Does input-liberalization affect firms' foreign technology choice?*

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Abstract

Foreign technology transfers play a key role in economic growth of developing countries. This paper investigates the effects of input-trade liberalization on firms' decision to upgrade foreign technology embodied in imported capital goods. We develop a theoretical model of endogenous technology adoption and heterogeneous firms. Assuming that imported intermediate goods and high-technology are complementary and the existence of technology adoption fixed costs, the model predicts a positive effect of input tariff reductions on firms' technology choice to source capital goods from abroad. This effect is heterogeneous across firms depending on their initial productivity level. Using firm-level data from India and imports of capital goods as a proxy of high technology, we demonstrate that the probability of importing capital goods is higher for firms producing in industries that have experienced greater cuts on tariff on intermediate goods. Our findings also suggest that only those firms in the middle range of the productivity distribution have benefited from input-liberalization to upgrade their technology. These empirical results are robust to alternative specifications that control for tariffs on capital goods, other reforms, industry, firm characteristics and alternative measures of technology.

Keywords: input-trade liberalization, firms' decision to import capital goods, firm heterogeneity and firm level data.

JEL Classification: F10, F14, D24 and D92.

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1 Introduction

Trade liberalization has been at the core of economic reforms implemented by several developing countries in the past two decades. Falling tariff and non-tariff barriers have produced steady growth in imports of intermediate and capital goods in developing countries, which are very dependent on foreign technology. The endogenous-growth literature has provided theoretical arguments for the role of foreign intermediate inputs in enhancing economic growth (Ethier, 1979, 1982; Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991). Recent firm-level studies have confirmed that input-trade liberalization played a key role on firm productivity growth (Schor, 2004; Amiti and Konings, 2007; Topalova and Khandelwal, 2010), the ability to introduce new products in the domestic market (Goldberg et al., 2010), export performance (Bas, 2012; Bas and Strauss-Kahn, 2012b) and mark-ups changes (DeLoecker et al., 2012).[1]

Although the impact of input liberalization on firm performance has been largely studied, the link between changes in tariff on intermediate goods and firms' technology choice has not been established yet. The aim of this paper is to fill this gap by investigating how input tariff cuts affect firms' decision to upgrade technology in a developing country. We use as a proxy of high and modern technology imports of capital equipement goods. We first develop a simple model of heterogeneous firms and endogenous technology adoption that rationalizes the channels through which input liberalization affects firms' decision to upgrade foreign technology embodied in imported capital goods. Input-trade liberalization reduces the costs of imported input varieties and allows firms to reduce their marginal costs and increase their profitability. In the presence of fixed cost of technology adoption, heterogeneous firms and complementarity between imported inputs and high foreign technology, the model yields two main testable implications. First, input tariff reductions increase the probability of importing capital goods. Second, the effect of input liberalization on firms' technology choice is heterogeneous across firms depending on their initial productivity level. Firms that will benefit from input liberalization are those with a high productivity level using low-technology before the input tariff cuts.

Next, we test the model implications using the Indian firm-level dataset, Prowess, over the

[1]Other works highlight a positive link between imports of intermediate goods and firm productivity in developing countries(Kasahara and Rodrigue, 2008; Halpern et al., 2009). Bas and Strauss-Kahn (2012a), using firm level data from France, show that importing intermediate goods from developed countries has a greater effect on firm TFP than imports of inputs from less developed economies. They also find that both imports of intermediate goods have a positive effect on the number of export varieties and destination countries.Kugler and Verhoogen (2009) analyze the quality of foreign relative to domestic inputs using detailed firm product level data from Colombia. They show that importers use more distinct categories of inputs and pay higher prices for imported inputs than for domestic inputs in the same product category.

1999-2006 period. This data was collected by the Centre for Monitoring the Indian Economy (CMIE).[2] The Prowess dataset provides information on imports distinguished by type of goods (capital equipment, intermediate goods and final goods). Given that about 75% of imports of capital goods in India is originated from high income OECD countries during this period, imports of capital goods seem to be a good proxy for foreign technology.[3] To establish the causal link between the availability of imported intermediate goods and firms' decision to import capital goods, we rely on the unilateral trade reform that took place in India at the end of the 1990s as a part of the 'Ninth Five-Year Plan'.[4] We depart from previous studies of input-liberalization by distinguishing tariffs on variable inputs from tariffs on capital equipment products. The empirical identification strategy disentangles the direct effects of tariffs on capital goods and the indirect effects of tariffs on intermediate goods on firms' decision to import capital equipment goods from abroad. Using effectively applied most favorite nation (MFN) tariffs data and input-output matrix, we construct tariff measures on variable inputs and on capital goods separately. We first present evidence showing that input tariff changes are uncorrelated with initial firm and industry characteristics. We then exploit this exogenous variation in input tariffs across industries to identify the effect of the availability of foreign intermediate goods on firms' decision to import capital goods taking into account changes in specific tariffs on capital goods.

The empirical findings confirm the theoretical predictions. Firms producing in industries with larger input-tariff cuts have a higher probability of importing capital goods. Our results imply that the average input tariff reductions during the 1999-2006 period, 12 percentage points, is estimated to produce a 2.6 percent increase in the probability of importing capital goods for the average firm and 4 percent for the average firm importing intermediate goods. These results take into account the direct effect of capital goods tariff changes. We then investigate if the effect of input liberalization is heterogeneous across firms. Only those firms in the middle range of the productivity distribution import capital goods after input tariff reductions. As predicted by the model, our findings suggest that the least productive firms do not benefit from input tariff cuts to upgrade foreign technology. Input-tariff cuts do not affect either the most productive firms that may be already producing with the foreign technology before the reform.

These findings are robust to specifications which control for industry and firm observable

[2]We focus on the period 1999-2006 in order to maximize the number of firms each year.

[3]This number is obtained by using the HS6 product-level bilateral trade BACI dataset developed by the CEPII (http://www.cepii.fr/anglaisgraph/bdd/baci.htm), combined with the Broad Economic product Classification provided by the United Nations (http://unstats.un.org/unsd/cr/registry/regot.asp?Lg=1) that distinguishes capital goods from other types of goods.

[4]Section 4 describes the policy instruments applied by the Indian Government during this reform.

characteristics that could be related to tariff changes and might change over time. The results are also robust and stable to several sensitivity tests. First, we investigate whether a reduction on tariff on intermediate goods is associated with the decision to start sourcing capital goods from abroad when we restrict our sample to firms that have not imported capital goods in the previous years. Second, the estimates are also robust when we take into account other reforms that took place in India. Third, the previous findings remain also stable when we exclude foreign or state-owned firms from the sample. Fourth, we also find a positive effect of input tariff cuts on the intensive margin of imports of capital goods. Finally, we show that as expected input tariff cuts are associated with an increase of imports on intermediate goods. We also find a positive effect of input-liberalization on an alternative technology measure (the decision to invest in R&D) and on other firm performance measures (firms' sales and wage-bill).

These findings contribute to the literature on trade liberalization and firms' technology choice. Most of the existent studies focus on the effects of foreign demand shocks on firms' technology upgrading related to output tariff changes affecting exports in bilateral trade agreements or expansion of other export opportunities (Verhoogen, 2008; Bustos, 2011; Aw et al., 2008, 2011). We investigate a different channel through which trade liberalization shapes firms' technology choice associated to a supply shock. Changes in tariffs on intermediate goods might affect firms' performance and thereby, firms' technology upgrading decision through multiple mechanisms: reduction of production costs, new varieties, quality/foreign technology transfer and complementarity between imported intermediate inputs and technology. Our findings show that input tariffs changes are also an important factor to explain firms' technology choice.

Our results also complete the existing evidence regarding the microeconomic effects of input-liberalization on firm performance. Concerning the case of India, most studies use the Prowess dataset to investigate the effects of trade liberalization in India in the early 1990s. Input-tariffs cuts have contributed significantly to firm productivity growth and also to the ability of firms to introduce new products. Topalova and Khandelwal (2010) show that input-trade liberalization improved firm productivity by 4.8 percent in India, while Goldberg et al. (2010) demonstrate that input-tariff cuts in India account on average for 31 percent of the new products introduced by domestic firms. DeLoecker et al. (2012) show that trade liberalization reduces prices and that output tariff cuts have pro-competitive effects. They find that price reductions are small relative to the declines in marginal costs due to the input tariff liberalization. Recent studies have focus on the role of input-liberalization in shaping firms' export performance in other developing countries. Using firm level data from Argentina, Bas (2012) finds that firms producing in industries with larger input-tariff cuts have a greater probability of entering the export market. Bas and Strauss-Kahn (2012b) show that Chinese firms that benefited from input tariff cuts bought more expensive inputs and raised their export prices. These findings suggest that input-liberalization induce firms to upgrade their inputs at low cost in view of a quality upgrading of their exported products.

The next section presents a simple theoretical framework of endogenous foreign technology adoption that rationalizes the main channels through which input liberalization affects firms' decision to import capital goods. Section III describes the data and section IV presents the trade-policy background in India and evidence on exogenous input tariff changes. Section V presents the estimation strategy and the empirical results. Section VI introduces several robustness tests. The last section concludes.

2 Theoretical model

Previous models of heterogeneous firms and technology or quality upgrading focus on the impact of external demand shocks through export trade variable costs or exchange rate variations on firms' decision to upgrade their technology/quality. Yeaple (2005) develops a trade model of ex-ante homogeneous firms, heterogeneous skills and technology choice. In this model firm heterogeneity is an endogenous result of the distribution of skilled workers and technology upgrading. Trade liberalization by a reduction of trade variable costs enhances technology adoption and skill-upgrading. Verhoogen (2008) develops a model of firm heterogeneity and quality differentiation, where more productive firms produce high quality goods to the export market. Expansion of export opportunities through exchange-rate devaluation leads more-productive firms to upgrade the quality of their goods for the export market, and raise wages. Bustos (2011) builds on Yeaple (2005) and Melitz (2003) to develop a trade model of heterogeneous firms and technology adoption. In her model also trade variable costs reductions affecting exports enhance technology upgrading.

We depart from these models of trade, heterogeneous firms and technology upgrading that focus on foreign demand shocks related to output tariff changes and expansion of other export opportunities. Our focus relies instead on a supply shock, namely variations in production costs associated to trade liberalization. Assuming that firms produce their final product with domestic and imported intermediate inputs and that foreign inputs, trade liberalization affects input tariffs and thereby firms' profitability. In this framework, input liberalization leads to firms' technology upgrading through a different mechanism relative to the previous models of firm heterogeneity and technology choice.

2.1 Set-up of the model

The aim of this section is to motivate our empirical analysis by introducing a simple model of endogenous technology adoption. The theory rationalizes the mechanisms through which input liberalization affects firms' decision to upgrade technology. The model is based on firm heterogeneity in terms of productivity à la Melitz (2003).

