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Abstract:

Using firm-level data for 1995-2010, this paper attempts to analyze the impact of trade liberalization on Indian manufacturing firms' productivity (using both gross output and value added specifications), comparing the effect of output tariff cuts with those from reductions in input tariffs. Estimation follows the fixed effects model, and the system GMM estimator for the dynamic version. The main explanatory variables are output tariff rates, input tariff rates, and quantitative restrictions. Control variables include several firm characteristics such as firm size, FDI and import intensity. An attempt is also made to study the differential effects of trade liberalization on productivity gains with regard to firms' initial-period level of technical efficiency. The results indicate that trade liberalization had a positive effect on manufacturing productivity in India.

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Trade Liberalization and Productivity of Indian Manufacturing Firms

Bishwanath Goldar and Isha Chawla

1. Introduction

There have been several econometric studies on the impact of trade liberalization on productivity in manufacturing in developing countries and most have found a positive effect of trade liberalization on productivity. These include Kim (2000) for Korea, Pavcnik (2002) for Chile, Ferreira and Luiz (2003) and Schor (2004) for Brazil, Fernandes (2007) for Columbia, Amiti and Konings (2007) for Indonesia, Ozler and Yilmaz (2007) for Turkey, Hu and Liu (2014) for China, and Jongwanich and Kohp (2017) for Thailand.[1]

Several such studies on the impact of trade liberalization on productivity have been undertaken for Indian manufacturing in the context of the major economic reforms including trade reforms that India undertook since 1991, and almost all of them have found a positive effect of trade liberalization on productivity in Indian manufacturing. These include Krishna and Mitra (1998), Chand and Sen (2002), Kambampati (2003), Goldar and Kumari (2003), Topalova (2004), Das (2006), Sivadasan (2006, 2009), Mitra and Ural (2008),[2] Topalova and Khandelwal (2011),[3] and Ghosh and Roy Biswas (2014).[4] Some of these studies have used industry-level or state-by-industry-level data, and some others have used firm-level or plant-level data.

[1] Analysis undertaken by Vu (2012) for Vietnam reveals a positive effect of trade liberalization on productivity. Aldaba (2010) finds some empirical support to the hypothesis that trade liberalization leads to productivity gains in a study undertaken for Philippines. In the econometric analysis undertaken, a significant positive effect of trade liberalization on productivity is found for firms belonging to the importable sectors.

[2] Goldar and Kumari (2003), Topalova (2004) and Sivadasan (2006, 2009) have found a positive effect of tariff reduction on productivity, while Das (2006) has found a productivity enhancing effect of removal of non-tariff barriers. Mitra and Ural (2008) have found that both tariff cuts and easing of non-tariff barriers have had a favourable effect on industrial productivity in India.

[3] Goldberg, Khandelwal, Pavcnik and Topalova (2010) find that trade liberalization in India contributed significantly to the introduction of new products by domestic industrial firms, which they feel is likely to be positively associated with productivity advance.

[4] One study that did not find a positive effect of trade liberalization on manufacturing productivity in India is Balakrishnan et al. (2000). A limitation of this study is the use of a dummy variable for time periods to capture the effect of reforms, not a variable (or variables) that directly measure changes in tariff and non-tariff barriers. It may be added here that Driffield and Kmabhampati (2003) in their study covering six manufacturing industries in India found that increased imports did not raise productivity which goes against the hypothesis that import liberalization promotes productivity in manufacturing.

The studies listed above used data for a period that covered India's trade liberalization of the 1990s, which is the initial phase of India's economic reforms. In a recent study, Das (2016) has presented econometric evidence which indicates that the trade reforms of the 1990s and further changes made in the 2000s had a positive effect on manufacturing productivity in India. Das (2016) used industry-level panel data for his analysis drawing data from ASI (*Annual Survey of Industries*, Central Statistics Office, Government of India), covering the period 1990-91 to 2009-10. Similarly, using firm-level data drawn from *Prowess* (CMIE, Center for Monitoring the Indian Economy), Mukherjee (2014) has studied the impact of trade liberalization on manufacturing firm productivity in India during the period 1999-2009 and found that trade liberalization raised productivity of large firms in India, but did not raise productivity of small and medium scale firms. This finding points to differential effects of trade liberalization on productivity of firms belonging to different size classes. Taking large, medium and small firms, together, the overall finding from their econometric results is that productivity of firms is positively impacted by trade liberalization – firm TFP is positively impacted by lowering of output tariff, input tariff or quantitative restrictions (QRs) on imports. Also mentionable here is the study undertaken by Gupta and Veeramani (2014) who have used data on manufacturing plants for the period 1998-99 to 2007-08 (drawn from ASI, unit level data) and have studied the mechanisms through which trade impacts productivity. They find a positive effect of trade liberalization on manufacturing plants' productivity.

This paper makes an attempt to analyze the impact of trade liberalization (primarily focusing on the reductions made in tariff rates on imports) on productivity of Indian manufacturing firms. The analysis is based on data on manufacturing companies drawn from *Prowess* is thus confined to the corporate sector segment of Indian manufacturing (this applies also to many of the earlier studies on the impact of trade reforms on Indian manufacturing based on company level data).

This paper presents an analysis similar to Topalova and Khandelwal (2011) who examined the impact of trade liberalization (focusing on reduction in tariff rates) on productivity of Indian manufacturing firms using firm (company)-level data (drawn from Prowess). The analysis was mainly focused on the period 1989 to 1996. This study, on the other hand, uses firm (company)-level data for the period 1997-98 (hereafter 1998) to 2009-10 (hereafter 2010). Evidently, this study is based on data for a much more recent period than that used by Topalova and Khandelwal (2011). This has an advantage as explained below.

