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Journal of International Economics 159 (2026) 104202

Contents lists available at ScienceDirect

Journal of International Economics

journal homepage: www.elsevier.com/locate/jie

Full length articles

Foreign direct investment, prices and efficiency: Evidence from India[☆]

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ARTICLE INFO

Dataset link: Foreign Direct Investment, Prices and Efficiency: Evidence from India (Reference data)

JEL classification:
F61
F23
G34
L25
D22
D24

Keywords:
Foreign direct investment
Spillovers
Productivity
Marginal costs
Prices
Markups
Multi-product firms

ABSTRACT

This paper uses a rich panel dataset of Indian manufacturers to analyze the effects of foreign direct investment (FDI) on domestic firms. Detailed product-level information on prices and quantities allows us to estimate physical productivity and marginal costs. In line with the previous literature, we find little evidence of horizontal spillovers based on commonly used measures of revenue productivity. In contrast, we measure sizable efficiency gains using measures that are not affected by pricing heterogeneity. Our results indicate that domestic firms do benefit from the ability of multinational subsidiaries to produce high-quality products at relatively low cost.

1. Introduction

It is well documented that multinational subsidiaries outperform purely domestic firms in terms of efficiency, value added and other indicators.[1] Since this productivity advantage might stem from intangible assets such as management practices, innovation and knowledge (e.g., Bloom and Van Reenen, 2010; Markusen, 1997, 2004; Guadalupe et al., 2012), policymakers – especially in developing and transition economies – often expect that foreign direct investment (FDI) leads to technology spillovers to domestic

☆ This project is funded by the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG), grant number STI 729/1, which is gratefully acknowledged. We would like to thank Maria Garcia-Vega, Sourafel Girma, Johannes Böhm, Ekaterina Kazakova, Richard Kneller, Justin Pierce, Florian Szücs as well as seminar and conference participants in Bergen, Delhi, Dublin, Düsseldorf, Göttingen, Nottingham, Stellenbosch and Trier for helpful comments and suggestions. Comments by the editor, Kim Ruhl, and two anonymous referees have greatly improved the paper. We would also like to thank Markus Funke, Maximilian Lückemann and Christina Wirths for their excellent research assistance. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors and should not be attributed to the World Bank.

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[1] See, for instance Greenaway and Kneller (2007), Helpman et al. (2004), Criscuolo et al. (2010) to name a few.

https://doi.org/10.1016/j.jinteco.2025.104202
Received 27 July 2022; Received in revised form 5 December 2025; Accepted 6 December 2025

Available online 17 December 2025
0022-1996/

firms. However, there is little evidence that exposure to FDI is associated with positive productivity effects within the same industry (for an overview of empirical literature see Keller, 2021; Iršová and Havránek, 2013).

The lack of evidence for spillovers in the existing literature may stem from the use of revenue-based measures of productivity which can be misleading in the presence of pricing heterogeneity (e.g., Syverson, 2011; Braguinsky et al., 2015; De Loecker et al., 2016). For instance, if FDI spillovers materialize as marginal cost reductions which are (partly) passed on to consumers through lower prices, revenue productivity will underestimate the efficiency gains from FDI. Further, prices and markups – and hence measured revenue productivity – may change due to competitive pressure from foreign investors even in the absence of changes in physical productivity. Accounting for price adjustments is therefore essential when estimating FDI spillovers.[2]

In this paper, we address this problem by using a rich dataset of Indian producers to revisit the question of whether FDI leads to productivity improvements in domestic firms. A unique feature of our dataset is that it contains information on prices and quantities at the firm-product level alongside standard measures of firms' input expenditures. This information, together with methodological advances in the estimation of production functions, proposed by De Loecker et al. (2016), allows us to estimate markups, marginal costs, and physical productivity and to analyze how these variables respond to changes in FDI exposure. The use of firm-product level data also allows us to measure exposure to foreign firms in a much more precise way than previous empirical studies.[3]

The case of India is particularly relevant for several reasons. First, earlier research has shown that the Indian economy is characterized by high within-industry dispersion of productivity (see, for instance, Syverson, 2011) and a substantial technology gap relative to Western economies in most industries (e.g., Hsieh and Klenow, 2009). This implies a high potential for efficiency gains from international technology spillovers. Furthermore, various economic reforms, such as the deregulation of foreign ownership caps have attracted large inflow of FDI. Finally, unlike most other countries, Indian firms are legally required to report sales and quantities at the product level. This unusually rich information is essential for our empirical approach.

We start by documenting performance differences between foreign- and domestically owned firms. Foreign affiliates appear to generate higher demand, charge higher markups and produce products of superior quality. On average, they produce at similar marginal costs, but conditional on quality within product categories, their marginal costs are lower. This indicates that the competitive advantage of multinational subsidiaries stems from the ability to produce high-quality goods at relatively low costs.

In line with most of the previous literature, we find little evidence of productivity spillovers to domestic firms using commonly applied measures of revenue productivity at the firm-level. However, we find sizable gains based on measures that are not affected by pricing heterogeneity such as physical productivity and marginal costs. Our results indicate that although markups tend to increase – likely due to an incomplete pass-through of cost savings – part of the efficiency gains are passed on to consumers in the form of lower prices. Our results further demonstrate that competitive pressure from foreign firms leads to a further decline in prices conditional on changes in marginal costs. These two channels explain why revenue-based measures of productivity are biased downward. An alternative, not mutually exclusive explanation, is that ignoring pricing heterogeneity can lead to biased elasticities in the production function, which in-turn affects measured productivity and markups.[4]

Since FDI may not be allocated randomly across industries, we use instrumental variables (IV) exploiting cross-industry and time-series variation in India's FDI liberalization. Various checks indicate that these liberalization events are uncorrelated with previous performance levels and trends at the firm and industry levels. Using this source of exogenous variation, we find even more substantial efficiency gains from exposure to horizontal FDI in domestic firms.[5] These results remain robust when controlling for other industry-level policy changes such as tariffs and de-licensing.

Moving the analysis to the product-level, we provide evidence that technology spillovers are likely to occur across product categories. Reductions in marginal costs, at a narrowly defined (12-digit) firm-product-level, are driven by the exposure to FDI in related products within (3-digit) industries. The presence of foreign investors in the same product category does not seem to result in additional cost reductions conditional on industry-level exposure, but does lead to a decline in prices, arguably due to increased competitive pressure. We also find that efficiency gains in domestic firms are concentrated among firms that initially produce products of relatively high quality. This suggests that Indian firms with sufficient absorptive capacity can learn from foreign multinationals how to produce high-quality products at relatively low cost.

Our findings are related to several strands of literature. First, there is a large literature on spillovers from foreign to domestic firms. The majority of studies finds little evidence for horizontal spillovers, i.e. productivity spillovers within the same industry. Even for developing countries, where potential efficiency gains are most substantial, the majority of existing studies has estimated insignificant or even negative effects of FDI on domestic firms (e.g., Haddad and Harrison, 1993; Aitken and Harrison, 1999; Girma

[2] It is common practice to deflate revenues using broad industry-level price deflators. However, such an approach is unlikely to fully resolve measurement concerns in the presence of pricing heterogeneity within industries (e.g., Bloom et al., 2013; De Loecker et al., 2016). The reliance on industry-level deflators is particularly problematic when these deflators are constructed from broad classifications, are based on firm populations that differ from those in the estimation sample, or when multi-product firms are included. Prior work emphasizes the importance of distinguishing between revenue- and quantity-based measures of productivity: Smeets and Warzynski (2013) and Garcia-Marin and Voigtländer (2019) in the context of exporting, Pierce (2011) in the context of anti-dumping, and Foster et al. (2008) in the analysis of within-industry reallocation.

[3] Keller and Yeaple (2009), Keller (2021) discuss the importance of taking multiple industry affiliations of foreign owned firms into account.

[4] Recently, Bond et al. (2021) show that without measures of quantities, it is not possible to consistently identify variation in markups and productivity across firms and time unless one imposes strong assumptions about demand or restrictions on output elasticities.

[5] Bau and Matray (2023) also study the effects of FDI liberalization in India and find a reduction in misallocation which they attribute to improved access to finance for domestic firms. In contrast, our paper analyzes within-firm changes in physical productivity due to spillovers from FDI. See Goldberg et al. (2009, 2010a), and De Loecker et al. (2016) for an analysis of India's trade liberalization. Other reforms in the Indian economy are, for instance, analyzed by Aghion et al. (2008) and Martin et al. (2017).

et al., 2015; Lu et al., 2017). The evidence is more positive for vertical spillovers, i.e. productivity improvements in potential suppliers of multinational subsidiaries (e.g., Javorcik, 2004; Havranek and Irsova, 2011).

The existing FDI literature is primarily concerned with the estimation of productivity spillovers rather than competitive effects. An exception is Aghion et al. (2009) who provide evidence that entry of foreign investors spurs innovation incentives of domestic firms in the UK. A few recent papers analyze the effects of FDI on product-level outcomes. Eck and Huber (2016) as well as Javorcik et al. (2018) find that horizontal FDI is correlated with higher likelihood of introducing technologically advanced products by domestic firms.

Our paper also speaks to a broader literature in international economics, which has studied performance differences between domestic and foreign-owned firms and the sources of multinational's productivity advantage (see Antràs and Yeaple, 2014, for an overview). Within this literature, a number of empirical studies have investigated the effect of cross-border mergers and acquisitions on various outcomes of acquisition targets (e.g. Arnold and Javorcik, 2009; Bircan, 2019; Fons-Rosen et al., 2021; Guadalupe et al., 2012; Javorcik and Poelhekke, 2017). Stiebale and Vencappa (2018) provide evidence on the effects of international acquisitions exploiting product-level data for India.[6] They use a method similar to that used in this paper to estimate productivity and marginal costs, concentrating instead on foreign takeovers to assess whether target firms benefit from acquisition by a foreign investor. In contrast, in this paper, we analyze whether foreign firms create spillovers to *domestic* firms that have not received FDI. We also employ a broader measure of exposure to FDI, based on the market share of foreign-owned firms. This measure comprises acquisition FDI but also greenfield investment and growth in existing foreign affiliates.

Finally, our paper is related to a literature which investigates the effects of FDI policy on the volume of foreign investment (e.g. Harding and Javorcik, 2011) and revenue-based measures of productivity (e.g., Eppinger and Ma, 2017; Lu et al., 2017; Genthner and Kis-Katos, 2022; Bau and Matray, 2023; Conteduca and Kazakova, 2021).

We contribute to the existing literature in various aspects. First, to the best of our knowledge, this is the first paper to estimate the effects of FDI on marginal costs and markups of domestic firms. Second, we show that the absence of information on quantities and prices leads to misleading conclusions about the existence and magnitude of FDI spillovers. Therefore, we argue that one reason for the lack of horizontal spillovers from FDI in the existing literature may lie in the measures of productivity employed. Third, we provide evidence on the importance of quality-based capabilities for the competitive advantage of multinational subsidiaries and the resulting spillovers to domestic firms. Fourth, our analysis differentiates between spillovers within and across product categories which has important implications for the effectiveness of FDI policy.

The rest of the paper is organized as follows. Section 2 provides a description of our datasets and details how we estimate productivity, markups and marginal costs. Results on spillovers from FDI to domestic firms are discussed in Section 3. Section 4 concludes.

2. Data and variables

2.1. Data

Our main data source is the *Prowess* database compiled by the Centre for Monitoring of the Indian Economy (CMIE). Prowess includes financial data for both publicly listed and private firms across all sectors.[7] These firms cover more than 70% of industrial output from the organized sector and 75% of corporate taxes and 95% of excise taxes collected by the government. Prowess also records firms' product-level data on quantities and values of sales and production.[8] We extracted data covering the period from 1988, the first year firms appear in the database, through 2017. Since our empirical framework requires comparable units for quantities and prices, we focus on the manufacturing sector.

Firms report the name of each product alongside information on the quantity and value of production and sales. Each product in Prowess is allocated a 20-digit code from CMIE's own internal classification of 5908 sub-industries and products. Of these, 4833 products fall under the manufacturing sector.[9] The first four digits of a product usually correspond to industries such as iron and steel. An example of two products that share the same 6-digit code but differ at the 8-digit level are pig iron and sponge iron. Steel castings and cast iron castings share the same 8-digit code but have a unique 12-digit code.

After aggregating products to a common 12-digit level, there are 2896 clean and unique CMIE product categories in our estimation sample.[10] Following De Loecker et al. (2016), we choose to aggregate products to a 12-digit level because the number of observations for some narrowly defined products is very small and the degree of disaggregation varies across products and industries. However, differences across products within 12-digit categories are rather small. Examples of 20-digit products that share a common 12-digit code include styrene butadiene rubber and styrene butadiene latex, or HDPE pipes and HDPE/LDPE tubes .

[6] Bircan (2019) provides related evidence using similar data on Turkish firms.

[7] This database has been used in a number of recent papers, e.g. De Loecker et al. (2016), Goldberg et al. (2009, 2010a,b).

[8] The 1956 Companies Act requires Indian firms to disclose data at this level of detail.

[9] CMIE's classification is largely based on the Indian National Industrial Classification (NIC) and the HS schedule. See Goldberg et al. (2010b) for a detailed description of the product-level data in Prowess.

[10] We lose a small number of product categories for which no non-missing values of prices and quantities are available.