The representative household allocates consumption from among the range of domestic final goods (j) produced using low-technology (Ω_l) and those produced using high-technology (Ω_h). The subscripts l and h represents firms producing with low- and high-technology. The standard CES utility function represents the consumer preferences
$C = \left(\int_{j \in \Omega_l} C_{lj}^{\frac{\sigma-1}{\sigma}} dj + \int_{j \in \Omega_h} C_{hj}^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}$.

The elasticity of substitution between both types of goods is given by $\sigma > 1$. The optimal relative demand functions are: $C_i = \left(\frac{P}{p_i} \right)^{\sigma} C$, where P represents the price index, C the global consumption and p_i the price set by a firm.

2.2 Production

There is a continuum of firms, which are all different in terms of their initial productivity draw (φ). This productivity draw is revealed from a common distribution density $g(\varphi)$, after firms decide to enter the market. Each firm produces its own variety of final good in a monopolistic competition market structure. In order to produce the final good (q_i) firms must pay a fixed production cost (f). Firms combine two types of intermediate goods to produce the final good: those produced in the home country (x_d) and those that are imported (x_m). To keep the model simple, we assume that all firms used both domestic and foreign intermediate goods.[5] Domestic intermediate goods are produced in perfect competition using one unit of labor, which is elastically supplied and the wage is used as a numeraire. Hence, the price of domestic inputs is equal to the wage which is normalized to one: $p_x = w = 1$. The price of imported inputs equals the price of domestic intermediate goods multiplied by the input tariff: $p_x \tau_m$.

We adopt a CES production function that combines domestic and imported intermediate goods to produce final goods (q_i). The elasticity of substitution between the two types of inputs is $\theta = \frac{1}{1-\alpha}$. Dometsic and imported inputs are imperfect substitutes, hence $0 < \alpha < 1$ and $1 \leq \theta \leq \infty$.

[5] In the case of India, 65% of firms used imported intermediate goods (see descriptive statistics in Table 1).

$$q_i(\varphi) = \varphi \left(x_{di}^{\alpha} + \gamma_i^{\alpha} x_{mi}^{\alpha} \right)^{\frac{1}{\alpha}} \qquad\qquad for \;\; i = \{l, h\} \tag{1}$$

This model builds on the assumption that imported intermediate inputs are complementary with high-technology. This assumption is realistic in the case of developing countries like India that are highly dependent on foreign technology embodied in imported capital equipment goods.[6] In that case, imported intermediate inputs are complementary with modern foreign capital goods. The descriptive evidence presented on Section 3.1. suggests that these assumptions are valid for the panel of Indian firms under analysis. The complementarity between imported inputs and high-foreign technology yields to a higher efficiency in the production process. The parameter γ represents this complementarity. The high value of this factor is only available to firms that pay the fixed technology cost (f_h). Therefore, $\gamma_h > 1$ if the firm produces with high-technology and $\gamma_l = 1$ if the firm produces with low-technology.

There are three types of fixed costs: (1) a fixed sunk entry cost (f_e), that firms have to pay to enter the market (e.g. costs to develop a blueprint), they pay the amortized per-period portion of this cost δf_e[7] ; (2) a fixed per-period production cost (f) that all firms incur to produce, such as that associated with investment in local distribution; and (3) a fixed high-technology adoption cost (f_h), which represents investment in new and more advanced technology is embodied in foreign capital goods. All fixed costs are measured in terms of labor.[8]

Two groups of firms can be identified: (1) low-technology firms, the lowest productivity firms producing with domestic technology (N_l); and (2) high-technology firms, the most productive firms, which have acquired the high-technology (N_h).

Firms, facing the demand $C_i = \left(\frac{P}{p_i}\right)^{\sigma} C$, with constant elasticity σ, choose the price that maximizes their profits:

$$p_i(\varphi) = \frac{\sigma}{\sigma - 1} \frac{c_i}{\varphi} \tag{2}$$

Prices reflect a constant markup $\frac{\sigma}{\sigma-1}$ over marginal cost. In this model, marginal costs can be divided into an intrinsic productivity term (φ) and the CES cost index (c_i), which combines the prices of domestic and imported intermediate goods. Since the price of domestic intermediate goods is equal to the wage which is used as a numeraire, the CES cost index for the low- and high-technology firms can be expressed as a function of input tariffs and the complementarity parameter:

[6] More than 75% of imports of capital equipment goods in India are originated from developed economies from OECD, according to our calculations using the CEPII-BACI data.

[7] The factor of discount is modeled following Melitz with a Poisson death shock probability (δ).

[8] This assumption allows us to study the decision of firms that face homogeneous fixed costs.

$c_l^{\frac{\alpha}{\alpha-1}} = 1 + \tau_m^{\frac{\alpha}{\alpha-1}}$ and $c_h^{\frac{\alpha}{\alpha-1}} = 1 + \left(\frac{\tau_m}{\gamma_h}\right)^{\frac{\alpha}{\alpha-1}}$. High-technology firms pay a fixed technology cost that allows them to reduce their marginal cost by increasing their efficiency through the complementarity between imported inputs and high technology embodied in imported capital goods. All firms that upgrade technology reduce their marginal cost by the same proportion ($\gamma_h > 1$). Otherwise, firms employ low-technology, where $\gamma_l = 1$. Note that the CES cost index of high-technology firms (c_h) is lower than the one of low technology firms (c_l). The ratio $\frac{c_h}{c_l}$ is then determined by:

$$\frac{c_h}{c_l} = \left(\frac{\tau_m^{\frac{\alpha}{1-\alpha}} + 1}{\tau_m^{\frac{\alpha}{1-\alpha}} + \gamma_h^{\frac{\alpha}{1-\alpha}}}\right)^{\frac{1-\alpha}{\alpha}} \tag{3}$$

This ratio expresses the relative cost of high-technology firms to low-technology firms. The relative costs $\frac{c_h}{c_l}$ is an increasing function of input tariffs. Partially differentiating equation (3) with respect to the input tariffs (τ_m), we find that $\partial\frac{c_h}{c_l}/\partial\tau_m > 0$ since $0 < \alpha < 1$ and $\gamma_h > 1$. The lower the input tariffs the lower the relative unit costs of firms using the high-technology.

This result is explained by the fact that using foreign technology improves the efficiency of production through the use of foreign inputs. Adopting the foreign technology induces a technical change that is biased towards the use of foreign inputs given the substitutability between domestic and foreign inputs in the CES production function. This makes the production process more sensitive to tariff changes.

Revenues and profits can then be expressed as a function of this ratio. Combining the demand and the price function, firms' revenues are given by $r_i(\varphi) = q_i(v)p_i(v) = r_i(\varphi) = \left(\frac{P}{p_i}\right)^{\sigma-1} R$. R is the aggregate revenue. Revenues of high-technology firms can be written as a function of revenues of low-technology firms $r_h(\varphi) = r_l\left(\frac{c_h}{c_l}\right)^{1-\sigma}$. Hence, firms that upgrade technology have a comparative advantage costs that allow them to raise their revenues by the term $\left(\frac{c_h}{c_l}\right)^{1-\sigma}$. Note that this term is higher than one since the elasticity of substitution among final goods is $\sigma > 1$ and $c_l > c_h$. Profits for both types of firms are given by $\pi_l(\varphi) = \frac{r_l(\varphi)}{\sigma} - f$ and $\pi_h(\varphi) = \frac{r_h(\varphi)}{\sigma} - f - f_h$. The most productive firms using high-technology embodied in imported capital goods have larger revenues and profits since they have a lower marginal cost due to (i) a better exogenous productivity draw (φ) and (ii) a higher input efficiency thanks to the complementarity between imported intermediate and the high-technology(γ_h).

2.3 Firm's decisions

The decision to exit or stay and produce

Firms have to pay a sunk entry cost to enter the market before they know what their productivity level will be. Entrants then derive their productivity φ from common distribution density $g(\varphi)$, with support $[0, \infty)$ and cumulative distribution $G(\varphi)$.[9] Since there is a fixed production cost (f), only those firms with enough profits to pay this cost can produce. The profits of the marginal firm that decides to stay and produce are equal to zero: $\pi_l\left(\varphi_l^*\right) = 0$. The value φ_l^* is the productivity cutoff to produce. This cutoff is determined by the following condition:

$$\frac{r_l\left(\varphi_l^*\right)}{\sigma} = f \tag{4}$$

Equation (4) implies that the productivity cutoff to produce is determined by $\varphi_l^{*\sigma-1} = f\ c_l^{\sigma-1}\frac{\sigma}{A}$, where $A = P^{\sigma-1}R\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}$.

The decision to adopt high-technology

If a firm decides to stay in the market once it has received its productivity draw, it may also decide to upgrade its technology to reduce its marginal costs on the basis of its profitability. Technology choice is endogenously determined by the initial productivity draw. Firms with a more favorable productivity draw have a higher potential payoff from upgrading foreign technology, and hence are more likely to find incurring the fixed technology cost worthwhile. Thus, firms that will upgrade technology are the most productive ones whose increase in domestic revenues due to the adoption of high technology enables them to pay the fixed technology cost. High-technology adoption allows firms to increase their profitability through the complementarity channel between imported intermediate and high technology embodied in imported capital goods in the production process.[10] The indifference condition for the marginal firm to acquire the new and more advanced technology is given by $\pi_h(\varphi_h^*) = \pi_l(\varphi_h^*)$:

$$\frac{r_h(\varphi_h^*) - r_l(\varphi_h^*)}{\sigma} = f_h \tag{5}$$

[9] These functions are defined in the Appendix.

[10] Firms' technology adoption decision takes place after they discover their productivity draw. There is no other uncertainty or additional time discounting apart from the probability of exit (δ). Thus firms are indifferent between paying the one time investment cost F_h or paying the amortized per period portion of this cost in every period $f_h = \delta F_h$.

φ_h^* is the minimum productivity level for the marginal firm able to adopt high technology. Equation (5) implies that $\varphi_h^{*\sigma-1} = \frac{f_h}{c_h^{1-\sigma}-c_l^{1-\sigma}}\frac{\sigma}{A}$. By combining equation (4) with (5), we obtain φ_h^* as an implicit function of φ_l^*:

$$\varphi_h^* = \varphi_l^* \left(\frac{f_h}{f}\right)^{\frac{1}{\sigma-1}} \left(\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right)^{\frac{1}{1-\sigma}} \tag{6}$$

The sorting of firms by technology status depends on the relationship between fixed costs and variable costs of importing intermediate goods. If fixed costs of adopting the high-technology are lower than fixed production costs all firms will use the high-technology. The partitioning condition that ensures that $\varphi_h^* > \varphi_l^*$ is given by $f_h > f\left(\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right)$.