In terms of the time period covered, this study is similar to Mukherjee (2014). Both studies are based on firm level data drawn from *Prowess* (CMIE). Das (2016) has also covered the period up to 2009-10. However, the analysis of the impact of trade liberalization undertaken in Das (2016) is based on industry-level data drawn from ASI and is therefore quite different from this study and the study undertaken by Mukerejee (2014).

The main advantage of the analysis presented in the paper over Topalova (2004), Topalova and Khandelwal (2011) and other such studies on the impact of trade liberalization on manufacturing productivity in India undertaken earlier with the help of company-level data (except Mukherjee, 2014) is that data for a more recent period (mostly 2000s) is covered which is arguably more suitable for assessing the impact of trade liberalization. It should be noted that in the 1990s, there was a significant level of water in tariff and therefore cuts in tariff did not materialize into commensurate increases in the degree of import competition.[5] Also, imports of manufactured consumer goods remained under QRs till 1999-2000, providing significant protection to domestic consumer goods manufacturing industries, which form a sizable part of India's manufacturing sector. By the early 2000s, most quantitative restrictions on imports of manufactured goods had been eliminated and by the mid-2000s the tariff rates had been brought down to such low levels that a further cut would put substantial competitive pressure on domestic manufacturing firms.[6] This would make the decade of the 2000s appropriate for studying the impact of tariff reduction on productivity.

Another claim that may be made in favour of the present study is that a good deal of care has been taken in the measurement of output and inputs and hence of total factor productivity (TFP), which is obviously important for assessing correctly the impact of trade liberalization on productivity. Two estimates of TFP are used for the analysis – one based on gross output function and the other based on value added function – permitting thereby a richer analysis of the impact of trade liberalization on TFP in manufacturing firms. The methodology of measurement of output, inputs and productivity is explained in detail later in Section 2 of the paper.

Econometric modelling for assessing the effect of trade liberalization on productivity involves the regression of firm-level TFP on a set of explanatory variables, some reflecting tariff rates and QRs and some others reflecting firm characteristics. The methodological details of econometric modeling are provided in Section 3 in which the empirical results are presented.

In this context, it may be mentioned that some studies (e.g., Schor, 2004 and Amiti and Konings, 2007) have shown that in comparison with the competition effect of output tariff cuts, the tariff cuts on intermediate inputs had a larger impact on firm productivity through increased access to intermediate inputs. For India, Topalova and Khandelwal (2011) found that while the pro-competitive effect of import liberalization (arising from reductions in tariff on imported products

[5] Note further that cuts in tariff were partly neutralized by depreciation in real effective exchange rate.

[6] See Goldar (2002, 2005) and Panagariya (2004), among others, for a discussion on changes in tariff and non-tariff barriers on imports in India in the 1990s and later. According to World Bank data on tariff rates on manufactured products, the average tariff rate applicable on India's imports was 83 percent in 1990, 57.1 percent in 1992, 32.8 percent in 1999, 31.8 percent in 2001, 28.7 percent in 2004, 15.9 percent in 2005, and about 8.6 percent in 2008 and 2009 [http://data.worldbank.org/indicator/TM.TAX.MANF.SM.AR.ZS?locations=IN , accessed on 17 September 2016].

that compete with the output of domestic producers) had a positive effect on firm productivity, the bigger impact emerged from the improved access to imported inputs, corroborating the findings of Schor (2004) and Amiti and Konings (2007). This aspect receives attention in the econometric analysis undertaken in Section 3 of the paper.

In addition, in the analysis undertaken, an attempt is made to relate productivity gains achieved by Indian manufacturing firms from a liberalized trade regime to their initial-period level of technical efficiency (reflecting distance from technology frontier). It may be mentioned in this context that, in a study of Indian firms, Aghion and Burgess (2003) came to the conclusion that firms closer to the technology frontier may be able to gain more from economic liberalization than the firms far from the frontier. This idea is explored further in this paper while assessing the impact of trade liberalization on firm performance. The question investigated is whether the firms with an initial-period low level of technical efficiency (which could be treated as an indication of relatively lower management capability and/or various economic handicaps faced by the firms) would find it difficult to take adequate advantage of the opportunities created by trade reforms. Alternatively, one may hypothesize that the firms with low initial level of technical efficiency came under greater competitive pressure from imported goods and therefore had greater compulsion to improve their competitiveness. The importance of this issue is that even if trade reforms commonly lead to better productivity of manufacturing firms which seems to be the general finding of the studies undertaken so far, the liberalization of imports and the associated challenges and opportunities may have differential effect on the performance of firms depending on their capabilities and circumstances in which they operate, and this may in turn cause inter-firm inequality in performance, particularly productivity, to go up or go down. How this tendency impacts the degree of inter-firm inequality in the wages paid to workers by the firms is also an interesting question.

The rest of the paper is organized as follows. As mentioned earlier, Section 2 is devoted to the methodology of TFP measurement. Section 3 presents the results of econometric analysis. It is divided into four sub-sections. Section 3.1 examines the impact of change in nominal and effective rates of protection on TFP. The impact of change in QRs is also considered. Section 3.2 goes into the issue of differential impact of cuts in output tariff and input tariff. Section 3.3 is devoted to robustness checks of the econometric results reported in Sections 3.1 and 3.2. Section 3.4 investigates whether the impact of trade liberalization on productivity differs among firms according to their initial period level of technical efficiency. The final section of the paper, Section 4, summarizes and concludes.

