Does Trade Liberalization Trigger Technology Upgrading? : Evidence from Indian Manufacturing Plants

Abstract

This paper studies the impact of trade liberalization on plant level productivity in Indian manufacturing industries during the period from 1998 to 2007. To guide empirical work, I introduce a model that explains the decision of heterogeneous firms to export and to engage in R&D. This model assumes that incumbent exporters improve their productivity with a reduction of trade costs because of technology upgrading. To identify this process, I conduct comparative statics analysis on the average of exporters' productivity without a reallocation of production factors, and it shows that the average productivity increases with trade liberalization. An empirical test of the model reveals that the average total factor productivity of incumbent exporters increases when trade costs decrease. Their average productivity increases 8 to 12 percentage points for 1 percentage point decrease in export tariff. This result suggests that exporters try to upgrade their technology when their profit increases with a reduction of trade costs.

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Acknowledgment:

I am deeply grateful to Kazuhiro Yuki whose comments and suggestions were innumerably valuable throughout the course of my study. I would also like to thank Takahiro Sato and his students whose meticulous comments were an enormous help to me. Moreover, when we presented this paper on the joint seminar of RIEB of Kobe university and Wadhwani Foundation, titled "Growth, Employment and Productivity: Indian Experience," I get valuable comments from the participants, especially, from Bishwanath Goldar.

1. Introduction

Under globalization, many developing countries are being asked to liberalize trade. However, it is not clear how the productivity of firms is improved by trade liberalization. Meltiz (2003) gives an answer that aggregate industry productivity is improved because of a better reallocation of production factors. That is, trade liberalization reallocates market shares towards exporters, the most efficient firms, increasing aggregate productivity. This channel is confirmed by many recent trade literatures (Pavcnik, 2002; Bernard et al., 2003; Bernard et al., 2007; Tybout, 2003; Trefler, 2004). Adding to the channel, Bustos (2011) gives another possible answer that it is also caused by adoption of more advanced technologies. Trade liberalization, to say in other words, reduces trade costs such as tariff or transportation costs, and then exporters try to upgrade their technologies using the profit caused by reduction of trade costs. Her model allows that the most efficient exporters invest an additional fixed cost to adapt the more advanced technology reducing their marginal cost, while Melitz's model assumes that the firm's productivity never changes during one's life. Other recent research has provided evidence that export market entry may increase the return to other complementary investments such as technology adoption, as examined theoretically in Atkeson & Burstein (2010), Burstein & Melitz (2012), Constantini & Melitz (2008) and Yeaple (2005). There are other possible channels that trade reforms increase within-firm productivity. Intensifying competition may force firms to improve their efficiency by reducing average costs (Helpman & Krugman, 1985), force firms to focus on their core competency products or product innovation (Bernard, Redding & Schott, 2006), reduce managerial slack and generate x-efficiency gains (Hicks, 1935), or raise innovation incentives among domestic productive firms because of threat of foreign entrants (Aghion et al., 2005).

In this paper, I focus on the second channel: upgrading technology. I separate this channel from a reallocation of production factors. Therefore, using Bustos's model, I conduct comparative statics analysis on the average of exporters' productivity on the assumption that non-exporter cannot enter the export market. Without a reallocation of production factors, in other words, entry and exit of firms, trade liberalization increases incumbent exporters' productivity because of technology upgrading.

To test whether exporters improve their productivity without the reallocation empirically, I use the plant level balanced panel data in Indian manufacturing industries over the period from 1998-99 to 2007-08. In India, trade liberalization is undergoing from late 1980's. However, with the economic reform at 1991 as a start, trade liberalization step forward. Many studies focus on this economic reform. Early studies about the relationship between liberalization and productivity reach conflicting conclusions: Krishna and Mitra (1998) uses firm-level data in the manufacturing sector from 1986-93 and find some evidence of an increase in growth rate of productivity in the years following the reform at 1991, while Balakrishnan et al. (2000), using the similar data sets, do not. Sivadasan (2009) finds an increase in average productivity among industries that experience a large drop in final goods import tariffs, relative to those that do not. Topalova and Khandelwal (2011) and Harrison et al. (2013) find that trade liberalization, particularly the decline in input tariffs, increases productivity. Moreover, Topalova and Khandelwal (2011) show that the effect of trade liberalization is much larger for the non-export-oriented industries than export-oriented industries[1]. However, those results might be caused by combination of the effect of a reallocation and that of technology upgrading, and they don’t consider about export tariff, which exporter pay directory.

In the present paper, I focus on whether incumbent exporter’s productivity is increased by technology upgrading. Indian trade policy 1997-2002 and 2002-2007 also carried forward the process of liberalization and globalization set in motion by the process of economic reforms. The creation of World Trade Agreement (WTO), the globalization of the world economy has developed at rapid pace, and India has concluded many trade agreements with trade partners. I analyze the relationship between trade reforms and productivity over the period. Advantages of plant data is that it is possible to control for the geographic characteristics, while firm data can't, and that the import tariff of export destination from India is exogenously decided from Indian trade policy.

[1] They follow a classification of industries in India by export orientation provided by Nouroz (2001).

The empirical tests reveal that trade liberalization triggers off an increase of average incumbent exporters' productivity. Their average productivity increases 8 to 12 percentage points for 1 percentage point decrease in export tariff. The results suggest that there is a process that incumbent exporter increases their productivity. The results link with other recent empirical research studying the relationship between trade liberalization and technology upgrading. Bustos (2011) shows Argentinian exporter increases investments in technology with tariff reduction under the MERCOSUR trade agreement. Lileeva & Trefler (2010) and Aw et al. (2011) also shows exporters engage more productive innovation and increases their productivity in Canada and Taiwan, respectively. This paper analyses Indian economy that has experienced the largest tariff reduction in the world, and shows the similar result with those studies.

The paper is organized as follows. Section 2 describes the theoretical framework. Section 3 explains the history of the trade liberalization in India. The empirical methodology is discussed in Section 4. Section 5 discusses using data. Section 6 discusses the empirical estimation of the relationship between trade reforms and productivity, and Section 7 concludes.