2.4 Equilibrium conditions

Due to the CES production function combining domestic and imported intermediate goods, unlike Melitz's model, the equilibrium productivity cutoff level to produce (φ_l^*) depends on the input tariffs (τ_m) and the complementarity parameter between imported inputs and high-technology(γ_h). The equilibrium value of φ_l^* is determined by two conditions: the zero cutoff profits condition (ZCP) and the free entry condition (FE). These conditions establish two different relationships between average profits and the productivity level of the marginal firm. The value of φ_l^* at equilibrium will then pin down the rest of the model's variables. All aggregate variables are defined in the theoretical appendix.

The Free Entry Condition (FE): before entering the market and knowing their productivity level, firms calculate the present value of average profit flows to decide whether to enter the domestic market. All firms except the marginal firms earn positive profits. Hence, average profit level $\widetilde{\pi}$ is positive. All average variables are defined in the aggregation section in the theoretical appendix. As in Melitz (2003), $\widetilde{v}$ is the present value of the average profit flows: $\widetilde{v} = \left[\sum_{t=0}^{\infty}(1-\delta)^t\,\widetilde{\pi}\right]$ and v^e is the net value of entry given by: $v^e = \frac{1-G(\varphi_l^*)}{\delta}\widetilde{\pi} - \delta f_e$. In equilibrium, where entry is unrestricted, the net value of entry is equal to zero. This free entry condition represent a relationship between the average profits and the low-technology productivity cutoff level where the cutoff is an increasing function of average profits :

$$\widetilde{\pi} = \frac{\delta f_E}{(1-G(\varphi_l^*))} \qquad \text{(FE)} \tag{7}$$

Once firms pay the fixed entry costs, entrants then draw their productivity from a known Pareto distribution function $g(\varphi) = \frac{k(\varphi_{\min})^k}{(\varphi)^{k+1}}$ with a lower bound $\varphi_{\min}$ and a shape parameter k. The cumulative distribution function is $G(\varphi) = 1 - \left(\frac{\varphi_{\min}}{\varphi}\right)^k$.

The Zero Cutoff Profit Condition (ZCP): also determines a relation between average profits of each type of firm and the productivity level of the marginal firm.

$$\widetilde{\pi} = \rho_l \pi_l(\widetilde{\varphi_l}) + \rho_h \pi_h(\widetilde{\varphi_h}) \qquad \text{(ZCP)} \tag{8}$$

Where φ_l and φ_h correspond to the average productivity levels of firms producing with low- and high-technology, which depend on the productivity cutoff levels. $\rho_h = \frac{1-G(\varphi_h^*)}{1-G(\varphi_l^*)}$ and $\rho_l = 1 - \rho_h$ represent the ex-ante probability of using high- and low-technology.

The free entry and zero cutoff profit conditions determine the equilibrium low-technology productivity cutoff level φ_l^*. The free entry condition represent a relationship between the average profits and the low-technology productivity cutoff level where the average profits are an increasing function of the cutoff. Under the zero cutoff profit condition, average profits are a decreasing function of the cutoff.

Proposition 1: *There exists a unique equilibrium cutoff (φ_l^*) determined by ZCP and FE condition.*

Proof. *See Appendix A*■

In this model the equilibrium productivity cutoff (φ_l^*) is a function of the input tariffs, the fixed costs and the complementarity technology parameter. This cutoff then determines the technological cutoff level (φ_h^*) defined in equation (6). The productivity cutoff to adopt high-technology is an increasing function of the input tariffs. Input tariff cuts reduce the high-technology productivity cutoff, allowing more firms to upgrade their technology embodied in imported capital goods. The most productive firms producing with low-domestic technology before input liberalization are the firms that will benefit from this reform. These firms will increase their profitability due to reduction of marginal costs and will be able to upgrade their technology. In this model, input-liberalization and technology adoption yield to a reduction of marginal costs through two channels. (1) *A cost channel:* input tariff cuts directly reduce the costs of imported inputs and (2) *a complementarity channel:* firms that are able to afford the fixed costs of high-technology will increase their efficiency by reducing even more their marginal costs due to the complementarity effect between imported intermediate goods and the modern high-technology in the production process.

Proposition 2: *The productivity technological cutoff* (φ_h^*) *is an increasing function of input tariff.* $\frac{\partial \varphi_h^*}{\partial \tau_m} > 0$.

Proof. *See Appendix A*■

2.5 Testable implications

One way that firms have to upgrade their technology in developing countries is through foreign technology transfers. Importing capital equipment goods allows firms to adopt a modern and high-technology relative to the domestic technology. In the empirical analysis, we use as the main proxy for high-technology imports of capital equipment goods. The simple model of heterogeneous firms and endogenous technology adoption presented in the previous section yields two testable implications on the relationship between changes in input tariffs and firms' decision to upgrade technology embodied in foreign capital goods.

First, proposition 2 implies that input tariff liberalization raises the number of firms that is able to afford the fixed costs of importing capital goods. Input tariff cuts increase the likelihood of firms that upgrade foreign technology embodied in imported capital goods.

Testable implication 1: *Input-liberalization has a positive effect on firms' decision to import capital goods.*

Second, the effect of input tariff reductions on firms' technology choice is heterogeneous across firms depending on their initial productivity level. The assumptions of firm heterogeneity and fixed costs of foreign technology adoption imply that those firms that will be able to benefit from input-liberalization are the most productive firms using low-technology before the reform.

Testable implication 2: *The effect of input-liberalization on firms' decision to import capital goods is heterogeneous across firms depending on their initial productivity level.*

In the following sections, we test these empirical implications using the episode of India's trade liberalization at the end of the nineties.

3 Data

3.1 Firm level data

The Indian firm-level dataset is compiled from the Prowess database by the Centre for Monitoring the Indian Economy (CMIE)[11]. This database contains information from the income statements and balance sheets of listed companies comprising more than 70 percent of the economic activity in the organized industrial sector of India. Collectively, the companies covered in Prowess account for 75 percent of all corporate taxes collected by the Government of India. The database is thus representative of large and medium-sized Indian firms.[12] As previously mentioned this dataset was already used in several studies on the performance of Indian firms.[13]

The dataset covers the period 1999-2006 and the information varies by year. It provides quantitative information on sales, capital stock, income from financial and non financial sources, consumption of raw material and energy, compensation to employees and ownership group. This dataset allows us to estimate firm TFP using the Levinsohn and Petrin (2003) methodology. The dataset contains also comprehensive information about the financial statements of firms such as total assets, current assets, total debt and liabilities.

The Prowess database provides detailed information on imports by category of goods: finished goods, intermediate goods and capital goods. In our main empirical specification, we use imports of capital goods (machinery and equipment) as a proxy of foreign technology. Although we are not able to test directly for the impact of imported capital goods depending on the country of origin (e.g developed vs. developing countries), one realistic assumption for the case of a developing country like India is that most imports of capital goods are sourced from more advanced economies. Looking at imports of capital goods at HS6 product level of India by country of origin reveals that about 75% of their imports came from developed countries in the period 1999-2006.[14]

Our sample contains information for 4,718 firms in organized industrial activities from manufacturing sector for the period 1999-2006. The total number of observations firm-year pairs is 19,685. In order to keep a constant sample throughout the paper and to establish the stability of the point estimates, we keep firms that report information on all the firm and industry level

[11] The CMIE is an independent economic center of India.

[12] Since firms are under no legal obligation to report to the data collecting agency, the Prowess data do not allow properly identifying entry and exit of firms.

[13] See Topalova and Khandelwal (2010), Topalova (2004), Goldberg et al. (2010), (Goldberg et al., 2009) Alfaro and Chari (2009), DeLoecker et al. (2012).

[14] We used the BACI database provided by the CEPII as well as the Broad Economic Categories (BEC) classification of HS6 products by intermediates, capital goods and consumption goods.

control variables. Although our panel of firms is unbalanced, there is no statistical difference in the average firm characteristics between the initial year (1999) and the final year (2006) of our sample.

Table 1 in the Appendix reports descriptive evidence of firm level variable used in the empirical analysis. During the period 1999-2006, 34 percent of firms in the sample import capital goods, while 65 percent of firms import intermediate goods. Looking at the firms that source both foreign goods reveals that most of the firms that import capital goods also purchase imported intermediate goods (32% of the firms in our sample). This descriptive evidence suggests that there exists a certain complementarity between imported capital and intermediate goods in India. The fact that not all firms that import intermediate goods are also able to source imported capital equipment goods imply that there might be fixed costs of foreign technology adoption embodied in imported capital goods that only a subset of firms is able to afford. Overall, this descriptive analysis confirms the main assumptions on the fixed costs of importing capital goods and the complementarity between imported intermediate and capital goods of the simple theoretical framework presented in the previous section.

3.2 Input-tariff data

To identify the impact of input-trade liberalization on firms' foreign technology choice, we use input tariffs at the 4-digit-NIC industry level. Tariffs data is provided by WITS and are at the industry level ISIC (rev 2) 4-digit.[15] In order to identify the effect of input tariff changes on firms' decision to import capital goods, we construct different tariffs measures for capital goods and for variable intermediate goods. In this sense, we depart from previous studies on input-trade liberalization that consider both variable inputs and capital goods in the construction of input tariffs.

This methodology allows us to disentangle the indirect effects of tariffs on intermediate goods on firms' decision to import capital goods from the direct effects of tariffs on capital goods. For each 4-digit industry, s, we generate a capital goods tariff as the weighted average of tariffs on the capital goods used in the production of the final goods of that 4-digit industry, where the weights reflect the share of capital goods of the final goods industry on total expenditures in capital goods using India's input-output matrix in 1993. We rely on fixed input weights and a pre-sample year input-output matrix to avoid possible endogeneity concerns between variations in input weights

[15] We use correspondence tables to convert tariffs into ISIC rev 3.1. that match almost perfectly with NIC 4-digit classification. This dataset is available at http://wits.worldbank.org/wits/.

and industry and firm performance. Using a disaggregated input-output matrix, 14 from a total of 55 industries are classified as capital goods.[16] Similarly, for each industry, s, we generate an input tariff as the weighted average of tariffs on all the other intermediate goods (excluding capital goods) used in the production of the final goods of that industry, where the weights reflect the input industry's share of the output industry's total expenditures in other inputs using India's input-output matrix in 1993.

We compute input (capital goods) tariffs as $\tau_{st} = \sum_z \alpha_{zs}\tau_{zt}$, where $\alpha_{\mathbf{zs}}$ is the value share of input (capital) z in the production of output in the 4-digit industry s. Take for example an industry that uses three different intermediate goods in the production of a final good. Suppose that the intermediate goods face a tariff of 5, 10 and 15 per cent, and value shares of 0.10, 0.30 and 0.60, respectively. Using this methodology, the input tariff for this industry is 12.5 percent ($5 \times 0.10 + 10 \times 0.30 + 15 \times 0.60$).