2. Firm-level TFP Estimates

2.1 Methodology of TFP estimation – econometric issues

The standard set-up used for estimating firm or plant level productivity posits firm *i*'s production function at time *t* (in logs) as:

$$y_{it} = f(k_{it}, l_{it}, m_{it}, \varepsilon_{it}; \beta) ...(2.1)$$

and that for the Cobb-Douglas specification is:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it} ...(2.2)$$

where k_{it} (capital) is a quasi-fixed input; l_{it} (labour) and m_{it} (intermediate inputs) are variable inputs respectively. ε_{it} (the Hicks neutral 'productivity shock') captures the effect of unobserved determinants of production, and β are the parameters. ε_{it} is assumed to be additively separable from the other production factors, and additively separable in a transmitted component ω_{it} ('unobserved productivity', a state variable that impacts the firm's decision rules), and an *i.i.d.* component η_{it} (that consists of unanticipated or unpredictable productivity shocks that the firm observes only after it makes its period *t* input decisions; measurement errors in inputs and/or output, and errors due to functional form discrepancies, assumed to be orthogonal to the regressors). The component ω_{it}, the anticipated productivity shock that firm *i* observes before it makes its period *t* input decisions, the endogenous part of the error term, is referred to as the firm's *total factor productivity* (TFP), taken to capture a systematic technology difference across firms.

In the *gross output* (GO) *specification* (with output as the dependent variable), log (TFP) is the residual from the linear regression:

$$\hat{\omega}_{it} = (y_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_m m_{it}) ...(2.3)$$

In the alternative, *value added* (VA) *specification*, log (TFP) is estimated as the residual from the linear regression of log of real value added on log of capital and log of labour inputs.

Several measurement and methodological issues or sources of potential biases arise in productivity estimates. Among *measurement* issues, Petrin and Levinsohn (2012) and Van Beveren (2012) among others note that the use of industry level price deflators for converting nominal value of output (revenue or value added) to real output causes *measurement error in output* to the extent that firm-level prices deviate from industry deflators, causing TFP estimates to include not only pure efficiency, but the unobserved price error likely to reflect the firm's market power/price-cost mark up (Katayama et al., 2009). Further, if the price error/unobserved firm-level price differences are correlated with input use, input coefficients and TFP estimates are likely to be biased causing an *omitted price bias.*[7] Further, *measurement error in input prices* (deviation in firm and industry level input prices) causes bias in TFP that is likely to be in the opposite direction from that caused by the price error (Van Beveren, 2012).[8]

To highlight some other *methodological* issues, (i) Gandhi, Navarro and Rivers (2011), among others, note that a 'value added bias' in productivity estimates results from the VA specification of the production function as this requires stronger conditions on the production technology (separability of intermediate inputs and primary inputs of capital and labour) and ignores the role of intermediate inputs; (ii) Another issue of major concern is the contemporaneous correlation between the observed input levels and the unobserved firm-specific productivity process making OLS (ordinary least squares) estimates biased and inconsistent. For instance, in a two input framework, in the most likely case of a positive correlation between the variable input, that adjusts rapidly, (say, labour), and the quasi-fixed input, (say, capital), OLS will tend to overestimate the labour and underestimate the capital coefficient (Levinsohn and Petrin, 2003, hereafter L-P).

The *semi parametric*, *proxy variables* approach estimates firm-level production functions while controlling for simultaneity bias. Olley and Pakes (1996) (hereafter O-P) show that for that subset of the data where an observed input decision of the firm, investment in physical capital, z_{it}, (a function of the state variables of the firm, namely, productivity ω_{it} and capital k_{it}) is strictly positive, if the production technology satisfies the invertibility condition, the demand function can be inverted and written as $\omega_{it} = g_t (k_{it}, z_{it})$ where $g_t = z_t^{-1}$. Unobserved productivity can thus be expressed only as a function of the observable inputs, namely the capital input and the proxy variable, and be controlled for in estimation. L-P note the non-positive investment reported in a large fraction of firm or plant level data sets, showing that while the intermittent investment behaviour of firms that causes zero investment observations restricts the applicability of the O-P approach, under certain assumptions, the optimal level of intermediate input demand can instead be used as the proxy variable.[9]

[7] Klette and Griliches (1996) point out that a negative correlation between input use and price error is likely to lead to an overestimation of TFP, the direction of the bias being opposite to that caused by simultaneity bias (De Loecker, 2007).

[8] Although industry-level price deflators are widely used in the absence of observable firm-specific prices, Banga (2003) is a major improvement over other productivity studies wherein a weighted average of firm-level prices for output and inputs is constructed as deflators instead.

[9] Goldar (2014) reviews recent studies on Indian manufacturing firms' technical efficiency and TFP, discussing the studies that deal with the influence of reforms, industrial climate, technology, services input and export intensity on firm or plant level productivity, some of which apply the L-P estimation approach.

2.2 Methodology of TFP estimation – data and variable construction

This study uses the firm-level database *Prowess* provided by the Centre for Monitoring the Indian Economy (CMIE) wherein manufacturing firms can be identified with the National Industrial Classification (NIC)-2008 sector to which they belong (NIC 10 to 32). The time period covered is 1994-95 (1995) through 2009-10 (2010). Based on Levinsohn and Petrin (2003) methodology that attempts to overcome simultaneity bias in production function estimation, and two specifications of the production function (namely, gross output and value added), estimates of TFP are made. For this purpose, attempts are made to improve on the measurement of input variables required for estimating firm productivity.[10]

The unbalanced panel is restricted to firms that are observed for at least three years; real output, real value added, real capital and the 'combined' real intermediate input (see below) are positive to allow for log transformations. Firm-year observations within each industry in the lower and upper 1 percentile of the distribution of the variables in the set x_o where x_o = (capital/output; capital/labour; energy/output) are removed as are firms with extreme output/input variation or reversals from year to year, thus restricting the sample to 57,697 observations (6,068 firms).

