXI >DX	DX >DXI	Two-way	DIDXI >D	D >DIDXI
							<i>D-Statistic (p-value)</i>			<i>D-Statistic (p-value)</i>			<i>D-Statistic (p-value)</i>			<i>D-Statistic (p-value)</i>		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1995	03	1214	1286	-	.017 (.278)	-.022 (.278)	.064 (.010)	.002 (.993)	-.064 (.006)	-	-	-	-	-	-	-	-	-
1996	02	1354	1402	-	-.001 (.284)	-.033 (.270)	.060 (.012)	.001 (.997)	-.060 (.007)	-	-	-	-	-	-	-	-	-
1997	05	1452	1468	-	-.024 (.271)	-.054 (.281)	.062 (.006)	.004 (.977)	-.062 (.003)	-	-	-	-	-	-	-	-	-
1998	08	1484	1562	-	-.037 (.284)	-.060 (.286)	.042 (.023)	.000 (1.00)	-.042 (.066)	-	-	-	-	-	-	-	-	-
1999	10	1520	1723	-	-.052 (.286)	-.060 (.295)	.023 (.735)	.007 (.906)	-.023 (.400)	-	-	-	-	-	-	-	-	-
2000	21	1509	1841	-.045 (.286)	-.043 (.290)	-.063 (.289)	.038 (.052)	-.038 (.996)	.114 (.081)	.098 (.916)	-.114 (.670)	.132 (.579)	.132 (.574)	-.064 (.878)	.121 (.873)	.079 (.769)	-.121 (.540)	
2001	65	1527	1810	-.043 (.288)	-.042 (.294)	-.049 (.298)	.023 (.750)	-.023 (.938)	.082 (.410)	.082 (.746)	-.074 (.430)	.069 (.969)	.069 (.641)	-.055 (.753)	.076 (.820)	.072 (.513)	-.076 (.481)	
2002	88	1568	1830	-.004 (.263)	-.035 (.290)	-.038 (.299)	.022 (.760)	-.016 (.417)	.182 (.623)	.036 (.802)	-.128 (.065)	.086 (.627)	.076 (.444)	-.086 (.357)	.114 (.182)	.038 (.780)	-.114 (.110)	
2003	97	1763	1982	.018 (.297)	-.020 (.289)	-.024 (.298)	.021 (.774)	.021 (.426)	.126 (.593)	.039 (.748)	-.126 (.054)	.125 (.145)	.052 (.652)	-.125 (.090)	.140 (.039)	.026 (.882)	-.140 (.026)	
2004	117	1824	2094	.034 (.300)	-.0004 (.290)	-.018 (.326)	.033 (.217)	.008 (.856)	-.033 (.115)	.097 (.208)	-.097 (.984)	.115 (.122)	.017 (.942)	-.115 (.083)	.124 (.052)	.014 (.952)	-.124 (.033)	
2005	145	1877	2200	.040 (.315)	.039 (.291)	.008 (.318)	.052 (.007)	.004 (.962)	-.052 (.004)	.068 (.507)	.062 (.352)	-.068 (.281)	.096 (.205)	-.043 (.652)	.101 (.099)	.027 (.820)	-.101 (.060)	
2006	176	1925	2252	.068 (.316)	.056 (.298)	.029 (.324)	.064 (.000)	.015 (.628)	-.064 (.000)	.047 (.844)	.034 (.682)	-.047 (.489)	.048 (.859)	-.048 (.502)	.088 (.134)	.013 (.944)	-.088 (.078)	
2007	211	1984	2183	.081 (.296)	.078 (.300)	.057 (.324)	.065 (.000)	.011 (.743)	-.065 (.000)	.045 (.790)	.045 (.574)	-.044 (.465)	.061 (.508)	-.033 (.279)	.088 (.686)	.027 (.081)	-.088 (.748)	
2008	241	1912	2150	.069 (.288)	.095 (.306)	.075 (.344)	.058 (.002)	.022 (.350)	-.058 (.001)	.065 (.280)	.065 (.155)	-.014 (.910)	.084 (.115)	-.008 (.067)	.055 (.973)	.055 (.485)	-.053 (.265)	
2009	244	1883	1979	.076 (.300)	.094 (.327)	.072 (.336)	.038 (.001)	.013 (.705)	-.038 (.054)	.034 (.957)	-.033 (.607)	.054 (.612)	-.054 (.579)	-.018 (.317)	.044 (.870)	.035 (.768)	-.044 (.573)	
2010	245	1644	1818	.087 (.298)	.107 (.310)	.081 (.332)	.052 (.016)	.005 (.947)	-.052 (.009)	.062 (.336)	.062 (.186)	-.037 (.554)	.084 (.115)	-.012 (.067)	.066 (.943)	.022 (.267)	-.066 (.806)	