Table 2 shows the average output, input and capital goods tariffs during the 1999-2006 period, in the initial, the final year and the change during the period. Average output tariffs have declined by 17 percentage points and average input tariffs by 12 percentage points during the period, while capital goods tariffs were only slightly reduced by 1 percentage point. There is also significant variation in movements in input tariffs by industry over the 1999-2006 period. Table 3 reports the percentage point change in all tariff measures between 1999 and 2006 across manufacturing industries. This descriptive evidence suggests that changes in input, output and capital goods tariffs were heterogeneous across sectors and also that they were weakly correlated. [17]

Two industry-level controls are included in the empirical specifications to control for competitive pressures. Since the period under analysis covers trade liberalization process started in the early 1990s, we introduce effectively applied output tariffs (collected rates) at the 4-digit NIC code level obtained from the World Bank (WITS). In order to capture domestic competition we use an Herfindhal index computed at the 2-digit NIC industry level. The Herfindahl index measures the concentration in sales for each industry.[18]

[16] Capital goods industries are tractors and agriculture machinery, industrial machinery, industrial machinery (others), office computing machines, other non-electrical machinery, electrical industrial machinery, communication equipments, other electrical machinery, electronic equipments, ships and boats, rail equipments, motor vehicles motor cycles and other transport equipments.

[17] The correlation between average output tariffs and input tariffs is 0.42 and with capital goods tariffs is -0.002.

[18] Herfindahl index is computed at the 2-digit industry level instead of at the 4-digit since we also include value added at the firm level as a control for firm size. When we use the Herfindahl at the 3 digit industry level it is dropped due to colinearity with firm value added.

4 Trade liberalization in India

4.1 Episodes of trade liberalization in India

The main feature of trade reform in India was the substantial trade-integration process experienced in the 1990s. In this section, we describe the different waves of India's trade liberalization and the trade-policy instruments that were applied.

India's trade policy during the 1970 and 80s was characterized by the license raj. This trade system was grounded on trade protection policies with an emphasis on import substitution. This trade regime was very restrictive, with high levels of nominal tariffs and import licenses in almost all sectors.

Two waves of trade liberalization can be distinguished in India during the 90s. The first unilateral trade-reform plan was launched in the early 1990 as a consequence of the debt crisis and as a part of an IMF program. Trade liberalization was at the core of structural reforms launched during the Eighth Five-Year Plan period from 1992-1997. Under this plan, gradual tariff cuts were applied in all sectors at the same time that non tariff barriers and licenses were removed. During this period also India becomes a member of the WTO (World Trade Organization) in 1995. One of the commitments of India when decides to join WTO is to continue the process of trade liberalization started at the early 90s. Although average tariff were reduced by 21 percentage points between 1992 and 1997, they remain relatively high in most sectors as compared to other developing countries. The average output tariffs across all industries is 35 percent in 1999.

The second wave of trade liberalization started at the end of the nineties when the government decides to launch the 'Ninth plan'. This second reform consisted in new tariff reductions and eliminations of remaining trade restrictions. As stated in the 'Ninth Five-Year Plan' one of the objectives concerning trade policy was: '"Import tariffs have also been reduced significantly over time, but our import tariff rates continue to be much higher than in other developing countries. Continuing with high levels of protection is not desirable if we want our industry to be competitive in world markets and it is therefore necessary to continue the process of phased reduction in import tariffs to bring our tariff levels in line with levels prevailing in other developing countries"'.[19] Between 1999 and 2006 average tariff were reduced by 17 percentage points from 35 percent in 1999 to 17.9 percent in 2006 (table 3).

Previous works on India's trade liberalization have mainly focused on the first wave of trade

[19]The objectives of the 'Ninth Plan' are explained in detailed in the Web site from the Planning Commission of the Government of India: http://planningcommission.nic.in/.

reforms. Goldberg et al. (2010), Topalova and Khandelwal (2010) and DeLoecker et al. (2012) investigate the effects of output and input tariff reductions on firms' product scope, TFP and markups during the period 1989-1997, respectively. In this work, we focus on the second wave of trade liberalization that took place at the end of the nineties and the consequent tariff reductions that were implemented afterwards. We restrict our analysis to the second wave of trade reform since during the first wave of trade liberalization between 1989 and 1998, the number of firms in the Prowess dataset in the manufacturing sector raise from around 1,500 in 1989 to 4,500 in 1998, while during the period 1999-2006, there is much less volatility in the sample of firms that ranges from 4,600 in 1999 to 5,000 in 2006. Since the Prowess dataset is a balance-sheet data and it is not compulsory for firms to report information, we can not relate the unbalance nature of the dataset in the early 90s to entry or exit of firms. Moreover, the information of interest for our analysis on imports of capital and intermediate goods has several observations with missing values in the initial period, while during the 1999-2006 period all firms report detailed information on the type of imported goods.

Focusing on the second trade reform plan implemented at the end of the 1990s has the advantage of relying on a panel that is more balanced and with complete information on firms' decision to import capital goods and intermediate products. However, the main issue that arises is wether firms have anticipated the following tariff reductions after the first trade liberalization plan was implemented. One simple exercise is to regress the change in output tariffs between 1999 and 2006 on initial tariff levels. The estimation results show a negative correlation between the change in tariffs and the level of tariffs at the beginning of the period, with a coefficient of -0.151 and a standard error of 0.084. The coefficient then is only significant at 10 percent. This estimation suggests that industries with the highest initial tariffs experienced the largest tariff reductions. The question here is whether firms in more protected industries have lobbied for lower tariffs. In the next section, we investigate this issue and present evidence that input tariff reductions during the second wave of trade reforms are uncorrelated with firm and industry characteristics at the end of the nineties when the second plan was launched.

4.2 Exogenous input tariffs variations

One of the challenges in the investigation of the relationship between input-tariff reductions and firm decisions to upgrade foreign technology embodied in imported capital goods is potential reverse causality between tariff changes and firms' import choices which would bias our estimates.

In this case, changes in input tariffs could reflect some omitted industry characteristics.

One way of addressing this issue is to test whether tariff changes are exogenous to initial industry and firm characteristics. Similar to previous works analyzing the effects of trade liberalization on different firm performance measures (Goldberg et al. 2010, Bas and Strauss-khan, 2012), we regress first changes in input tariffs on a number of industry characteristics computed as the size-weighted average of firms' characteristics in the initial year of our sample. Table 4 shows the coefficients on the change in input tariffs (1999-2006) on industry level regressions of initial industry characteristics (sales, capital stock, wage-bill, imports of intermediates and capital goods) on these tariff changes and 2-digit industry fixed effects. The estimates confirm that input tariff changes between 1999 and 2006 were uncorrelated with initial industry-level outcomes in 1999. As such, it seems unlikely that firms producing in industries with greater input-tariff cuts were able to lobby for these lower tariffs.

Next, we extend the analysis of Goldberg et al. (2010) on the period 1989-1997 by providing additional evidence that input tariff changes between 1999 and 2006 were uncorrelated with initial firm performance measures in 1999 that we are considering in this analysis. Table 5 shows estimates from regressing firm characteristics in 1999 such as the importer status, the logarithm of imports of capital goods, the share of imported capital goods over total sales, the logarithm of capital stock and firm TFP on the variation in input tariffs across industries between 1999 and 2006. Had the government targeted specific firms/industries in its second plan of trade liberalization, we would expect tariff changes to be correlated with initial firm performance. However, the correlation is insignificant.

This evidence suggests that the government did not take into account pre-reform trends in firms' imports of capital goods and other performance measures when deciding to reduce tariff in the second wave of trade reform at the end of the nineties.

5 Estimation strategy

5.1 Input tariff cuts and firm decision to import capital goods

Using specific tariffs on inputs (different from capital goods tariffs) to identify changes in access to foreign intermediate goods across industries, we investigate the relationship between the availability of imported intermediate goods and firms' decision to import capital goods. To test the first implication of the model, we estimate the probability that firm i imports capital goods in year t using the following linear probability model:

$$Importer(k)_{ist} = \gamma_1 Input\tau_{s,t\text{-}1} + \gamma_2 Z_{s,t\text{-}1} + \gamma_3 X_{i,t\text{-}1} + \mu_i + \upsilon_t + \epsilon_{ist}$$

(I)

Here $Importer(k)_{iskt}$ is a dummy variable for firm i producing in industry s having positive imports of capital goods in year t. $Input\ \tau_{s,\ t\text{-}1}$ represents the MFN input tariffs with respect to the Rest of The World of industry s in year $t-1$. $Z_{s,t\text{-}1}$ is a set of industry level control variables and $X_{i,t\text{-}1}$ is a set of firm level observable characteristics varying over time. All specifications include firm fixed effects, μ_i, that take into account unobservable firm characteristics and year fixed effects that control for macroeconomic shocks affecting all firms and industries in the same way, υ_t. Since tariffs vary at the 4-digit industry level over time, so the errors are corrected for clustering across 4-digit industries-year pairs.

As discussed above, input-tariff changes are not correlated with either initial firm characteristics or industry characteristics during the period 1999-2006. To deal with additional concerns of reverse causality and omitted variables, we introduce different control variables at the industry level which may affect firms' import decisions of capital goods and could reflect the effects of input-tariff changes. The γ_1 coefficient on input tariffs might then simply be picking up the effects of variations of tariffs on capital goods. Hence, we first include India's import tariffs on capital goods to capture the direct effects of variations in tariffs affecting capital equipement products on firms' decision to import those capital goods. Second, all specifications also introduced tariffs for final goods. This variable captures foreign competition pressures. Finally, we also include a Herfindhal index at the sectoral level to control for domestic competition pressures.

Next, we explicitly take into account changes in observable firm characteristics that could affect firms' import patterns. Using the same dataset, Bas and Berthou (2012a) have found evidence on a positive correlation between firms' decision to import capital goods and firms' capital intensity. We therefore expect that non-importing Indian firms which experienced significant growth in their capital intensity during the period under analysis were more likely to import capital goods. $X_{i,t\text{-}1}$ is a set of firm level controls such as firms' capital intensity (measured as capital stock over wage-bill) and the age of the firm. The Prowess dataset contains the year of creation of the firm that allows computing the age of the firm.[20]

Table 6 shows the estimation results for equation (I) using a within-firm estimator. These

[20] The Prowess dataset does not report consistent information on number of employees.

results show the impact of lower input tariffs on the decision to import capital goods. In column (1) the coefficient on the input tariffs is negative and significant at the 5% confidence level, indicating that the drop in input tariffs between 1999 and 2006 increased the probability of importing capital goods. The estimated input tariff coefficient is robust to the inclusion of MFN tariffs for final goods set India. In column (2) we introduce tariffs on capital goods to be sure that the input tariffs are not just capturing the effect of changes in direct tariffs of imported capital equipment products. Not surprisingly, reductions on tariffs on capital goods enhance the probability of upgrading foreign technology embodied in imported capital goods. More interesting, the indirect effect of reductions of tariffs on intermediate inputs remains robust and stable. This finding indicates that our input tariff measures are not picking up the effects of variations on trade variable costs on capital goods imports. We next include additional industry and firm level variables to control for industry and firm observable characteristics that vary over time and which could be related to input tariffs. The coefficient of interest on input tariff is robust and stable when we control for domestic competition measured by the Herfindhal index, the age of the firm and firm capital intensity in column (3). The coefficient on input-tariff changes remains negative, significant and stable, however. It is very similar in size to the estimations with only industry-level controls shown in columns (1) and (2).