Nominal gross output is taken as sum of sales and change in stock of finished and semi-finished goods. The measure of *real gross output* is obtained by using the 3-digit industry-level price deflators constructed from the WPI series, obtained from the Office of the Economic Advisor (OEA), Ministry of Commerce and Industry of India, (http://eaindustry.nic.in/) (1993/94=100 series and 2004/05=100 series, spliced and rebased to 1999/00=100).

Nominal value-added is nominal value of output minus the nominal value of intermediate inputs. The measure of *double-deflated real value added* is used for the analysis and is defined as real output minus the real cost of intermediate inputs (raw materials, energy, and services) where the three components of intermediate inputs are deflated with their separate deflators.

The value of raw materials is the sum of the value of raw materials, stores and spares, and the value of packaging and packing expenses, measured in current prices. The *real value of raw materials* is obtained by deflating raw materials expenses with the 3-digit industry-specific price index for raw materials (1999/00=100) constructed using the Input-Output Transactions Table

[10] Previous studies for Indian manufacturing firms or plants, even while estimating the production function at the industry level, generally apply a 2-input structure (estimating the labour and capital coefficients using the VA specification), even while the assumption of separability between primary inputs of capital and labour, and intermediate inputs is not validated (Pradhan and Barik, 1998). Also, studies based on the GO specification have mostly applied a 3- or 4- input structure (estimating the labour, capital, raw materials and energy coefficients). Only a few studies, such as Goldar (2004), Banga and Goldar (2007), Virmani and Hashim (2011) and Arnold et al. (2015) have highlighted and included the increasingly important services input in production function estimation.

(IOTT) for the Indian economy for the benchmark years 1993/94 and 2003/04, drawn from www.mospi.gov.in/cso_rept_pubn.htm.

The value of energy is the value of expenses on power, fuel and water charges in current prices. The *real value of energy* is obtained by deflating energy expenses with the 3-digit industry-specific price index for energy (1999/00=100) constructed using IOTT 1993/94 and 2003/04.

Box 1: Data Sources for TFP Estimation

Main data source

1. Centre for Monitoring the Indian Economy (CMIE) *Prowess* database.

Additional data sources

1. WPI series, obtained from the Office of the Economic Advisor (OEA), Ministry of Commerce and Industry of India, http://eaindustry.nic.in/, (1993/94=100 and 2004/05=100).
2. National Accounts Statistics (NAS), www.mospi.gov.in/cso_rept_pubn.htm.
3. Input-Output Transactions Table (IOTT) for the Indian economy for the benchmark years 1993/94 and 2003/04. www.mospi.gov.in/cso_rept_pubn.htm.
4. Consumer Price Index for Urban Non-Manual Employees (CPI-UNME, 1985/86=100, CSO).
5. *Annual Survey of Industries (ASI) data from EPWRF for 1973/74 to 2003/04, Volume II,* Time-Series Data on ASI (1998/99 to 2007/08), ASI Summary Results for the Factory Sector 2008/09, ASI (Volume1) Factory Sector, 2009/10.
6. Concordance tables between NIC-1998 and NIC-2004 available at *mospi.nic.in/mospi_new/upload/nic_2004_concor_tab1.pdf* and between NIC-2004 and NIC-2008 available at *mospi.nic.in/mospi_new/upload/nic_2008_17apr09.pdf*

The value of services input is the sum of expenses on heterogeneous services comprising rent and lease rent, repairs and maintenance, insurance, outsourced manufacturing jobs, outsourced professional jobs, selling and distribution expenses, travel expenses, communication expenses, printing and stationary expenses and financial services, measured in current prices. The *real value of services* is obtained by deflating services expenses with the 3-digit industry specific deflator for services (1999/00=100) constructed using IOTT 1993/94 and 2003/04 along with implicit deflators for services sectors formed with the help of data taken from National Accounts Statistics.

Given the incomplete coverage of the employment indicator in the company database, labour input is imputed by using a modified version of the 'ASI-based approach' which involves: i) the computation of an average wage rate, taken as emoluments per employee, at the 2-digit or 3-digit industry level, obtained by dividing ASI data on total emoluments by the total persons engaged and ii) dividing each firm's wage bill obtained from the company database by this computed average wage rate to arrive at an imputed measure of the employment in the firm. *Annual Survey of Industries* (*ASI*) *EPWRF database for 1973/74 to 2003/04* (*Volume II*)*,* Time-Series Data on ASI (1998/99 to 2007/08), ASI Summary Results for the Factory Sector 2008/09, ASI (Volume 1) Factory Sector, 2009/10, and concordance tables between NIC-1998, NIC-2004 and NIC-2008 are used to obtain the time series of the imputed 3-digit ASI average wage rates.[11] This study attempts to address the uniform wage rate shortcoming of the 'ASI-based approach' by adjusting the labour measure for a 'wage premium' based on ownership groups, wherein the 'wage premium' for group, government and foreign firms is estimated from a *random-effects* model, applied over 2006-10 to a smaller sample of firms (that is, to firms that report their employment indicator in the company database).[12]

Drawing firm-level data on gross fixed assets (GFA), net fixed assets (NFA) and depreciation from the company database, the Perpetual Inventory Method as in Srivastava (1996), Balakrishnan, Pushpangadan and Babu (2000), and Kato (2009) is followed with some modifications to construct firm-level real net stock of capital. This involves constructing the replacement cost series from the book value or the historic price series of capital as provided in the database, and subsequently deflating it by the capital price deflator series (1999/00 = 100) that is worked out using *National Accounts Statistics* Back Series 2007 (1950/51 to 1999/00) (available at www.mospi.gov.in/cso_rept_pubn.htm), NAS 2007, 2009 and 2011. While previous literature assumes constant growth of investment all firms belonging to all industries, ASI data obtained from EPWRF for 1973/74 to 2003/04, Volume II allows computing industry-specific growth of investment at the 3-digit industry level thus allowing a greater level of disaggregation and variation across industries.

