Trade Liberalization and Investment in Imported and Domestic Capital Goods: Evidence from India*

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Abstract

We evaluate the impact of trade liberalization on the firm's decision to invest in imported and domestic capital goods. Employing firm-level panel data from India's CMIE Prowess database for a period during which a large scale trade liberalization occurred (1989-1997), we estimate dynamic investment equations using the system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). In order to identify the direct effect of lower prices of imported capital goods as a result of reduction in tariffs, we distinguish between tariffs on capital goods, intermediate inputs and final outputs, and control for them simultaneously. Consistent with theory, we find that a reduction in import protection on capital goods and intermediate inputs lead to higher firm-level investment in imported capital goods, whereas reductions in output tariffs result in lower investment. We also find that firms with greater market power lower investment in both imported and domestic capital goods more aggressively following reductions in output tariffs. When we consider the heterogeneous effects of lower tariffs on firms of different sizes, we find the largest impacts on the investment decisions of firms that are in the middle of the size distribution.

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1 Introduction

Economic theory emphasizes the importance of free trade for stimulating investment in new technologies and thereby enhancing productivity. In the last decades, a large number of developing countries and emerging economies have abandoned protectionist policies in an attempt to boost economic growth (e.g. Brazil, Chile, Colombia, Mexico, India). Wacziarg and Welch (2008) report that by 2000, more than 70 percent of the world's countries were open to trade, as defined by Sachs and Warner (1995). To date, however, only a few studies have investigated the impact of trade liberalization on capital accumulation. Moreover, the literature has not fully analyzed how trade liberalization can improve productivity by allowing firms to invest in more efficient and R&D intensive imported capital goods, as opposed domestic capital goods.[1] In this paper, we distinguish investment in foreign capital goods from investment in domestic capital goods, and focus on how reductions in tariffs (on capital goods imports, intermediate input imports and imports of final goods) impact investment decisions in the two types of capital goods. In particular, we estimate the effect of the Indian trade liberalization on firm level investment in domestic and imported capital goods using firm-level panel data from India's CMIE Prowess database.

The trade liberalization episode in India provides a natural setting to study the question at hand. High tariff and non-tariff barriers characterized India's trade policy regime in the decades preceding the nineties. The Indian economy experienced a balance of payment crisis in 1991. Support from the IMF was contingent on economic reforms. As part of the IMF conditionality, trade barriers on imports into India were reduced in the years that followed. Between 1989 and 1997, the average tariff rates on final goods, intermediate inputs and capital inputs declined by between 50 to 65 percentage points, with considerable variation in reductions across industries.

We motivate the empirical specification by providing a theoretical framework, where monopolistically competitive firms import both capital goods and intermediate inputs, and sell their output domestically where they face competition from foreign imports. The dynamic problem of the firm involves the investment decision, where the domestic and foreign capital investment are imperfect substitutes for each other. The firm maximizes the expected present value of the stream of profits

[1] Eaton and Kortum (2001) document the fact that production of capital equipment and R&D intensive goods are concentrated in a few developed countries, and in the rest of the world investment in these capital goods consist of imports.

and optimally decides how much to invest in domestic and imported capital goods.[2] The model predicts that by lowering the relative price of imported capital goods, reduced capital goods tariffs should boost investment in foreign capital. Similarly, a reduction in intermediate input tariffs leads to an increase in investment not only imported but also domestic capital goods, since lower input prices increases the marginal profitability of total capital used in production. On the other hand, lower output tariffs expose firms to heightened foreign competition and erode marginal profitability of capital, which then leads the firms to invest less in imported and domestic capital goods.

To test these predictions, we use a panel data of Indian firms obtained from the CMIE Prowess database. We employ the data on manufacturing firms from 1989 to 1997 and estimate the reduced form dynamic investment equation using the systems-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). The use of firm panel data allows us to control for time invariant firm level unobservables relevant to firm level investment decisions, as well as time varying unobservables common to all firms. In addition, we are also able to include other firm level relevant factors, such as cost of imported intermediate inputs and mark-ups, that influence how tariff reductions might impact firm investment decisions. In evaluating the impact of trade liberalization on investment decisions, we distinguish between tariffs on capital goods, intermediate inputs, and final products. By separating the effects of tariffs on capital goods and intermediate inputs, we are able to evaluate a direct channel through which trade liberalization impacts investment decisions– the price of foreign capital goods.

Consistent with our theoretical framework, we find that the reduction in capital goods tariffs led to an increase in the investment in foreign capital goods, but not the domestic capital goods. Specifically, we find that a 10 percentage point decrease in the capital goods tariffs led firms to increase investment in foreign capital goods by 9.17 percent on average. A similar 10 point percentage point reduction in input tariffs led to a 5 percent increase in investment in foreign capital. Also in line with theory, we find that the reductions in output tariffs affect investment adversely. This adverse impact prevails not only for investment in imported capital goods, but also for domestic capital goods in firms with higher market power.

[2]The implications from our theoretical and empirical model are in terms of the investment rate for imported capital goods $\left(\frac{I_M}{K}\right)$, and investment rate for domestic capital goods $\left(\frac{I_D}{K}\right)$. We use investment and investment rate interchangeably throughout the paper.

Our paper contributes to the growing literature that evaluates the impact of trade liberalization on capital accumulation. The estimates we obtain from investment Euler equations complement the findings in Bas and Berthou (2013), who show that reductions in tariffs on intermediate inputs increased the probability of importing capital goods for firms in the middle range of the productivity distribution. Moreover, our paper extends the results in Kandilov and Leblebicioglu (2012), who study the impact of trade liberalization on firm investment in Mexico. While they treat all investment as domestic investment and examine how lower tariffs can influence the investment decisions through the marginal profitability of capital as a result of greater competition and lower costs of variable inputs, in this paper, we additionally analyse the direct effect of changes in the price of imported capital goods on investment in foreign and domestic capital goods. Hence, we are able to provide direct evidence showing that the largest gains from trade liberalization for capital accumulation occurs through the reductions in the price of foreign capital.[3]

Our work is also related to the broader literature on trade liberalization and productivity. Evidence from Colombia, Chile, Indonesia and India suggests that lower tariffs lead to efficiency gains for firms. (See Topalova and Khandelwal (2011), Amiti and Konings (2007), Fernandes (2007), Pavcnik (2002)). Eaton and Kortum (2001) find that manufacturing of equipment (which is a highly R&D intensive industry) and world R&D activity are concentrated in seven countries, and most of the import of capital equipment in the developing world is from these seven countries. As such, studying the impact of tariff cuts on investment in imported capital goods provides insights into one possible mechanism through which productivity improvements take place.

The rest of the paper is organized as follows. Section 2 describes the trade liberalization experience in India. In Section 3, we develop a simple theoretical framework which will motivate the empirical specification. In Section 4 we describe the data and how we construct the tariffs of interest. Section 5 present our empirical model, and section 6 discussed our findings. Finally, section 7 concludes the paper.

[3]Other studies on trade policy reform and aggregate investment have been cross country or industry level studies which have analyzed the impact of output tariff reductions. See Wacziarg and Welch (2008), Ibarra (1995), for example.

2 Background on Tariff Liberalization

India adopted a highly restrictive trade policy post-independence. It was characterized by high tariff and non-tariff barriers on imports across industries. In the eighties, the government began the process of gradual deregulation of the economy in order to promote exports. However, import tariff rates continued to be high. In 1990, the average tariff rate was over 90 percent while the maximum tariff rates in some industries was close to 300 percent.

A combination of several factors contributed to the balance of payment crisis of 1991. The conflict in the Middle East resulted in high oil prices and a fall in worker remittances from abroad. There was a decline in export growth due to slow growth in India's major trading partners. This combined with the political uncertainty lead to a loss in investor confidence and large capital outflows from the country (see Cerra and Saxena (2002)). Foreign exchange reserves reached dangerously low levels. The Government requested a standby arrangement with the IMF in August 1991. IMF aid was conditional on India undertaking the process of liberalizing its economy. One of the conditions was the reduction in the levels and dispersion of tariffs on imports. Trade barriers on imports into India were reduced in the years that followed.

By 1997, import tariffs were cut to less than half of 1992 levels. Figure 1 shows the evolution of mean tariffs levels on final goods, intermediate inputs and capital goods between 1989 and 2001. In addition to a reduction in average tariff levels, the standard deviation of final goods tariffs, intermediate input tariffs and capital input tariffs also reduced over the period as can be seen in Figure 2. Thus, industries with the highest tariff levels experienced the largest cuts.[4] Table 1 provides the details of the changes in tariffs on final goods, intermediate inputs and capital goods across all two digit manufacturing industries. While there was variation in 1990 tariff levels across industries, the table convincingly shows that the tariff reductions in final goods, intermediate inputs and capital inputs occurred across the board in all industry groups.