Finally, if the availability of foreign intermediate goods induces firms to start importing capital goods, we would expect the effect of lower input-tariffs to be greater for firms that actually import intermediate inputs. Columns (4) and (5) carry out this test. First, we inlcude a dummy variable equal to one if the firm imports intermediate goods. Firms sourcing inputs from abroad are more likely to also import capital goods (column 4). Next, we introduce an interaction between input tariff and importer of intermediate goods status (column 5). The estimated coefficient implies that a 10 percentage point fall in input tariffs leads to 2.1% to almost 3.2% increase in the probability of importing capital goods for the average firm and for those actually importing intermediate goods. Between 1999 and 2006, input tariffs declined on average by 12 percentage points, with an associated implied increase in the probability of importing capital goods of about 2.6 percent for the average firm and almost 4 for the average firm importing intermediate goods.

5.2 The heterogeneous effects of input tariff cuts

The simple model presented in Section II, shows that input-trade liberalization affects firms differently according to their initial productivity. The most productive firms might already import capital goods before input-trade liberalization. While the least productive firms might not be able to afford the fixed cost of importing capital goods despite input tariff changes. The model predicts that firms using low technology before the reform that have a certain productivity level closed to the high-technology productivity cutoff will benefit more from the availability of intermediate goods to face the sunk costs of importing capital goods than do others. We explore in this section whether the impact of input-tariff changes on firms' decision to import capital goods depends on previous firm productivity.

To investigate this heterogeneity, we introduce interactions between input-tariff changes and firms' TFP in the initial year of the sample (1999). Firms are divided up into four initial TFP quartiles, with the first quartile representing the least productive firms.[21] We then interact input-tariff with the firm's initial TFP quartiles. We estimate the following linear probability model for the decision to import capital goods:

$$Importer(k)_{ist} = \sum_{\rho=1}^{4} \chi^{\rho}(Input\tau_{s,t-1} \times Q_{is}^{\rho}) + \sum_{\rho=2}^{4} \lambda^{\rho} Q_{is}^{\rho} + \gamma_2 Z_{s,t\text{-}1} + \gamma_3 X_{i,t\text{-}1} + \mu_i + \upsilon_t + \epsilon_{ist}$$

(II)

Here $Importer(k)_{ist}$ is a dummy variable for firm i in 4-digit industry s having positive imports of capital goods in year t. Firms are classified into four quartiles (Q) of TFP in 1999 by ρ: Q_{is}^{1} is a dummy variable for firm i belonging to the first quartile and so on. $Input\tau_{s,t-1} \times Q_{is}^{\rho}$ are the interaction terms between the quartiles and input tariff. We include the same industry (output tariffs, capital goods tariffs and Herfindhal index) and firm level (age, capital intensity and importer of intermediate goods) controls as in the previous estimations.

The estimation results for equation (II) are presented in Table 7. Column (1) reports as a benchmark the estimates presented in column (4) of Table6. Columns (2) to (4) introduce the interaction terms between input tariffs and firms' initial TFP quartiles. The impact of input tariffs on the probability of importing capital goods is only significant for the third initial TFP quartile. This result is consistent with the predictions of our model. Since firms faced fixed sunk costs of importing capital goods, only those firms that were not importing capital goods before the input-tariff reform and that are productive enough to pay the importing fixed costs are able to import capital goods thanks to the reduction of input tariffs.

[21] Firm TFP is estimated using the Levinsohn and Petrin (2003) methodology.

6 Robustness tests

6.1 The decision to start importing capital goods

We explore the robustness of our baseline specification when we restrict our sample to firms that have not imported capital goods in the previous years. We investigate whether a reduction on tariff on intermediate goods is associated with the decision to start sourcing capital goods from abroad.

The estimates from linear probability estimations of equation (I) with firm and year fixed effects for the restricted sample of firms that have not imported capital goods in the last four years are reported in columns (1) to (2) of Table 8. In this case, the coefficients on input tariff are higher compared to the baseline specification. We should keep in mind that this could be due to the reduction of the sample size to half from 19,685 to around 10,000 observations. The point estimates indicate that a 10 percentage point reduction of input tariffs increases the probability to start importing capital goods by 4 percent (columns (1) and (2)). When we restrict our sample to firms that have not imported capital goods before, the coefficient on input tariff is still negative, significant and stable (columns (3) and (4)).

As an alternative test we include the past experience on importing capital goods in the baseline estimations. In this case, we keep the full sample of firms and include the lagged importer status of capital goods of the firm measured by a dummy variable that is equal to one if the firm has been an importer of capital goods in the previous years. This specification allows us to take into account the past experience of importing capital goods that can reduce the fixed costs in the present. These results are reported in columns (5) and (6). As expected the previous import status has a positive effect on the decision of importing capital goods in year t. The point estimates of input tariffs remain almost unchanged relative to the ones presented in the baseline specifications in Table 6.

These findings confirm positive effect of tariff reductions on intermediate goods to start sourcing capital goods from abroad.

6.2 Other reforms in India

During nineties India has experienced structural reforms in several areas of the economy. In order to test if the coefficient on input tariffs is picking up the effects of other reforms that took place in India, we carry out alternative sensitivity tests.

Table 9 presents the results. The benchmark estimation presented in column (3) of table 6 is reported in column (1). Next, we include in column (2) industry-year fixed effects to take into account all unobservable characteristics varying over time that could affect industries. In this case only the interaction term between input tariff and the importer of intermediate goods status variable is included. The coefficient of this interaction term is negative and significant, and the magnitude is very similar to the one found in the baseline specification (column (5) in Table 6). Since other reforms like labor market regulations were introduced at the beginning of the nineties at the State level, we introduce region fixed effects to control for unobservable characteristics affecting the 21-Indian states in column (3). As can be seen the coefficient of interest on input tariffs

In the last column, we test whether input tariff liberalization is capturing the effects of financial development. In a previous work, Bas and Berthou (2012b) show that firms located in states with higher financial development have experienced a greater value added and capital growth. We investigate here if there is a joint effect between trade liberalization and financial reform, by including the interaction term of both variables. The findings presented in column (4) suggest that firms located in those regions with a higher level of financial development have benefited the most from input tariff cuts to upgrade foreign technology embodied in imported capital goods.

Overall, these results confirm that our previous findings do not suffer from omitted variables bias related to other policy-reforms that took place in India.

6.3 Alternative samples

In this section, we address another potential concern related with firms' ownership. We test our main specification for different samples of firms to investigate whether firms' ownership is driving our previous results.

Previous studies on multinational firms show that foreign firms in developing countries tend to use more advanced technologies and be more productive relative to domestic firms (Javorcik, 2004). In general, the fact that foreign companies are more efficient and use more advanced technology could potentially explain our results. Foreign affiliates might benefit more from input tariff changes to upgrade foreign technology embodied in imported capital goods since they have connections with foreign headquarters located abroad. In order to address this issue, we exclude from our sample multinational firms in columns (1) and (2) of Table 10. Our coefficients of interest on input tariff remain robust and stable when we restrict the sample to domestic firms, implying that input liberalization matters for non multinational firms.

Moreover, previous works using the same firm-level dataset have emphasized the role of state-owned firms relative to private companies in India (Topalova, 2004; Alfaro and Chari, 2009). One could argue that state-owned companies might have a greater lobby power to induce the government to reduce tariff on those goods that they use as intermediate ones in the production of final goods. In order to address this issue, we restrict the sample to private firms in columns (3) and (4), while columns (5) and (6) present the results for state-owned companies. The point estimates of input tariff remain robust and stable for the sample of private firms. However, it is no longer significant when we restrict the sample to state-owned firms. This result suggests that state companies did not benefit from input tariff reductions to import capital goods. These tests confirm that different firm ownership characteristics are not picking up our previous findings.

6.4 Input-tariff cuts and the intensive margin of imports of capital goods

If imports of intermediate goods are complementary with imports of capital goods, we expect that input tariff reductions will also enhance larger volumes of imports of capital goods. One concern that arises in the estimation of the determinants of the intensive margin of imports of capital goods is that this variable is observed only over some interval of its support. In this case, the sample is a mixture of observations with zero and positive values. An OLS estimation of the logarithm of imports of capital goods will exclude the zero import values leading to sample-selection bias and inconsistent parameter estimates as the censored sample is not representative of the entire sample of Indian firms.

There are two different ways for addressing this issue. The first way is to rely on an OLS estimation with firm fixed effects regressing import shares (imports of capital goods over total sales) on input tariffs. This dependent variable retains the observations on non-importing capital goods firms and is a similar strategy to that in Equation (I). Nevertheless, the drawback is that it does not address the censored nature of the data. The distribution of import shares is indeed left-censored, and as such produces inconsistent estimates under linear models as the expected value of a censored variable is a non-linear function of the covariates.[22] For this case, the Tobit estimation is more suitable than OLS. We thus also present Tobit estimates with imports of capital goods shares on the left-hand side explicitly taking censoring into account by considering the zero

[22]In addition, OLS estimation yields predicted values of the dependent variable outside of the valid range as it ignores the censored nature of the dependent variable.

values as a left-censored. The predicted values from Tobit estimations account for the lower limit of the censored data.[23] Tobit models with individual fixed effects have an incidental parameters problem, and are generally biased (Greene 2003). We thus report results from both pooled Tobit, without unobserved effects (either fixed or random), and random effects Tobit.[24]

Table 11 shows the results for the share of imports of capital goods over total sales. Columns (1) and (2) shows the within firm estimation of input tariff changes on import shares using OLS with firm fixed effects. Once we control for firm and industry characteristics in column (2), the coefficient on input-tariff is still negative and significant, implying that input-trade liberalization increases the share of imports of capital goods. However, as previously noted, this specification ignores the censored nature of the data and yields inconsistent estimates. Columns (3) and (4) show the marginal effects at the sample mean from pooled Tobit estimation of tariffs on imports of capital goods shares; columns (5) to (6) show the results from random-effects Tobits. The coefficient of interest on input tariffs is negative and significant in all of the specifications. The results presented in column (6) imply that a 10 percentage point fall in input tariffs leads to a 0.67% rise in import shares for the average firm.

6.5 Input tariffs reductions and other firm outcomes

The theoretical model presented in Section 2 emphasizes that input-tariff reductions allow firms to increase their efficiency. If the availability of imported inputs is a factor in greater performance, it should also affect other firm outcomes besides imports of capital goods.

First, we show that input tariff reductions are associated with an expansion of firms' imported inputs. Column (1) of Table 12 shows the estimates of regressing the share of imported intermediate goods over total inputs of firm i in year t on input tariffs in $t-1$. As can be notice, input tariff cuts have induced an expansion of imported inputs.