Further, following Griliches (1979), R&D expenditures are used as the basis for measuring firm level 'knowledge' or R&D 'capital' stock, constructed using the Perpetual Inventory Method (as in Coe and Helpman, 1995, with some simplifying assumptions). 'Knowledge' capital stock is then combined with physical capital stock for production function estimation, thus allowing greater dispersion in the approximation to the true heterogeneity in the capital stock across firms.

The GO and VA production function parameters are estimated at the 2-digit industry/industry group level, using 'combined' intermediate inputs as the intermediate input proxying for unobserved productivity shocks. An estimate of firm-level productivity for firm *i* at time *t* is

[11]Concordance tables between NIC-1998 and NIC-2004 available at m*ospi.nic.in/mospi_new/upload/nic_2004_concor_tab1.pdf* and between NIC-2004 and NIC-2008 available at *mospi.nic.in/mospi_new/upload/nic_2008_17apr09.pdf* are used.

[12] Previously, Goldar, Renganathan and Banga (2004) adjust the wage rate for foreign owned firms in the industry as 10% higher than the industry average as obtained from ASI.

obtained as the difference between the firm's actual output and its predicted output. As in Delgado et al. (2002) and Topalova and Khandelwal (2011), among others, a relative firm-level productivity index is constructed as the deviation of the estimated productivity of each individual firm-year observation from the mean industry observation in the base year (1995),[13] to ensure that the productivity level comparisons between any two firm-year observations, in both cross section and panel are transitive.

3. Empirical Results

3.1 Impact of Lowering of Tariff Rates and QRs on Firm TFP

Econometric Model and Estimation

The specification of the econometric model used for assessing the impact of tariff and QRs on TFP is similar to that used by Amiti and Konings (2007). The dependent variable is $\ln(TFP_{ijt})$, i.e. logarithm of TFP of *i*'th firm in *j*'th (NIC three-digit) industry in year *t*. The main explanatory variables are output tariff rate i.e. nominal rate of protection (for industry *j* in year *t*) or effective rate of protection accorded by tariff (for industry *j* in year *t*), QRs (quantitative restrictions measured by frequency ratio, for industry *j* in year *t*) and a set of variables representing firm characteristics. The model may be written as

$$lnTFP_{ijt} = \alpha_0 + \alpha_{ij} + \beta_1 TR_{jt} + \beta_2 QR_{jt} + \gamma X_{ijt} + u_{ijt} \ldots (3.1)$$

In this equation, X_{ijt} is a set of control variables and γ is the corresponding vector of parameters, and u_{ijt} is the random error term. α_{ij} allows for firm fixed effects. TR is the nominal or effective rate of protection, used in alternate specifications of the model. QR denotes quantitative restrictions.

The nominal and effective protection rates used for the analysis are the same as those used in Das, 2016 (kindly provided by Dr. Deb Kusum Das for this study). These are available at 3-digit industry level according to NIC-1987 for the period 1997-98 to 2009-10.[14] The protection rates according to NIC-1987 have been mapped into NIC-2008 for use in this study because in the *Prowess* data the industrial classification of firms has been provided according to NIC-2008.

[13] Following Pavcnik (2002) the reference firm is taken to be a hypothetical firm with output and input levels that equal the geometric mean of the output and inputs over all firms in the base year of the sample period and with the respective industry's estimated input coefficients.

[14] Though TFP estimates have been made for the period 1995 to 2010, the econometric analysis is confined to the period 1998 to 2010 because data on tariff rates and QRs are not available for the years before 1997-98.

The QR data have been taken directly from the Report (Das, 2016, Table A.3. pages 68-71). In the Report, average frequency ratios[15] for different industries are available for the periods 1997-98 to 2002-03 and 2003-04 to 2009-10. The period averages have been applied to all years within the period to create a time series for each industry. Needless to say that this is a limitation of the variable on QRs used in this study.

Control variables used for the analysis, which represent firm characteristics, are: dummy variables for small size firms and medium size firms based on firm size measured in terms of logarithm of total assets, R&D intensity (share of R&D capital stock out of total capital stock), royalty payment to sales ratio, export intensity (exports to sales ratio) and import intensity (imports to sales ratio). In addition, in some specifications of the model, in order to assess the impact of FDI (foreign direct investment) on TFP, a dummy variable for FDI firms, i.e. firms with foreign equity participation, has been used. This is based on the equity share of foreign promoter(s) with the cut-off level being taken as 10%. If a firm reaches this level of foreign equity participation in a particular year, the dummy variable is assigned value one (zero for earlier years) for that year and for all subsequent years in the period under study even if the foreign equity share in the firm goes down later and falls below 10%. Detailed data on shareholding pattern in companies is available in Prowess dataset from 2000-01 onwards. Hence, a shorter period 2000-01 to 2009-10 is considered for econometric analysis when the FDI variable is included in the model estimated.

Since panel data are used, the estimation of the specified equation (3.1) has been done by the fixed effects model. In some specifications of the model, year dummies have been included to capture year specific effects.[16] Since the tariff and QRs data are available at 3-digit NIC which has been applied to all firms belonging to those industries, in the computation of standard errors of the parameter estimates correction for clustering has been done at 3-digit NIC level.