2. Theory

In this part, I conduct comparative statics analysis on exporters' average productivity affected by a decrease of trade costs. I show that their average productivity increases without entry of non-export firms, relatively inefficient firms, into the export market when trade costs decrease, while it decreases taking into account the reallocation of production factors. Before the analysis, I explain Bustos's model briefly. In her model, technology upgrading is allowed whereas another setting is same as Melitz's.

A. Setup of the Model

This model assumes two symmetric countries, a single primary factor L, and a single Dixit-Stiglitz goods sector with differentiated varieties that consumers view as symmetric. The wage is the numeraire, and all aggregate variables are the same for both countries because of the symmetric assumption. Competition takes the form of Dixit-Stiglitz monopolistic competition among firms facing iceberg cost ($\tau > 1$). To enter the industry in a given country, firms pay a fixed cost consisting of f_e units of labor. Firms are assumed to be heterogeneous with respect to their marginal production cost $(1/\varphi)$ or productivity (φ). Entrants draw their productivity from a known Pareto cumulative distribution function $G(\varphi) = 1 - \varphi^{-k}$ with $k > 1$. The firm learns its productivity after it has paid the entry cost.

Selling a new variety in a domestic market also requires the firm to pay a fixed sunk cost consisting of f units of labor that reflects the cost of adapting the variety to market-specific standards, regulations and norms. To enter the export market, firms must pay an additional fixed cost consisting of f_x units of labor.

Firms can choose to upgrade their technology reducing their marginal cost of production by paying additional fixed costs. In this model, firm with technology l adapts technology h paying additional fixed costs. Technology l features a lower fixed cost f_l $(= f)$ and a higher marginal cost $(1/\varphi)$, while technology h a higher fixed cost $f_h(= \eta f)$ and a lower marginal cost $(1/\gamma\varphi)$, where $\eta > 1$ and $\gamma > 1$. In every period there is an exogenous probability of exit (δ).

The preferences of a representative consumer are given by a CES utility function over a continuum of goods indexed by ω with an elasticity of substitution $\sigma = \frac{1}{1-\rho} > 1$. These preferences generate a demand function $q(\omega) = EP^{1-\sigma}[p(\omega)]^{-\sigma}$, where $p(\omega)$ is the price of each variety, $P = \left[\int_0^M p(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}$ is the price index of the industry, M is the number of existing varieties, and E is aggregate expenditure in the country.

Under Dixit-Stiglitz competition, firms find it optimal to charge a constant profit margin, $1/\rho$. A firm with productivity φ using technology l charges the price $p_l^d(\varphi) = 1/(\rho\varphi)$ in the domestic market and higher price in the export market $p_l^x(\varphi) = \tau/(\rho\varphi)$, whereas A firm with productivity γφ using technology h charges the price $p_h^d(\varphi) = 1/(\rho\varphi\gamma)$ in the domestic market and $p_h^x(\varphi) = \tau/(\rho\varphi\gamma)$ in the export market.

Profits of each firms, which use technology l or h, and exports or not, are expressed as following equations.

Profits if only serving the domestic market and using technology l is

$$\pi_l^d(\varphi) = = \frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1} - f \qquad (1).$$

Profits if serving the domestic and exporting markets, and using technology *l* is

$$\pi_l^x(\varphi) = [1+\tau^{1-\sigma}]\frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1} - f - f_x \qquad (2).$$

Profits if serving the domestic and exporting markets, and using technology *h* is

$$\pi_h^x(\varphi) = [1+\tau^{1-\sigma}]\frac{1}{\sigma}E(P\rho)^{\sigma-1}\varphi^{\sigma-1}\gamma^{\sigma-1} - \eta f - f_x \qquad (3).$$

Note that using technology *h* and serving only the domestic market is always dominated by some other choice.

B. Productivity Cutoff Points

Define the exit productivity cutoff, the productivity cutoff for exporting and the productivity cutoff for adopting technology h as $\varphi^*, \varphi_x,$ and φ_h, respectively. Note that there is a range of productivity levels where exporting is profitable but adopting technology h is not, so that the marginal exporter uses technology *l*, in other wards, $\varphi_x < \varphi_h$. Those cutoffs are obtained using the zero profit condition ($\pi_l^d(\varphi^*) = 0$), the indifference condition for exporting ($\pi_l^d(\varphi_x) = \pi_l^x(\varphi_x)$), the indifference condition for adopting technology h ($\pi_l^x(\varphi_h) = \pi_h^x(\varphi_h)$) and the free entry condition.

The equilibrium price (*p*), number of firms (*M*) and the distribution of active firms' productivities in the economy are determined by the free entry condition. Free entry requires that the sunk entry cost equals the present value of expected profits:

$$f_e = [1 - G(\varphi^*)]\frac{1}{\delta}\bar{\pi} \qquad (4),$$

where $1 - G(\varphi^*)$ is the probability of engaging in production, δ is an exogenous probability of exit and $\bar{\pi}$ are per-period expected profits[2]. The result of calculation of $\bar{\pi}$ is as follows,

$$\bar{\pi} = \frac{\sigma-1}{k-\sigma-1} f\Delta,$$

where $\Delta = 1 + \left(\tau^{\sigma-1}\left(\frac{f_x}{f}\right)\right)^{\frac{-k}{\sigma-1}}\left(\frac{f_x}{f}\right) + \left(\frac{\eta-1}{(1+\tau^{1-\sigma})(\gamma^{\sigma-1}-1)}\right)^{\frac{-k}{\sigma-1}}(\eta-1) \qquad (5).$

Now we can solve for the exit cutoff using the zero profit condition and the free entry condition, as

[2] See Bustos (2011) online appendix A.2, for the calculation of $\bar{\pi}$.

$$\varphi^* = \left(\frac{\sigma-1}{k-\sigma+1}\frac{f}{\delta f_e}\Delta\right)^{\frac{1}{k}} \qquad (6).$$