Table 1
Firms, products and ownership across industries.

NIC codes	Sector	All firms	Single-product	No. of products	Domestic	Foreign
10, 11, 12	Food, beverages and tobacco	1505	766	254	1444	61
13, 14, 15	Textiles, wearing apparel and leather	1478	851	208	1458	20
16, 17, 18	Wood, paper products and printing	430	305	80	421	9
19, 20, 21	Coke, chemicals and pharmaceuticals	2106	1118	919	1985	121
22	Rubber and plastics	610	408	127	591	19
23	Non-metallic minerals product	410	319	110	394	16
24, 25	Basic metal and fabricated metal	1496	895	224	1461	35
26	Computers & electronics	458	301	338	425	33
27	Electrical	416	276	201	393	23
28	Machinery & equipment	594	360	283	540	54
29, 30	Motor vehicles and transport equipment	453	356	152	417	36
10–30	All manufacturing	9956	5955	2896	9529	427

The aggregated product codes were subsequently mapped to India's National Industrial Classification (NIC) to facilitate matching with FDI liberalization indicators. Prowess also contains information at the firm-level such as sales, material costs, wage bill and capital stock (measured by gross fixed assets).[11]

It further includes data on the share of foreign equity for listed firms in each year. For both listed and non-listed firms, time-varying information on whether a firm is part of a domestic (private or government) or foreign business group is available. This measure contains the percentage of foreign promoters for Indian listed companies. We complement this measure with information on firm's ownership type for non-listed firms. In our analysis, we consider firms with more than 25% foreign shares as foreign-owned firms. We classify firms as privately or government-owned Indian firms if they have less than 25% foreign equity, and as privately foreign-owned firms if they have more than 25% foreign equity.[12]

Table 1 reports the coverage of firms, products and firms' ownership in our sample. For our empirical analysis, we use data on 9956 firms and 30,013 firm-products, distributed across 11 broad (roughly two-digit) manufacturing sectors. 4.2% of the firms in our estimation sample have at least 25% of foreign ownership, and about 60% of the firms are single-product firms.[13]

2.2. Main variables

2.2.1. Estimating physical productivity, markups and marginal costs

To estimate productivity, markups, and marginal costs, we follow the methodology introduced by De Loecker et al. (2016), henceforth LGKP.[14] This method accounts for endogeneity of production inputs similar to standard techniques in the productivity literature (Ackerberg et al., 2015; Levinsohn and Petrin, 2003; Olley and Pakes, 1996). In addition, it relies on the availability of quantities and prices at the product level to separate physical productivity from revenue-based productivity. Examples of products in our sample are bread and sugar which belong to the industry "manufacture of food products". Another example is the industry "Manufacture of rubber products" which includes products such as cycle tyres and moped tyres. LGKP's approach also introduces a control function for unobserved input prices and a method to recover the allocation of inputs across products. We briefly describe the methodology below.

Consider a production function for firm i producing a product j at time t:

$$Q_{ijt} = F(M_{ijt}, K_{ijt}, L_{ijt})\Omega_{it} \tag{1}$$

where Q_{ijt} denotes physical output, M_{ijt} denotes a freely adjustable input (materials in our case), K_{ijt} and L_{ijt} are capital stock and labor input, respectively and Ω_{it} denotes total factor productivity (TFP). All production inputs are defined in physical units. A firm minimizes costs for each product and takes the production function and input costs as given.[15]

[11] Unfortunately, the database does not contain direct information about the skill level of employees or the quality of capital and materials. However, as we discuss in the next section, our empirical framework will control for heterogeneity in quality using a control function approach.

[12] Eck and Huber (2016) use a similar strategy to construct a measure of foreign ownership. Our results are robust towards using alternative thresholds of foreign ownership. On average, foreign shares represent 58.5% of listed private-foreign owned firms' shares and 7.8% of listed private-Indian and government-owned firms' shares. Unfortunately, Prowess does not provide information about the country of foreign investors. For international M&A, which we also observe in another database, 26% of foreign investors are from Europe, 21% from North America, 11% from Mauritius and 11% from high-income Asian countries (Japan, Hong Kong, Singapore), the rest of investors is dispersed around the world.

[13] The share of single-product firms in our sample is comparable to Bernard et al. (2010), who report 61% for the United States in 1997. It is slightly higher than the 53% reported for India by Goldberg et al. (2010b). This difference partly reflects the greater coverage of smaller firms in the more recent version of Prowess, and partly our aggregation of similar products into broader categories for estimation. Consistent with other studies on multi-product firms, our definition of a product refers to a category (e.g., motorcycles or sponge iron), rather than a unique variety within that category. Among foreign-owned firms in our sample, the share of single-product firms is 5%.

[14] LGKP investigate the effect of India's trade liberalization on output prices, markups and marginal costs using the same main data source, but covering an earlier time period.

[15] We estimate the production function separately by industry to allow for industry-specific parameters.

As shown by De Loecker and Warzynski (2012) and LGKP, this cost minimization yields an expression for the firm-product specific markup as:

$$\mu_{ijt} = \left(\frac{P_{ijt}Q_{ijt}}{W_{ijt}^M M_{ijt}}\right)\frac{\partial Q_{ijt}(.)}{\partial M_{ijt}}\frac{M_{ijt}}{Q_{ijt}} = \frac{\theta_{ijt}^M}{\alpha_{ijt}^M} \tag{2}$$

where P_{ijt} denotes the output price, W_{ijt}^M is the input price of materials, α_{ijt}^M is the ratio of expenditures on input M_{ijt} to a product's revenue and θ_{ijt}^M is the elasticity of output with respect to this input. Intuitively, the output elasticity equals the input's revenue share only under perfect competition. Under imperfect competition, the output elasticity exceeds the revenue share.[16] As we describe below, θ_{ijt}^M can be estimated from a production function and α_{ijt}^M can be calculated, once the allocation of inputs across a firm's product have been estimated. Marginal costs (mc_{ijt}) can then be calculated as the ratio of observed prices to estimated markups:

$$mc_{ijt} = \frac{P_{ijt}}{\mu_{ijt}} \tag{3}$$

The basis for productivity estimation is the logarithmic version of Eq. (1) with an additive error term, ϵ_{ijt}, which captures measurement error:

$$q_{ijt} = f_j(\boldsymbol{v}_{ijt};\boldsymbol{\beta}) + \omega_{it} + \epsilon_{ijt} \tag{4}$$

where $\boldsymbol{v}_{ijt}$ denotes a vector of logarithmic physical inputs (capital k_{ijt}, labor l_{ijt} and materials m_{ijt}) allocated to product j and ω_{it} is the log of TFP. For our application, we rely on a translog production function, hence[17]:

$$\begin{aligned} f_j(\boldsymbol{v}_{ijt};\boldsymbol{\beta}) =& \beta_l l_{ijt} + \beta_m m_{ijt} + \beta_k k_{ijt} + \beta_{lm} l_{ijt} m_{ijt} + \beta_{lk} l_{ijt} k_{ijt} + \beta_{mk} m_{ijt} k_{ijt} \\ &+ \beta_{ll} l_{ijt}^2 + \beta_{mm} m_{ijt}^2 + \beta_{kk} k_{ijt}^2 + \beta_{lmk} l_{ijt} m_{ijt} k_{ijt} \end{aligned} \tag{5}$$

Physical inputs can be expressed as $v_{ijt} = \rho_{ijt} + \tilde{v}_{it} - w_{ijt}$, where $\tilde{v}_{it}$ denotes observed input expenditures at the firm-level, ρ_{ijt} is the log of the input share allocated to product j and w_{ijt} denotes the log of an input price index (defined as deviations from industry-specific deflators). When the log of input allocations, ρ_{ijt}, is captured by a function $A(\rho_{ijt}, \tilde{\boldsymbol{v}}_{it}, \boldsymbol{\beta})$ and the log of the unobserved input price index, w_{ijt}, is captured by a function $B(w_{ijt}, \rho_{ijt}, \tilde{\boldsymbol{v}}_{it}, \boldsymbol{\beta})$, output can be rewritten as a function of firm-specific input expenditures rather than unobserved product-specific input quantities[18]:

$$q_{ijt} = f_j(\tilde{\boldsymbol{v}}_{ijt};\boldsymbol{\beta}) + A(\rho_{ijt}, \tilde{\boldsymbol{v}}_{it}, \boldsymbol{\beta}) + B(w_{ijt}, \rho_{ijt}, \tilde{\boldsymbol{v}}_{it}, \boldsymbol{\beta}) + \omega_{it} + \epsilon_{ijt} \tag{6}$$

Estimation of the parameters of the production function is based on a sample of single-product firms for which $A(.)$ can be ignored. Unobserved input prices w_{it} in $B(.)$ are approximated by output prices (p_{it}), market shares (s_{it}), product dummies ($\boldsymbol{D}_i$), and export status (ex_{it}) to account for differences in product quality and local input markets. We also include variables capturing foreign ownership (FO) and exposure to FDI (FDI_{it}), which we define below, as we want to allow for the possibility that foreign ownership and the presence of foreign investors affect input prices.

Material demand is assumed to be a function of productivity, other inputs, output prices, market share, product, export and FDI, hence: $\tilde{m}_{it} = m(\omega_{it}, \tilde{k}_{it}, \tilde{l}_{it}, p_{it}, \boldsymbol{D}_i, s_{it}, ex_{it}, FO_{it}, FDI_{it})$. Inverting the material demand function yields an expression for productivity: $\omega_{it} = h(\tilde{\boldsymbol{v}}_{it}, \boldsymbol{c}_{it})$, where $\boldsymbol{c}_{it}$ includes all variables from the input demand function except input expenditures.

The use of single-product firms induces a further complication of endogenous sample selection since single-product firms may be less productive compared to multi-product firms. Analogous to the exit correction proposed by Olley and Pakes (1996), the probability of remaining a single-product firm (SP_{it}) is a function of previous year's productivity and an unobserved productivity cutoff.[19]

For the evolution of productivity, the following law of motion is assumed:

$$\omega_{it} = g(\omega_{i,t-1}, ex_{i,t-1}, FO_{i,t-1}, FDI_{i,t-1}, SP_{it}) + \zeta_{it} \tag{7}$$

In addition to export status and the probability of remaining a single-product firm, we allow the evolution of productivity to depend on exposure to FDI and foreign ownership. We follow LGKP and base our moment conditions of the combined error term $\zeta_{it} + \epsilon_{ijt}$ as suggested by Wooldridge (2009).

To estimate TFP, we subtract estimates of $f(.)$ and $B(.)$ from predicted output net of measurement error. It is important to control for FDI exposure in the inverted input-demand function, so that variation due to FDI is not attributed to measurement error.[20] For

[16] This framework assumes that there are no static sources of market power in *input* markets, i.e. $\frac{\partial W_{ijt}^M}{\partial M_{ijt}} = 0$. While a violation of this assumption would affect estimated markups and marginal costs, it would not affect the estimated effect of FDI exposure as long as market power in input markets is constant over time or its change is uncorrelated with the change in FDI exposure. Further, it assumes that there is no misallocation of materials. This assumption is in line with Bau and Matray (2023) who study misallocation in labor and capital markets but abstract from misallocation in material markets.

[17] The translog production function yields a physical output-material elasticity: $\theta_{ijt}^M = \beta_m + \beta_{lm} l_{ijt} + \beta_{mk} k_{ijt} + 2\beta_{mm} m_{ijt} + \beta_{lmk} l_{ijt} k_{ijt}$ which varies across firms within industries and nests a Cobb–Douglas production function as a special case. For the Cobb–Douglas production function, $f_j(\boldsymbol{v}_{ijt};\boldsymbol{\beta}) = \beta_l l_{ijt} + \beta_m m_{ijt} + \beta_k k_{ijt}$ and $\theta_{ijt}^M = \beta_m$.

[18] See LGKP for the exact functional form of $A(.)$ and $B(.)$ for the translog and the Cobb–Douglas case.

[19] SP_{it} is estimated by a Probit regression of a dummy variable for remaining a single-product firm on $\tilde{\boldsymbol{v}}_{i,t-1}$ $\boldsymbol{c}_{i,t-1}$, investment, year and industry dummies.

[20] Similarly, LGKP control for tariffs in the input demand function and the law of motion before estimating the effects of tariff changes on variables estimated from the production function in the first step.

multi-product firms, we assume that TFP is constant across products within a firm-year, and that the coefficients of their production and input price correction function are the same as those of single-product firms. These assumptions enable solving a non-linear equation system to back out unobserved input allocations. We discuss the estimation procedure in more detail in Appendix C. We also experiment with the alternative assumption that inputs are allocated according to products' revenue shares which enables to recover a firm-product specific value of TFP (Foster et al., 2008; Orr, 2022).

2.2.2. Revenue-based TFP from firm-level revenue function

We estimate revenue-based total factor productivity at the firm-level using the estimation method suggested by Ackerberg et al. (2015), henceforth ACF. Specifically, we estimate:

$$R_{it} = \tilde{F}(\tilde{M}_{it}, \tilde{K}_{it}, \tilde{L}_{it})\tilde{\Omega}_{it} \tag{8}$$

R_{it} denotes deflated revenues and $\tilde{\Omega}_{it}$ is a revenue-based efficiency measure. We use a material demand function similar to the LGKP estimator: $\tilde{m}_{it} = m_t(\tilde{\omega}_{it}, \tilde{k}_{it}, \tilde{l}_{it}, ex_{it}, FO_{i,t-1}, FDI_{i,t-1})$.