Regression Results

The regression results are presented in Tables 1 and 2. The model has been estimated separately for the gross output function based TFP estimates and the value added function based TFP estimates (hereafter GO_TFP and VA_TFP respectively). The year fixed effects are included in the estimates presented in Table 2. This is not done in the estimates presented in Table 1. Also, the FDI firm dummy variable has been included in the estimates in Table 2, not in the estimates in Table 1.

[15] For discussion on frequency ratio and the method that has been used for its computation see Das (2016).
[16] Year dummies have been included in the model specification used by Topalova and Khandelwal (2011) who note that these dummies capture macro-economic shocks.

The results presented in Tables 1 and 2 reveal a significant negative effect of nominal and effective protection (accorded by tariff) on TFP of manufacturing firms, implying thereby that a lowering of tariff rates on imported manufactured goods raises TFP of Indian manufacturing firms. These results are in conformity with the findings of similar studies for Indian manufacturing undertaken earlier. It is particularly important to note that the results obtained in this study in respect of nominal and effective rates of protection are consistent with the findings of Topalova and Khandelwal (2011), Mukherjee (2014), Gupta and Veeramani (2014) and Das (2016).

Table 1: Trade Barriers and TFP, Manufacturing Firms, 1998-2010, Regression Results

Explanatory variables	Value added function based TFP		Gross output function based TFP	
	Regression-1	Regression-2	Regression-3	Regression-4
NRP	-0.0115 (-4.05)***		-0.0035 (-4.37)***	
ERP		-0.0078 (-2.53)**		-0.0023 (-2.66)**
QR	-0.0026 (-1.26)	-0.0038 (-1.99)**	-0.0009 (-1.43)	-0.0013 (-2.37)**
Small firm dummy	-0.347 (-7.22)***	-0.378 (-6.91)***	-0.098 (-6.67)***	-0.108 (-6.30)***
Medium firm dummy	-0.066 (-2.63)**	-0.081 (-2.98)***	-0.026 (-3.89)***	-0.031 (-4.13)***
Import intensity	0.377 (3.04)***	0.420 (3.44)***	0.044 (1.35)	0.057 (1.76)*
Export intensity	0.150 (2.56)***	0.163 (2.82)***	0.020 (1.05)	0.024 (1.31)
R&D capital stock share in total capital stock	0.129 (0.19)	0.271 (0.37)	0.180 (1.06)	0.224 (1.21)
Royalty-sales ratio	0.930 (3.43)***	0.957 (3.60)***	0.221 (3.74)***	0.229 (3.78)***
Constant	-0.091	-0.156	0.143	0.123
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No
R-squared	0.012	0.013	0.024	0.021
F value and (Prob.>F)	22.7 (0.00)	24.1 (0.00)	25.1 (0.00)	26.0 (0.00)
No. of observations	46087	46087	46087	46087

Note: Dependent variable: ln(TFP). t-values in parentheses. Robust standard errors, corrected for clustering at 3-digit industry level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

Table 2: Trade Barriers and TFP, Manufacturing Firms, 2001-2010, Additional Regression Results

Explanatory variables	Value added function based TFP		Gross output function based TFP	
	Regression-5	Regression-6	Regression-7	Regression-8
NRP	-0.0102 (-2.48)**		-0.0032 (-2.84)***	
ERP		-0.0060 (-1.53)		-0.0020 (-1.86)*
QR	0.0026 (0.86)	0.0032 (1.07)	0.0006 (0.73)	0.0007 (0.93)
Small firm dummy	-0.208 (-5.39)***	-0.210 (-5.42)***	-0.065 (-5.68)***	-0.065 (-5.70)***
Medium firm dummy	-0.016 (-0.73)	-0.017 (-0.78)	-0.014 (-2.14)**	-0.014 (-2.18)**
Import intensity	0.187 (1.85)*	0.193 (1.90)*	-0.005 (-0.16)	-0.004 (-0.11)
Export intensity	0.057 (0.94)	0.058 (0.98)	-0.007 (-0.34)	-0.007 (-0.33)
R&D capital stock share in total capital stock	0.259 (0.68)	0.278 (0.72)	0.255 (3.03)***	0.261 (3.06)***
Royalty-sales ratio	0.520 (4.78)***	0.525 (4.68)***	0.120 (2.03)**	0.121 (2.06)**
FDI firm dummy	0.222 (2.15)**	0.228 (2.21)**	0.046 (1.75)*	0.048 (1.80)*
Constant	-0.346	-0.500	0.072	0.027
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R-squared	0.017	0.029	0.028	0.033
F value and (Prob.>F)	23.9 (0.00)	26.0 (0.00)	22.8 (0.00)	27.0 (0.00)
No. of observations	37012	37012	37012	37012

Note: Dependent variable: ln TFP. t-values in parentheses. Robust standard errors, corrected for clustering at 3-digit industry level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

A negative coefficient is found for the variable representing QRs in the estimated regression equations presented in Table 1. In two cases, the coefficient is statistically significant. This is broadly consistent with the results obtained by Mukherjee (2014) who has undertaken a similar study for Indian manufacturing using firm-level *Prowess* data and has used a variable representing QRs in the models estimated. Das (2016) has found a negative relationship between import coverage ratio and TFP and also between frequency ratio and TFP in his econometric analysis done at the industry level. Thus, the results obtained in this study shown in Table 1 are in agreement with the findings of Das (2016). It therefore appears from the results given in Table 1 that the easing of quantitative restrictions on imports of manufactured products raises manufacturing productivity. It should be noted, however, that when year dummies are included (results reported in Table 2), the coefficient of the QR variable is found to be positive (not tallying with the results in Table 1) and statistically insignificant. This is perhaps due to certain deficiencies in the manner in which the variable has been constructed for the study –averages of the QR variable for two periods taken from Das (2016) have been applied to all years in those periods.