Substituting this to the indifference condition for exporting, the indifference condition for adopting technology h, we get φ_x and φ_h:

$$\varphi_x = \left(\frac{\sigma-1}{k-\sigma+1}\frac{f}{\delta f_e}\Delta\right)^{\frac{1}{k}} \tau \left(\frac{f_x}{f}\right)^{\frac{1}{\sigma-1}} \qquad (7)$$

$$\varphi_h = \left(\frac{\sigma-1}{k-\sigma+1}\frac{f}{\delta f_e}\Delta\right)^{\frac{1}{k}} \frac{1}{(1+\tau^{1-\sigma})^{\frac{1}{\sigma-1}}} \left(\frac{\eta-1}{\gamma^{\sigma-1}-1}\right)^{\frac{1}{\sigma-1}} \qquad (8).$$

This model shows trade liberalization or reduction of trade costs τ causes the following results[3]:

1. *The fraction of serving firms that export, and the fraction of serving of firms that use technology h increase.*
2. *Expected profits increases.*
3. *The exit productivity cutoff increase, that is,* $\frac{\partial\varphi^*}{\partial\tau} < 0$.
4. *The productivity cutoff for exporting decreases, that is,* $\frac{\partial\varphi_x}{\partial\tau} > 0$.
5. *The productivity cutoff for adopting technology h decreases, that is,* $\frac{\partial\varphi_h}{\partial\tau} > 0$.

C. Comparative Statics Analysis of Average Exporters' Productivity

On the purpose of identifying effects of upgrading technology on the productivity of exporters, I conduct comparative statics analysis on their aggregate productivity affected by trade liberalization.

Weighted average productivity of the exporting firms $(\bar{\varphi}_x)$ is represented as following equations,

$$\bar{\varphi}_x \equiv \left[\int_{\varphi_x}^{\varphi_h} \varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_x)}d\varphi + \int_{\varphi_h}^{\infty} \gamma^{\sigma-1}\varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_x)}d\varphi\right]^{\frac{1}{\sigma-1}}$$

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3 See Bustos (2011) online appendix B, for the detailed calculation of the result 3 to 5.

$$= \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \times \varphi_x \times \left\{1-(1-\gamma^{\sigma-1})(\left\{\frac{\tau^{1-\sigma}}{(1+\tau^{1-\sigma})}\frac{\frac{\eta-1}{\gamma^{\sigma-1}-1}}{\frac{f_x}{f}}\right\}^{\frac{1}{\sigma-1}})^{\sigma-k-1}\right\}^{\frac{1}{\sigma-1}} \quad (9).$$

Take the derivative of exporter's average productivity, $\bar{\varphi}_x$, with respect to τ:

$$\frac{\partial\bar{\varphi}_x}{\partial\tau} > 0 \quad (10).$$

Trade liberalization trigger off a decrease of weighted average productivity of the exporting firms. The detailed calculation of this is expressed in Appendix A.1. This process includes the two effects; entry of relatively higher productivity non-exporting firms to the export market, and upgrading technologies of exporting firms. The first effect has positive impact on exporters' average productivity but the second has negative. The result indices first effect dominates second effect, decreasing weighted average productivity of the exporting firms with a tariff reduction.

Melitz's model is assumed as a special case of Bustos's: $\gamma = \eta = 1$. The average productivity of exporters in Melitz's is

$$\bar{\varphi}_{x,Melitz} = \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \times \varphi_x \qquad (11).$$

The derivative of exporter's average productivity, $\bar{\varphi}_{x,Melitz}$, with respect to τ is also positive, $\frac{\partial\bar{\varphi}_{x,Melitz}}{\partial\tau} > 0$. While this result is same as Bustos's model, this process includes only the effect of the reallocation of production factors.

Next, I conduct comparative statics analysis on exporters' aggregate productivity without a reallocation of production factors. For this, I assume the productivity cutoff for exporting is fixed and it is expressed as $\varphi_{x,fixed}$. The result is as follows,

$$\frac{\partial\bar{\varphi}_x}{\partial\tau} = -(1-\gamma^{\sigma-1})(\sigma-k-1)\left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \times \varphi_{x,fixed} \times \left\{1-(1-\gamma^{\sigma-1})(\frac{\varphi_h}{\varphi_{x,fixed}})^{\sigma-k-1}\right\}^{\frac{1}{\sigma-1}-1} \times (\varphi_h)' < 0$$

(12).

Without a reallocation of production factors, in other words, entry and exit of firms, trade liberalization has a positive effect on exporters' productivity because of technology upgrading, while Melitz's model predicts their productivity never change.

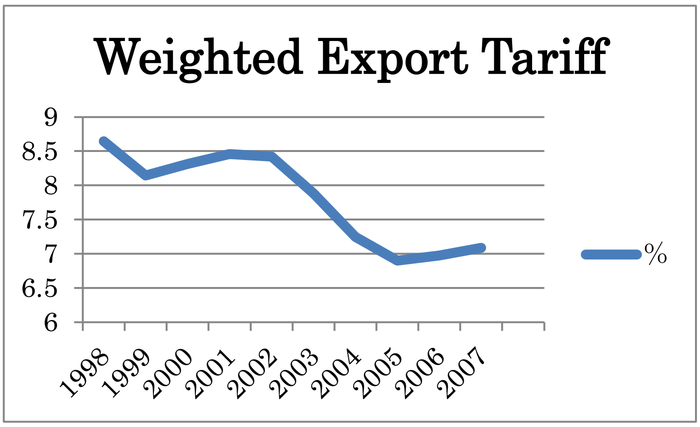
To test whether exporters improve their productivity without the reallocation empirically, I analyses the relationship between productivity and trade reforms using

Indian manufacturing balanced plant data without exit and entry of firms. Before those analyses, it is useful to know the history of Indian trade liberalization. Section 3 explains the history briefly.