Next, we explore the relationship between input-tariff cuts and domestic sales, the decision to invest in R&D and firms wages. We thus estimate equation (I) with these firm performance variables as the dependent variables. The effect of input tariff reductions on firms' sales is not significant for the average firm (column (2)). However, those firms that actually import intermediate

[23]We should keep in mind that Tobit estimation relies on the assumption of homoskedastic normally-distributed errors for consistency.

[24]In the random effects Tobit, firm unobserved heterogeneity is assumed to be part of the composite error. Random-effects Tobits are unbiased if firm characteristics are exogenous (uncorrelated with the regressors). Honore (1992) has developed a semiparametric method dealing with this issue which captures unobserved time-invariant individual heterogeneity. He proposes a trimmed least squares estimator of censored regression models. Nevertheless, this semiparametric estimator for fixed-effect Tobits is not suitable here due to the relatively small sample size.

goods have benefited from input tariff cuts to increase their sales as showed in column (3).

Using as an alternative measure of technology upgrading R&D investments, columns (4) to (5) explore the effects of input-tariff changes on the decision to invest on R&D. The dependent variable is a dummy equal to one if the firm reports positive R&D investments in year t. We also find here that lower input tariffs are associated with increased firm technology upgrading. This empirical evidence is consistent with previous work. Goldberg et al. (2010) find an increase in both the number of new domestic products, productivity gains and domestic sales after cuts in input tariffs in India. Amiti and Konings (2007) show that the productivity gains of Indonesian firms rise with input-tariff reductions, and Teshima (2009) finds positive effects of output-tariff reductions on firm R&D activities via foreign competition, but insignificant effects from input-tariff cuts. Bas (2012) shows that Argentinean firms expand their technological expenditures after input tariff cuts.

Finally, we investigate the relationship between input tariff changes and firms' wage-bill. Amiti and Davis (2010), find that input liberalization boosts firms' wages for those firms importing intermediate goods in Indonesia. Unfortunately, the Prowess dataset does not report consistent information on the number of employees, so we have to rely on firms' wage-bill instead of firms' wages. The estimates presented in columns (6) and (7) shows that input liberalization in India is also associated with a greater wage-bill.

7 Conclusion

The main contribution of this paper to the literature on the micro-economic effects of input liberalization on firm performance is to investigate theoretically and empirically the efficiency gains from input-trade liberalization on firms' decision to source capital goods from abroad.

We develop a simple theoretical model of heterogeneous firms that explains the channels through which changes on tariff on intermediate goods might affect firms' technology upgrading decision. Assuming that foreign intermediate and high-technology are complementary and fixed costs of technology upgrading, the model predicts a positive effect of reductions of tariff on intermediate goods on firm' choice to adopt a high-foreign technology. The impact of input liberalization is heterogeneous across firms depending on their initial productivity level.

Using firm-level data from India and imports of capital goods as a proxy of modern and high-technology, we test the main implications of the model. Our findings demonstrate that the probability of importing capital goods is higher for firms producing in industries that have experienced greater cuts on tariff on intermediate goods. Looking at the heterogeneous effect of input-liberalization, we find that only those firms in the middle range of the productivity distribution have benefited from input tariff cuts. These empirical findings are robust to alternative specifications that control for imported capital goods tariffs, other reforms, and industry and firm characteristics.

References

Alfaro, L. and Chari, A. (2009). India transformed? insights from the firm level 1988-2005. NBER Working Papers 15448.

Amiti, M. and Konings, J. (2007). Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *American Economic Review*, 97(5):1611–1638.

Aw, B., Roberts, M., and Xu, D. (2008). R&d investments, exporting, and the evolution of firm productivity. *American Economic Review*, 98:451–56.

Aw, B., Roberts, M., and Xu, D. (2011). R&d investment, exporting, and productivity dynamics. *American Economic Review*, 101:1312–44.

Bas, M. (2012). Input-trade liberalization and firm export decisions: Evidence from argentina. *Journal of Development Economics*, 97:481ï¿½493.

Bas, M. and Berthou, A. (2012a). The decision to import capital goods in india: Firms' financial factors matter. World Bank Economic Review, forthcoming.

Bas, M. and Berthou, A. (2012b). The unequal effects of financial development on firms' growth in india. Mimeo.

Bas, M. and Strauss-Kahn, V. (2012a). Does importing more inputs raise exports? firm level evidence from france. Mimeo.

Bas, M. and Strauss-Kahn, V. (2012b). Trade liberalization and export prices: The case of china. Mimeo.

Bustos, P. (2011). Trade liberalization, exports and technology upgrading: Evidence on the impact of mercosur on argentinean firms. *American Economic Review*, 101:304–340.

DeLoecker, J., Goldberg, P. K., Khandelwal, A. K., and Pavcnik, N. (2012). Prices, markups and trade reform.

Ethier, W. (1979). Internationally decreasing costs and world trade. *Journal of International Economics*, 9:1–24.

Ethier, W. (1982). National and international returns to scale in the modern theory of international trade. *The American Economic Review*, 72:389ï¿½405.

Goldberg, P., Khandelwal, A., Pavcnik, N., and Topalova, P. (2009). Trade liberalization and new imported inputs. *American Economic Review Papers and Proceedings*, 99(2):494–500.

Goldberg, P. K., Khandelwal, A. K., Pavcnik, N., and Topalova, P. (2010). Imported intermediate inputs and domestic product growth: Evidence from india. *The Quarterly Journal of Economics*, 125(4):1727–1767.

Grossman, G. and Helpman, E. (1991). Innovation and growth in the global economy. *Cambridge, MA: MIT*.

Halpern, Koren, and Szeidl (2009). Imported inputs and productivity. CEPR N. 5139.

Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic firms? in search of spillovers through backward linkages. *American Economic Review*, 94(3):605–627.

Kasahara and Rodrigue (2008). Does the use of imported intermediates increase productivity? plant-level evidence. *Journal of Development Economics*, 87:106–118.

Kugler, M. and Verhoogen, E. (2009). Plants and imported inputs: New facts and an interpretation. *American Economic Review Papers and Proceedings*, 99(2):501–507.

Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, 70(2):317–341.

Melitz, M. (2003). The impact of trade on intra-industry reallocations and agregate industry productivity. *Econometrica*, 71:1695–1725.

Rivera-Batiz, L. and Romer, P. (1991). International trade with endogenous technological change. *European Economic Review*, 35(4):971–1001.

Schor (2004). Heterogeneous productivity response to tariff reduction: evidence from brazilian manufacturing firms. *Journal of Development Economics*, 75:373–396.

Teshima, K. (2009). Import competition and innovation at the plant level: Evidence from mexico. Mimeo Columbia University.

Topalova, P. (2004). Overview of the indian corporate sector: 1989-2002. IMF Working Papers 04/64.

Topalova, P. and Khandelwal, A. (2010). Trade liberalization and firm productivity: The case of india. Forthcoming The Review of Economics and Statistics.

Verhoogen, E. (2008). Trade, quality upgrading and wage inequality in the mexican manufacturing sector. *Quarterly Journal of Economics*, 123:489ï¿½530.

Yeaple, S. (2005). A simple model of firm heterogeneity, international trade and wages. *Journal of International Economics*, 65:1–20.

A Theoretical Appendix

Aggregation

The distribution of the productivity levels of low- and high-technology firms is represented by $\mu_l(\varphi)$ and $\mu_h(\varphi)$, respectively. Therefore, $\mu_l(\varphi)$ is the conditional distribution of $g(\varphi)$ on $[\varphi_l^*, \varphi_h^*]$ while $\mu_h(\varphi)$ is the conditional distribution of $g(\varphi)$ on $[\varphi_h^*, \infty)$. The cumulative distributions for each type of firms are $G(\varphi_l^*)$ and $G(\varphi_h^*)$.

These distributions define the weighted averages of the firms' productivity levels as functions of the cutoffs. $\widetilde{\varphi_l}$ is the low-technology average productivity level and $\widetilde{\varphi_h}$ represents the ex-ante weighted average productivity level of high-foreign-technology firms before they decide to import capital goods. The average productivity for each group of firms writes: $\widetilde{\varphi_l}^{\sigma-1} \equiv \frac{1}{G(\varphi_h^*)-G(\varphi_l^*)} \int_{\varphi_l^*}^{\varphi_h^*} (\varphi)^{\sigma-1} g(\varphi)d\varphi$, and $\widetilde{\varphi_h}^{\sigma-1} \equiv \frac{1}{1-G(\varphi_h^*)} \int_{\varphi_h^*}^{\infty} (\varphi)^{\sigma-1} g(\varphi)d\varphi$.

The ex-post average productivity of high-foreign-technology firms has to take into account the increase in the firms' efficiency due to the acquisition of the more advanced technology complementary with imported intermediate inputs. The adoption of the high technology allows these firms to reduce their unit costs and raise their market shares by this term $\left(\frac{c_h}{c_l}\right)^{1-\sigma}$. Notice that average revenues of high-technology firms can be expressed as $r_h(\widetilde{\varphi_h}) = r_l(\widetilde{\varphi_h}) \left(\frac{c_h}{c_l}\right)^{1-\sigma}$. Therefore, the weighted average productivity index of the economy $(\widetilde{\varphi_T})$ represents the market shares of all types of firms: $\widetilde{\varphi_T}^{\sigma-1} = \frac{1}{N} \left[N_l \left(\widetilde{\varphi_l}\right)^{\sigma-1} + N_h \left(\frac{c_h}{c_l}\right)^{1-\sigma} \left(\widetilde{\varphi_h}\right)^{\sigma-1}\right]$.

The number of firms producing with low technology $(N_l = \rho_l N)$ and those producing with high technology $(N_h = \rho_h N)$ are determined by the total number of firms (N) and the probabilities of using low and high technology. $\rho_h = \frac{1-G(\varphi_h^*)}{1-G(\varphi_l^*)}$ and $\rho_l = 1 - \rho_h$ represent the ex-ante probability of using high- and low-technology, which depend on productivity cutoff levels. The low- and high-technology average productivity levels and the aggregate productivity index define all the aggregate variables.

The global accounting condition establishes that the sum of revenues from production factors (aggregate domestic and imported intermediate goods (X, X_m) and labor (L) used to paid all fixed costs) is equal to the aggregate revenue of the economy. Aggregate revenues in the economy $(R = PY)$ are determined by the total number of firms and the average revenue $R = N\widetilde{r}$. Taking into account that the price of domestic inputs is equal to the wage and that the wage is a numeraire, the global accounting condition can be then written as $N\widetilde{r} = L + X + \tau_m X_m$.