The coefficients of dummy variables for small size firms and medium size firms are found to be negative. This indicates that, other things remaining the same, the level of TFP in a large firm is higher than that in a small firm or in a medium size firm. The gap appears to be relatively bigger between large and small firms than between large and medium size firms. It would be seen from Tables 1 and 2 that the coefficient of the dummy variable for small firms is negative and statistically significant in all the estimated regression equations. The results suggest that in comparison with a large firm, a small firm has about 20 to 40 percent lower TFP when one considers VA_TFP (TFP estimates based on value added function), and the gap is about 6 to 11 percent when one considers GO_TFP (TFP estimates based on gross output function). By comparison, the estimated gap in TFP level between large firm and medium size firm is relatively much smaller.

Turning now to other firm characteristics, the coefficient of the FDI firm dummy variable is consistently positive and statistically significant. This shows a positive effect of FDI on TFP of domestic manufacturing firms. The results in respect of R&D, royalty, export intensity and import intensity are somewhat mixed. The coefficients have the expected sign and are found to be statistically significant in some of the regression equations estimated but not in others. Disregarding these variations, the overall picture that emerges from the regression results is that R&D expenditure, royalty payments, export intensity and import intensity bear a positive relationship with productivity of manufacturing firms in India. Among these variables, the import intensity variable deserves special attention since this is connected with access to imported inputs. The coefficient of import intensity is found to be positive in most equations estimated and found statistically significant in several of them. This finding may be interpreted as beneficial effect of import liberalization on firm productivity through increased access to imported inputs.

3.2 Output Tariff Rates versus Input Tariff Rates, Which has greater impact?

In was mentioned in the introductory section of the paper that Schor (2004), Amiti and Konings (2007) and several other studies have found that in comparison with the competition effect of output tariff cuts, the tariff cuts on intermediate inputs had a larger impact on firm productivity through increased access to intermediate inputs. In their analysis done for Indian manufacturing, Topalova and Khandelwal (2011) have reported similar findings. They note that while the pro-competitive effect of import liberalization (arising from reductions in tariff on imported products that compete with the output of domestic producers) had a positive effect on firm productivity, the bigger impact emerged from the improved access to imported inputs. Mukherjee (2014) reaches the same conclusion when he observes the impact of a reduction in input tariff is bigger than a similar reduction in output tariff. Nataraj (2011) has studied this issue for Indian manufacturing and found that while the productivity enhancing effect of trade liberalization operated through reduction in final goods prices in the case of informal sector manufacturing enterprises, the productivity gains in the case of formal sector manufacturing enterprises was primarily driven by concurrent reductions in input tariffs.

Given that there is some evidence presented in earlier studies to indicate that in regard to productivity gains in India's corporate sector manufacturing firms arising from trade liberalization, reductions in input tariff has been a more important factor than reductions in final output tariffs, this issue has been investigated further in this paper. For this purpose, the following model has been estimated.

$$lnTFP_{ijt} = \alpha_0 + \alpha_{ij} + \beta_1 OTR_{jt} + \beta_2 ITR_{jt} + \beta_3 QR_{jt} + \gamma X_{ijt} + u_{ijt} \ldots (3.2)$$

In this equation, OTR denotes output tariff rate and ITR denote input tariff rate.[17]

Since panel data are used, the estimation of the above equation (3.2) has been done by the fixed effects model. In some specifications of the model, year dummies have been included to capture year specific effects. In the computation of standard errors of the parameter estimates, correction for clustering has been done at 3-digit NIC level.

The regression results are presented in Table 3. In Regressions (9) and (11), year dummies have been included and in regressions (10) and (12) this has not been done.

The regression results in Table 3 are similar to those in Table 2 and therefore do not require any detailed discussion. The important point to note is that the coefficient of output tariff variable is negative and statistically significant, but the coefficient of input tariff variable is statistically insignificant in all four regressions and wrongly signed in two cases. Evidently, the results obtained in this study are sharply at variance with the findings of several earlier studies for India and some studies for other developing countries.

There is high correlation between inter-temporal movements in output tariff rates and input tariff rates. It becomes therefore difficult to ascertain the individual impact of these two components.

[17] Input tariff rates have been computed for different 3-digit industries. For this purpose input-weights have been taken from IOTT for 2007-08. The nominal rates of protection or tariff rates for different manufacturing three-digit industries are used for this purpose (as one industry's products enter as input in another industry). These are the same as those used for the analysis in Section 3.1. In addition, tariff rates for certain categories of agricultural products and mineral products have been used in the computation of input tariff rates as these are utilized as inputs by manufacturing industries.

One possible approach that may be taken to assess the impact of the two components is to take them in separate regression equations as done by Mukherjee (2014). The results obtained by taking the output and input tariff rates separately are shown in Table 4. Regression (11) of Table 3 has been re-estimated by first dropping output tariff rate and then by dropping input tariff rate. The results do not show that the impact of reduction in input tariff is greater than a similar reduction in output tariff. Rather, the opposite is suggested. This has been investigated further by interacting input tariff with import intensity of firms. The results do not change much and therefore not show here.