Since we are estimating TFP at the firm-level and include single- and multi-product firms, the material demand function does not depend on the product-specific variables – price, market share and product dummies – and does not include an indicator for single-product firms.[21] Inverting the material-demand function yields an expression for revenue productivity: $\tilde{\omega}_{it} = h_t(\tilde{\boldsymbol{v}}_{it}, ex_{it}, FO_{i,t-1}, FDI_{i,t-1})$

For the evolution of productivity, the following law of motion is assumed:

$$\tilde{\omega}_{it} = g(\tilde{\omega}_{i,t-1}, ex_{i,t-1}, FO_{i,t-1}, FDI_{i,t-1}) + \tilde{\xi}_{it} \tag{9}$$

The measure $\tilde{\omega}_{it}$ reflects what a researcher can estimate from typical firm-level data without information on firm-specific input and output prices.

2.2.3. Productivity measures from physical and revenue-based production function

To illustrate the reasons why the two productivity measures may differ, consider a simplified production function with a single input and one product per firm. We follow the previous literature and define revenue productivity as: $\tilde{\Omega} = P \times \Omega$. Abstracting from estimation problems and measurement error, a regression of physical output on physical inputs, $q = x\beta + \omega$, identifies "true" (log) technical efficiency $\omega = \ln(\Omega)$. A typical revenue-based production function estimates: $p + q = x\beta + \tilde{\omega}$, where $\tilde{\omega} = \omega + p$. Hence, changes in physical productivity are fully reflected in revenue-based TFP measures only when pass-through of efficiency to prices is zero (see, for instance, Garcia-Marin and Voigtländer, 2019). Further, revenue-based productivity can increase even in the absence of efficiency gains when markups and prices increase.

When there is heterogeneity in input prices as well, a firm-level revenue function estimates $p + q = \tilde{x}\beta + \breve{\omega}$ where $\tilde{x} = x + w$, and $\breve{\omega} = \omega + p - \beta w$.[22] The LGKP framework aims to control for w using a control function which depends on prices, market shares, product dummies, export status and FDI variables (see Eq. (6)), and identifies physical TFP, ω, under the assumptions discussed in Section 2.2.1. Further, using revenues and expenditures instead of quantities, the coefficients β will be different across the two estimation methods. This will imply differences in estimated productivity even conditional on input and output measures. Estimated productivity from the revenue function is then: $\omega^R = \omega + p - w\breve{\beta} - (\breve{\beta} - \beta)x$.

2.2.4. Indicators of product quality

We use two indicators of product quality. The first indicator comes directly from the production function estimation and is based on heterogeneity in input prices. Following LGKP, we assume that input prices are a function of product quality which in turn depends on market share and price. The idea is that high quality outputs require high quality inputs which tend to have high input prices. Our first measure of (input) quality is therefore the predicted input price index, $\hat{w}_{ijt}$, which we use in the control function.

An alternative approach to measuring quality follows Amiti and Khandelwal (2013) and Khandelwal et al. (2013) and is based on the intuition that, within product categories, varieties of higher quality should generate higher demand conditional on price. Under the assumption that consumers maximize a CES utility function, one can write:

$$q_{ijt} + \sigma p_{ijt} = \alpha_j + \alpha_t + \iota_{ijt} \tag{10}$$

where q_{ijt} and p_{ijt} denote logarithmic quantities and prices, α_j and α_t are product and year fixed effects and σ is the elasticity of substitution between varieties within a market.[23] Quality is inferred from this specification as $\gamma_{ijt} = \iota_{ijt}/(\sigma - 1)$. Because this approach assumes a CES utility function, it ignores heterogeneity of markups within product categories. Therefore, it does not rely on our estimated production-function elasticities or markups, allowing a robustness check that does not depend on the production-function specification. We use industry-specific levels of σ estimated for imports into India by Broda and Weinstein (2006) to avoid having to estimate demand for each product category.

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[21] In the robustness checks discussed in Section 3.5, we construct a measure of revenue TFP using coefficients estimated from single-product firms to analyze how the choice of sample contributes to the differences between QTFP and RTFP.

[22] A revenue based production function where inputs are measured as expenditures identifies true productivity only when pass-through of input to output prices is complete and is therefore unlikely to address the problem of unobserved input and output price differences.

[23] See, for instance, Khandelwal et al. (2013) for details on the derivation. A similar specification has, for instance, also been applied by Breinlich et al. (2016) recently.

Table 2
Foreign ownership premia.

	(1)	(2)	(3)	(4)	(5)	(6)
	ln(sales) product	ln(quantity) product	ln(price) product	ln(markup) product	ln(quality) input product	ln(quality) output product
Foreign	0.989***	0.761***	0.228***	0.268***	0.190**	0.701***
	(0.094)	(0.117)	(0.080)	(0.063)	(0.076)	(0.099)
N	169 295	169 295	169 295	169 295	169 295	165 937
Product-year FE	Yes	Yes	Yes	Yes	Yes	Yes
	(7)	(8)	(9)	(10)	(11)	(12)
	ln(margcost) unadjusted product	ln(margcost) quality-adj. product	ln(margcost) quality-adj. product	ln(QTFP) LGKP firm	ln(RTFP) ACF firm	ln(products) count firm
Foreign	−0.040	−0.244***	−0.464***	0.036	0.097***	0.079**
	(0.106)	(0.064)	(0.082)	(0.135)	(0.022)	(0.031)
N	169 295	169 295	165 937	41 253	41 253	41 253
Product-year FE	Yes	Yes	Yes	No	No	No
Industry-year FE	No	No	No	Yes	Yes	Yes
Input-quality control	No	Yes	No	No	No	No
Output-quality control	No	No	Yes	No	No	No

Notes. The table reports coefficients from OLS regressions. Foreign is a dummy variable indicating foreign ownership of at least 25%. Dependent variables in columns 1-9 denote products' sales, quantity, price, markup, quality and marginal cost. Markup and marginal cost are calculated as expressed in Eqs. (2) and (3). Indicators for product quality are calculated as explained in Section 2.2.4. In columns 8-9, we control for a third-order polynomial in input and output quality control. ln(QTFP) denotes the logarithm of physical total factor productivity at the firm-level. ln(RTFP) denotes the logarithm of revenue-based total factor productivity at the firm-level estimated using the method proposed by Ackerberg et al. (2015). ln(products) denotes firm's number of products. Standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

3. Empirical analysis

3.1. Descriptive analysis

In this subsection, we discuss some characteristics of our firm- and product-level variables and analyze how they differ across domestic- and foreign-owned firms.

Table A.1 in the Appendix A depicts median and mean elasticities of output with respect to all inputs estimated from separate production functions for each industry. We use a translog production function that allows for elasticities and return to scale parameters to vary across industries as well as firms and firm-products within industries. The estimates indicate increasing returns to scale with an average of 1.07 across all industries. Returns to scale for the median firm within each industry are above 1 in all industries and range between 1.02 and 1.19. Table A.2 in the Appendix A reports markups of products across industries. The estimates indicate a median markup of 1.32, ranging between 1.20 and 2.03.

Table 2 reports coefficients from OLS regressions of key variables on a foreign ownership indicator and industry-year or product-year dummies. As column (1) shows, foreign-owned firms generate, on average, almost one log point higher sales than domestic Indian firms. Columns (2) and (3) indicate that about three quarters of the difference in sales are due to higher quantities produced and one quarter is due to higher prices. Column (4) shows that foreign firms charge higher prices because of higher markups, calculated as in Eq. (2). A plausible explanation for higher quantities sold besides higher prices and markups is that foreign-owned firms produce products of higher (perceived) quality. Columns (5) and (6) confirm this hypothesis using the more formal indicators of product quality discussed in Section 2.2.4. Hence, foreign firms seem to use inputs of higher quality and produce products with higher appeal to consumers.

Results in column (7) indicate that foreign-owned firms produce with slightly lower marginal costs, but the differences are not statistically significant. However, due to relatively higher quality of their products, it is misleading to draw conclusions about foreign firms' efficiency from raw differences in marginal costs. Since high-quality products typically require more expensive inputs, the fact that foreign-owned firms do not have higher marginal costs indicates superior efficiency.[24] This interpretation is confirmed in columns (8) and (9) where we control for quality-differences using a third-order polynomial in either the input or the output-based measure.[25] The results indicate that foreign-owned firms produce with significantly lower marginal costs *conditional on quality*. Hence, the average foreign firm produces with higher efficiency than a domestic firm that produces products of comparable quality in the same category.

[24] The average elasticity of marginal cost with respect to quality in our sample – estimated from a simple regression of log marginal costs on log quality and product-year fixed effects – is 0.86 for input quality and 0.59 for output quality.

[25] We obtain very similar results when we control for quality without higher order terms.

Differences in physical TFP between foreign and domestic firms are not statistically significant, which is likely due to more elaborate production techniques that produce high-quality products.[26] Finally, foreign firms appear to be more profitable on average, as indicated by higher revenue TFP, and they produce a slightly higher number of products. In the following section, we aim to analyze whether some of the superior performance of foreign-owned firms spills over to domestic firms in India.

Table A.3 in the Appendix A reports means and standard deviations of firm-level measures of revenue, labor, capital, materials and other variables, comparing domestic- and foreign-owned firms at the firm-level. Foreign-owned firms generate on average higher revenues and capital stock, face higher wage bills and spend more on materials. They also produce more products, but report lower export share relative to domestically firms. Single-product firms are smaller than multi-product firms and are characterized by lower TFP. Table A.4 in the Appendix A provides separate statistics for foreign and domestic single-product firms.

3.2. Spillovers from FDI to domestic firms

3.2.1. Baseline specification

Our empirical strategy aims to identify the effects of FDI on domestic firms. We start our analysis at the firm-level. This serves two purposes. First, it allows us to directly compare the results of efficiency measures, which are unaffected by pricing heterogeneity, to revenue-based productivity measures that one can obtain using commonly available firm-level datasets. Further, recent evidence indicates that, compared to firm-product-level markups, firm-level markups – and hence the derived marginal cost changes – are more robust to within-firm productivity differences and to different assumptions about joint production (Cairncross et al., 2023).

We estimate the following regression at the firm-level:

$$\Delta y_{it} = \phi \Delta FDI_{it} + \Delta x'_{i(k)t}\gamma + d_t + g_i + \Delta u_{it} \tag{11}$$

Δy_{it} is the change in a firm-level outcome such as productivity of firm i at time period t. FDI_{it} measures firm-level exposure to horizontal FDI which is defined below. In our main specification, we relate changes in productivity to changes in FDI in the same year, but we also experiment with lagged values. $x'_{i(k)t}$ is a vector of control variables where k indicates industries, d_t denotes time dummies which control for macroeconomic changes common to all firms and u_{it} is an error term. In some specifications, we add firm-fixed effects g_i. Although equations in differences already control for time-invariant unobserved heterogeneity (e.g. firms with higher FDI exposure might have higher productivity due to better management or technologies employed), including firm fixed effects allows for firm-specific permanent differences in *growth paths* across firms with different exposure to FDI. The equation is estimated for firms that are domestically owned in all sample periods.

For product-level outcomes, we estimate a similar regression:

$$\Delta y_{ij(k)t} = \phi_1 \Delta FDI^{product}_{jt} + \phi_2 \Delta FDI^{industry}_{kt} + \Delta x'_{j(k)t}\gamma + d_t + g_{ij} + \Delta u_{ijt} \tag{12}$$

where j refers to a 12-digit product category within an industry k. This specification allows us to distinguish between spillovers from FDI in the same product category j and spillovers across products categories within the same industry k. We control for unobserved heterogeneity at the firm-product level, g_{ij}, using firm-product fixed effects. This controls for the possibility that foreign investors might enter into product categories with higher permanent performance growth.

Exposure to FDI at the product and industry-level is measured as the share of sales generated by foreign-owned firms[27]:

$$FDI^{product}_{jt} = \frac{\sum_{i \in j,t} s_{ijt} \times foreign_{it}}{\sum_{i \in j,t} s_{ijt}} \tag{13}$$

$$FDI^{industry}_{kt} = \frac{\sum_{i \in k,t} s_{ikt} \times foreign_{it}}{\sum_{i \in k,t} s_{ikt}} \tag{14}$$

where s_{ijt} (s_{ikt}) denotes sales at the product (industry) level and $foreign_{it}$ is a dummy variable indicating foreign ownership.

The mean values of FDI exposure variables are 0.122 for $FDI^{industry}$ and 0.076 for $FDI^{product}$. The values of the 25th percentile, median and 75th percentile for $FDI^{industry}$ are 0.027, 0.062 and 0.182. For $FDI^{product}$, the median is 0 and the 75th percentile is 0.057. Hence, foreign investors tend to have higher market shares in larger product categories.

To generate a firm-specific measure of FDI exposure, we aggregate FDI at the industry (or product) level using lagged sales shares within firms as weights:

$$\Delta FDI_{it} = \sum_k \frac{s_{ik,t-1}}{S_{i,t-1}} \Delta FDI^{industry}_{kt} \tag{15}$$

where $S_{i,t-1}$ denotes sales at the firm level. In our baseline specification, we construct firm-level exposure to FDI from 3-digit industries. We apply a similar weighting scheme to aggregate industry-level controls (e.g., tariffs and de-licensing) to the firm level. For our outcome variables, we use the average of sales shares in t and $t-1$ as weights, as the composition of products can change across years.