Figure 1 and Table 1 also show that most of the reductions in tariffs took place in the years immediately following the crisis between 1992 and 1997. While tariff cuts continued into the second

[4] Average Tariffs for manufacturing was calculated as the simple average of tariffs of all two digit manufacturing industries, where the tariffs on the two digit industries was the simple average of all four digit industries within each two digit industry. The standard deviation of tariffs was calculated across five digit industry levels, the lowest industry classification.

half of the period (between 1997 and 2001), they had more or less leveled off in the later years. Tariffs on final goods dropped from 85 percent to 42 between 1992 and 1997 and reduced to 34 percent by 2001. Similarly, tariffs on capital goods fell from 83 percent to 34 between 1992 and 1997, and to 30 percent by 2001 while tariffs on intermediate inputs reduced from 72 to 32 between 1992 and 1997, and to 29 percent by 2001. These patterns are displayed across the major industries.

We confine our study to early part of the trade liberalization episode until 1997. We do so because of concerns about trade policy being endogenously determined in the period after 1997. The literature on the political economy of trade policy has recognized that groups of firms and workers can influence governments when trade policy is set or that governments may protect industries with low productivity or investment levels (see, for example, Grossman and Helpman (1994); Hillman (1982)). In India, economic policy is broadly set according to five-year plans. Trade policy was determined in the Second Plan (1956-1961) and had not changed over the years even as industries evolved over time. Given the earlier inward looking economic policies and the crisis of 1991, Hasan et al. (2007) argue that tariff reforms in 1992 came as a surprise and were externally driven.

Topalova and Khandelwal (2011) use the Annual Survey of Industry data to check whether the changes in tariffs between 1987 and 1997 across industries were motivated by political considerations. They use a range of industry characteristics such as employment, wages and average factory size to capture electoral power, industry concentration measures and political pressure groups and find no correlation between tariff reductions and pre-reform industry characteristics in 1987. By the end of the Eight Plan (1992-1997), external pressures had abated. India continued with trade reforms in the Ninth Plan (1997-2002). Trade policy in later years could have been influenced by political factors. Topalova and Khandelwal (2011) find evidence that in the years after 1997, tariff cuts may have been more selective to protect less efficient industries. Thus, similar to Goldberg et al. (2010), Topalova and Khandelwal (2011) and De Loecker et al. (2012), we focus on the first half of the period of trade reforms until 1997.

We extend the analysis on trade endogeneity in Topalova and Khandelwal (2011) by providing additional evidence that tariffs levels between 1992-1997 were uncorrelated with the firm outcome measures we consider in this paper. One potential issue that may affect the reliability of our estimates of the impact of tariff liberalization on firm-level investment decisions is if the Indian

policy makers chose import protection measures in response to industry level investment rates in domestic and foreign capital goods. If this was indeed the case, we would expect current investment rates in domestic and foreign capital goods to predict future measures of import protection.

We calculate industry level investment rates in foreign and domestic capital as the sales weighted average of firm-level investment rates in foreign and domestic capital goods respectively.[5] We then regress industry level output tariffs, intermediate input tariffs and capital goods tariffs in period $t+1$ on industry level domestic good investment rates in period t. The results are presented in Table 3, Panel A. We also regress regress industry level output tariffs, intermediate input tariffs and capital good tariffs in period $t+1$ on industry level investment rates in imported capital goods during period t and present the results in Table 3, Panel B. We control for industry and year fixed effects in these regressions and weight each industry by the number of firms in the industry in the particular year.

The results show that for the period of our study, none of the three tariff rates (on final output, intermediate inputs and capital goods) depend on industry level investment rates in either domestic or foreign capital goods. None of the six estimated coefficients are statistically significant, with a mix of positive and negative estimates.

3 Theoretical Framework

In order to motivate the empirical specification, and to illustrate how tariffs on capital goods, intermediate inputs and final output can enter the investment decisions of a firm, we present a simple model of investment. We consider the investment problem of a monopolistically competitive firm that imports some of its capital, in addition to some of its variable inputs of production, and sells its output in the domestic market, where it faces foreign competition. Investment in domestic and imported capital goods are imperfect substitutes. At the beginning of period t, the firm optimally chooses the level of variable inputs and the output price and how much to invest in the two types of capital.

Firm i enters period t with K_{it-1} units of capital. Due to a one period time-to-build lag, the

[5] Here, industry refers to the four digit industry level.

new capital resulting from investment becomes productive in the following period, i.e., production in period t depends on K_{it-1}. The firm chooses total investment expenditures I_{it} to maximize the expected present value of current and future profits subject to the standard capital accumulation equation. Total investment comprises purchases of domestic and imported capital goods that are combined with a constant elasticity of substitution (CES) aggregator

$$I_{it} = \left[(1-\mu_i)^{\frac{1}{\omega}} I_{Dit}^{\frac{\omega-1}{\omega}} + \mu_i^{\frac{1}{\omega}} I_{Mit}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}, \tag{1}$$

where I_{Dit} and I_{Mit} are the purchases of domestic and imported capital goods, $\omega > 0$ is the elasticity of substitution between them, and μ_i is the weight on imported capital goods in the investment basket.[6] We normalizing the price of the investment basket to 1, and denote the relative price of imported capital goods with $\tau_t^K P_{Mt}$, where τ_t^K is the tariff imposed on imported capital goods. From the firm's cost-minimization problem, we obtain the following demand function for imported capital goods:

$$I_{Mit} = \mu_i \left(\tau_t^K P_{Mt}\right)^{-\omega} I_{it}. \tag{2}$$

The demand function shows that the direct mechanism through which tariffs on capital goods affect investment decisions. All else constant, a reduction in the tariffs on capital goods, τ_t^K, lowers the relative price of investment in imported capital, and thereby increases the demand for it.

Let Π_{it} be the maximum profit of firm i obtained by choosing the optimal level of variable inputs and the output price. The expected present value of profits is given by:

$$V_{it}(K_{it-1}) = \max_{I_{it}} \left\{ \Pi_{it} - G\left(K_{it-1}, I_{it}\right) - I_{it} + \beta E_t \left[V_{it+1}(K_{it}) \right] \right\} \tag{3}$$

subject to

$$K_{it} = (1-\delta) K_{it-1} + I_{it}, \tag{4}$$

where β is the discount factor, δ is the rate of depreciation, and $G\left(K_{it-1}, I_{it}\right)$ denotes the cost of altering the capital stock, which leads to a loss of a fraction of total investment. The first order

[6] We assume that the elasticity of substitution between domestic and foreign capital goods is constant across firms and across time, but the weights, μ_i, are firm-specific.

conditions of the firm's problem yield the following equation:

$$1+\frac{\partial G\left(K_{it-1},I_{it}\right)}{\partial I_{it}}=\beta E_t\left[\frac{\partial \Pi_{it+1}}{\partial K_{it}}-\frac{\partial G\left(K_{it},I_{it+1}\right)}{\partial K_{it}}+(1-\delta)\left(1+\frac{\partial G\left(K_{it},I_{it+1}\right)}{\partial I_{it+1}}\right)\right]. \quad (5)$$

This standard Euler equation implies that along the optimal path, the marginal cost of investing in a new unit of composite capital equals the present discounted value of the marginal return to capital. The marginal return depends on the marginal profitability of capital (net of adjustment costs) and the value of undepreciated capital.

In order to characterize the marginal profitability of capital, $\frac{\partial \Pi_{it+1}}{\partial K_{it}}$, we assume that the firm sells its product in the imperfectly competitive domestic market. The demand the firm faces is given by

$$x_{it}=\left(\frac{p_{it}}{P_t}\right)^{-\theta}X_t, \quad (6)$$

where x_{it} is the demand for firm i's product, p_{it} is the price the firm charges, P_t and X_t are the aggregate price level and aggregate demand, respectively. The parameter $\theta>1$ denotes the price elasticity of demand, which indicates the substitutability between the varieties.[7] Given the demand function and the amount of capital at the beginning of the period, the firm optimally chooses the price of its output, in addition to the level of domestic and foreign variable inputs. Hence, at the beginning of each period, firm i maximizes profits conditional on all available information:

$$\Pi_{it}=\max_{p_{it},L_{it},L^*_{it},}\left[x_{it}p_{it}-w_tL_{it}-\left(\tau^I_t w^*_t\right)L^*_{it}\mid \Omega_{t-}\right] \quad (7)$$

subject to

$$x_{it}=F(K_{it-1},L_{it},L^*_{it})$$

where x_{it} is the product demand given in equation (6); L_{it} and L^*_{it} are the domestic and foreign inputs with prices (in units of the domestic currency) w_t and w^*_t, respectively, and τ^I_t is the tariff imposed on imported inputs; and Ω_{t-} is the information set available at the beginning of period t.