3. Indian trade liberalization

Since the creation of World Trade Agreement (WTO), the globalization of the world economy has developed at rapid pace. India's top 10 export partners includes the U.S.A, United Arab Emirates, China, Singapore, the U.K., Hong Kong, Netherland, Germany, Belgium, and Italy at 2007. All of them are the members of WTO, while China assessed at 2001. Moreover, India has concluded many trade agreements with trade partners. In 2000's, India concluded the bilateral trade agreements with Sri Lanka, Afghanistan, Chile, Singapore, Nepal, Korea, Bhutan and Bangladesh. In recent years, India concluded CEPA with Malaysia and Japan at 2011. India also concluded the multilateral trade agreement with ASEAN, MERCOSUR, SAFTA, BIMSTEC and APTA. Some bilateral or multilateral trade agreements are still under negotiation. Under such circumstances, the export tariffs which India face has been decreasing. Figure 3.1 shows the decreasing trend.

Figure 3.1 Weighted Export Tariff



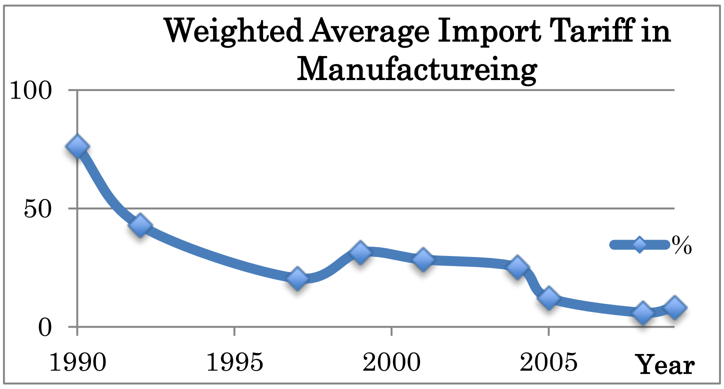
Source: Author's Calculation

Before 1991, trade policy was characterized by high tariffs and pervasive import restrictions. However, in the aftermath of a balanced-of-payments crisis, India launched the dramatic economic reform as a part of an IMF adjustment program. The IMF support was conditional on macroeconomic stabilization policies and structural reforms, and trade policy was an important component of these reforms. Under the export-import policy 1992-1997, the average tariffs fell from more than 87% in 1990 to 39% by 1996. Nontariff barriers (NTBs) were reduced from 87% in 1987 to 45% in 1994 (Topalova and Khandelwal, 2011). In the 1991 reform, most of quantitative restrictions on import of capital goods and intermediate inputs were removed. Figure 3.1 shows a weighted average tariff in manufacturing decreased from 1991 to 1997.

The export-import policy 1997-2002 did not carry forward tariff reduction, while this policy has further simplified the procedures and reduced the interface between exporters and the Director General of foreign Trade (DGFT) by reducing the number of documents required for export by half. Under the this policy, quantitative restrictions on imports of manufactured consumer goods and agricultural products were finally removed on April 1, 2001. However, the average tariff rate increased in the period because of the imposition on those items in anticipation of the removal of quantitative restrictions. In February 2002, the government signaled a return to reducing tariff protection. The peak duty rate was reduced to 30 percent, a number of duty rates at the higher end of the existing structure were lowered, while many low-end duties were raised to 5 percent. (Ahluwalia, 2002)

The subsequent policy, the export-import policy 2002-2007, was on the line of trade liberalization. Previous 5 years, tariff rate did not apparently decline. Therefore, government tried to decline the peak rate dramatically. While, the policy was modified in 2004 with the change in government and was incorporated into the new five years export-import policy for the period 2004-09, the trend for decreasing tariff didn't change. Figure 3.2 shows a weighted average tariff in manufacturing is decreasing at the period, while that is slightly changed in the previous 5 years.

Figure 3.2 Weighted Average Tariff in Manufacturing



Source: UNCTAD TRAINS database.

4. Methodology

I use Total Factor Productivity (TFP) as plant's productivity, and explain how TFP is measured, in this section. Then an empirical strategy for identifying the impact of tariff liberalization on exporters' average productivity is explained.

A. *Measuring TFP*

I first construct measures of plant-level TFP following the methodology of Levinsohn and Petrin (2003). Capital and labor are generally chosen by the firm, and the unobserved productivity, say ω_{it}, will affect the input choices. Ollay and Pakes (1996) solve this endogeneity using a plant's investment as a proxy for the unobservable productivity shocks to correct for the simultaneity in the plant's production function. The inclusion of a proxy that controls for the part of the error correlated with inputs ensures that the variation in inputs related to the productivity term will be eliminated. Since monotonicity of the investment equation allows us to invert this to recover ω_{it}, it would not be monotonic with zero investment levels. Therefore Levinsohn and Petrin (2003) use a plant's raw material inputs as a proxy.

According to Petrin and Levinsohn (2004), assuming a Cobb-Douglas production function, the estimating equation is,

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \eta_{it} \quad (13),$$

where y_{it} is the log of value added of plant i at time t; k_{it} is the log of plant's capital stock; and l_{it} are the logs of labor, respectively. While η_{it} is an error term that is uncorrelated with input choice, the simultaneity problem arises from the

ω_{it} term, a plant-specific, time-varying productivity shock that cannot be observed by the econometrician but may be correlated with the firm's choice of variable inputs: *m* and *k*. It assumes that given k_{it}, the firm decides on l_{it} and then, given l_{it}, determines the intermediate input m_{it}. Assuming the intermediate input *m* is monotonic in the plant's productivity for all relevant levels of capital and $m_{it} = m_{it}(\omega_{it}, k_{it})$, we rewrite ω_{it} term as $\omega_{it} = \omega_{it}(m_{it}, k_{it})$. Then we rewrite equation (13) as

$$y_{it} = \beta_l l_{it} + \phi_{it}(m_{it}, k_{it}) + \eta_{it} \qquad (14),$$

where $\phi_{it}(m_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \omega_{it}(m_{it}, k_{it})$. Substituting a third-order polynomial approximation in k_{it} and m_{it} in place of ϕ_{it}, estimate β_l using OLS. For any candidate value β_k^*, I compute a prediction for ω_{it}: $\widehat{\omega}_{it} = \widehat{\phi}_{it} - \beta_k^* k_{it}$. Using these values, a consistent approximation to $E[\omega_{it}|\omega_{it-1}]$ is given by the predicted values from the regression:

$$\widehat{\omega}_{it} = \gamma_0 + \gamma_1\omega_{it-1} + \gamma_2\omega_{it-1}^2 + \gamma_3\omega_{it-1}^3 + \epsilon_{it} \quad (15),$$

which LP call $E\left[\widehat{\omega_{it}|\omega_{it-1}}\right]$.