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[26] Consistent with Forlani et al. (2016), we find a negative correlation between physical TFP and quality. See also the discussion in Stiebale and Vencappa (2018), Appendix C.

[27] This measure of exposure to horizontal FDI is standard in the literature (see, e.g., Javorcik, 2004; Iršová and Havránek, 2013).

Table 3
Horizontal FDI and firm-level outcomes.

	(1)	(2)	(3)	(4)	(5)
	$\Delta ln(QTFP)$	$\Delta ln(RTFP)$	$\Delta ln(price)$	$\Delta ln(markup)$	$\Delta ln(margcost)$
Panel A: 1-year differences					
ΔFDI	0.333**	−0.065	−0.176***	0.220**	−0.396***
	(0.152)	(0.053)	(0.065)	(0.092)	(0.108)
N	34 580	34 580	34 580	34 580	34 580
Year FE	Yes	Yes	Yes	Yes	Yes
Panel B: with lead indicator					
ΔFDI	0.321**	−0.071	−0.174***	0.215**	−0.389***
	(0.150)	(0.053)	(0.065)	(0.092)	(0.106)
ΔFDI_{t+1}	−0.106	−0.050	0.015	−0.041	0.056
	(0.115)	(0.041)	(0.051)	(0.069)	(0.081)
N	34 580	34 580	34 580	34 580	34 580
Year FE	Yes	Yes	Yes	Yes	Yes
Panel C: with firm fixed effects					
ΔFDI	0.366**	−0.065	−0.236***	0.238**	−0.474***
	(0.164)	(0.055)	(0.067)	(0.100)	(0.116)
N	34 580	34 580	34 580	34 580	34 580
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Panel D: 2-years differences					
ΔFDI	0.363**	−0.034	−0.223***	0.240**	−0.463***
	(0.167)	(0.054)	(0.068)	(0.099)	(0.116)
ΔFDI_{t-1}	−0.015	0.141***	0.059	0.008	0.051
	(0.135)	(0.048)	(0.056)	(0.079)	(0.091)
N	34 580	34 580	34 580	34 580	34 580
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Panel E: 3-years differences					
ΔFDI	0.316*	−0.020	−0.197***	0.283**	−0.480***
	(0.172)	(0.058)	(0.071)	(0.111)	(0.130)
ΔFDI_{t-1}	−0.013	0.152***	0.076	0.056	0.020
	(0.134)	(0.049)	(0.054)	(0.086)	(0.096)
ΔFDI_{t-2}	−0.042	0.048	0.086	0.165**	−0.079
	(0.159)	(0.053)	(0.066)	(0.080)	(0.097)
N	29 708	29 708	29 708	29 708	29 708
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Notes. The table reports coefficients from OLS estimations. ΔFDI denotes horizontal foreign direct investment at the 3-digit industry-level weighted using lagged sales shares of products within firms. $\Delta ln(QTFP)$ denotes the logarithm of physical total factor productivity at the firm-level. $\Delta ln(RTFP)$ denotes the logarithm of revenue-based total factor productivity at the firm-level estimated from a revenue function using Ackerberg et al. (2015) methodology. $\Delta ln(price)$ is the logarithm of firm-level products' price weighted using sales shares of products within firms. $\Delta ln(markup)$ is the logarithm of firm-level products' markup weighted using sales shares of products within firms. $\Delta ln(margcost)$ is the logarithm of firm-level products' marginal cost weighted using sales shares of products within firms. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table 3 reports estimates of different variants of Eq. (11). In Panel A, one-year differences are reported. Column (1) indicates that a 1 percentage point increase in exposure to FDI induces an approximately 0.33% increase in physical productivity of domestic firms. This results indicates that domestic firms seem to be able to improve production technologies when exposed to competition by foreign multinationals.

Interestingly, when we use a measure of revenue-based TFP ($RTFP$), estimated using sales as output in a firm-level production function, as commonly used in the literature, the coefficient for FDI exposure is negative and not statistically significantly different from zero (see column 2). Column (3) shows estimates using changes in average prices as an outcome variable. The results show that prices of domestic firms seem to decline when the presence of foreign-owned firms increases. Columns (4) and (5) decompose changes in prices into markups and marginal costs. Notably, prices do not decline due to falling markups which would be expected if foreign firms purely increase competitive pressure without generating spillovers.[28] In contrast, marginal costs decline at a magnitude that is similar to the increase in physical TFP, and a bit less than half of these cost savings seem to be passed on to consumers.

[28] We discuss pro-competitive effects in more detail in Section 3.3.

The results suggest that the common conclusion in the existing literature – that there is little evidence of horizontal spillovers in the form of efficiency gains – may be partly driven by changes in output prices, which are hidden in commonly used measures of revenue TFP, rather than by constant levels of physical TFP and production costs.

As we discuss in Section 2.2.3, a revenue-based production function generates an estimate of TFP: $\tilde{\omega} = \omega + p$. Hence, lower prices imply lower values of measured revenue TFP (De Loecker et al., 2016).[29] A further source of bias when using sales instead of quantities is that inputs might be correlated with output prices – and hence with the error term – an issue not addressed by standard estimation techniques. This can bias elasticities and, consequently, estimates of TFP and markups.

Our specification in first differences removes permanent heterogeneity in performance levels of firms with different exposure to FDI. It is, however, important to acknowledge that these characteristics may evolve differently over time. To address this concern, we adopt several strategies. First, we add the lead of exposure to FDI, $\Delta FDI_{i,t+1}$ to Eq. (11). This allows us to test for changes in domestic firms' characteristics that took place prior to the increase in foreign presence. Results in Panel B of Table 3 show that this does not seem to be an important problem as all the coefficients for the lead indicator are rather small and statistically insignificant while the coefficients of the contemporaneous FDI variable remain stable.

Second, we add firm fixed effects to Eq. (11) which allows to control for permanent differences in growth paths across firms. As shown in Panel C, including these fixed effects slightly increases the estimated impacts on physical TFP, prices, and marginal costs. We prefer this more rigorous specification as it accounts for differential trends across firms. We use it as a basis for further variations and extensions in the rest of the paper.

In alternative specifications (Panels D and E), we add lagged changes of FDI exposure to the model. Our conclusions regarding changes in efficiency remain qualitatively similar. There is little evidence of an increase or decay in spillovers over time. There is some evidence of a further markup increase induced by two-year lagged changes in FDI exposure, possibly due to delayed pass-through and adjustments within product categories over time. There are several potential reasons why efficiency gains happen rather quickly. First, copying existing knowledge from foreign-owned firms can affect productivity faster than producing own knowledge. Second, increased competition through FDI exposure may force domestic firms to become more productive.

Third, we use instrumental variables, which exploit cross-industry and time series variation in FDI reforms. We describe this identification strategy in detail in the next section.

3.2.2. *Using exogenous variation from India's FDI liberalization*

Our baseline specification assumes that changes in exposure to foreign firms (ΔFDI_{it}) are exogenous to the growth of firm performance—conditional on firm fixed-effects and other controls. Consistent with this assumption, lead variables of FDI seem to be uncorrelated with current values of firm performance. Nonetheless, although our baseline specification allows for correlation between FDI and firm- and industry-specific growth paths, a potential concern is that foreign investors select into industries based on changes in expected future growth leading to a spurious correlation between FDI exposure and efficiency. To address this potential concern, we exploit cross-industry and time-series variation in India's FDI liberalization within an instrumental variable approach.

Prior to 1991, foreign investment in India was only allowed in few industries through governmental approval and was restricted to 40% of equity. Upon the adoption of the IMF structural adjustment program in August 1991,[30] the cap on foreign equity increased to 51% and became automatically approved. Since then, the cap on foreign equity as well as the number of liberalized manufacturing industries started to increase gradually.

We followed Bau and Matray (2023) and collected yearly changes in FDI liberalization reforms using official press notes published by the Indian Ministry of Commerce and Industry.[31] We mapped the list of collected industries to five-digit industries in Prowess which are based on the NIC. We found that a total of 37 five-digit manufacturing industries were liberalized to allow up to 100% foreign equity by 2006. We focus our analysis on the list of industries that were liberalized after 2000, to avoid capturing the effect of other major reforms during the nineties such as de-licensing and trade liberalization.[32] Therefore, our instrument captures the change in FDI policy that happened after 2000 at the five-digit industry level (which affected 6% of industries in our sample). Nonetheless, we control for measures of tariffs and de-licensing in some of our specifications as a robustness check. A list of liberalized industries can be found in Table A.5 in the Appendix A.

A potential concern is that FDI liberalization did not occur randomly but was targeted towards industries based on their performance. For instance, policy makers might believe that industries with specific characteristics might cope with foreign competition in a better way or have the absorptive capacity to benefit from spillovers. To investigate whether this is likely to be the case, we checked the correlation between the incidence of FDI liberalization and past performance at the 5-digit industry level.[33] Specifically, we regressed a dummy variable for FDI liberalization in a current year on lagged levels and growth rates of

[29] If prices were constant across firms within an industry, output prices could be controlled for by commonly used industry deflators. However, this is not the case if there is pricing heterogeneity across firms within industry—which is common in our sample. Further, even if there was no pricing heterogeneity within industries, aggregate deflators that will assign one industry code per firm will still not be sufficient since many firms produce outputs in various industries. Note that the expression abstracts from input price heterogeneity which is taken into account in our empirical framework.

[30] After a balance of payment crisis in India in 1990, IMF support was granted conditional on reforms including foreign equity liberalization, tariff reductions and de-licensing during the 1990s. See Topalova and Khandelwal (2011) for a detailed discussion.

[31] These are available at https://dipp.gov.in/policies-rules-and-acts/press-notes-fdi-circular, accessed March 8, 2020.

[32] See, for instance, Aghion et al. (2008) and De Loecker et al. (2016) for analyzes of de-licensing and trade reforms in India.

[33] Our approach is similar to Topalova and Khandelwal (2011) who analyze the potential endogeneity of India's trade liberalization to industry characteristics and firm performance.

Table 4
Exogeneity of India's FDI liberalization reforms.

Panel A:	dependent variable: lib								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$ln(marketsize)_{t-1}$	0.001 (0.003)								
$\Delta ln(marketsize)_{t-1}$		−0.004 (0.006)							
$\Delta ln(marketsize)_{t-3}$			−0.005 (0.007)						
$capitalintensity_{t-1}$				−0.000 (0.000)					
$\Delta capitalintensity_{t-1}$					0.000 (0.000)				
$\Delta capitalintensity_{t-3}$						0.000 (0.000)			
$ln(QTFP)_{t-1}$							−0.003 (0.003)		
$\Delta ln(QTFP)_{t-1}$								−0.005 (0.004)	
$\Delta ln(QTFP)_{t-3}$									0.001 (0.003)
N	622	610	601	622	610	601	622	610	601
Panel B:	dependent variable: lib								
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
$ln(markup)_{t-1}$	0.003 (0.005)								
$\Delta ln(markup)_{t-1}$		−0.000 (0.004)							
$\Delta ln(markup)_{t-3}$			0.004 (0.004)						
$ln(price)_{t-1}$				0.002 (0.002)					
$\Delta ln(price)_{t-1}$					0.002 (0.003)				
$\Delta ln(price)_{t-3}$						0.003 (0.002)			
$ln(margcost)_{t-1}$							0.001 (0.002)		
$\Delta ln(margcost)_{t-1}$								0.001 (0.003)	
$\Delta ln(margcost)_{t-3}$									0.000 (0.003)
N	617	607	595	622	610	601	617	607	595

Notes. The table reports coefficients from linear probability models. lib denotes FDI liberalization reforms at the 5-digit industry-level. $marketsize$ denotes domestic market size measured as the logarithm of total sales aggregated at the 5-digit industry-level. $capitalintensity$ denotes capital intensity measured as the ratio between firms' capital value (fixed assets) and wages aggregated at the 5-digit industry-level. $ln(QTFP)$ denotes the logarithm of industry-level firms' physical total factor productivity weighted using firm's share of sales within industries. $ln(price)$ $ln(markup)$ and $ln(margcost)$ denote the logarithm of industry-level product price, markups and marginal cost weighted using firm's share of sales within industries. Standard errors are clustered at the five-digit industry level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

domestic market size (captured by the log of total sales) and average values of TFP, capital intensity, markups, prices, and marginal costs. Table 4 shows results from linear probability models, which indicate that neither lagged levels, 1-year or 3-year growth rates of any of these variables are statistically significantly correlated with FDI liberalization.[34]

As the results are consistent with FDI liberalization events being exogenous to the performance of domestic firms, we proceed with assessing their impact on firm- and industry-level exposure to foreign investors using the following equation at the firm-level:

$$\Delta FDI_{it} = \alpha_i + \delta POSTlib_{it} + \tau_t + e_{it}$$

The firm-specific variable $POSTlib_{it} = \sum_k s_{ik} POSTlib_{kt}$ captures exposure to FDI reforms, where s_{ik} denotes the share of sales that firm i generates from 5-digit industry k at the time when it enters the sample and $POSTlib_{kt}$ denotes the post-liberalization period and equals one for all periods following FDI liberalization in a given five-digit industry. We estimate these equations using firm fixed effects to account for unobserved heterogeneity. Columns (1)-(3) of Table 5 show variants of this specification using

[34] We reach similar conclusions when we estimate a Probit model instead of a linear probability model and when we run separate regressions for the two main liberalization episodes 2001 and 2006. Results are available upon request.