[7] We assume that individuals consume a continuum of imperfectly substitutable domestic and foreign goods ($x(z)$ and $x^*(z)$, respectively), and the consumption basket is formed by the following CES aggregator:

$$X_t=\left(\int_0^a x(z)^{\frac{\theta-1}{\theta}}\,dz+\int_a^1 x^*(z)^{\frac{\theta-1}{\theta}}\,dz\right)^{\frac{\theta}{\theta-1}}.$$

We assume that the production function, $F(\cdot)$, is homogeneous of degree one.

Using the first order conditions from the optimization problem (7), and the fact that $F(\cdot)$ is homogeneous of degree one, we differentiate the resulting profit function to obtain the expression for the marginal profitability of capital:

$$\frac{\partial \Pi_{it}}{\partial K_{it-1}} = \left[\frac{1}{K_{it-1}} \left(\frac{x_{it} p_{it}}{\psi} - w_t L_{it} - \left(\tau_t^I w_t^* \right) L_{it}^* \right) \mid \Omega_{t-} \right], \tag{8}$$

where $\psi = \frac{\theta}{\theta - 1}$ denotes the mark-up (price-to-cost margin). It is straightforward to show how changes in input tariffs can affect marginal profitability of capital, and therefore investment decisions in both domestic and imported capital goods, using equation (8). For a given level of imported inputs, L_{it}^*, a reduction in input tariffs, τ_t^I, lowers the cost of using imported inputs, and hence raises the marginal profitability of capital and investment.

We can also demonstrate how output tariffs affect investment decisions using equation (8). Changes in output tariffs affect marginal profitability of capital through changes in foreign competitors' prices and as a result the firm's sales, $x_{it} p_{it}$. In order to illustrate this effect, first consider the aggregate price index, which enters the demand function in equation (6):

$$P_t = \left[\int_0^a p_t(z)^{1-\theta} \, dz + \int_a^1 \left(\tau_t^O p_t^*(z) \right)^{1-\theta} \, dz \right]^{\frac{1}{1-\theta}}, \tag{9}$$

where $p_t(z)$ is the price of a domestic variety z in the interval [0,a) , and $p_t^*(z)$ is the price of a foreign competitor z^* in the interval [a,1]. The effective price of a foreign good is $\tau_t^O p_t^*(z)$, where τ_t^O is the output tariff levied on foreign products. Next, consider how changes in τ_t^O affect sales through competitor's prices:

$$\frac{\partial \left(x_{it} p_{it} \right)}{\partial \tau_t^O} = \theta \frac{x_{it} p_{it}}{P_t} \frac{\partial P_t}{\partial \tau_t^O} = \theta \frac{x_{it} p_{it}}{\tau_t^O} (1 - a) \left(\frac{P_{Ft}}{P_t} \right)^{1-\theta} > 0, \tag{10}$$

where P_{Ft} is the foreign competitors' price index.[8] The positive relationship in expression (10) between sales and output tariffs implies that a reduction in τ_t^O lowers the effective price individuals pay on foreign varieties, thereby reducing the demand for firm i's product. As a result, the reduction

[8]The foreign competitors' price index is given by $P_{Ft} = \frac{1}{1-a} \left[\int_a^1 (\tau_t^O p^*(z)^{1-\theta}) \, dz \right]^{\frac{1}{1-\theta}}$.

in output tariff lowers marginal profitability of capital and investment.

Equation (8) reveals an additional important factor that mediates the relationship between investment and changes in tariffs. The firm's mark-up, ψ_i, which is closely linked to the degree of competition, as well as the industry structure, plays an important role in determining the sensitivity of investment to changes in tariffs. A firm with a higher monopoly power, hence a higher mark-up, may be affected more adversely by a reduction in output tariffs due to the import competition that lower tariffs generate. On the other hand, the reduction in output tariffs may not affect a low mark-up firm as much, since it has already been exposed to ample competition.[9]

To characterize the investment Euler equation (5), we adopt the standard convex adjustment cost assumption, and adopt the following functional form:

$$G\left(K_{t-1}, I_t\right) = \frac{\gamma_0}{2}\left(\frac{I_t}{K_{t-1}} - \gamma_1\right)^2 K_{t-1}, \tag{11}$$

where γ_0 and γ_1 are adjustment cost parameters. We can obtain the fully-parametrized Euler equation by substituting the partial derivatives of the adjustment cost function in equation (11), and the marginal profitability of capital in equation (8) into equation (5). Furthermore, using the demand for imported capital goods in (2), or the counterpart demand function for the domestic capital goods, we can write the investment Euler equation in terms of investment in imported capital goods or in terms of investment in domestic capital goods. Given the functional forms, this produces a non-linear equation in the variables of interest. In order to simplify the interpretation of the coefficients and to obtain an equation that can be used as the basis for our empirical specification, we linearize the Euler equation using a first-order Taylor approximation around the steady state. After linearizing and rearranging the terms, we obtain the following investment equation for imported capital goods:

$$\frac{I_{Mit}}{K_{it-1}} = E_t\left[\phi_0 + \phi_1\frac{I_{Mit+1}}{K_{it}} + \phi_2\frac{S_{it+1}}{K_{it}} - \phi_3\frac{Z_{it+1}}{K_{it}} - \phi_4\frac{Z^*_{it+1}}{K_{it}} + \phi_5\left(\tau^K_{t+1}P_{Mt+1}\right) - \phi_6\left(\tau^K_t P_{Mt}\right)\right] \tag{12}$$

where S_{it+1} is the value of total sales ($x_{it+1}p_{it+1}$), Z_{it+1} is the cost of domestic inputs ($w_{t+1}L_{it+1}$),

[9] We can formally show that the elasticity of mark-up adjusted sales with respect to the output tariff is increasing in the size of the mark-up: $\frac{\partial(x_{it}p_{it}/\psi_i)}{\partial\tau^O_t}\frac{\tau^O_t}{(x_{it}p_{it}/\psi_i)} = \frac{1}{(1+\psi_i)^2}(1-a)\left(\frac{P_{Ft}}{P_t}\right)^{1-\theta} > 0$.

and Z^*_{it+1} is the cost of imported inputs ($\tau^I_{t+1} w^*_{t+1} L^*_{it+1}$). The ϕ's are constants that are functions of the structural parameters of the model. See the Appendix for the details of the Taylor approximation and the expressions for the ϕ's. We can similarly obtain a linear equation for investment in domestic capital goods, which can be used as the basis for the empirical specification for the domestic capital goods. Equation (12), which presents the first-order approximation of the model, shows that the investment process depends on the current and expected prices of imported capital, as well as future investment, expected sales, expected domestic costs and imported input costs.

4 Data

The firm level variables are from Prowess, a panel data of Indian firms. This data is collected by the Centre for Monitoring of the Indian Economy (CMIE). It contains data on listed and unlisted firm and acounts for about 70 percent of organized industrial activity. The data have been used in several papers including Goldberg et al. (2010) and Topalova and Khandelwal (2011). In addition to the variables commonly found in most firm-level data sets (capital stock, sales, wages, expenditure on intermediate inputs etc.), the data also contains information on the foreign exchange transactions of firms, including the imports of capital goods. This, along with the capital stock series allows us to construct the domestic and foreign capital investment series for the firms.

Firms are classified into industries based on the 2008 National Industrial Classification (NIC). The NIC 2008 classification is based on the International Standard Industrial Classification (ISIC) Rev.4. We use data on manufacturing firms (NIC two digits, 10 through 31) . For the period of the study, we have data on $9,486$ firm-year observations. The $2,512$ unique firms in the data are classified into 99 four digit industry groups. To construct firm-level total investment expenditures, we take the annual difference in the current value of the gross fixed assets, which measures the value of the firm's capital. As imports of capital goods measure investment expenditures in foreign capital, we subtract imports of capital goods from total investment expenditures to calculate investment in domestic capital goods.

As shown in Section 3, firm's market power could determine how investment rates respond to changes in tariffs. Firms with high market power can be more sensitive to reductions in output

tariffs due to increased competition from abroad while they can also be less sensitive to changes in intermediate input tariffs. We use use firm-level markups as a proxy for market power in our estimations. We construct the markup variable using the information provided in Prowess. Following Campa and Goldberg (1999), the average markup, ψ_i, for firm i (averaged over our sample period from 1990 to 1997) is defined as

$$\psi_i = \frac{value\,of\,sales_i + \Delta inventories_i}{payroll_i + cost\,of\,materials_i} \tag{13}$$

We expand our baseline specifications to explore the complementary nature of the use of imported intermediate inputs and imported capital inputs. We construct measures of the share of imported intermediate inputs (Imported Intermediates/Total Intermediate Inputs) and average cost of imports of intermediate inputs (by firm over the sample period).