The estimate of β_k is defined as a solution to the minimization of

$$min_{\beta_k^*} \sum_t (y_{it} - \beta_l l_{it} - \beta_k^* k_{it} - E\left[\widehat{\omega_{it}|\omega_{it-1}}\right])^2 \quad (16).$$

Bootstrap approach is used to construct standard errors for the estimates $\beta_l$and β_k.

As the result of this approach, a plant's TFP is obtained. Using this TFP, I examine how trade liberalization, a decrease of trade costs affects on the incumbent exporter's TFP.

B. Empirical Strategy

To identify the impact of tariff liberalization on incumbent exporters' productivity, I estimate following equation:

$$\begin{aligned}\ln tfp_{ijt} = {} & \alpha + \alpha_i + \alpha_t + \beta(Export\ tariff_t \times ExporterD_{ijt}) + \gamma Output\ tariff_{jt} \\ & + \delta ImporterD_{ijt} + \eta Input\ tariff_{jt} + \lambda(Input\ tariff_{jt} \times ImporterD_{ijt}) \\ & + X_{ijt}\theta + \varepsilon_{ijt} \qquad (17),\end{aligned}$$

where $\ln tfp_{ijt}$ is log of total factor productivity of factory i in industry *j* at time *t*, $tariff_{jt}$ is at valorem tariff, $ExporterD_{ijt}$ and $ImporterD_{ijt}$ are the exporter and importer dummy which is 1 if a factory is exporter and X_{ijt} is a vector of factory characteristics including ownership categories(private stand-alone, private group and government owned), size categories[4], State and Industry dummies. The model predicts that exporters increase their productivity along with the reduction of export tariff. I would therefore expect $\beta < 0$. According to Amiti & Knonigs (2007), input and output tariffs, in other words, intermediate and final good imported tariffs increase firm's productivity. In Indian context, Topalova and Khandelwal (2011) and Harrison et al. (2011) find that the decline in input tariffs increase productivity rather than the decline in output tariffs. The interaction term between input tariff and importer dummy reflects the direct effect of the decline of input tariff on importers' productivity. A negative and significant coefficient on the interaction term, λ, would imply that importers do reap higher benefits from lower input tariffs than non-importers. I hypothesize that δ is positive, indicating that imported inputs generate some kind of technological externality. Note that I exclude exporter dummy because of the limitation of data that the status of exporter does not change during the period.

5. Data

A. Data

Plant Information

I use plant level panel data for Indian manufacturing during the period from 1998-99 to 2007-08. The unit level information comes from the Annual Survey of Industries (ASI) data, undertaken by the Central Statistical Organization (CSO), which is the annual census-cum-sample survey of all the formal manufacturing factories for all the industries across all the states. The ASI data cover two sets of surveys: census and sample. The census survey, which captures all enterprises, includes those enterprises, which hire more than 200 workers, and sample survey includes the enterprises, which hire less than 200 workers[5]. Enterprises in sample survey are selected by stratified

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[4] According to Topalova and Khandelwal (2011), the firm size categories are small if average sales over the sample are less than the median, medium if sales are larger than median but less than the 99th percentile, and large if sales exceed the 99th percentile.

[5] The threshold is changed from 200 workers to 100 workers in 2000. However I use the

multi-stage sampling and then this survey sampled the one third of the enterprises listed. The units in the census sector are approached for data collection on a complete enumeration basis every year. Using the data from the census sector, I use a balanced panel of enterprises, which the set of enterprises whose information is available for all years, for estimation purposes. The data set contains information about 665 individual manufacturing enterprises.

Unfortunately, the data from ASI for the period 1998-99 and 2007-08 does not contain the information about exports. Therefore, I tried to match the cross section ASI data in 1997-98, which contains the information about factory's exporting revenue, to the panel data. Since there is, however, no identical factory ID in the data at 1997-98, I identify the same factory contained in the data at 1997-98 and on or after 1998-99 matching the following variables: state, type of ownership, type of organization, rural or urban, and net fixed asset. In theory, the end of the net fixed asset of last financial year must coincide with the beginning of the net fixed asset of this financial year. There is the deviation of those around 30% on average even within the panel set. Therefore I presume that the factory of 1997-98 and on or after 1998-99 are same if the deviation is less than 30% and the other time invariant variables are same. Fortunately, there is about 2% deviation on average in the balanced panel set. The balanced data set contains information about 170 individual manufacturing enterprises with the information about exports.

Export tariff

I construct a database of annual Indian's export tariff data for 1998 to 2007 based on World Integrated Trade Solution (WITS) data, and Import and Export data from Ministry of Commerce and Industry. The export tariff for year t is constructed as

$$export\ tariff_t = \sum_j \alpha_{jt} \cdot import\ tariff_{jt},$$

where α is country j's share of the amount of export value from India and $import\ tariff$ is country j's average Most Favored Nation (MFN) import tariff at year t. The number of countries to calculate the export tariff is 142. Figure 3.1 shows

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previous threshold because of making balanced panel data.

that average export tariff fells from more than 8.6% at the point 1998 to 7.1% at the point 2007. The tariff rate is measured as percentage.