**Table A.4...continued**

Year	VA specification (based on WL-P approach), S2											
	DIDXI			DX			D			DX vs. D		
	Mean (SD)	Mean (SD)	Mean (SD)	Two -way	DX >D	D >DX	Two -way	DIDXI >DX	DX >DIDXI	Two -way	DIDXI >D	D >DIDXI
(1)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)
1997	-	-1.02 (1.13)	-1.16 (1.10)	.071 (.011)	.001 (.997)	-.071 (.006)	-	-	-	-	-	-
1998	-	-1.06 (1.11)	-1.28 (1.14)	.087 (.000)	.003 (.990)	-.087 (.000)	-	-	-	-	-	-
1999	-	-1.13 (1.13)	-1.32 (1.13)	.078 (.001)	.009 (.902)	-.078 (.001)	-	-	-	-	-	-
2000	-1.13 (.904)	-1.09 (1.11)	-1.36 (1.12)	.115 (.000)	.000 (1.00)	-.115 (.000)	.187 (.568)	.140 (.556)	-.187 (.352)	.293 (.098)	.076 (.841)	-.293 (.078)
2001	-.878 (.950)	-1.12 (1.12)	-1.27 (1.10)	.064 (.008)	.000 (.999)	-.064 (.004)	.170 (.065)	.016 (.971)	-.170 (.044)	.216 (.008)	.000 (1.00)	-.216 (.007)
2002	-.924 (.940)	-1.08 (1.11)	-1.23 (1.12)	.054 (.032)	.000 (1.00)	-.054 (.018)	.145 (.057)	.023 (.921)	-.145 (.037)	.173 (.013)	.011 (.981)	-.173 (.010)
2003	-.852 (1.109)	-.983 (1.12)	-1.16 (1.10)	.071 (.002)	.004 (.967)	-.071 (.001)	.115 (.179)	.015 (.960)	-.115 (.108)	.177 (.007)	.009 (.984)	-.177 (.005)
2004	-.653 (1.07)	-.935 (1.18)	-1.097 (1.15)	.069 (.002)	.003 (.978)	-.069 (.001)	.134 (.042)	.015 (.951)	-.134 (.027)	.190 (.001)	.005 (.995)	-.190 (.001)
2005	-.646 (1.16)	-.794 (1.18)	-1.06 (1.22)	.093 (.000)	.000 (1.00)	-.093 (.000)	.108 (.088)	.016 (.938)	-.108 (.054)	.169 (.001)	.005 (.991)	-.169 (.001)
2006	-.457 (1.21)	-.726 (1.15)	-.982 (1.22)	.107 (.000)	.000 (.999)	-.107 (.000)	.105 (.047)	.000 (1.00)	-.105 (.029)	.165 (.000)	.000 (1.00)	-.165 (.000)
2007	-.404 (1.19)	-.642 (1.21)	-.933 (1.200)	.124 (.000)	.004 (.967)	-.124 (.000)	.092 (.065)	.002 (.998)	-.092 (.039)	.166 (.000)	.003 (.997)	-.166 (.000)
2008	-.347 (1.19)	-.601 (1.19)	-.901 (1.24)	.126 (.000)	.000 (.999)	-.126 (.000)	.099 (.028)	.005 (.987)	-.099 (.017)	.183 (.000)	.001 (.999)	-.183 (.000)
2009	-.372 (1.15)	-.650 (1.18)	-.906 (1.22)	.112 (.000)	.001 (.998)	-.112 (.000)	.105 (.016)	.000 (1.00)	-.105 (.010)	.176 (.000)	.000 (1.00)	-.176 (.000)
2010	-.345 (1.17)	-.564 (1.12)	-.863 (1.21)	.125 (.000)	.000 (1.00)	-.125 (.000)	.099 (.029)	.007 (.979)	-.099 (.018)	.168 (.000)	.000 (1.00)	-.168 (.000)

Notes: Notes: GO specification (based on L-P approach): TFP estimates obtained from a gross output specification of the production function, using Levinsohn and Petrin (2003) approach. VA specification (based on W-LP approach): TFP estimates obtained from a value added specification of the production function, using Wooldridge (2009) approach.