We supplement the firm data with data on policy variables. The data on final goods tariffs are from Topalova and Khandelwal (2011). These data were made available based on the NIC 1987 three digit classification and were matched to NIC 2008 four digit industries.[10] We use the data on output tariffs to construct input tariffs similar to Amiti and Konings (2007) by passing output tariff through the input-output (I-O) matrix. However, unlike Amiti and Konings (2007) who construct an aggregate input tariff, we construct separate tariffs for intermediate inputs and capital goods. Classification of Industries into intermediate and capital goods was done based on the United Nations classification by Broad Economic Categories. We use the I-O Transactions Table from India for $1993-1994$ to obtain the weights for constructing the intermediate inputs and capital inputs tariffs. Sectors $77-84$ and $87-96$ are classified as capital goods industries and the remaining sectors up until sector 98 are classified as intermediate inputs industries. The sectors from the I-O Table were matched to the NIC Industries and the input tariffs were constructed as follows:

$$\tau_{kt}^{j} = \sum_{s} w_{sk}^{j} \tau_{st} \tag{14}$$

where j refers to capital or intermediate inputs, τ_{kt}^{j} is the j input tariff of industry k in period t, w_{sk}^{j} is the value share of industry s in output of industry k and τ_{st} is the output tariff of industry

[10]The NIC 1987 three digit industries correspond to NIC 2008 four digit industries. However, because of reclassification of industrial groups over time, in some cases, they were matched to five digit industries.

s in period t. The weights are constructed from the I-O coefficient matrix of $1993-1994$ such that $\sum_s w_{sk}^j = 1$ for each j.

The government also introduced other industrial reforms during the period. These include liberalizing the licensing requirements (for setting up and expanding capacity) and lowering of entry barriers to foreign investment. We control for these concurrent reforms in our empirical specifications. The data on these policy variables are from Topalova and Khandelwal (2011). The data are coded between 0 and 1 and are industry and time varying. They represent the share of products in an industry subject to licensing requirements (License) and the share of products which have automatic approval for foreign investment (FDI).

Table 2 presents the summary statistics for our dependent variables (domestic and foreign investment rates) and all the explanatory variables (both firm-level variables and policy variables) used in our specifications.

5 Empirical Investment Equation and Estimation

The theoretical framework in Section 3 motivates the relationship between investment and tariffs. For brevity, we refer to the tariffs on intermediate inputs as input tariffs and the tariffs on capital inputs as capital tariffs. The theoretical framework illustrates how capital, input and output tariffs enter investment decisions, and it also suggests other firm-specific determinants of investment (such as sales and costs). Because our main goal is to estimate the impact of trade liberalization on investment in imported and domestic capital goods, instead of focusing on the structural process, we estimate reduced form equations for investment in imported capital goods and investment in domestic capital goods separately.[11]

We start by estimating the following baseline specification, which takes equation (12) as its

[11] In their review of the empirical literature that uses firm- or plant-level data to estimate an investment equation, Bond and Van Reenen (2008) note that this type of reduced form model can be interpreted as representing an empirical approximation to the underlying investment process.

basis, and focuses on the main effect of tariffs on investment:

$$\frac{I_{ijt}}{K_{ijt-1}} = \alpha_1 \frac{I_{ijt-1}}{K_{ijt-2}} + \alpha_2 \frac{S_{ijt}}{K_{ijt-1}} + \alpha_3 \frac{S_{ijt-1}}{K_{ijt-2}} + \alpha_4 \frac{C_{ijt}}{K_{ijt-1}} + \alpha_5 \frac{C_{ijt-1}}{K_{ijt-2}} + \alpha_6 \tau_{jt}^{KT} + \alpha_7 \tau_{jt}^{IT} + \alpha_8 \tau_{jt}^{OT} + \upsilon_i + \eta_t + \varepsilon_{ijt}, \tag{15}$$

where $\frac{I_{ijt}}{K_{ijt-1}}$ denotes investment in imported capital goods (I_M), or investment in domestic capital goods (I_D), for firm i, in industry j in year t; and $\frac{S_{ijt}}{K_{ijt-1}}$ and $\frac{C_{ijt}}{K_{ijt-1}}$ are the firm's total sales and cash flow, respectively, normalized by its capital stock.[12] The terms τ_{jt}^{KT}, τ_{jt}^{IT}, and τ_{jt}^{OT} denote the capital-goods, input, and output tariff measures for industry j, in year t, respectively. Note that we include industry specific input, capital and output tariffs as measures of protection in the baseline specification (15) simultaneously. It is important to include all of these three measures together in the model because they are positively correlated (see Figure 1). As we demonstrate in the results section, if we exclude one or more from the specification, for example if we only include output tariffs, omitted variable bias becomes a potential issue.

In order to address some of the econometric issues in estimating the empirical relationship between investment and these tariff measures, we modify equation (12) in a number of ways. First, following Fazzari et al. (1988), we include cash flow as a proxy for financing constraints, which arise due to capital market imperfections. Cash flow can be an important determinant of investment for Indian firms, since firms might find it difficult to smooth investment via external capital markets.[13] Empirically, cash flow is constructed as the difference between sales and total costs, adjusted for taxes and depreciation.[14] Because costs and cash flow are highly correlated, we include only cash flow in the specification in order to minimize collinearity problems.[15] Second, to allow for serial correlation in sales and cash flow, we include the current and the lagged values of those variables. Moreover, we include the lagged investment rate to control for the autocorrelation that may arise due to adjustment costs. The specification also includes firm specific fixed effects, υ_i, that capture the time-invariant plant-level determinants of investment, as well as year dummies, η_t, that capture

[12] The normalization by capital stock naturally arises in a model with quadratic adjustment costs, and it allows us to control for the size of the firm.

[13] Examples of previous work that have shown the importance of financing constraints for investment in developing countries include Jaramillo et al. (1996), Love (2003), and Harrison et al. (2004).

[14] Total costs include domestic and imported material costs, as well as labor costs and costs of industrial and non-industrial services.

[15] The results including costs in addition to sales and cash flow are similar to those reported in the following sections, and they are available upon request.

aggregate economy-wide fluctuations. Macroeconomic factors common to all firms, such as changes in the exchange rates, will be captured by these year effects. However, firms in different industries might face different economic conditions or different productivity trends. In order to allow for industry-specific productivities, we include interaction terms between two-digit industry dummies and a linear time-trend. Moreover, in some specifications, we include interaction terms between the time trend and a full set of state dummies in order to control for economic trends that differ across various regions. Finally, we assume that the error term, ε_{ijt}, is i.i.d with $E(\varepsilon_{ijt}) = 0$.

In order to analyze the heterogeneity in the investment behavior of firms, we augment the baseline specification (15) in three important ways based on the implications of our theoretical framework. First, we recognize that imported intermediate goods may be complementary to imported capital goods. Therefore, importers of intermediates might not only respond to reductions in input tariffs more strongly, but also respond to reductions in capital tariffs more intensely. To capture this channel, we calculate the average cost of imported intermediate inputs for each firm, and include its interactions with the capital-goods and input tariff measures. We expect a firm with higher imported intermediate costs to benefit more from the reductions in input and capital tariffs. Second, to check how the impact of trade liberalization on investment depends on the firm's mark-up, we include an interaction term between the mark-up and the output tariff measure. As discussed in Section 3, a reduction in output tariffs can reduce investment more in high mark-up firms, as they begin to face more stiff competition from abroad and experience a decrease in marginal profitability. Hence, we expect this interaction term to intensify effects of the output tariffs. Third, we explore the heterogeneity in the impact of lower tariffs on investment in imported and domestic capital goods across the firms of different sizes. To that end, we divide all firms into the four quartiles of the initial firm size distribution, where initial size is measured by the firm's sales, and generate size dummies. We then interact the dummy variables with the tariff measures.

We estimate the dynamic investment equation (15) and the augmented specifications using the *system-GMM estimator* of Arellano and Bover (1995) and Blundell and Bond (1998). This estimator for panel data sets with short time dimension addresses the potential biases that arise from the correlation between the firm fixed effects, υ_i, and the lagged dependent variable, $\frac{I_{ijt-1}}{K_{ijt-2}}$, as well as the endogeneity of sales, $\frac{S_{ijt}}{K_{ijt-1}}$, and cash flow, $\frac{C_{ijt}}{K_{ijt-1}}$. The system-GMM estimator

combines the first-difference equations, whose regressors are instrumented by their lagged levels, with equations in levels, whose regressors are instrumented by their first-differences.[16] We treat all of the firm specific variables as endogenous, and use lagged values dated $t-2$ and $t-3$ as the GMM-type instruments. We also include lags 2 and 3 of total intermediate costs and other expenses in the set of GMM-type instruments. We employ and report the second order serial correlation tests and the Sargan-Hansen tests of over-identification to check the validity of our instruments.[17]

6 Results

We start by estimating the impact of capital, input and output tariffs on firm's investment in imported capital goods in India, as specified in equation (15). In this first set of results, we evaluate the average impact of the trade liberalization on investment in imported capital goods, and show how changes in capital, input and output protection measures affect investment differently, as our theoretical framework suggests. We then present the estimates we obtain for investment in domestic capital goods, which show that investment in domestic goods is not as responsive to trade liberalization. In subsection 6.2, we analyze the complementarity between imported capital goods and imported intermediate inputs, and ask whether firms that rely more on imported inputs benefit more from trade liberalization. Also in the same subsection, we document the importance of the firm's market power, as proxied by the size of the firm's mark-up, in mediating the effects of trade liberalization on not only investment in imported capital, but also in domestic capital goods. Finally in subsection 6.3, we discuss the heterogeneity in the impact of the trade liberalization across firms of different size.