Table 5
FDI liberalization reforms and firm-level exposure to FDI.

	(1)	(2)	(3)	(4)
	ΔFDI			
$POSTlib_t$	0.016***		0.000	
	(0.001)		(0.003)	
$POSTlib_{t-1}$		0.020***	0.023***	
		(0.001)	(0.003)	
$POSTlib_{t+1}$			−0.004*	
			(0.002)	
$D(2004) \times POSTlib_{t-1}$				0.019***
				(0.001)
$D(2005) \times POSTlib_{t-1}$				0.030***
				(0.001)
$D(2006) \times POSTlib_{t-1}$				0.003**
				(0.002)
$D(2007) \times POSTlib_{t-1}$				−0.006***
				(0.001)
$D(2008) \times POSTlib_{t-1}$				0.061***
				(0.004)
$D(2009) \times POSTlib_{t-1}$				0.017***
				(0.003)
$D(2010) \times POSTlib_{t-1}$				0.001
				(0.001)
$D(2011) \times POSTlib_{t-1}$				0.072***
				(0.004)
$D(2012) \times POSTlib_{t-1}$				−0.047***
				(0.018)
$D(2013) \times POSTlib_{t-1}$				−0.027
				(0.019)
$D(2014) \times POSTlib_{t-1}$				0.010
				(0.008)
N	34 580	34 580	34 580	34 580
Firm FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Notes. The table reports coefficients from OLS estimations. ΔFDI denotes horizontal foreign direct investment at the industry-level weighted by lagged sales shares of products within firms. $POSTlib$ denotes post-liberalization periods, which equals one for all periods following FDI liberalization in a given five-digit industry, and is aggregated to the firm-level using initial sales shares. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

different lags of the post-liberalization indicator. It seems that foreign investors respond to the liberalization with a lag as the association between post-liberalization periods and foreign investor presence is increasing over time. This is in line with Harding and Javorcik (2011) who find that the effects of investment promotion on FDI inflows is strongest after 2–3 years.[35] A potential concern is that FDI flows react in advance to expected liberalization events in the future. However, column (4) shows that leads of FDI liberalization periods are only weakly associated with current exposure to FDI indicating the limited role of anticipation effects. Column (5) interacts the post-liberalization dummy with indicators for the years 2004–2014. Having shown the relevance of investment liberalization for FDI exposure, we use post-liberalization periods interacted with time dummies as IV for our performance regressions.

A potential threat to our identification strategy is that other reforms might be confounding with FDI liberalization episodes. Although the most significant changes induced by these reforms occurred prior to the FDI liberalization period we focus on, we assess the robustness of our results by controlling for trade liberalization and de-licensing. Specifically, we use industry-level tariffs and dummy variables for de-licensing which we weight by firms' sales share in the same way as our FDI liberalization indicators.[36]

Table 6 shows second stage results of our instrumental variable strategy. The first stage F-test indicates that our excluded instruments are highly statistically significant and above conventional critical values of weak identification tests. The results confirm the conclusions of our OLS regressions. Exposure to FDI – induced by FDI liberalization – generates higher physical TFP, higher markups, lower prices and lower marginal costs for domestic firms. Again, using a revenue-based measure of TFP does not uncover positive spillovers. The magnitudes of the estimated effects is larger than in the OLS estimates. For instance, a one percentage point

[35] Note that as our variable of interest is measured as the market share of foreign investors, there might be an additional time lag between foreign entry and FDI exposure.

[36] We collected information on de-licensing from Aghion et al. (2008) and from official press notes published by the Indian Ministry of Commerce and Industry. Tariff data were sourced from the World Integrated Trade Services (WITS).

Table 6
Horizontal FDI and firm-level outcomes: 2sls estimation.

	(1)	(2)	(3)	(4)	(5)
	$\Delta ln(QTFP)$	$\Delta ln(RTFP)$	$\Delta ln(price)$	$\Delta ln(markup)$	$\Delta ln(margcost)$
ΔFDI	1.427**	−0.207	−0.663*	0.891*	−1.554***
	(0.690)	(0.252)	(0.348)	(0.481)	(0.566)
N	34 580	34 580	34 580	34 580	34 580
First stage F-test			176.341		
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Notes. The table reports coefficients from instrumental variable regressions with firm and year fixed effects. ΔFDI denotes horizontal foreign direct investment at the 3-digit industry-level weighted by lagged sales shares of products within firms. $\Delta ln(QTFP)$ denotes the logarithm of physical total factor productivity at the firm-level. $\Delta ln(RTFP)$ denotes the logarithm of revenue-based total factor productivity at the firm-level estimated from a revenue function using Ackerberg et al. (2015) methodology. $\Delta ln(price)$ is the logarithm of firm-level products' price weighted using sales shares of products within firms. $\Delta ln(markup)$ is the logarithm of firm-level products' markup weighted using sales shares of products within firms. $\Delta ln(margcost)$ is the logarithm of firm-level products' marginal cost weighted using sales shares of products within firms. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

increase in FDI induced by liberalization generates a marginal cost reductions of approximately 1.5%. A potential explanation for the larger magnitudes compared to the baseline OLS regressions is that the IV estimates reflect local average treatment effects, i.e. firms in liberalized industries might benefit more from spillovers than the average firm across industries. While the increase in FDI exposure after liberalization is observed across industries, it is especially pronounced in the pharmaceutical and chemical sectors, where knowledge and spillovers may play a particularly important role. Alternative partial explanations are a bias towards zero in OLS estimates due to a self-selection of foreign investors into industries with lower future productivity growth or measurement error in our FDI exposure variable.

3.3. Competitive effects, technology upgrading, and reallocation

Our results so far have indicated that the presence of foreign investors can generate spillovers to domestic firms, and are not negatively associated with domestic firms' markups. In this subsection, we discuss potential pro-competitive effects of FDI. Note that non-negative (average) effects of FDI on markups do not allow us to draw conclusions about competitive effects. The reason is that FDI generates spillovers in the form of lower marginal costs which will affect markups in the presence of incomplete pass-through. Hence, we need to condition on marginal cost changes to identify pro-competitive effects.[37] We rerun our baseline markup regression controlling for a third order polynomial of changes in marginal costs, to allow for a flexible relationship between costs and markups. Results depicted in column (1) of Panel A in Table 7 indicate that conditional on changes in marginal costs, markups indeed fall when exposure to FDI increases. A 10 percentage point increase in FDI exposure is associated with a 1.4% reduction in markups—conditional on marginal cost changes and their effects on markups through incomplete pass-through.

This pro-competitive effect raises the question of the extent to which domestic firms are crowded out by foreign investors. Columns (2) and (3) in Table 7 show results using firm-level sales and quantities as outcome variables.[38] Results indicate that foreign presence induces a decline in sales of domestic firms. More than two thirds of this decline in sales is due to lower prices, while the effect on quantities is negative but not statistically significant.[39] Panel B demonstrates that the effects are qualitatively similar and more pronounced, although less precisely estimated, when we use liberalization episodes as instruments.

In models with imperfect competition, lower marginal costs are associated with lower prices and higher demand. In contrast, competitive pressure, for instance induced by entry, would lead to lower prices and lower demand for incumbent firms. Hence, if foreign firms would purely generate positive spillovers without taking demand away from Indian firms, we would expect quantities of domestic firms to increase when marginal costs and prices fall. The combination of lower marginal costs, lower prices and declining (or non-increasing) quantities therefore suggests that FDI leads to both technology spillovers and competitive pressure.[40]

The positive effects of FDI exposure on productivity and cost reductions raise the question whether domestic firms undertake investments to increase their efficiency. This could happen when domestic firms aim to escape foreign competition or when they invest to absorb the knowledge generated by foreign-owned firms. To investigate this channel, we study the association of FDI exposure with investment in research and development (R&D) in Table 8. Indeed, it seems that domestic firms spend more on R&D when faced with higher presence of foreign firms. This effect is consistent with technology upgrading in domestic firms. Previous literature has documented a strong contemporaneous relationship between R&D and innovation output (e.g., Hall et al., 1986) which could explain part of the productivity increases in domestic firms.

[37] See LGKP for a related discussion in the context of India's trade liberalization. The average pass-through rate in our sample, estimated from a regression of changes in log prices on changes in log marginal costs is about 0.29, slightly below the one estimated by LGKP.

[38] To obtain changes in weighted firm-level quantities, we deflate observed firm-level sales by price changes.

[39] Note that changes in the log of sales are exactly due to changes in log quantities plus changes in log prices.

[40] We discuss the association of FDI exposure with firm exit and product dropping in Section 3.4.2.

Table 7
Competitive effects of FDI.

	(1)	(2)	(3)
	$\Delta ln(markup)$	$\Delta ln(sales)$	$\Delta ln(quantities)$
Panel A: OLS estimation			
ΔFDI	−0.141**	−0.290***	−0.054
	(0.058)	(0.081)	(0.102)
Panel B: 2sls estimation			
ΔFDI	−0.290	−0.833***	−0.169
	(0.277)	(0.316)	(0.446)
N	34 580	34 580	34 580
First stage F-test	116.6		
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Polynomial in marginal cost changes	Yes	No	No

Notes. The table reports coefficients from linear regressions. ΔFDI denotes horizontal foreign direct investment at the 3-digit industry-level weighted by sales shares of products within firms. $\Delta ln(markup)$ is the logarithm of firm-level products' markup weighted by sales shares of products within firms. $\Delta ln(sales)$ is the logarithm of firm-level sales. $\Delta ln(quantities)$ is the logarithm of firm-level product quantities weighted by sales shares of products within firms. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table 8
Horizontal FDI and R&D.

	(1)	(2)	(3)	(4)
	$\Delta ln(R\&D)$ OLS	$\Delta(R\&D/sales)$ OLS	$\Delta ln(R\&D)$ 2sls	$\Delta(R\&D/sales)$ 2sls
ΔFDI	0.813***	0.008**	−0.499	0.035**
	(0.291)	(0.004)	(0.914)	(0.015)
N	7459	34 580	7459	34 580
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	7459	34 580	7459	34 580
First stage F-test			52.340	124.017
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes. The table reports coefficients from linear regressions. ΔFDI denotes horizontal foreign direct investment at the 3-digit industry-level weighted by lagged sales shares of products within firms. $\Delta ln(R\&D)$ is the logarithm of firm-level expenditure in R&D. $\Delta(R\&D/sales)$ is the ratio of firm-level expenditure in R&D to total sales (mean value= 0.04). Standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

To investigate an alternative channel, we estimate separate spillover effects for firms with high and low marginal revenue products of capital, following Bau and Matray (2023) who stress the impact of foreign firms on access to finance and misallocation of capital. We do not find statistically significantly different effects for firms with low and high marginal revenue products of capital as depicted in Table A.6 in the Appendix A.

3.4. Product-level analysis

3.4.1. Main results at the product level

In this section, we move the analysis to the product level to obtain a better understanding about where efficiency gains and price reductions are realized.

Table 9 shows estimates of Eq. (12) in which we relate product-level prices, markups and marginal costs to industry (3-digit) and product-level (12-digit) exposure to FDI. Note that the industry measure of FDI includes FDI in the same product category. Hence, the coefficient for industry-level FDI has to be interpreted conditional on foreign exposure at the product-level, while the coefficient for product level FDI measures differences between spillovers within and across product categories. In Panel A, we report results using OLS specifications in first differences with firm-product and year fixed-effects. The results in column (1) indicate that exposure to FDI leads to a decline in prices, and this effect is stronger within the same product category. A one-percentage-point increase in the market share of foreign investors in other product categories within the same industry results in an approximately 0.16% decrease in the prices of domestic firms, and the decrease is about 0.09% larger for FDI in the same product category.[41] In

[41] These numbers are calculated as $\exp(-0.101) - 1$ and $\exp(-0.190) - 1$.

Table 9
Horizontal FDI and product-level outcomes.

	(1)	(2)	(3)
	$\Delta ln(price)$	$\Delta ln(markup)$	$\Delta ln(margcost)$
Panel A: OLS estimation			
ΔFDI (industry)	−0.190***	0.086	−0.276***
	(0.051)	(0.075)	(0.082)
ΔFDI (product)	−0.101***	−0.142**	0.041
	(0.033)	(0.055)	(0.056)
N	134 543	134 543	134 543
Firm-product FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Panel B: 2sls estimation			
ΔFDI (industry)	−0.237	2.656**	−2.893**
	(0.708)	(1.237)	(1.384)
ΔFDI (product)	−0.342	−1.961**	1.618
	(0.655)	(1.151)	(1.327)
N	134 543	134 543	134 543
First stage F-test	295.82		
Firm-product FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes. The table reports coefficients from linear regressions. ΔFDI (industry) denotes horizontal foreign direct investment at the 3-digit industry level. ΔFDI (product) denotes horizontal foreign direct investment at the 12-digit product level. $\Delta ln(price)$ is the logarithm of products' price. $\Delta ln(markup)$ is the logarithm of products' markup. $\Delta ln(margcost)$ is the logarithm of products' marginal cost. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

columns (2) and (3), we decompose changes in prices into markups and marginal costs. The results indicate that the reasons for price declines differ between industry- and product-level exposure to FDI. The more negative price effects for product-level FDI seem to be entirely due to declining markups while there is no evidence for additional changes in marginal costs. These results are consistent with a competition effect rather than technology spillovers from FDI. When competitive pressure from foreign firms in the same product category increases, domestic firms are induced to reduce their margins.