D: purely domestic firm, DX: pure export firms that also serve the domestic market, DXI: firms that export and invest overseas, DIDXI: outward investing firms (includes DXI: firms that export and invest overseas, and DI: firms that invest overseas but do not export)

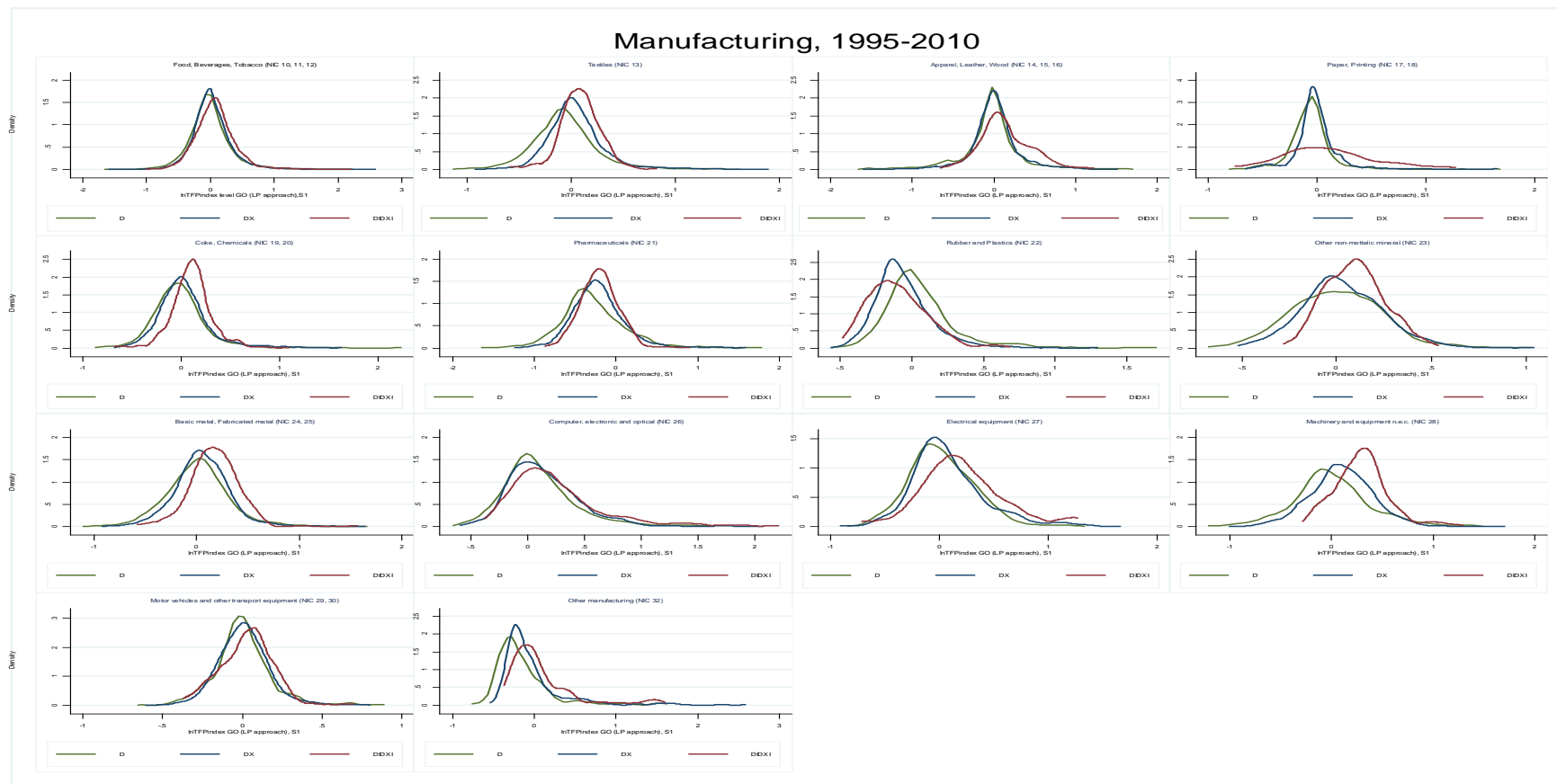
S2: DX if export intensity is  $\geq 1\%$ , DXI if export intensity is  $\geq 1\%$  and foreign investment intensity is  $\geq 1\%$ , DI non-exporter firms with foreign investment intensity  $\geq 1\%$ .

Corrected *p*-values in parentheses. Two-way stands for combined K-S.

Source: *Prowess 4* and own calculations.

**Figure F.1: Density plots of  $\ln$  (TFP) index at two digit level, manufacturing, 1995-2010**

The distribution for DIDXI firms is more shifted to the right for Machinery and equipment n.e.c. (NIC 28). The figure shows the same direction of result for all industries except Rubber and plastics (NIC 22).



Source: *Prowess 4* and own calculations.



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