[16] The *system-GMM estimator* builds on the *difference-GMM estimator* of Arellano and Bond (1991), which uses only the differenced equations, instrumented by the lagged levels of the regressors. If the regressors are persistent, then their lagged levels are shown to be weak instruments. See Arellano and Bover (1995) and Blundell and Bond (1998) for more details. To avoid this drawback of the *difference-GMM estimator*, we opt for the *system-GMM estimator*.

[17] All the estimations and tests were done using the *xtabond2* command in Stata 12.

6.1 Main Effects of Trade Liberalization on Investment in Imported and Domestic Capital Goods

Table 4 presents the results from our baseline specification (15) for investment in imported capital goods, which includes firm and year fixed effects, as well as industry specific time trends. In order to illustrate the importance of including all three measures of tariffs in evaluating the impact of trade liberalization econometrically, we first include only the output tariff measure, and then progressively add input and capital goods tariffs. Column (1) of Table 4 shows that, as our theoretical model suggests, the coefficient on output tariffs is positive, but it's not statistically significant. The positive coefficient suggests that a reduction in output tariffs might lower the marginal profitability of capital due to intensified foreign competition, and thereby lower investment in imported capital. When we add input tariffs in column (2), the coefficient on output tariffs increases slightly but remains insignificant. The negative coefficient on input tariffs, albeit being small and insignificant, suggests that a reduction in input tariffs may increase investment in imported capital by lowering the cost of intermediate inputs and therefore increasing the marginal profitability of capital. Next, we include tariffs on capital goods in column (3). As expected, the coefficient on capital goods tariffs is negative and it is highly significant at the 1 percent level. The coefficient on input tariffs remains insignificant, and the coefficient on output tariffs further increases, and becomes significant at 10 percent, demonstrating the importance of controlling for all three tariff measures in order to identify their effects on investment decisions.

In column (4), we augment the specification with a measure of licenses, which measures the share of products that are subject to an industrial license, and with a measure of openness to FDI, both of which are obtained from Topalova and Khandelwal (2011). The results show that the coefficients on the tariff measures remain virtually unchanged. While the coefficient on both licence coverage and FDI openness are negative, only the former is significant. This result suggests that the higher the share of products subject to licensing in an industry, the lower the marginal profitability of capital will be, and therefore, the lower the investment in imported capital goods will be. In the last column, we further augment the specification with state-specific time-trends, capturing, for example, different dynamic productivity trends across the states in India.[18] Accounting for

[18]The state indicators in our data is that they are based on the state where the firm head-quarter is located, which

the state trends increases the impact of input tariffs in magnitude, making it significant at the 10 percent level, suggesting that a reduction in input tariffs increases investment in imported capital by lowering the cost of intermediate inputs and therefore increasing the marginal profitability of capital. This result is consistent with the findings in Bas and Berthou (2013), who find that a reduction in input tariffs increased the probability of importing capital goods for Indian firms. Additionally, we find that the coefficient on output tariffs becomes significant at the 5 percent level, and the coefficient on the capital goods tariffs remain highly significant at the 1 percent level when we include state-specific time trends.

Focusing on the most general specification with state-specific time trends are in column (5) of Table 4, we can quantify the impact of reductions in tariffs on investment in imported capital goods. The estimated coefficient on the capital goods tariffs of -0.033 indicates that the semi-elasticity of the investment rate, $\frac{I_{Mijt}}{K_{ijt-1}}$, with respect to capital goods tariffs is 0.00917 at the sample mean, which suggests that a 10 percentage point reduction in the capital goods tariffs leads to a 9.17 percent increase in investment in imported capital goods.[19] Given the estimate on input tariffs of -0.018, a similar 10 percentage point reduction in input tariffs implies a 5 percent increase in invested in imported capital goods. The larger and statistically more significant impact of the change in capital goods tariffs is not surprising, since it directly increases the demand for imported capital goods by making them cheaper. The input tariffs, on the other hand, work indirectly through the demand for imported intermediate inputs. When intermediate inputs become cheaper as a result of a reduction in input tariffs, firms are able to import more intermediate inputs, increasing the marginal profitability of capital. We investigate this mechanism further in the next subsection. Lastly, we evaluate the effect of output tariffs. The coefficient of 0.014 suggests that a 10 percentage point decrease in output tariffs leads to a 3.89 percent decrease in investment in imported capital goods by reducing the marginal profitability of capital due to intensified foreign competition.

In all five specifications, lagged investment is positive and statistically significant, demonstrating the serial correlation in investment in imported capital goods. In terms of other firm-specific determinants, only the coefficient on lagged sales is statistically significant at the 10 percent level.

might not necessarily be the location where the investment and the production take place.

[19]The semi-elasticity of the investment rate, $\frac{I_{Mijt}}{K_{ijt-1}}$, with respect to capital goods tariffs, τ^K_{jt}, at the sample mean is calculated as -0.00033/0.036=0.00917.

All specifications in Table 4 are supported by the tests of over-identifying restrictions, for which the Hansen test statistic fails to reject the validity of the instrument sets. Moreover, the tests for serial correlation, which are applied to the residuals in the first differenced equations ($\Delta\varepsilon_{ijt}$), show that we can reject the null-hypothesis of no first-order serial correlation, but cannot reject the null-hypothesis of no second order serial correlation.[20] The fact that the errors only have first order autocorrelation confirms the validity of instruments dated $t-2$ and $t-3$.

Next we investigate whether trade liberalization has impacted investment in domestic capital goods similarly. Table 5 presents the results for estimating equation (15) for investment in domestic capital goods. We would expect the input and output tariffs to have the same effect on investment in domestic capital goods and foreign goods, since both tariff measures affect the marginal profitability of capital (see equation (8)), which would matter for both investment decisions. However, how capital goods tariffs affect investment in domestic capital goods is a priori ambiguous. If domestic and foreign capital goods are substitutes for each other, a reduction in capital goods tariffs should lower investment in domestic capital goods, since it would make imported capital goods relatively cheaper. If they are complements, however, cheaper foreign capital goods could also make the firm purchase more domestic capital goods.

Following the same progression of specifications as in Table 4 for investment in imported capital goods, we find that none of the coefficients on tariff measures are precisely estimated. While the sign of the coefficients all tariff measure conform the estimates for imported capital goods in the comprehensive specification in column (5), they are not statistically significant. Given these results, one can prematurely assume that trade liberalization did not have any effects on investment in domestic capital goods. However, as we show in the following subsections, how a firm adjusts investment decisions given changes in tariffs depends on its market power, and accounting for the firm's mark-up is important in uncovering the impact of trade liberalization on investment in domestic capital goods.

[20] Assuming that the residuals, ε_{ijt}, in equation (15) are i.i.d, we expect $\Delta\varepsilon_{ijt}$ in the first-differenced equations to have first order autocorrelation.

6.2 Imported Intermediate Inputs and Firm's Mark-up

Equation (8) in Section 3 illustrates how a reduction in input tariffs, τ_t^I, can increase investment by lowering the cost of using imported inputs, and thereby raising the marginal profitability of investment in both imported and domestic capital goods. Hence, a firm requiring the use of imported inputs should benefit more from a reduction in input tariffs. Moreover, firms that use imported intermediate inputs that are complements to imported capital goods in the production process might invest more when capital becomes cheaper as a result of lower capital goods tariffs. To test these predictions explicitly, we augment our baseline specification (15) with two interaction terms - one between the input tariff and the firm's average imported intermediate costs, and a second term between the capital goods tariffs and the firm's average imported intermediate costs. We additionally include the fraction of intermediate inputs that are imported to account for the complementarity between imported capital goods and imported intermediate inputs.