The equilibrium mass of producing firms is obtained by plugging the average firm revenue into the global accounting condition. The average firm revenue is determined by the FE (7) and the ZCP (8) conditions: $\widetilde{r} = \rho_l r_l(\widetilde{\varphi_l}) + \rho_h r_h(\widetilde{\varphi_h}) = (\widetilde{\pi} + f + f_h\rho_h)\,\sigma$. The equilibrium mass of firms producing in any period is $N = \frac{wL+X+\tau_m X_m}{(\widetilde{\pi}+f+f_h\rho_h)\sigma}$.

Proof of Proposition 1

We assume that productivity draws are distributed according to a Pareto distribution $g\,(\varphi) = \frac{k(\varphi_{\min})^k}{(\varphi)^{k+1}}$ with a lower bound $\varphi_{\min}$ and a shape parameter k indexing the dispersion of productivity levels among firms. Let the lower bound $\varphi_{\min} = 1$, the condition that ensures a finite mean of firm size is $k > \sigma - 1$. The cumulative distribution function is $G(\varphi) = 1 - \left(\frac{\varphi_{\min}}{\varphi}\right)^k$.

FE (7) and ZCP (8) conditions jointly determine the equilibrium cutoff level (φ_l^*). In order to obtain this cutoff, we use the technology productivity cutoff, the average productivity for low-and high-technology ($\widetilde{\varphi_l}, \widetilde{\varphi_h}$) firms and the probability of using low- and high-technology (ρ_l, ρ_h).

The average productivity of low-technology firms under the pareto distribution is given by $\widetilde{\varphi_l} \equiv \upsilon\varphi_l^* \left[\frac{1-(\xi)^{-k+\sigma-1}}{1-\xi^{-k}}\right]^{\frac{1}{\sigma-1}}$ if $\quad \varphi_l^* < \varphi < \varphi_h^*$, where $\upsilon = \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}}$ and $\xi = \left(\frac{\delta f_h}{f}\right)^{\frac{1}{\sigma-1}} \left[\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right]^{\frac{1}{1-\sigma}}$.

The average productivity of high-technology firms under the pareto distribution writes $widetilde\varphi_h \equiv \upsilon\varphi_h^*$ if $\varphi > \varphi_h^*$.

The probability of using low technology is $\rho_l = 1 - \left(\frac{\varphi_l^*}{\varphi_h^*}\right)^k$, while the probability of using high technology is $\rho_h = \left(\frac{\varphi_l^*}{\varphi_h^*}\right)^k$.

The equilibrium cutoff level (φ_l^*) is then determined by:

$$\varphi_l^{*k}\delta f_E = f\ \left[(\upsilon)^{\sigma-1} - 1\right] + \left[\left[\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right]^{\frac{k}{\sigma-1}} \delta f_h \left(\frac{\delta f_h}{f}\right)^{\frac{k}{1-\sigma}} \left[(\upsilon)^{\sigma-1} - 1\right]\right] \tag{A.1.}$$

■

Proof of Proposition 2

The proposition 2 states that the productivity technological cutoff (φ_h^*) is an increasing function of input tariff (τ_m).

Keeping in mind that $\frac{c_h}{c_l}$ is an increasing function of ${\tau_m}$[25], we take the partial derivative of the productivity technological cutoff (φ_h^*) determind in Equation (6) with respect to $\frac{c_h}{c_l}(\tau_m)$:

$$\frac{\partial \varphi_h^*}{\partial \frac{c_h}{c_l}(\tau_m)} = \frac{\varphi_h^*}{\varphi_l^*}\left[\frac{\partial \varphi_l^*}{\partial\left(\frac{c_h}{c_l}\right)} + \varphi_l^*\left[\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right]^{-1}\left(\frac{c_h}{c_l}\right)^{-\sigma}\right] \tag{A.2.}$$

Next, we partially differentiate equation (A.1) φ_l^* with respect to $\frac{c_h}{c_l}$, to obtain $\frac{\partial \varphi_l^*}{\partial\left(\frac{c_h}{c_l}\right)}$:

$$\frac{\partial \varphi_l^*}{\partial \frac{c_h}{c_l}(\tau_m)} = (-1)\left(\varphi_l^{*k}\right)^{\frac{1}{k}-1}\left[\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right]^{\frac{k}{\sigma-1}-1}\left(\frac{c_h}{c_l}\right)^{-\sigma}\left[\frac{f_h}{f_E}\left(\frac{\delta f_h}{f}\right)^{\frac{k}{1-\sigma}}\left[(\upsilon)^{\sigma-1} - 1\right]\right] \tag{A.3.}$$

Using $\partial\frac{\frac{c_h}{c_l}}{\tau_m} > 0$, $\left(\frac{c_h}{c_l}\right)^{1-\sigma} > 1$ and $(\upsilon)^{\sigma-1} > 1$, yields to $\frac{\partial \varphi_l^*}{\partial \frac{c_h}{c_l}(\tau_m)} < 0$,

Plugging equation (A.3) into equation (A.2), a sufficient condition for $\frac{\partial \varphi_h^*}{\partial \frac{c_h}{c_l}(\tau_m)} > 0$ is:

$$\varphi_l^{*k} > \left[\left(\frac{c_h}{c_l}\right)^{1-\sigma} - 1\right]^{\frac{k}{\sigma-1}}\left[\frac{f_h}{f_E}\left(\frac{\delta f_h}{f}\right)^{\frac{k}{1-\sigma}}\left[(\upsilon)^{\sigma-1} - 1\right]\right]$$

To prove that this condition holds, we plug in the equation above φ_l^* as determined in proposition 1 and we obtain: $\frac{f}{\delta f_E}\left[(\upsilon)^{\sigma-1} - 1\right] > 0.$, where $\frac{f}{\delta f_E} > 0$ and $(\upsilon)^{\sigma-1} - 1 > 0$. Indeed, $\frac{\partial \varphi_h^*}{\partial\left(\frac{c_h}{c_l}\right)} > 0$.

■

[25] Partially differentiating equation (3) with respect to the input tariffs (τ_m), we find that $\partial\frac{c_h}{c_l}/\partial\tau_m > 0$ since $0 < \alpha < 1$ and $\gamma_h > 1$.

Table 1: Descriptive evidence firm level variables

	1999-2006
Importer capital goods (%)	34
Importer inputs (%)	65
Importer capital goods and inputs (%)	32
Log of capital intensity(capital stock/wage-bill)	2.213
	(1.122)
Age	25
	.(19)
Log of firm TFP (Levinsohn and Petrin)	1.369
	(0.537)

Notes: The table reports the average percentage of importers during the period 1999-2006, the average level of firm capital intensity, age and TFP. Standards errors are reported in parentheses.

B Empirical Appendix

Table 2: Descriptive evidence of average tariff measures

	(1) 1999-2006	(2) 1999	(3) 2006	(4) Change 1999-2006
Tariffs on final goods	28,4%	35,3%	17,9%	-17 p.p.
Tariffs on capital goods	2,0%	2,1%	1,2%	-1 p.p.
Tariffs on other inputs	25,3%	28,4%	16,6%	-12 p.p.

Notes: Columns (1) to (3) report the average levels of tariffs on final goods, capital goods and other inputs over the period, in 1999 and 2006. The last column present the percentage change of tariffs between 1999 and 2006. Capital goods tariffs are a weighted average of output tariffs on the capital goods used in the production of the final goods of that 4-digit industry, where the weights reflect the share of capital goods of the final goods industry on total expenditures in capital goods . Input tariffs are computed as the weighted average of tariffs on all the other intermediate goods (excluding capital goods) used in the production of the final goods of that industry. To disentangle capital goods tariffs from other input tariffs, 14 industries are classified as capital goods producers. These industries are tractors and agriculture machinery, industrial machinery, industrial machinery (others), office computing machines, other non-electrical machinery, electrical industrial machinery, communication equipments, other electrical machinery, electronic equipments, ships and boats, rail equipments, motor vehicles motor cycles and other transport equipments.

Table 3: Heterogeneous change in tariffs across industries between 1999 and 2006 (percentage points)

Industry name	(1) Output tariffs	(2) Capital goods tariffs	(3) Other Input tariffs
Beverages	-27	-0,34	-11
Tobacco products	-9	-0,92	-5
Cotton textiles	-6	-0,20	-9
Carpet weaving	-20	-0,11	-22
Readymade garments	-18	-0,16	-22
Miscellaneous textile products	-22	-0,31	-19
Wood and wood products	-23	-0,34	-19
Paper, paper prod.	-24	-0,11	-19
Leather footwear	-26	-0,09	-19
Leather and leather products	-25	-0,22	-18
Rubber products	-22	-0,05	-15
Plastic products	-23	-0,04	-20
Inorganic heavy chemicals	-25	-0,31	-18
Fertilizers	-21	-0,13	-17
Pesticides	-16	-0,12	-16
Paints, varnishes and lacquers	-23	-0,11	-19
Drugs and medicines	-19	-0,05	-17
Soaps, cosmetics	-23	-0,11	-18
Synthetic fibers, resin	-16	-0,08	-20
Other chemicals	-20	-0,03	-9
Structural clay products	-24	-0,56	-16
Cement	-25	-0,47	-19
Other non-metallic mineral prods.	-19	-0,24	-18
Iron and steel casting	-29	-0,17	-3
Non-ferrous basic metals	-25	-0,14	-16
Hand tools, hardware	-20	-0,15	-8
Miscellaneous metal products	-23	-0,18	-8
Tractors and agri. machinery	-21	-5,93	-8
Industrial machinery	-13	-7,79	-5
Industrial machiner y(others)	-15	-3,33	-6
Machine tools	-15	-0,80	-8
Office computing machines	-19	-3,48	-15
Other non-electrical machinery	-16	-4,10	-6
Electrical industrial Machinery	-19	-3,95	-11
Electrical wires and cables	-23	-0,65	-18
Batteries	-24	-0,54	-18
Electrical appliances	-24	-1,57	-15
Communication equipments	-18	-5,78	-9
Other electrical Machinery	-19	-4,22	-13
Electronic equipments	-18	-6,95	-9
Ships and boats	-14	-4,17	-9
Rail equipments	-22	-4,80	-5
Motor vehicles	-21	-4,49	-9
Motor cycles and scooters	-8	-3,47	-8
Bicycles, cycle-rickshaw	-19	-8,82	-6
Watches and clocks	-24	-1,32	-14
Miscellaneous manufacturing	-16	-1,02	-15

Notes: The table reports the percentage point change in tariffs on final goods, capital goods and other inputs between 1999 and 2006 for each manufacturing industry.

Table 4: Exogeneity test on input tariffs

Dependent variable: change in input tariffs between 1999-2006

	(1)	(2)	(3)	(4)	(5)
Sales (s,1999)	-0.001				
	(0.006)				
Capital stock (s,1999)		-0.003			
		(0.006)			
Wage-bill (s,1999)			0.000		
			(0.006)		
Imports capital goods (s,1999)				-0.005	
				(0.004)	
Imports intermediate goods (s,1999)					0.001
					(0.005)
Industry 2 digit NIC fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	52	52	52	52	52
R-squared	0.801	0.802	0.800	0.810	0.800

Notes: The dependent variable is the changes in input tariffs between 1999 and 2006. The table shows regressions at the 4-digit industry level of changes in input tariffs on different industry level characteristics and 2 digit industry fixed effects. All industry-level variables are expressed in logarithms. Heteroskedasticity-robust standards errors are reported in parentheses.