Import tariff

I construct a database of annual final goods tariff, output tariff data from 1998 to 2007 at the four-digit level of National Industrial Classification (NIC) Code based on WITS. Missing year, 1998 is filled in simply by using the data for previous year. Tariff data for India are drawn at the four-digit of the Harmonized System classification, which are converted to International Standard Industrial Classification of All Economic Activities (ISIC) Revision 3 by using the appropriate concordance table available from WITS. NIC 98[6] at four-digit level has the one to one correspondence with ISIC Rev 3 at four-digit level. The tariff rate is measured as percentage. The intermediate tariff, input tariff for industry j is constructed as

$$input\ tariff_{jt} = \sum_s \alpha_{st} \cdot output\ tariff_{st},$$

where α is the share of input s in the value of output j.

B. Descriptive Statistics

Table 5.1 shows the descriptive statistics of main variables. I use deflated value added as output, deflated fixed asset as capital, and total man-days employed as labor. From this table, it is evident that the value added of plant is, on average, Rs. 443 million. Moreover, fixed asset of firm is on average Rs. 869 million. Average number of employees of firm is about 260, 000 man days. The range of export tariff is from 6.9% to 8.6%. The range of output tariff is much larger than that of input tariff. Former is from 0% to 260%, and the average of output tariff is 28.2%. Latter is from 6.2% to 30.2%, and the average of input tariff is 16.9%. The ratios of exporter and importer are 46% and 54%, respectively. Most of plants are owned as private alone. The size category is determined as the definition. The plant's years in operation are on average 29 years.

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[6] This is the version of NIC in 1998.

Table 5.1 Descriptive statistics of main variables

Variables		NOB	Mean	SD	Minimum	Maximum
Real Value Added	(milion Rs.)	1675	443	1,420	11,507	23,500
Real Fixed Asset	(milion Rs.)	1697	869	4,430	583	90,500
Man-days employed	(mandays)	1695	262,634	762,718	26	11,800,000
Real Computer Investment	(milion Rs.)	1640	492	3,987	0	83,772
Export tariff	(%)	1700	7.81	0.65	6.90	8.64
Output tariff	(%)	1640	28.20	18.74	0.00	260.00
Input tariff	(%)	1696	16.91	5.34	6.21	30.15
ExportD	(Indicater)	1700	0.46	0.50	0	1
ImportD	(Indicater)	1700	0.54	0.50	0	1
Private Alone	(Indicater)	1700	0.97	0.17	0	1
Private joint	(Indicater)	1700	0.01	0.11	0	1
Government owned	(Indicater)	1700	0.02	0.13	0	1
Medium	(Indicater)	1700	0.48	0.50	0	1
Small	(Indicater)	1700	0.51	0.50	0	1
Large	(Indicater)	1700	0.02	0.13	0	1
Age	(Year)	1700	29	17	2	112
Age sq	(Year sq)	1700	1,118	1,425	4	12,544

Source: Author's Calculation

6. Results

I estimate TFP following Lavinson and Petrin (2003) method. Table 6.1 shows the estimated output elasticity of capital or labor. I assume the production function is the constant return to scale since the estimation fail to reject $\mathrm{l} + \mathrm{k} = 1$, statically.

Table6.1: Output elasticity	
l	0.562*** (0.066)
k	0.353*** (0.114)
Observations	1672
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *Source: Author's Calculation*	

I confirm the results of Bernard and Jensen (1999) that exporters are more efficient and larger in the sense of employment, and pay higher wages. For confirmation, I estimate following equation at the year 1998-99,

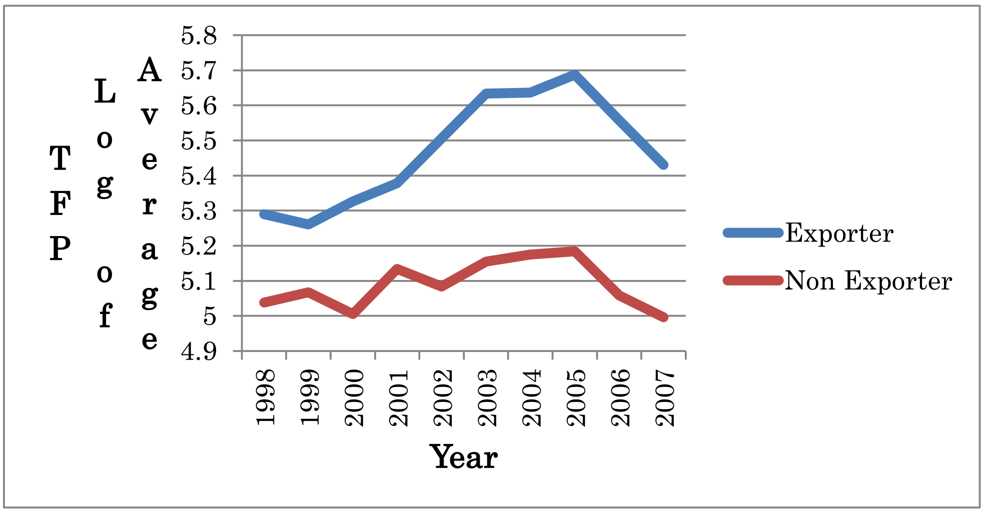
$$v_{ij,1998} = \alpha + \gamma Export_{ij,1998} + \varepsilon_{ij,1998} \qquad (18),$$

where v_{ijt} is log TFP, log employment, or log labor cost of factory i in industry j at time t, $Export_{ijt}$ is the export dummy which is 1 if a factory is exporter. Table 6.2 shows the result of those estimations. This indicates that exporters are more efficient, larger in the sense of employment, and pay higher wages initially. Therefore I confirm that the self-selection hypothesis is appropriate in India.