The results for investment in imported intermediate goods are presented in column (1) of Table 6. The coefficient on the share of imported intermediate inputs is positive, suggesting that the firms that import a larger fraction of their inputs invest more in imported capital goods; however, it is not estimated significantly. The main effects of the capital goods tariff and input tariff are again negative and statistically significant at -0.031 (0.012) and -0.021 (0.010), respectively. As expected, both interaction terms are also negative although they are not statistically significant. The joint significance tests show that while capital goods tariff and its interaction with imported intermediate costs are jointly highly significant with a p-value of 0.009, input tariff and its interaction are marginally insignificant with a p-value of 0.107. The estimated coefficients on capital good tariffs (-0.031) and its interaction with average imported input costs (-0.052) imply that a firm facing the average amount of import costs (0.342 billion rupees, real) would increase investment by 8.66 percent given a 10 percent reduction in capital good tariffs. The effect is larger at 9.35 for a firm facing import costs that are one standard deviation above the mean import costs. Similarly, the coefficients on input tariffs (-0.021) and its interaction with mean import costs (-0.015) suggest that a firm with the average amount of import costs would increase investment by 5.85 percent given a 10 percent reduction in input tariffs. At 6.05 percent, the impact is slightly higher for a firm with import costs that are 1 standard deviation above the mean import costs. While these

marginal effects are small, they suggest added benefits of trade liberalization for firms that rely heavily on intermediate inputs, and consistent with previous work by Kandilov and Leblebicioglu (2012), who have shown that such firms raise total investment more given a reduction in input tariffs. Moreover, these results are consistent with the findings in Bas and Berthou (2013), who find that the reduction in input tariffs between 1999-2006 in India (12 percentage points) led to an increase in the probability of importing capital goods of 2.6 percent for the average firm, and almost 4 percent for the average firm importing intermediate goods.

When we analyze the imported intermediate goods channel for investment in domestic capital goods in column (3), we again do not find any statistically significant results. Although not precisely estimated, the coefficients on capital goods and input tariffs, as well as the coefficients on the interaction terms, in column (3) are negative, hinting that reductions in these tariff measures may be affecting firms that import intermediate inputs.

Next, we consider the miscellaneous effects of output tariff measures for firms with various levels of market power. The theoretical framework in Section 3 illustrates how the effect of output tariffs can be increasing in the size of the firm's mark-up. A firm with higher market power, i.e., with a higher mark-up, can be affected more adversely by lower output tariffs because of the heightened import competition that erodes the marginal profitability of the firm. To test this mechanism, we augment our baseline specification with mark-up interactions. The results for investment in imported capital goods are presented in column (2) of Table 6. As expected, the interaction term between the mark-up and the output tariff is positive, implying that a reduction in output protection lowers investment more in high mark-up firms. While the interaction term is significant at the 5 percent level, the main effect of the output tariff is not significant.[21] The estimated coefficients jointly imply that a reduction in output tariffs of 10 percentage points lowers investment by 4.71 percent for a firm with the average mark-up (0.618), and it lowers investment by 6.57 percent for a firm with a mark-up that is one standard deviation above the mean (0.706=0.618+0.088). The coefficients on capital goods and input tariffs are very similar to the ones in the baseline specification (column (5) of Table 4, and are significant at the 5 and 10 percent levels, respectively.

Column (4) of Table 6 presents the estimates for investment in domestic capital goods, including

[21] The main effect and the interaction are jointly significant at the 1 percent level.

the interaction term between output tariffs and the firm's average mark-up. The results show that both the output tariff measure and the its interaction with the mark-up is highly significant. The positive coefficient on the interaction term suggest that firms with higher market power, i.e., a higher mark-up, will reduce investment in domestic capital more aggressively, as their market power will get eroded by foreign competition. The estimates of the main effect of output tariff and its interaction with the mark-up implies that a 10 percentage point reduction in the output tariff lowers investment investment in domestic capital goods by 3.24 percent at the sample mean.[22] At 5.86 percent, the effect is close to being twice as big for firms that have average mark-ups which are one standard deviation above the mean. Additionally, the negative coefficient on the main effect (-0.370) and the positive coefficient on the interaction term (0.726) suggest that only firms that average mark-ups higher than 0.51 lowers investment in domestic goods. Given that the value of the 10th percentile of the mark-up distribution in our sample is 0.529, more than 90 percent of the firms lowered investment in domestic capital goods due to the heightened competition the firms faced following the trade liberalization.

6.3 Heterogeneity in the Impact of Lower Tariffs

Lastly, we analyze the heterogeneity in the impact of lower tariffs on investment in imported and domestic capital goods. Building on the work of Melitz (2003), theoretical and empirical studies such as Bustos (2011) and Bas and Berthou (2013), have shown that faced with lower tariffs, firms will have an incentive to upgrade technology given the expanded export opportunities or the cheaper inputs. Both studies suggest that this incentive is not the same for all firms - it varies with productivity, and that only firms in the middle-range productivity are impacted by the changes in tariffs. Similar effects of the trade liberalization in India on firm-level investment are also likely to exist. For example, as capital goods or input tariffs fall, firms in the middle of the productivity distribution are most likely to experience the largest investment incentive due to the lower prices of imported capital goods and intermediate inputs. Lower tariffs can spur investment for these firms, which were likely on the margin in investing in imported or domestic capital goods. On the other hand, incentive of cheaper capital goods and imported intermediate goods might not

[22]The domestic capital goods investment rate, $\frac{I_{Dijt}}{K_{ijt-1}}$, is 0.243 at the mean.

be large enough for least efficient firms, for which the marginal profitability of capital would be quite low before and after the fall in tariffs. Similarly, the most productive establishments might not increase their investment by much because they had likely already achieved a high investment rate based on the high expected level of sales before the trade liberalization.

To empirically test for heterogeneity in the impact of India's trade liberalization on firm-level investment, we divide all firms into 4 groups - the four quartiles of the initial firm size distribution, where initial size is a proxy for initial productivity.[23] We then estimate the following expanded version of our baseline specification (15):

$$\frac{I_{ijt}}{K_{ijt-1}} = \alpha_1 \frac{I_{ijt-1}}{K_{ijt-2}} + \alpha_2 \frac{S_{ijt}}{K_{ijt-1}} + \alpha_3 \frac{S_{ijt-1}}{K_{ijt-2}} + \alpha_4 \frac{C_{ijt}}{K_{ijt-1}} + \alpha_5 \frac{C_{ijt-1}}{K_{ijt-2}} + \\ + \sum_{r=1}^{4} \gamma^r_{\tau^{KT}} (\tau^{KT}_{jt} \times Q^r_{ij}) + \sum_{r=1}^{4} \gamma^r_{\tau^{IT}} (\tau^{IT}_{jt} \times Q^r_{ij}) + \sum_{r=1}^{4} \gamma^r_{\tau^{OT}} (\tau^{OT}_{jt} \times Q^r_{ij}) + \upsilon_i + \eta_t + \varepsilon_{ijt}, \qquad (16)$$

where r indexes the four quartiles of the size distribution and Q_{ij} is the indicator variable equal to one when firm i belongs to quartile r.[24]

The estimates are presented in Table 7. In general, the results are consistent with expectations and imply that the impact of lower capital goods tariffs is the highest for the middle quartiles. For investment in imported capital goods, we find that the impact of the reduction of capital goods tariffs is largest for firms in the second quartile, and at -0.077 (0.026) it is more than twice the average impact of -0.033 (0.011) that we estimated for all firms in our baseline specification (15) (see Table 4). The estimate for the third quartile is also highly significant, and at -0.035 (0.016) it is close to the average impact in the full sample. The effects of lower input and output tariffs are less precisely estimated, and in the case of output tariffs, the coefficients imply that the impact increases with the size quartiles, suggesting larger firms might have faced more stiff foreign competition and lowered investment.

We find the largest impact of lower capital goods tariffs on investment in domestic capital goods

[23] We use initial firm-level (log) sales relative to the average as a measure of the firm's initial size. Bustos (2011), and Kandilov and Leblebicioglu (2012) use initial firm-level (log) employment relative to the 4-digit-industry average as a measure of the firm's initial size; whereas Bas and Berthou (2013) use initial TFP. Because we do not have number of employees in our data-set, we cannot use employment as a measure of firm size. The results look similar if we use initial total compensation as the measure of firm size.

[24] Note that we do not include the size indicator dummies in the regression as they categorize firms based on their initial size, which is time-invariant.

in the third quartile of the distribution. The estimate of -0.204 (0.110) is about 60 percent larger than the average impact of -0.121 (0.092) for all firms in our baseline specification (see Table 5). The estimate for the fourth quartile, -0.143 (0.084), is also significant at 10 percent. Similarly, we also find that the largest impact of lower output tariffs on investment in domestic capital goods was felt in the third quartile of the distribution. While the coefficients for the first and the seconds quartiles are negative and insignificant, at 0.169 (0.085), the one for the third quartile is more than twice the size of the coefficient (0.061, s.e.=0.042) for the full sample in Table Table 5. The estimate for the fourth quartile is also positive, albeit insignificant. As in the specifications with the mark-up interactions, these results suggest that larger firms were adversely affected by the reduction in output tariffs, due to increased foreign competition, and lowered investment also in domestic capital goods. These results also underscore the importance of controlling for heterogeneity in uncovering the impact of trade liberalization in domestic capital goods.

7 Conclusion

To be completed...