Table 5: Initial firm characteristics in 1999 and input tariff changes between 1999-2006

	(1) Importer of K	(2) Imports K /sales	(3) Capital stock	(4) TFP	(5) sales
Δ Input tariffs(s,99-06)	-0.404	-0.038	-1.519	-0.413	-1.264
	(0.874)	(0.031)	(1.243)	(0.352)	(1.244)
2 digit NIC fixed effects	yes	yes	yes	yes	yes
Observations	1,714	1,714	1,714	1,702	1,714
R-squared	0.087	0.029	0.041	0.215	0.044

Notes: The dependent variables in each column are the initial firm-level outcomes in 1999. The table shows the coefficients on changes in input tariffs between 1999 and 2006 from firm-level regressions of initial firm characteristics on input tariff changes and 2 digit industry fixed effects. Firm-level variables are expressed in logarithms except for the impporter of capital goods dummy and the ratio of imports of capital goods over total sales. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry level.

Table 6: Input-tariff liberalization and firms' decision to import capital goods, 1999-2006

Dependent variable: dummy equal to one if the firm i imports capital goods in t.					
	(1)	(2)	(3)	(4)	(5)
Input tariff(s)(t-1)	-0.235**	-0.213**	-0.208**	-0.216**	0.002
	(0.098)	(0.100)	(0.098)	(0.096)	(0.110)
Input tariff(s)(t-1) × Importer inputs					-0.325***
					(0.084)
Capital goods tariff(s)(t-1)		-1.098**	-1.089**	-1.143**	-1.135**
		(0.547)	(0.547)	(0.544)	(0.542)
Output tariff(s)(t-1)	0.106	0.123*	0.120	0.118	0.118
	(0.079)	(0.075)	(0.074)	(0.073)	(0.073)
Herfindhal index(s)(t-1)			0.004	0.004	0.004
			(0.003)	(0.003)	(0.003)
Age			0.050*	0.045	0.051*
			(0.028)	(0.028)	(0.028)
Capital intensity(i)(t-1)			0.010	0.009	0.010
			(0.006)	(0.006)	(0.006)
Importer inputs				0.100***	0.185***
				(0.011)	(0.025)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	19,685	19,685	19,685	19,685	19,685
R-squared	0.009	0.009	0.009	0.016	0.017

Notes: The dependent variable is a dummy for firm i having positive imports of capital goods in year t. Output tariff(s)(t-1) are MFN applied tariffs from WITS-WB dataset at the 4 digit industry level and input and capital goods tariffs are constructed separately using these output tariffs and India 1993 input-output matrix. Importer inputs is a dummy equal to one if the firm imports intermediate goods. Herfindhal index(t-1) measures the concentration of sales of the industry. Capital intensity (i,t-1) is measured by capital stock over the wage-bill. The Prowess dataset reports the year of creation of the firm that allows to construct the age of the firm. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year pairs. ***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.

Table 7: The heterogeneous effects of input-tariff liberalization on firms' decision to import capital goods, 1999-2006

Dependent variable: dummy equal to one if the firm i imports capital goods in t.				
	(1)	(2)	(3)	(4)
Input tariff(s)(t-1)	-0.216**			
	(0.096)			
Input tariff(s)(t-1) × First quartile TFP (99)		-0.116	-0.116	-0.129
		(0.156)	(0.156)	(0.157)
Input tariff(s)(t-1) × Second quartile TFP (99)		-0.221	-0.221	-0.227
		(0.150)	(0.150)	(0.150)
Input tariff(s)(t-1) × Third quartile TFP (99)		-0.277**	-0.277**	-0.281**
		(0.133)	(0.133)	(0.133)
Input tariff(s)(t-1) × Fourth quartile TFP (99)		-0.068	-0.068	-0.072
		(0.139)	(0.139)	(0.139)
Age	0.045		-0.001	0.006
	(0.028)		(0.042)	(0.041)
Capital intensity(i)(t-1)	0.009			0.012*
	(0.006)			(0.007)
Importer inputs	0.100***	0.094***	0.094***	0.094***
	(0.011)	(0.013)	(0.013)	(0.013)
Capital goods and output tariff(s)(t-1)	Yes	Yes	Yes	Yes
Herfindhal index(s)(t-1)	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	19,685	12,783	12,783	12,783
R-squared	0.016	0.013	0.013	0.013

Notes: The dependent variable is a dummy for firm i having positive imports of capital goods in year t. Input tariff(s)(t-1) are interacted with quartiles of firm TFP in 1999. Firm TFP is estimated using the Levinsohn and Petrin (2003) methodology. All control variables are defined in table 6. Industry control variables (output tariffs, capital goods tariffs and the Herfindhal index) are included in all specifications. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year. pairs.***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.

Table 8: The decision to start importing capital goods and past import experienced

Dependent variable: dummy equal to one if the firm i imports capital goods in t.						
	(1)	(2)	(3)	(4)	(5)	(6)
	non importer in the past 4 years		first time importing		past import experience	
Input tariff(s)(t-1)	-0.376***	-0.342***	-0.883***	-0.895***	-0.216**	-0.211**
	(0.096)	(0.090)	(0.324)	(0.327)	(0.099)	(0.098)
Capital goods tariff(s)(t-1)	-1.374**	-1.369**	-2.010*	-2.019*	-1.090**	-1.082**
	(0.614)	(0.605)	(1.163)	(1.163)	(0.540)	(0.540)
Output tariff(s)(t-1)	0.069	0.063	0.770***	0.774***	0.123*	0.120
	(0.065)	(0.065)	(0.220)	(0.222)	(0.074)	(0.074)
Importer capital goods(t-1)					0.030**	0.029**
					(0.015)	(0.015)
Industry level controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm level controls	No	Yes	No	Yes	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,053	10,053	3,490	3,490	19,685	19,685
R-squared	0.034	0.037	0.039	0.039	0.010	0.010

Notes: The dependent variable is a dummy for firm i having positive imports of capital goods in year t. All control variables are defined in table 6. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year. pairs.***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.

Table 9: Other reforms in India

Dependent variable: dummy equal to one if the firm i imports capital goods in t.				
	(1)	(2)	(3)	(4)
Input tariff(s)(t-1)	-0.208**		-0.219**	
	(0.098)		(0.102)	
Capital goods tariff(s)(t-1)	-1.089**		-1.207**	
	(0.547)		(0.527)	
Output tariff(s)(t-1)	0.120		0.153**	
	(0.074)		(0.076)	
Input tariff(s)(t-1) × Importer inputs		-0.348***		
		(0.084)		
Importer inputs		0.190***		
		(0.025)		
Input tariff(s)(t-1) × Credit/GDP(r)(t-1)				-0.294***
				(0.100)
Credit/GDP(r)(t-1)				0.008
				(0.029)
Industry level controls	Yes	Yes	Yes	Yes
Firm level controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry year fixed effects	No	Yes	No	Yes
Region year fixed effects	No	No	Yes	No
Observations	19,685	19,685	19,685	19,685
R-squared	0.009	0.037	0.033	0.009

Notes: The dependent variable is a dummy for firm i having positive imports of capital goods in year t. All control variables are defined in table 6. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year. pairs.***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.

Table 10: Alternative samples: the role of firm ownership

Dependent variable: dummy equal to one if the firm i imports capital goods in t.						
	(1)	(2)	(3)	(4)	(5)	(6)
	Without MNF firms		Private firms		State firms	
Input tariff(s)(t-1)	-0.214**	-0.211**	-0.253**	-0.251**	0.279	0.219
	(0.105)	(0.103)	(0.106)	(0.105)	(0.353)	(0.347)
Capital goods and output tariff(s)(t-1)	Yes	Yes	Yes	Yes	Yes	Yes
Herfindhal index(s)(t-1)	Yes	Yes	Yes	Yes	Yes	Yes
Firm level controls	No	Yes	No	Yes	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18,317	18,317	15,393	15,393	4,292	4,292
R-squared	0.009	0.009	0.008	0.009	0.012	0.016

Notes: The dependent variable is a dummy for firm i having positive imports of capital goods in year t. All control variables are defined in table 6. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year. pairs.***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.

Table 11: Input-tariff liberalization and the intensive margin of imports of capital goods, 1999-2006

Dependent variable: the share of imported capital goods over total sales of the firm i in t.						
	(1)	(2)	(3)	(4)	(5)	(6)
	Within		Pooled Tobit		Random effects Tobit	
Input tariff(s)(t-1)	-0.0248**	-0.0279**	-0.0660**	-0.0629**	-0.0708**	-0.0693**
	(0.0116)	(0.0121)	(0.0280)	(0.0279)	(0.0276)	(0.0275)
Capital goods and output tariff(s)(t-1)	Yes	Yes	Yes	Yes	Yes	Yes
Herfindhal index(s)(t-1)	Yes	Yes	Yes	Yes	Yes	Yes
Firm level controls		Yes		Yes		Yes
Firm fixed effects	Yes	Yes				
Random effects					Yes	Yes
Industry fixed effects			Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,685	19,685	19,685	19,685	19,685	19,685
R-squared	0.008	0.010				
Log likelihood	5002	5002	5002	5002	5002	5002
Sigma u			0.0678	0.0674	0.0602	0.0594
Sigma e					0.0513	0.0513

Notes: The dependent variable is the share of imported capital goods over total sales of the firm i in t. All control variables are defined in table 6. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year pairs. ***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.

Table 12: Input liberalization and other firm performance outcomes

	(1) Imported inputs	(2) Sales	(3) Sales	(4) R&D	(5) R&D	(6) Wages	(7) Wages
Input tariff(s)(t-1)	-0.112***	-0.217	0.391	-0.154**	0.012	-0.901***	-0.301
	(0.040)	(0.320)	(0.364)	(0.063)	(0.074)	(0.223)	(0.253)
Input tariff(s)(t-1) × Importer intermediates goods			-0.950***		-0.251***		-0.920***
			(0.213)		(0.064)		(0.170)
Importer intermediates goods			0.624***		0.089***		0.455***
			(0.069)		(0.018)		(0.053)
Capital goods and output tariff(s)(t-1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Herfindhal index(s)(t-1)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,334	19,685	19,685	19,685	19,685	19,657	19,657
R-squared	0.005	0.033	0.071	0.011	0.013	0.040	0.065

Notes: The dependent variables are defined in each column. All control variables are defined in table 6. Heteroskedasticity-robust standards errors are reported in parentheses. Errors are corrected for clustering at the 4-digit industry-year. pairs.***, **, and *indicate significance at the 1, 5 and 10 percent levels respectively.