Table 6.2: Characteristics of exporters			
Dependent	Log of TFP	Log of Employment	Log of Wage
Export-dummy	0.252** (0.120)	0.856*** (0.209)	1.445*** (0.267)
Constant	5.038*** (0.082)	11.346*** (0.140)	16.941*** (0.183)
Observations	164	169	169
R-squared	0.020	0.089	0.144
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *Source: Author's Calculation*			

I compare average TFP growth between exporters and non-exporters at the period from 1998-99 to 2007-08. Figure 6.1 indicates that exporters dominate non-exporters in every year. Moreover, former's growth of average TFP is different from latters after 2001-02. In this period, the export and import tariffs decreased drastically. Therefore this result suggests that tariff reduction have different impact between average TFP growth of exporters and that of non-exporters.

Figure 6.1: Comparison of log of TFP between exporters and non-exporters



Source: Author's Calculation

The results from estimating equation (17) for the period 1998-99 to 2007-08 are presented in Table 6.3. Column 1 indicates that exporter is reactive to export tariff reduction. Exporters' average TFP increases 11 percentage points for 1 percentage point decrease in export tariff. The regression in column 2 includes the import tariff on final goods, output tariff. The results are same as column 1, qualitatively. Column 3 includes the import tariff on intermediate goods, input tariff and importer dummy, then column 4 includes the interaction term with input tariff and importer dummy. Those results suggest that, in addition to the exporter's productivity growth along with the reduction of export tariff, the importer improvers their productivity along with the reduction of input tariff. This result is consistent with Topalova and Khandelwal (2011). In column 5, the some control variables, ownership categories, size categories, state and industry dummies, are included. This result indicates that export and importer's productivity increase along with the reduction of export and input tariff, respectively. In addition that, bigger factory is more productive than smaller.

Those results are coincident with the prediction of Bustos's model. Then those suggest that trade liberalization would induce incumbent exporters to upgrade their technology.

Table6.3 The impact of trade liberalization on productivity

	(1)	(2)	(3)	(4)	(5)
Export tariff × ExportD	−0.115***	−0.125***	−0.122***	−0.0795**	−0.0801**
	(0.034)	(0.036)	(0.036)	(0.038)	(0.037)
Output tariff		−0.0006	−0.00001	−0.0002	0.0001
		(0.00181)	(0.00184)	(0.00184)	(0.00155)
Input tariff			−0.011	0.004	0.011
			(0.009)	(0.010)	(0.011)
ImportD			0.0895*	0.372***	0.234**
			(0.047)	(0.098)	(0.095)
Input tariff × ImportD				−0.0173***	−0.0112**
				(0.005)	(0.005)
Private joint					0.621
					(0.434)
Government owned					−0.084
					(0.389)
Medium					−0.842***
					(0.125)
Small					−1.374***
					(0.135)
Age					0.003
					(0.006)
Age sq					−0.0001
					(0.0001)
Factory FE	YES	YES	YES	YES	
Year FE	YES	YES	YES	YES	YES
State FE					YES
Industry FE					YES
Constant	5.588***	5.653***	5.776***	5.367***	6.210***
	(0.144)	(0.153)	(0.213)	(0.245)	(0.652)
Observations	1,672	1,612	1,608	1,608	1,608
R-squared	0.068	0.068	0.069	0.076	0.153
Number of panelid	170	164	164	164	164

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Authors' Calculation

7. Robustness check

Computer investment

The growth of TFP may not directly reflect the technology upgrading. See Foster et al. (2008), Hsieh and Klenow (2009), and Bernard et al. (2010). Therefore I also use the computer investment as a proxy of technology, and estimate equation (17) using computer investment as the dependent variable instead of TFP. Table 7.1 shows the results. It suggests that tariff reduction leads to increase computer investment of exporters in any specification. In other wards, exporters upgrade their technology along with export tariff reduction. However, while in column (4) importers invest for computer than non-importer and increase the volume along with the input tariff reduction, in column (3) and (5) those situations are not observed statically. Moreover, private joint plants invest for computer than private alone plants.

Coefficient of Variation of TFP

Bustos's model predicts that the exporting plant with relatively low productivity try to invest and adapt high technology along with tariff reduction. This mechanism suggests that tariff reduction leads to shrink the coefficient of variation of TFP within exporters. Figure 7.1 shows the change of the coefficient of variation of TFP within exporters. The change is consistent with the change of export tariff (see Figure 3.1).

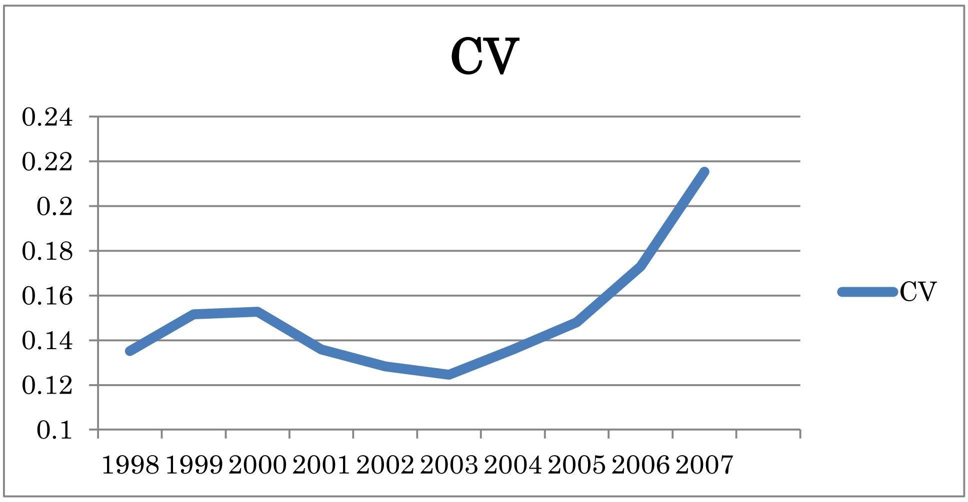
Table 7.1 The impact of trade liberalization on computer investment