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Figure 1: Average Tariff Rates (In Percent)

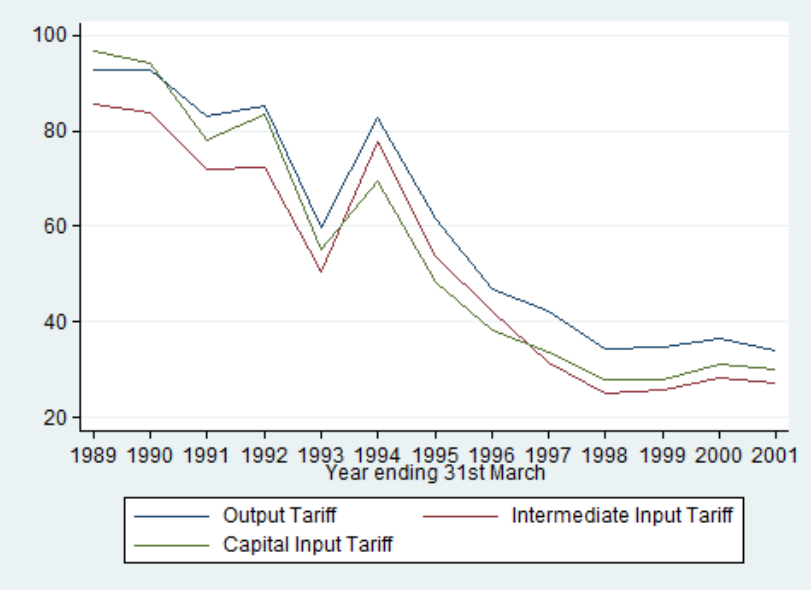

Figure 2: Standard Deviation of Tariffs

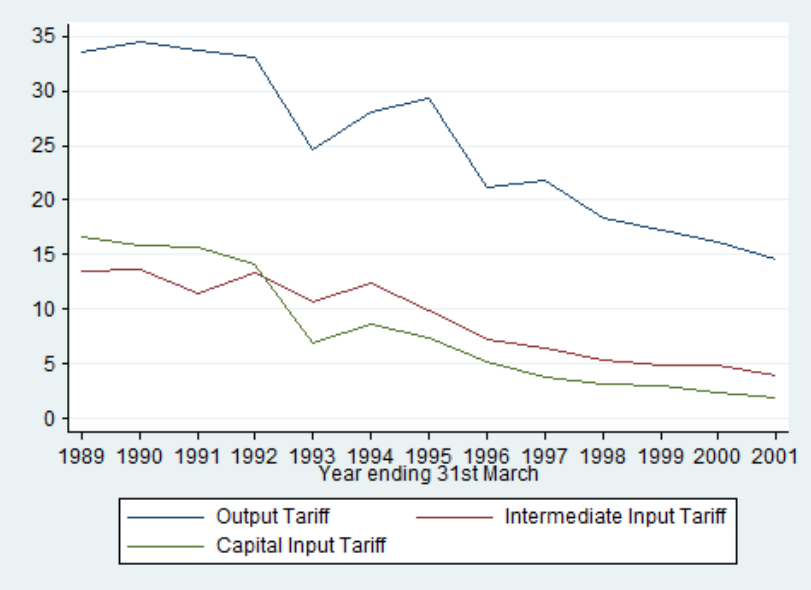

Table 1: Tariff Rates (By Industry)

	Output Tariff			Intermediate Input Tariff			Capital Input Tariff		
Industry	1990	1997	2001	1990	1997	2001	1990	1997	2001
Basic Metals	94	29	31	74	28	26	98	32	31
Beverages	155	127	97	83	37	32	100	32	32
Chemicals and Chemical Products	112	39	32	92	34	29	106	32	31
Coke and Petroleum Products	80	30	26	56	19	15	123	32	31
Computer, Electronic Products	111	32	22	92	34	30	99	39	29
Electrical Equipment	83	43	32	92	33	31	86	35	29
Fabricated metal Products	100	32	33	80	30	29	106	32	31
Food Products	85	35	34	73	31	29	93	31	29
Furniture	103	48	35	94	32	29	88	32	30
Leather Products	82	37	31	86	25	21	92	36	30
Machinery and Equipment	74	29	26	87	32	30	77	31	27
Motor Vehicles, Trailers	97	45	34	92	33	31	95	42	33
Non-Metallic Mineral Products	89	47	34	76	34	28	105	34	31
Other Transport Equipment	74	43	32	90	33	30	82	43	33
Paper Products	81	24	25	65	21	20	91	32	28
Pharmaceuticals	99	40	35	93	35	31	100	33	30
Recorded Media	58	20	19	68	20	19	90	34	30
Rubber and Plastic Products	108	45	34	118	35	29	109	33	31
Textiles	94	50	32	88	44	28	84	30	27
Tobacco Products	100	50	35	84	35	28	76	30	29
Wearing Apparel	100	50	35	93	46	30	78	31	28
Wood Products	65	32	35	72	24	23	96	33	30
Total	93	42	34	84	32	27	94	34	30

Table 2: Summary Statistics

Variable	Mean	St. Dev.	Min	Max
Investment in Domestic Capital Goods $\left(\frac{I_{Dijt}}{K_{ijt-1}}\right)$	0.243	0.669	0	22.62
Investment in Foreign Capital Goods $\left(\frac{I_{Fijt}}{K_{ijt-1}}\right)$	0.0361	0.187	0	10.05
Sales $\left(\frac{S_{ijt}}{K_{ijt-1}}\right)$	3.298	6.114	0.00419	409.9
Cash-Flow $\left(\frac{C_{ijt}}{K_{ijt-1}}\right)$	-0.248	0.869	-32.62	3.956
Average Imported Input Costs (Rs. Billion)	0.00123	0.00591	0	0.167
Share of Imported Intermediate Inputs	0.147	0.213	0	8.297
Average Markup (ψ_i)	0.618	0.0884	0	1.128
Output Tariff $\left(\frac{\tau^O_{jt}}{100}\right)$	0.594	0.244	0.0857	3.263
Intermediate Input Tariff $\left(\frac{\tau^I_{jt}}{100}\right)$	0.543	0.182	0.142	1.115
Capital Input Tariff $\left(\frac{\tau^K_{jt}}{100}\right)$	0.532	0.198	0.260	1.274
License	0.113	0.273	0	1
FDI	0.579	0.419	0	1

Notes: The number of observations is $9,486$ and the number of firms is $2,512$.

Table 3: Trade Policy Endogeneity: Current Trade Policy and Past Investment

	(1)	(2)	(3)
Dependent Variable	Output Tariff	Intermediate Input Tariff	Capital Input Tariff
Panel A			
Domestic Investment Rate	0.059	-0.001	0.237
	(0.225)	(0.142)	(0.143)
Observations	673	673	673
R-squared	0.814	0.903	0.945
Panel B			
Foreign Investment Rate	-0.775	-0.201	0.392
	(1.331)	(0.686)	(0.425)
Observations	673	673	673
R-squared	0.814	0.903	0.945

Notes: Panel A presents the regressions of current trade policy tool on lagged domestic investment rate. Panel B presents the panel regressions of current trade policy tool on lagged foreign investment rate. Estimations include controls for years and four-digit industry and are weighted by the number of firms in each four-digit industry in each particular year. Standard errors are robust and they are clustered at the four-digit industry level.

Table 4: Main Effects of Trade Liberalization on Investment in Imported Capital Goods

Dependent Variable: $\frac{I_{Mijt}}{K_{ijt-1}}$	(1)	(2)	(3)	(4)	(5)
Lagged dependent variable $\left(\frac{I_{Mijt-1}}{K_{ijt-2}}\right)$	0.087***	0.087***	0.087***	0.087***	0.087***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Sales $\left(\frac{S_{ijt}}{K_{ijt-1}}\right)$	0.003	0.003	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Lagged sales $\left(\frac{S_{ijt-1}}{K_{ijt-2}}\right)$	0.001*	0.001*	0.001*	0.001*	0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Cash-flow $\left(\frac{C_{ijt}}{K_{ijt-1}}\right)$	0.011	0.011	0.011	0.011	0.011
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Lagged cash-flow $\left(\frac{C_{ijt-1}}{K_{ijt-2}}\right)$	0.013	0.013	0.013	0.013	0.013
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Output tariff $\left(\frac{\tau^O_{jt}}{100}\right)$	0.006	0.008	0.012*	0.012*	0.014**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
Input tariff $\left(\frac{\tau^I_{jt}}{100}\right)$		-0.009	-0.008	-0.008	-0.018*
		(0.012)	(0.012)	(0.012)	(0.010)
Capital goods tariff $\left(\frac{\tau^K_{jt}}{100}\right)$			-0.040***	-0.040***	-0.033***
			(0.013)	(0.012)	(0.011)
License				-0.009***	-0.008**
				(0.003)	(0.003)
FDI				-0.004	-0.003
				(0.006)	(0.005)
Regional time trends	no	no	no	no	yes
Number of observations	9,486	9,486	9,486	9,486	9,486
Hansen-Sargan test (p-value)	0.641	0.628	0.645	0.648	0.594
1st order serial correlation test (p-value)	0.007	0.007	0.007	0.007	0.007
2nd order serial correlation test (p-value)	0.238	0.236	0.235	0.233	0.230

Notes: The estimates and standard errors are obtained from the two-step system GMM procedure with the Windmeijer (2005) small-sample correction. All firm-specific regressors are treated as endogenous. A set of year effects and industry-specific time trends are included in all specifications. Standard errors in parentheses. The p-values for the Hansen over-identification test and the second order serial correlation tests are reported. ***, **, * denote significance at the 1, 5, and 10% level, respectively. Lags 2 and 3 of the investment rate, sales and cash-flow are included as GMM-type instruments. All other industry-level variables are included as IV-type instruments.