In contrast, price declines due to foreign exposure in other product categories are entirely due to reductions in marginal costs which are partly passed on to consumers. These results are consistent with technology spillovers rather than a competition effect. This seems plausible as the degree of competition across product categories is arguably limited. As an example consider the industry "manufacture of food products" (NIC code 107) which includes products such as bread, cocoa beans, pizzas and sugar. Another example is the industry "Manufacture of rubber products" which includes products such as cycle tyres, moped tyres, foam & rubber mattresses and rubber foam. It is clear that from a consumer's perspective, different products within an industry are unlikely to be substitutes. However, similar production processes are often used across products within industries which makes technology spillovers plausible.

Some readers might find it surprising that spillovers are not higher within than across product categories. However, this is in line with the existing literature on spillovers which provides more robust evidence for cross-industry (Jacobian) compared to within-industry (Marshallian) spillovers (see the overview in Beaudry and Schiffauerova, 2009). A possible explanation for the lack of additional spillovers within product categories is that competition negatively impacts domestic firms due to business stealing, which forces them to move up their marginal cost function (Aitken and Harrison, 1999) or reduces incentives for technology adoption if domestic firms are too far away from the technological frontier (Aghion et al., 2009).

Panel B of Table 9 shows corresponding instrumental variable results. We use two separate instruments for the product-level regressions: $POSTlib_{kt}$, a dummy variable indicating post-liberalization periods in liberalized industries and $POSTlib_{kt} \times \frac{s_{j,t-1}}{s_{k,t-1}}$, i.e. post-liberalization dummies weighted by lagged sales shares of products within industries (to predict FDI exposure at the product-level). The second instrument relies on the assumption that firms do not shift production across products within industries in anticipation of FDI liberalization.[42] Although the estimates are quite noisy, the results confirm that efficiency gains in the form of lower marginal costs are realized from spillovers at the industry-level, while there is no evidence for additional gains from exposure to FDI in the same product category. The results of the over-identification tests demonstrates that for conventional levels of significance, we cannot reject exogeneity of each instrument once we accept exogeneity of the other. The corresponding first stage results, depicted in Table A.7 in the Appendix A, show that the instruments are jointly significant and above common thresholds of conventional critical values of weak identification tests.

[42] We found very similar results when we measure sales shares at the beginning of our sample period.

Table 10
Product-level heterogeneous effects.

	(1)	(2)	(3)	(4)
Dependent variable	$\Delta ln(margcost)$	$\Delta ln(margcost)$	$\Delta ln(margcost)$	$\Delta ln(margcost)$
Sample split	lagged margcost	lagged revenue	lagged output quality	lagged input quality
Panel A: 1st quartile				
ΔFDI (industry)	−0.043	−0.009	−0.124	−0.152
	(0.167)	(0.248)	(0.207)	(0.183)
ΔFDI (product)	−0.019	−0.013	0.118	0.031
	(0.105)	(0.144)	(0.120)	(0.098)
N	33 636	33 641	33 511	33 831
Panel B: 2nd quartile				
ΔFDI (industry)	−0.256*	−0.365**	−0.022	0.062
	(0.155)	(0.175)	(0.176)	(0.159)
ΔFDI (product)	−0.091	−0.006	−0.076	−0.025
	(0.094)	(0.118)	(0.163)	(0.138)
N	33 636	33 654	34 216	39 871
Panel C: 3rd quartile				
ΔFDI (industry)	−0.496***	−0.421***	−0.243	−0.403*
	(0.186)	(0.152)	(0.170)	(0.223)
ΔFDI (product)	0.006	0.034	0.015	0.031
	(0.119)	(0.094)	(0.097)	(0.131)
N	33 636	33 614	31 395	27 204
Panel D: 4th quartile				
ΔFDI (industry)	−0.143	−0.258*	−0.353**	−0.487***
	(0.183)	(0.141)	(0.157)	(0.183)
ΔFDI (product)	0.057	0.071	0.101	0.035
	(0.105)	(0.093)	(0.104)	(0.113)
N	33 635	33 634	32 605	33 637
Firm-product FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Notes. The table reports coefficients from OLS estimations. ΔFDI (industry) denotes horizontal foreign direct investment at the 3-digit industry level. ΔFDI (product) denotes horizontal foreign direct investment at the 12-digit product level. Sample splits in columns (1) to (4) are according to quartiles of sales, marginal costs, input quality and output quality, respectively. These variables are measured at time period t-1 and are demeaned by product category-year. $\Delta ln(margcost)$ is the logarithm of products' marginal cost. Initial quality in column (3) is measured based on Khandelwal et al. (2013). Initial quality in column (4) is based on input price index derived from the physical TFP estimation as explained in Section 2.2.1. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

3.4.2. Heterogeneous effects, product and firm survival

In this subsection, we discuss heterogeneity of product-level adjustments and additional product-level outcomes. The results of the previous subsections show that domestic firms can increase their efficiency when they are exposed to foreign investors. In order to understand where these efficiency gains are realized, we estimate heterogeneous effects which account for initial characteristics of domestic firms and their products.

Specifically, in Table 10, we look at heterogeneous effects on marginal costs at the product level and split the sample into quartiles according to initial values of marginal costs, revenue and quality at the firm-product level. Interestingly, the results indicate that efficiency gains are mostly realized in high-cost and high-quality products. Overall, gains from FDI seem to be concentrated among those domestic firms that are initially relatively similar to foreign investors: large firms producing products of high quality which are, however, not physically more productive than the average firm. Given the characteristics of foreign-owned firms, it seems plausible that technology spillovers are concentrated among domestic firms that specialize in high-quality production rather than in low-cost firms.[43]

Next, we analyze differences between single- and multi-product firms. The results in Table A.8 in the Appendix A indicate that the effects of industry-level FDI on cost reductions, and corresponding price declines, only materialize significantly for multi-product firms. A potential explanation is that single-product firms lack the absorptive capacity to benefit from foreign investors in the form of higher spillovers. The estimated effects of FDI in the same product category are qualitatively similar between the two groups, but more pronounced for multi-product firms; indicating that they are more likely to compete with foreign-owned firms.

We also investigate whether the effects of FDI exposure differ across a firm's core product and other products. We define a core product as the product with the highest sales share within firm-years before the change in FDI is measured. As this distinction only applies to multi-product firms, we drop single-product firms from the sample. As documented in column (2) of Table A.9 in the

[43] Unfortunately, our FDI liberalization instruments are not sufficiently strong to predict FDI exposure in each of the various subsamples.

Appendix A, we find, on average, smaller markup declines from FDI exposure in the same product category when the focal product is a firm's core product. This indicates that firms are better able to absorb spillovers and cope with competition from foreign-owned firms in their core competence area. We also estimate larger cost reductions through FDI spillovers in the same product category, but the effects are not statistically significant (Column 3).

While our main product-level analysis is focused on changes within firm-products over time, we also analyze whether foreign competition is associated with product dropping in domestic firms. For this purpose, we estimate a linear probability model in which we relate the probability of product dropping (or adding) to foreign exposure at the product- and industry-level. The results, documented in columns (4) and (5) of Table A.9 in the Appendix A, indicate that the likelihood of product dropping increases with exposure to foreign competition in the same product category. An increase in the market share of foreign investors by 10 percentage points is associated with an increase in the probability of product dropping of about 0.9 percentage points. There is no statistically significant correlation with foreign competition at the industry-level. This result is consistent with product market competition taking place at the 12-digit level, but not at the broader industry level. There seems to be no statistically significant difference between firms' core and non-core products.[44]

In Table A.10, we correlate FDI exposure with the probability of firm exit.[45] Using our baseline measure of firm-level FDI exposure, aggregated from 3-digit market shares, we do not find any statistically significant effects. However, when we aggregate firm exposure to FDI from 12-digit market shares, we do see a positive associated between FDI exposure and domestic firms' exit probability.

3.5. Extensions and robustness checks

In this subsection, we discuss the results of various additional robustness checks which include the measurement of FDI exposure, additional control variables, alternative measures of TFP, and excluding different subsamples of firms. The results are documented in Online Appendix B.

We start by discussing alternative measures of exposure to FDI. Our baseline specification uses one-year lagged sales shares to aggregate product-level FDI exposure to the firm-level. As our time period is relatively long, using time-varying weights has the advantage that we capture the most relevant market to domestic firms at the time when FDI in their industry changes. However, it has the disadvantage that the weights potentially change in response to previous increases in FDI. In an alternative specification, we therefore use time-invariant sales shares, measured in the period when a firm enters the sample. Results documented in Panel A of Table B1 show that the results are very similar to our baseline specification. Further, we experiment with FDI exposure measured at the firms' main industry which is common in the previous FDI literature that relies on firm-level data without information on products produced. Consistent with prior studies, we exclude exports from this measure. Results depicted in Panel B of Table B1 confirm our conclusions from the firm-specific FDI exposure measures.

As our results indicate the importance of using quantities for productivity estimation, it might be tempting to also construct an FDI exposure measure which is based on quantities rather than revenues. There are, however, several challenges with a quantity-based FDI measure. First, since our main measure of FDI exposure is at the 3-digit level, it includes several product categories with different units of measurement. Second, due to quality differences across products, quantities are not always comparable, even within narrowly defined product categories. These issues are unimportant when analyzing changes within products over time (as we do with our dependent variables). However, when constructing a measure based on cross-sectional variation across products, these differences have to be taken into account. To deal with these problems, we predict expected prices based on the product category and proxies for product quality. For this purpose, we ran regressions with an exponential mean – estimated by Poisson Pseudo maximum likelihood – to explain output prices using 12-digit product category-year fixed effects and region-(4-digit postal index (PIN))-year fixed effects and, in addition an input-based or both input- and output-based proxies for product quality. We then deflate firm-product level sales values by firm-product prices relative to prices predicted from this regression. The resulting measure is equivalent to weighting firm-product level quantities with average prices per product category and quality-level. Panel C and Panel D of Table B1 show that result using measures of FDI exposure from quantity indices confirm our previous conclusions on FDI spillovers.

We also checked the robustness of our results towards different measures of productivity. Revenue TFP in our baseline specification is based on estimated coefficients from a revenue function (as this is what a researcher can estimate from typical financial data at the firm-level). Hence, as we discuss in Section 2.2.3, the results between physical TFP and revenue based TFP in our baseline specification can differ due to different measures of output – holding production function coefficients fixed – and differences in estimated elasticities from the production function. To check the importance of these two channels, we construct an alternative measure of revenue TFP where we add output price changes to our estimated physical TFP measure from LGKP. This eliminates any difference from estimated production function coefficients. As we document in column 1 of Table B2, such a measure yields a coefficient that is less than half of the size of the baseline physical TFP estimate and is not statistically significant. The remaining difference from our baseline revenue TFP estimate stems from differences in production coefficients and/or differences in input prices.

[44] We found no meaningful association between exposure to FDI and the probability of product additions.

[45] While it is likely that firms that we do no longer observe in the database have exited the market, there is no clear distinction between firms exiting and data missing for different reasons.

In our baseline specification, we derive physical TFP from coefficients estimated from single-product firms. In contrast, the coefficients to estimate revenue TFP are estimated from the full sample of firms (since typical financial data does not allow to differentiate between single- and multi-product firms). To check the importance of the different samples to estimate production function coefficients, we conducted two additional checks. First, we construct revenue TFP from coefficients estimated from a sample of single-product firms only. For this purpose, we use the same control function for single-product firms as in the LGKP estimates. Second, we estimate QTFP at the firm-level using a quantity index at the firm-level as dependent variable. To construct this index, we deflate firm-level revenues by a Pasche-type firm-level price index. The price index takes value one in the first year a firm enters the sample. We add price changes which we aggregate from firm-products to the firm-level using sales shares in the previous year as weights. We also construct a firm-level control function for unobserved input prices by aggregating product-level prices and market shares to the firm-level. Column 2 of Table B2 shows that the effect of FDI on revenue TFP remains statistically insignificant when revenue TFP is constructed from single-product firm coefficients. Column 3 shows results for QTFP, constructed from the firm-level quantity index.[46] The results confirm positive effects on QTFP, indicating that the samples used to estimate production function coefficients do not drive differences between RTFP and QTFP.

Our baseline LGKP estimates assume a constant value of TFP across products within a firm-year to solve for unobserved input allocations. As an alternative, we assign inputs to products based on revenue shares as suggested by Orr (2022) and Foster et al. (2008). This allows us to compute a firm-product specific measure of TFP. We construct a revenue-based TFP measure at the product level by adding price changes. In a second set of product-level TFP measures, we ignore the input price correction function. This allows us to check the sensitivity of our results towards two of the main behavioral assumptions of LGKP: the input allocation rule and the input price correction function. Results depicted in Table B3 confirm the positive association between industry-level FDI exposure and product-level physical TFP but no significant relationship with revenue-based TFP. This result holds with (columns 1 and 2) and without (columns 3 and 4) controlling for input price heterogeneity. Yet, the latter shows some additional positive association between product-level FDI exposure and physical TFP.