	(1)	(2)	(3)	(4)	(5)
Export tariff × ExportD	−771.9***	−791.6***	−806.4***	−630.2***	−658.4***
	(211.4)	(220.7)	(222.8)	(236.4)	(237.6)
Output tariff		−8.284	−8.922	−9.672	−3.029
		(11.26)	(11.54)	(11.53)	(7.11)
Input tariff			10.39	72.02	65.95
			(58.38)	(64.69)	(64.98)
ImportD			108.60	1,281**	901.10
			(291.30)	(607.40)	(581.00)
Input tariff × ImportD				−71.89**	−41.73
				(32.69)	(31.75)
Private joint					15,729***
					(1281.00)
Government owned					476.30
					(1128.00)
Medium					−7,290***
					(742.40)
Small					−7,320***
					(782.70)
Age					5.00
					(23.54)
Age sq					−0.114
					(0.28)
Factory FE	YES	YES	YES	YES	
Year FE	YES	YES	YES	YES	YES
State FE					YES
Industry FE					YES
Constant	3,108***	3,423***	3,229**	1,528	6,473***
	(876.4)	(941.9)	(1318.0)	(1526.0)	(2366.0)
Observations	1,697	1,637	1,633	1,633	1,633
R-squared	0.026	0.028	0.028	0.031	0.045
Number of panelid	170	164	164	164	164

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Calculation

Figure 7.1 The Coefficient of Variation of TFP



8. Conclusion

In this paper, I conduct comparative statics analysis on the average of exporters' productivity on the basis of Bustos's model. As a result, without a reallocation of production factors, in other words, entry of non-export firms, relatively inefficient firms, into the export market, trade liberalization has a positive effect on exporters' productivity because of technology upgrading.

An empirical test of this prediction using the balanced plant level panel data in India over the period from 1998-99 to 2007-08 reveals that trade liberalization trigger off a increase of average incumbent exporters' productivity and the computer investment. It suggests that incumbent exporters engage more productive innovation and increases their productivity along with reduction of export tariff. This process is consistent with the theoretical assumption. Other possibility is increases in productivity after firms enter the export market (Van Biesebroeck, 2005 and De Loecker, 2007), while the data couldn't identify when firm enter the export market. Moreover, raising innovation incentives among domestic productive firms caused by threat of foreign entrants may explain the situation (Aghion et al., 2005).

Note that the limitation of data is the status of exporter does not change during the period I examine because only initial year data contains that information. Moreover, for identifying the same factory contained in the data at 1997-98 and on or after 1998-99, while I allow 30% deviation of fixed assets, this method is suffered from sample selection bias because I may choose only the plant with a good accounting system, and drop some samples whose has the insufficient system. Therefore, as a future subject, I would use other methods for matching, for example propensity score matching. Other future subject is to construct the export tariff at industry level.

Appendix

A.1

Weighted average productivity of the exporting firms $(\bar{\varphi}_x)$ is represented as following equations,

$$\bar{\varphi}_x \equiv \left[\int_{\varphi_x}^{\varphi_h} \varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_x)}d\varphi + \int_{\varphi_h}^{\infty}\gamma^{\sigma-1}\varphi^{\sigma-1}\frac{g(\varphi)}{1-G(\varphi_x)}d\varphi\right]^{\frac{1}{\sigma-1}}$$

$$= \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \times (\varphi_x)^{\frac{k}{\sigma-1}} \times \left\{(\varphi_x)^{\sigma-k-1} - (1-\gamma^{\sigma-1})(\varphi_h)^{\sigma-k-1}\right\}^{\frac{1}{\sigma-1}}$$

$$= \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \times \varphi_x \times \left\{1-(1-\gamma^{\sigma-1})(\frac{\varphi_h}{\varphi_x})^{\sigma-k-1}\right\}^{\frac{1}{\sigma-1}}$$

$$= \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}} \times \varphi_x \times \left\{1-(1-\gamma^{\sigma-1})(\left\{\frac{\tau^{1-\sigma}}{(1+\tau^{1-\sigma})}\frac{\frac{\eta-1}{\gamma^{\sigma-1}-1}}{\frac{f_x}{f}}\right\}^{\frac{1}{\sigma-1}})^{\sigma-k-1}\right\}^{\frac{1}{\sigma-1}}$$

$$= A \times \varphi_x \times C^{\frac{1}{\sigma-1}} \qquad (8),$$

$where \ \frac{\varphi_h}{\varphi_x} = \left\{\frac{\tau^{1-\sigma}}{(1+\tau^{1-\sigma})}\frac{\frac{\eta-1}{\gamma^{\sigma-1}-1}}{\frac{f_x}{f}}\right\}^{\frac{1}{\sigma-1}} > 1,\ A = \left[\frac{k}{k-(\sigma-1)}\right]^{\frac{1}{\sigma-1}}, C = 1-(1-\gamma^{\sigma-1})\left\{\frac{\tau^{1-\sigma}}{(1+\tau^{1-\sigma})}\frac{\frac{\eta-1}{\gamma^{\sigma-1}-1}}{\frac{f_x}{f}}\right\}^{\frac{\sigma-k-1}{\sigma-1}} > 1.$

Differentiating the term, C, as $k > (\sigma-1)$, I get

$$\frac{\partial C}{\partial \tau} = -(1-\gamma^{\sigma-1})\left\{\frac{\frac{\eta-1}{\gamma^{\sigma-1}-1}}{\frac{f_x}{f}}\right\}^{\frac{\sigma-k-1}{\sigma-1}}\left[\{k-(\sigma-1)\}\tau^{k-(\sigma-1)}(1+\tau^{1-\sigma})^{\frac{\sigma-k-1}{\sigma-1}}\{\tau^{-1}-(1+\tau^{1-\sigma})^{-1}\tau^{-\sigma}\}\right] > 0 \quad .$$

Using this result, take the derivative of exporter's average productivity, $\bar{\varphi}_x$, with respect to τ,

$$\frac{\partial \bar{\varphi}_x}{\partial \tau} = A\left[(\varphi_x)'\, C^{\frac{1}{\sigma-1}} + \frac{1}{\sigma-1}\, C^{\frac{1}{\sigma-1}-1}\frac{\partial C}{\partial \tau}\varphi_x\right] > 0 \quad .$$

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