Table 5: Main Effects of Trade Liberalization on Investment in Domestic Capital Goods

Dependent Variable: $\frac{I_{Dijt}}{K_{ijt-1}}$	(1)	(2)	(3)	(4)	(5)
Lagged dependent variable $\left(\frac{I_{Dijt-1}}{K_{ijt-2}}\right)$	0.032*	0.032*	0.032*	0.031*	0.036
	(0.017)	(0.017)	(0.017)	(0.017)	(0.023)
Sales $\left(\frac{S_{ijt}}{K_{ijt-1}}\right)$	0.018***	0.018***	0.018***	0.018***	0.020***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)
Lagged sales $\left(\frac{S_{ijt-1}}{K_{ijt-2}}\right)$	0.012	0.012	0.012	0.012	0.012**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.005)
Cash-flow $\left(\frac{C_{ijt}}{K_{ijt-1}}\right)$	-0.122	-0.121	-0.121	-0.120	-0.162
	(0.178)	(0.177)	(0.177)	(0.177)	(0.185)
Lagged cash-flow $\left(\frac{C_{ijt-1}}{K_{ijt-2}}\right)$	0.173	0.173	0.173	0.172	0.204
	(0.133)	(0.132)	(0.131)	(0.131)	(0.128)
Output tariff $\left(\frac{\tau^O_{jt}}{100}\right)$	0.047	0.037	0.043	0.043	0.061
	(0.040)	(0.038)	(0.041)	(0.041)	(0.042)
Input tariff $\left(\frac{\tau^I_{jt}}{100}\right)$		0.052	0.048	0.049	-0.010
		(0.085)	(0.084)	(0.084)	(0.091)
Capital goods tariff $\left(\frac{\tau^K_{jt}}{100}\right)$			-0.060	-0.057	-0.121
			(0.093)	(0.095)	(0.092)
License				0.012	0.008
				(0.021)	(0.022)
FDI				0.004	0.017
				(0.026)	(0.028)
Regional time trends	no	no	no	no	yes
Number of observations	9,486	9,486	9,486	9,486	9,486
Hansen-Sargan test (p-value)	0.124	0.125	0.128	0.125	0.106
1st order serial correlation test (p-value)	0.000	0.000	0.000	0.000	0.000
2nd order serial correlation test (p-value)	0.717	0.714	0.717	0.720	0.852

Notes: The estimates and standard errors are obtained from the two-step system GMM procedure with the Windmeijer (2005) small-sample correction. All firm-specific regressors are treated as endogenous. A set of year effects and industry-specific time trends are included in all specifications. Standard errors in parentheses. The p-values for the Hansen over-identification test and the second order serial correlation tests are reported. ***, **, * denote significance at the 1, 5, and 10% level, respectively. Lags 2 and 3 of the investment rate, sales and cash-flow are included as GMM-type instruments. All other industry-level variables are included as IV-type instruments.

Table 6: Imported Inputs and Mark-up Channels

Dependent variable:	$\frac{I_{Mijt}}{K_{ijt-1}}$		$\frac{I_{Dijt}}{K_{ijt-1}}$	
	(1)	(2)	(3)	(4)
Lagged dependent variable $\left(\frac{I_{Mijt-1}}{K_{ijt-2}}\right)$	0.087***	0.085***		
	(0.009)	(0.009)		
Lagged dependent variable $\left(\frac{I_{Dijt-1}}{K_{ijt-2}}\right)$			0.038*	0.034*
			(0.019)	(0.020)
Sales $\left(\frac{S_{ijt}}{K_{ijt-1}}\right)$	0.003	0.003	0.011	0.010
	(0.002)	(0.002)	(0.007)	(0.007)
Lagged sales $\left(\frac{S_{ijt-1}}{K_{ijt-2}}\right)$	0.001*	0.001	0.007	0.007
	(0.001)	(0.001)	(0.008)	(0.008)
Cash-flow $\left(\frac{C_{ijt}}{K_{ijt-1}}\right)$	0.009	0.009	-0.176	-0.173
	(0.018)	(0.019)	(0.187)	(0.200)
Lagged cash-flow $\left(\frac{C_{ijt-1}}{K_{ijt-2}}\right)$	0.013	0.012	0.158	0.150
	(0.008)	(0.008)	(0.125)	(0.133)
Share of imported intermediate inputs	0.093		0.043	
	(0.067)		(0.201)	
Output tariff $\left(\frac{\tau^O_{jt}}{100}\right)$	0.014**	-0.030	0.054	-0.370***
	(0.007)	(0.024)	(0.037)	(0.122)
Output tariff*mark-up $\left(\frac{\tau^O_{jt}}{100} * \psi_i\right)$		0.076**		0.726***
		(0.037)		(0.182)
Input tariff $\left(\frac{\tau^I_{jt}}{100}\right)$	-0.021**	-0.017	-0.012	-0.041
	(0.010)	(0.010)	(0.081)	(0.079)
Input tariff*Average Imported Input Costs $\left(\frac{\tau^I_{jt}}{100} * \frac{IM_i}{100}\right)$	-0.015		-0.085	
	(0.058)		(0.364)	
Capital goods tariff $\left(\frac{\tau^K_{jt}}{100}\right)$	-0.031**	-0.038***	-0.087	-0.102
	(0.012)	(0.011)	(0.090)	(0.099)
Capital goods tariff*Average Imported Input Costs $\left(\frac{\tau^K_{jt}}{100} * \frac{IM_i}{100}\right)$	-0.052		-0.075	
	(0.036)		(0.148)	
License	-0.009**	-0.008**	0.006	0.011
	(0.004)	(0.003)	(0.021)	(0.021)
FDI	-0.006	-0.003	0.016	0.015
	(0.005)	(0.005)	(0.026)	(0.023)
Number of observations	9,486	9,486	9,486	9,486
Hansen-Sargan test (p-value)	0.575	0.427	0.202	0.284
1st order serial correlation test (p-value)	0.007	0.007	0.000	0.000
2nd order serial correlation test (p-value)	0.219	0.231	0.957	0.997

Notes: The estimates and standard errors are obtained from the two-step system GMM procedure with the Windmeijer (2005) small-sample correction. All firm-specific regressors are treated as endogenous. A set of year effects, industry-specific and state-specific time trends are included in all specifications. Standard errors in parentheses. The p-values for the Hansen over-identification test and the second order serial correlation tests are reported. ***, **, * denote significance at the 1, 5, and 10% level, respectively. Lags 2 and 3 of the investment rate, sales and cash-flow are included as GMM-type instruments. All other industry-level variables are included as IV-type instruments.

Table 7: Heterogeneity of the impacts across size groups

	(1)	(2)
Dependent Variable:	$\frac{I_{Mijt}}{K_{ijt-1}}$	$\frac{I_{Dijt}}{K_{ijt-1}}$
Capital goods tariff– First quartile	-0.030	-0.019
	(0.037)	(0.222)
Capital goods tariff– Second quartile	-0.071***	-0.038
	(0.027)	(0.158)
Capital goods tariff– Third quartile	-0.039**	-0.193*
	(0.016)	(0.110)
Capital goods tariff– Fourth quartile	-0.023	-0.117
	(0.014)	(0.090)
Input tariff– First quartile	-0.022	0.209
	(0.035)	(0.217)
Input tariff– Second quartile	0.022	0.033
	(0.026)	(0.151)
Input tariff– Third quartile	-0.023	-0.037
	(0.017)	(0.104)
Input tariff– Fourth quartile	-0.035**	-0.010
	(0.015)	(0.107)
Output tariff– First quartile	0.010	-0.077
	(0.020)	(0.108)
Output tariff– Second quartile	0.007	-0.018
	(0.014)	(0.071)
Output tariff– Third quartile	0.018	0.174**
	(0.019)	(0.088)
Output tariff– Fourth quartile	0.022**	0.028
	(0.011)	(0.048)

Notes: The reported coefficients are the interaction terms between the corresponding tariff measure and the initial size dummy for the four quartiles. The initial size measure is constructed as the initial sales of the firm normalized by the total sales in the corresponding 4-digit industry,.