Our estimation procedure for production functions, and especially the measurement of markups and marginal costs, assumes that firms minimize costs. While this assumption is plausible for the vast majority of firms, it might be violated for firms with government ownership which can follow different objectives. For this purpose, we reran our baseline regressions excluding state-owned firms. Results in Table B4 shows that this does not affect our main conclusions. Table B5 shows results for government-owned firms only. These are not statistically significant, which could be due to the objectives of these firms. It should be noted, however, that the sample size is rather small.

As another check on the choice of the estimation sample, we excluded firms that have been directly affected by M&As as target or acquirer during or sample period. This specification addresses concerns that domestic firms might merge to cope with foreign competition. Productivity gains from these consolidations should not be attributed to FDI spillovers. As we show in Table B6, we estimate similar effects when we exclude merging firms from the sample.

Next, we extend our FDI exposure measure to test for regional and vertical spillovers. To analyze whether FDI spillovers have a local dimension, we add the market share of foreign firms with headquarters in the same region – defined as 2-digit and 4-digit PIN code areas – to our main specification.[47] Results, displayed in Table B7 in Online Appendix B show that exposure to FDI in the same region – holding industry exposure fixed – is indeed associated with somewhat higher physical TFP. Somewhat surprisingly, the effects on marginal costs are not significantly larger than those from our baseline FDI measure. A potential explanation is that foreign investors create productivity spillovers, but as they compete for the same local inputs, there is a countervailing effect on marginal costs. Unfortunately, Prowess only reports the location of firms' headquarters, not of individual plants and production sites. The latter might be more relevant for the transmission of local knowledge. It could be an interesting question for future research to disentangle the effects on FDI on inputs and output markets.

While the focus of our paper lies on horizontal FDI, previous research has found evidence for significant vertical spillovers. We follow Javorcik (2004) and add measures of backward and forward FDI, which capture exposure to foreign investment in upstream and downstream industries, weighted by input–output coefficients. We measure backward FDI as $FDI_{kt}^{back} = \sum_{l \neq k} \alpha_{kl} FDI_{kt}$, where α_{kl} is the proportion of sector k output supplied to sector l. Forward FDI is computed as $FDI_{kt}^{forw} = \sum_{m \neq k} \sigma_{km} \frac{\sum_{i \in m} foreign_{it} \cdot (S_{it} - EX_{it})}{\sum_{i \in m} (S_{it} - M_{it})}$, where σ_{km} is the share of inputs purchased by industry k from industry m in total inputs sourced by sector j and EX denotes exports. Consistent with our horizontal FDI measure, we aggregate vertical FDI exposure to the firm-level using sales shares as weights.

We use input–output coefficients from the World Input-Output Database (WIOD, 2016 release). We experimented with time-constant IO-weights calculated from the year 2003 to reduce endogeneity problems and time-varying IO weights which are more prone to endogeneity concerns but measure industry-linkages over a long sample period more accurately. Results in Table B8 indicate positive FDI spillovers through backward linkages on TFP. This is consistent with conclusions from the existing literature. We also find a negative effect on prices and marginal costs of domestic firms. Most importantly, none of the measures of vertical FDI affects our conclusions regarding the effect of horizontal foreign investment.[48]

[46] The number of observations is slightly reduced for this specification as we can only use firms without gaps in product-level information to construct the price index. The conclusions regarding markups and marginal costs from this specification are also similar to our baseline specification. Results are available upon request.

[47] We did not find evidence for regional spillovers based on broader geographic regions or states. Results are available upon request.

[48] Our conclusion regarding the effect of horizontal FDI does not change when we calculate exposure to vertical FDI using either OECD input–output tables or input–output tables constructed from Prowess. The latter are based on information on raw material inputs for single-product firms, which can be assigned to industries in the same way as production outputs. We also reach similar conclusions when we add vertical FDI measures to product-level regressions. Results are available upon request.

As a further check, we also constructed a measure of input similarity following Boehm et al. (2023). This variable is constructed as the inner product of industries' input expenditure shares. It varies between zero (when two industries have no inputs in common) and one (when all expenditure shares of the two industries are identical). We then calculate an input similarity weighted FDI exposure measure as: $ISFDI_{kt} = \sum_{o \neq k} \kappa_{ko} FDI_{ot}$ where κ_{ko} measures input similarity between industries k and o. Results depicted in Table B9 indicate that this additional control variable does not affect our conclusions either.

To disentangle the effects of FDI spillovers, we differentiate between FDI exposure from entering foreign firms, new products added by incumbent foreign firms, and changes in sales shares of existing products by incumbent foreign firms. Table B10 suggests that the estimated spillover effects from entering firms and new products are slightly higher than those of remaining FDI shares. However, the differences are not statistically significant. While one would intuitively think that spillovers should be predominantly driven by new firms and products, foreign firms often enter with a relatively small production scale and expand over time.

We also ask whether the spillovers we are estimating are specific to foreign-owned firms or reflect those of more successful firms in general. To distinguish between spillovers from foreign and domestic firms, we have calculated an exposure measure to domestic multi-product firms based on the market share of these firms (without the focal domestic firm) in an analogous way to our FDI exposure variables. The results depicted in Table B11 indicate that there are no significant spillovers from domestic multi-product firms as opposed to foreign firms.

Further, we check the robustness towards controlling for region-year fixed effects, defined at the 4-digit postal index code. These specifications address concerns that our results pick up variation in policy measures, infrastructure or access to credit, that vary across states or different geographic areas and are potentially correlated with domestic firm performance and FDI. Results depicted in Panel A of Table B12 show that our baseline results do not pick up regional differences. If anything, the results on physical TFP and marginal costs become stronger. Further, we check the robustness towards sector-specific trends that might capture broad technological changes and industry-specific policies in Panel B of Table B12. For this purpose, we control for 2-digit-industry-year fixed effects based on firms' main industry. This reduces the remaining variation in FDI exposure across firms substantially. It is therefore unsurprising that the estimated effect on physical TFP – which has no variation across a firms' products and is therefore mostly determined by a firms' main industry – becomes smaller. Reassuringly, the effects for variables that are aggregated from firms' products – and are therefore to a lesser extent driven by firms' main sector – such as markups and marginal costs, are very similar compared to our baseline specification.

Finally, we discuss threats to identification of our instrumental variable strategy. Our IV exploits industry-level variation in FDI regulations. It is therefore important, that this variable does not pick up the effect of other policy reforms that are not directly related to foreign investment. For this purpose, we added control variables for de-licensing and tariffs, which we obtained from Aghion et al. (2008) and from World Integrated Trade Services (WITS), respectively. De-licensing is measured by the fraction of products within an industry where de-licensing took place. Tariffs are measured as the average of most-favored nation tariffs across products, defined according to the HS classification, within industries. We aggregate these measures to the firm-level using sales shares as weights, i.e. we use the same level of aggregation as for our measure of FDI exposure.[49] As Table B13 shows, our IV results do not change notably when these control variables are added. We also checked whether including and instrumenting for backward and vertical FDI affects our results. As Table B14 shows, although the results for backward FDI become more pronounced, this specification does not change the coefficients for horizontal FDI by much, compared to our baseline IV regression.

4. Conclusion

A large literature documents superior performance of multinational subsidiaries relative to domestic firms. The entry of multinationals through foreign direct investment therefore has the potential to generate positive productivity spillovers. Empirical studies have, however, mostly measured insignificant or even negative spillover effects from exposure to FDI in the same industry. We argue that a potential explanation for this results is the use of revenue-based measures of productivity which are affected by prices. If domestic prices decline when exposure to foreign multinationals increases, revenue productivity underestimates efficiency gains from FDI.

In this paper, we exploit a dataset which includes prices and quantities at the firm-product level for the Indian manufacturing sector. This data, together with recent advances in the estimation of production functions, allows us to estimate the effects of FDI on marginal costs and physical productivity of domestic firms. In line with most of the previous literature, we find little evidence for technology spillovers based on commonly used measures of revenue productivity. In contrast, we estimate sizeable gains using measures that are not affected by pricing heterogeneity. Our baseline regressions indicate that a one percentage point increase in FDI exposure, measured as the share of output produced in foreign-owned firms, results in a 0.3% increase in physical TFP and an approximately 0.4% decrease in marginal costs of domestic firms. Using exogenous variation from India's FDI liberalization, we estimate even larger gains for increased FDI exposure induced by liberalization events. Since these efficiency gains are partly passed on to consumers in the form of lower prices, they might be hidden in measures of revenue TFP that have been commonly used in the FDI literature.

Our product-level results indicate that there are substantial spillovers across products within industries which lead to lower marginal costs in domestic firms. Exposure to FDI in the same narrowly defined product category leads to a decline in markups and prices but little additional changes in marginal costs. Positive spillover effects seem to be concentrated among relatively large firms

[49] Our classification of products in Prowess is not identical to the HS classification which is why we have to aggregate tariffs to the industry-level first.

Table A.1
Elasticities from production function: Means, *medians*, (standard deviation).

Sector	Observations	Labor	Materials	Capital	RTS
Food, beverages and tobacco	27 088	0.27	0.71	0.04	1.02
		0.25	*0.72*	*0.04*	*1.02*
		(0.14)	(0.21)	(0.15)	(0.08)
Textiles, wearing apparel and leather	20 562	0.16	0.74	0.12	1.03
		0.15	*0.75*	*0.14*	*1.05*
		(0.07)	(0.08)	(0.05)	(0.08)
Wood, paper products and printing	5889	0.21	0.80	0.07	1.09
		0.18	*0.81*	*0.06*	*1.02*
		(0.17)	(0.13)	(0.11)	(0.19)
Coke, chemicals and pharmaceuticals	54 919	0.30	0.70	0.10	1.11
		0.29	*0.70*	*0.09*	*1.10*
		(0.13)	(0.11)	(0.09)	(0.07)
Rubber and plastics	10 660	0.21	0.66	0.11	0.99
		0.20	*0.69*	*0.15*	*1.08*
		(0.17)	(0.17)	(0.12)	(0.26)
Non-metallic minerals products	7135	0.24	0.66	0.16	1.08
		0.22	*0.65*	*0.16*	*1.03*
		(0.15)	(0.08)	(0.08)	(0.15)
Basic metal and fabricated metal	25 286	0.17	0.77	0.10	1.05
		0.15	*0.77*	*0.08*	*1.02*
		(0.08)	(0.05)	(0.11)	(0.10)
Computers and electronics	9322	0.32	0.63	0.22	1.18
		0.31	*0.64*	*0.23*	*1.15*
		(0.14)	(0.09)	(0.08)	(0.13)
Electricals	11 066	0.17	0.84	0.05	1.07
		0.16	*0.84*	*0.05*	*1.05*
		(0.10)	(0.08)	(0.21)	(0.11)
Machinery and equipment	15 799	0.31	0.67	0.16	1.15
		0.30	*0.67*	*0.16*	*1.10*
		(0.15)	(0.12)	(0.04)	(0.13)
Motor vehicles and transport equipment	11 047	0.20	0.74	0.24	1.18
		0.18	*0.74*	*0.23*	*1.19*
		(0.17)	(0.13)	(0.15)	(0.22)
All manufacturing	198 773	0.24	0.72	0.11	1.08
		0.22	*0.72*	*0.12*	*1.07*
		(0.14)	(0.13)	(0.12)	(0.14)

Notes. The table shows output from physical production functions with respect to input quantities. RTS denotes return to scale. Observations denotes the total number of observation used to identify parameters of the production functions.

with intermediate productivity levels and producers of high-quality products. Interestingly, these seem to be those domestic firms that are relatively similar to the average foreign firm to begin with.

From an economic policy point of view, our results indicate that FDI reforms can increase the efficiency of domestic firms in liberalized industries. Since spillovers appear to materialize across products within industries, attracting FDI might be most beneficial in product categories that share technological similarities with related products produced by domestic firms even if they do not compete in the same product market. Since spillovers seem to be concentrated among high-quality producers, FDI liberalization might yield higher gains once industries in developing countries have reached a certain level of maturity. For future research, it would be worth exploring whether our results hold in different countries with different levels of development. It would also be valuable to examine how domestic firms adjust their product characteristics in the long run when exposed to foreign competition.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

The authors have no conflicts of interest to declare that are relevant to the content of this article.

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

The authors have no financial or proprietary interests in any material discussed in this article.

Appendix A. Additional tables

See Tables A.1–A.10.

Table A.2
Markups across industries.

Sector	Observations	Markup	
		Mean	Median
Food, beverages and tobacco	25 614	3.85	1.32
Textiles, wearing apparel and leather	19 940	3.08	1.36
Wood, paper products and printing	5705	3.73	1.61
Coke, chemicals and pharmaceuticals	52 232	3.56	1.25
Rubber and plastics	10 150	3.19	1.24
Non-metallic minerals products	6654	4.89	2.03
Basic metal and fabricated metal	24 063	3.32	1.20
Computers and electronics	8666	4.53	1.24
Electricals	10 219	5.35	1.45
Machinery and equipment	14 831	4.04	1.24
Motor vehicles and transport equipment	10 553	3.94	1.35
All manufacturing	188 627	3.75	1.32

Notes. The table reports the mean and median markup by sector for the sample 1988–2017.

Table A.3
Firm characteristics: Means (standard deviation)

Variables	Definition	Domestic ownership	Foreign ownership	Single-product firms	Multi-product firms
Sales	Operating income	2754.82	7071.66	1401.19	3883.88
		(9333.539)	(16690.742)	(5694.741)	(11571.499)
Labor	Salaries and wages	174.74	495.32	92.07	249.62
		(617.122)	(1012.399)	(364.098)	(758.632)
Materials	Expenditure on raw materials	1202.62	2632.91	675.82	1615.68
		(3421.357)	(6033.346)	(2288.907)	(4163.137)
Capital stock	Gross fixed assets	1684.26	2997.57	924.95	2219.62
		(6112.142)	(7561.173)	(3744.578)	(7168.698)
No. of products	Product count	2.75	3.26	1.00	3.75
		(2.415)	(2.785)	(0.000)	(2.556)
Export share	Foreign exchange earnings/sales	0.21	0.16	0.25	0.18
		(0.296)	(0.272)	(0.320)	(0.280)
TFP	Physical productivity	1.85	2.00	1.45	1.86
		(1.955)	(2.373)	(3.145)	(1.988)

Notes. The table reports mean values of variables by group. Based on 87,571 and 5830 firm-year observations of domestic- and foreign-owned firms, respectively. And, based on 32,750 and 60,662 firm-year observations of single- and multi-product firms, respectively. Monetary variables are measured in Rs. million.

Table A.4
Single-product firm characteristics: Means, (standard deviation).

Variables	Domestic	Foreign
Sales	1204.51	4877.85
	(4750.432)	(13932.588)
Labor	79.74	310.82
	(321.133)	(777.589)
Materials	600.90	2002.52
	(1988.311)	(5114.849)
Capital stock	827.86	2655.72
	(3394.120)	(7448.899)
Export share	0.26	0.21
	(0.323)	(0.286)
TFP	1.49	0.84
	(3.115)	(3.591)

Notes. The table reports mean values of variables by group. Based on 31,013 and 1737 firm-year observations of domestic- and foreign-owned single-product firms, respectively. Monetary variables are measured in Rs. million.

Appendix B. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jinteco.2025.104202.

Data availability

Foreign Direct Investment, Prices and Efficiency: Evidence from India (Reference data) (Mendeley Data)

Table A.5
List of industries with FDI liberalization.

5-digit NIC code	Industry name	Year of liberalization
10 792	Coffee curing, roasting, grinding blending etc. and manufacturing of coffee products	2006
11 011	Manufacture of distilled, potable, alcoholic beverages such as whiskey, brandy, gin, 'mixed drinks' etc.	2006
11 012	Manufacture of country liquor	2006
11 019	Distilling, rectifying and blending of spirits	2006
12 001	Stemming and redrying of tobacco	2006
12 002	Manufacture of bidi	2006
12 007	Manufacture of catechu(katha) and chewing lime	2006
12 008	Manufacture of pan masala and related products.	2006
12 009	Manufacture of other tobacco products including chewing tobacco n.e.c.	2006
20 291	Manufacture of matches	2006
20 293	Manufacture of essential oils; modification by chemical processes of oils and fats	2006
20 296	Manufacture of chemical elements and compounds doped for use in electronics	2006
20 299	Manufacture of various other chemical products	2006
21 002	Manufacture of allopathic pharmaceutical preparations	2001
21 003	Manufacture of 'ayurvedic' or 'unani' pharmaceutical preparation	2001
21 004	Manufacture of homeopathic or biochemic pharmaceutical preparations	2001
21 006	Manufacture of medical impregnated wadding, gauze, bandages, dressings, surgical gut string etc.	2001
21 009	Manufacture of other pharmaceutical and botanical products n.e.c. like hina powder etc.	2001
22 112	Manufacture of rubber tyres and tubes for cycles and cycle-rickshaws	2006
22 113	Retreading of tyres; replacing or rebuilding of tread on used pneumatic tyres	2006
22 119	Manufacture of rubber tyres and tubes n.e.c.	2006
22 191	Manufacture of rubber plates, sheets, strips, rods, tubes, pipes, hoses and profile-shapes etc.	2006
22 193	Manufacture of rubber contraceptives	2006
22 199	Manufacture of other rubber products n.e.c.	2006

Table A.6
Firm-level FE estimations and marginal revenue of product capital.

	(1)	(2)	(3)	(4)	(5)
	$\Delta ln(QTFP)$	$\Delta ln(RTFP)$	$\Delta ln(price)$	$\Delta ln(markup)$	$\Delta ln(margcost)$
ΔFDI	0.390*	−0.019	−0.262***	0.237**	−0.500***
	(0.210)	(0.070)	(0.086)	(0.119)	(0.138)
ΔFDI*$highMRPK$	−0.065	−0.128	0.072	0.001	0.071
	(0.287)	(0.119)	(0.127)	(0.217)	(0.240)
N	34 580	34 580	34 580	34 580	34 580
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Notes. The table reports coefficients from OLS estimations. ΔFDI denotes horizontal foreign direct investment at the 3-digit industry-level weighted using lagged sales shares of products within firms. $highMRPK$ denotes firms with a higher marginal revenue product of capital than the median in a give 3-digit sector and year. $\Delta ln(QTFP)$ denotes the logarithm of physical total factor productivity at the firm-level. $\Delta ln(RTFP)$ denotes the logarithm of revenue-based total factor productivity at the firm-level estimated from a revenue function using the Ackerberg et al. (2015) methodology. $\Delta ln(price)$ is the logarithm of firm-level products' price weighted using sales shares of products within firms. $\Delta ln(markup)$ is the logarithm of firm-level products' markup weighted using sales shares of products within firms. $\Delta ln(margcost)$ is the logarithm of firm-level products' marginal cost weighted using sales shares of products within firms. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A.7
First stage results for product-level 2sls estimation.

	(1)	(2)
	ΔFDI (industry)	ΔFDI (product)
$D(2004) \times POSTlib_{t-1}$	0.019*** (0.001)	−0.010* (0.006)
$D(2005) \times POSTlib_{t-1}$	0.027***(0.002)	−0.010*** (0.003)
$D(2006) \times POSTlib_{t-1}$	0.002 (0.001)	−0.006 (0.006)
$D(2007) \times POSTlib_{t-1}$	−0.008***(0.002)	0.010** (0.004)
$D(2008) \times POSTlib_{t-1}$	0.088*** (0.002)	0.005 (0.006)
$D(2009) \times POSTlib_{t-1}$	−0.002 (0.004)	0.006** (0.003)
$D(2010) \times POSTlib_{t-1}$	−0.004*** (0.001)	0.003 (0.003)
$D(2011) \times POSTlib_{t-1}$	0.041*** (0.004)	0.018*** (0.003)
$D(2012) \times POSTlib_{t-1}$	−0.018 (0.011)	0.009 (0.008)
$D(2013) \times POSTlib_{t-1}$	−0.034*** (0.008)	0.016* (0.008)
$D(2014) \times POSTlib_{t-1}$	0.013*** (0.004)	0.009** (0.004)
$D(2004) \times POSTlib_{t-1} \times saleshare_j$	0.012*** (0.002)	0.040*** (0.010)

(*continued on next page*)

Table A.7 (*continued*).

$D(2005) \times POSTlib_{t-1} \times saleshare_j$	0.013*** (0.002)		0.080*** (0.005)
$D(2006) \times POSTlib_{t-1} \times saleshare_j$	0.016*** (0.003)		0.012 (0.011)
$D(2007) \times POSTlib_{t-1} \times saleshare_j$	0.020*** (0.003)		−0.018** (0.008)
$D(2008) \times POSTlib_{t-1} \times saleshare_j$	0.022*** (0.003)		0.177*** (0.011)
$D(2009) \times POSTlib_{t-1} \times saleshare_j$	0.040*** (0.007)		0.022*** (0.005)
$D(2010) \times POSTlib_{t-1} \times saleshare_j$	0.018*** (0.003)		−0.009** (0.005)
$D(2011) \times POSTlib_{t-1} \times saleshare_j$	0.101*** (0.009)		0.167*** (0.008)
$D(2012) \times POSTlib_{t-1} \times saleshare_j$	−0.019 (0.026)		−0.157*** (0.022)
$D(2013) \times POSTlib_{t-1} \times saleshare_j$	−0.078*** (0.024)		−0.273*** (0.061)
$D(2014) \times POSTlib_{t-1} \times saleshare_j$	0.006 (0.016)		−0.014 (0.017)
N	134 543		134 543
First stage F-test		61.35	
Sanderson–Windmeijer test (p-value)	64.16 (0.000)		74.40 (0.000)
Firm FE	Yes		Yes
Year FE	Yes		Yes

Notes. The table reports first-stage OLS coefficients from the 2SLS estimation. ΔFDI (industry) denotes horizontal foreign direct investment at the 3-digit industry-level. ΔFDI (product) denotes horizontal FDI at the 12-digit product level. $POSTlib$ takes value of one in all years after FDI liberalization in an industry. $D(2004)$ ($D(2005) \ldots \ldots D(2014)$) takes value of one in the year 2004 (2005...2014). Bootstrapped standard errors are reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A.8
Horizontal FDI and product-level outcomes: Single-product vs. multi-product firms.

	(1)	(2)	(3)
	$\Delta ln(price)$	$\Delta ln(markup)$	$\Delta ln(margcost)$
Panel A: Single-product firms			
ΔFDI (industry)	0.006	−0.083	0.089
	(0.120)	(0.092)	(0.146)
ΔFDI (product)	−0.129	−0.026	−0.103
	(0.091)	(0.057)	(0.105)
N	20 938	20 938	20 938
Panel B: Multi-product firms			
ΔFDI (industry)	−0.230***	0.127	−0.357***
	(0.053)	(0.101)	(0.101)
ΔFDI (product)	−0.102***	−0.160***	0.058
	(0.036)	(0.062)	(0.060)
N	113 605	113 605	113 605
Firm-product FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes. The table reports coefficient from OLS estimations. Panel A includes single-product firms. Panel B includes multi-product firms. ΔFDI (industry) denotes horizontal foreign direct investment at the 3-digit industry level. ΔFDI (product) denotes horizontal foreign direct investment at the 12-digit product level. $\Delta ln(price)$ is the logarithm of products' price. $\Delta ln(markup)$ is the logarithm of products' markup. $\Delta ln(margcost)$ is the logarithm of products' marginal cost. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A.9
Horizontal FDI and product-level outcomes: Heterogeneity by core product.

	(1)	(2)	(3)	(4)	(5)
	$\Delta ln(price)$	$\Delta ln(markup)$	$\Delta ln(margcost)$	$Product\ drop$	$Product\ drop$
ΔFDI (industry)	−0.248***	0.053	−0.301**	0.035	0.018
	(0.066)	(0.125)	(0.119)	(0.049)	(0.047)
ΔFDI (product)	−0.131***	−0.229***	0.097	0.087***	0.082***
	(0.047)	(0.078)	(0.075)	(0.013)	(0.015)
ΔFDI (industry)*$CoreProd_{t-1}$	0.058	0.254	−0.197		−0.001
	(0.097)	(0.175)	(0.174)		(0.045)
ΔFDI (product)*$CoreProd_{t-1}$	0.102	0.245*	−0.142		0.023
	(0.069)	(0.126)	(0.133)		(0.021)

(*continued on next page*)

Table A.9 (*continued*).

N	113 605	113 605	113 605	147 086	147 086
Firm-product FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Notes. The table reports coefficients from OLS estimations. ΔFDI (industry) denotes horizontal foreign direct investment at the 3-digit industry level. ΔFDI (product) denotes horizontal foreign direct investment at the 12-digit product level. $CoreProd$ denotes the core product of the firm which is the product representing the highest sales share. $\Delta ln(price)$ is the logarithm of products' price. $\Delta ln(markup)$ is the logarithm of products' markup. $\Delta ln(margcost)$ is the logarithm of products' marginal cost. Bootstrapped standard errors are clustered at the firm-level and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A.10
Horizontal FDI and firm exit.

	(1) $firm\ exit$	(2) $firm\ exit$	(3) $firm\ exit$	(4) $firm\ exit$	(5) $firm\ exit$	(6) $firm\ exit$
ΔFDI (industry)	0.012	−0.046	0.044	−0.016	0.044	−0.015
	(0.045)	(0.047)	(0.046)	(0.048)	(0.074)	(0.062)
ΔFDI (product)		0.157***		0.165***		0.169***
		(0.029)		(0.029)		(0.029)
N	35 498	35 498	34 669	34 669	34 669	34 432
Firm FE	No	No	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	No	No
Sector FE	Yes	Yes	No	No	No	No
Sector-year FE	No	No	No	No	Yes	Yes

Notes. The table reports coefficient from OLS regressions. FDI (industry) denotes horizontal foreign direct investment at the 3-digit industry-level weighted by lagged sales shares of products within firms. ΔFDI (product) denotes horizontal foreign direct investment at the 12-digit product-level weighted by lagged sales shares of products within firms. $firm\_exit$ equals one if the firm exits the sample. Sector fixed effects and clusters refer to the 2-digit industry code. Standard errors are clustered and reported in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

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