Table 3: Output and Input Tariff, and TFP, Manufacturing Firms, 2001-2010, Regression Results

Explanatory variables	Value added function based TFP		Gross output function based TFP	
	Regression-9	Regression-10	Regression-11	Regression-12
NRP (output tariff rate)	-0.0112 (-1.83)*	-0.0160 (-2.93)***	-0.0032 (-1.78)*	-0.0046 (-2.55)**
Input tariff rate	0.0019 (0.27)	-0.0026 (-0.41)	0.00001 (0.00)	-0.0010 (-0.47)
QR	0.0028 (0.95)	-0.0002 (-0.13)	0.0006 (0.78)	-0.0004 (-0.79)
Small firm dummy	-0.209 (-5.49)***	-0.224 (-5.82)***	-0.065 (-5.79)***	-0.068 (-5.98)***
Medium firm dummy	-0.017 (-0.75)	-0.024 (-1.09)	-0.014 (-2.14)**	-0.016 (-2.36)**
Import intensity	0.188 (1.87)*	0.193 (1.91)*	-0.005 (-0.16)	-0.004 (-0.13)
Export intensity	0.057 (0.95)	0.051 (0.87)	-0.007 (-0.34)	-0.008 (-0.40)
R&D capital stock share in total capital stock	0.262 (0.69)	0.302 (0.73)	0.255 (3.04)***	0.266 (2.85)***
Royalty-sales ratio	0.519 (4.82)***	0.510 (4.95)***	0.120 (2.03)**	0.119 (1.82)*
FDI firm dummy	0.223 (2.15)**	0.232 (2.21)**	0.046 (1.75)*	0.048 (1.82)*
Constant	-0.352	0.023	0.079	0.018
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	No	Yes	No
R-squared	0.018	0.003	0.028	0.016
F value and (Prob.>F)	26.8 (0.00)	29.1 (0.00)	37.2 (0.00)	24.2 (0.00)
No. of observations	37012	37012	37012	37012

Note: Dependent variable: ln TFP. t-values in parentheses. Robust standard errors, corrected for clustering at 3-digit industry level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

Table 4: Output and Input Tariff, and TFP, Manufacturing Firms, 2001-2010, Additional Regression Results

Explanatory variables	Gross output function based TFP		
	Regression-11	Regression-11a	Regression-11b
NRP (output tariff rate)	-0.0032 (-1.78)*		-0.0032 (-2.84)***
Input tariff rate	0.00001 (0.00)	-0.0020 (-1.09)	
QR	0.0006 (0.78)	0.0007 (1.05)	0.0006 (0.73)
Small firm dummy	-0.065 (-5.79)***	-0.065 (-5.82)***	-0.065 (-5.68)***
Medium firm dummy	-0.014 (-2.14)**	-0.014 (-2.22)**	-0.014 (-2.14)**
Import intensity	-0.005 (-0.16)	-0.003 (-0.08)	-0.005 (-0.16)
Export intensity	-0.007 (-0.34)	-0.005 (-0.26)	-0.007 (-0.34)
R&D capital stock share in total capital stock	0.255 (3.04)***	0.257 (3.14)***	0.255 (3.03)***
Royalty-sales ratio	0.120 (2.03)**	0.132 (2.76)***	0.120 (2.03)**
FDI firm dummy	0.046 (1.75)*	0.048 (1.83)*	0.046 (1.75)*
Constant	0.079	0.028	0.072
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R-squared	0.028	0.042	0.028
F value and (Prob.>F)	37.2 (0.00)	18.5 (0.00)	22.8 (0.00)
No. of observations	37012	37012	37012

Note: Dependent variable: ln TFP. t-values in parentheses. Robust standard errors, corrected for clustering at 3-digit industry level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

3.3 Robustness Checks

The results of the econometric analysis presented in Sections 3.1 and 3.2 revealed a significant negative relationship between output tariff rates on imports of manufactured products (i.e. the nominal rate of protection) and productivity of manufacturing firms engaged in the production of those products, reflecting primarily the pro-competitive effect of import liberalization. The implication of this finding is that trade liberalization has a positive effect on manufacturing productivity in India. As mentioned earlier, these results obtained in this study are in line with the findings of a large number of such studies on Indian manufacturing undertaken in the past as well as the findings of several such studies undertaken for other developing countries.

While the finding of a significant negative relationship between nominal protection rate and TFP of Indian manufacturing firms in the analysis above seems plausible and is empirically supported by the findings of several earlier studies, there are certain econometric estimation issues in the methodology employed in Sections 3.1 and 3.2 and it is therefore important to carry out robustness checks. One important issue is endogeneity of tariff rates; the level of productivity of manufacturing industries might be influencing the level at which the tariff rates are set (i.e. less efficient industries may enjoy a higher tariff and non-tariff protection because the fear of employment loss may dissuade the government from lowering the level of protection against imports). Another issue is that since TFP is assumed to follow a Markov process, a lagged productivity term needs to be included in the model (Topalova and Khandelwal, 2011). Again, one may argue that tariff changes may have an impact on productivity only with a lag. Hence, the tariff variable should be introduced in the model with a lag.

Considering the estimation issues raised above, the following three models have been estimated:

$$lnTFP_{ijt} = \alpha_0 + \alpha_{ij} + \beta_1 OTR_{j,t-1} + \gamma X_{ijt} + u_{ijt} \ldots (3.3)$$

$$\Delta^3 lnTFP_{ijt} = \alpha_0 + \alpha_{ij} + \beta_1 \Delta^3 OTR_{jt} + \gamma \Delta^3 X_{ijt} + u_{ijt} \ldots (3.4)$$

$$lnTFP_{ijt} = \alpha_0 + \alpha_{ij} + \lambda lnTFP_{ij,t-1} + \beta_1 \Delta OTR_{jt} + \beta_2 \Delta OTR_{j,t-1} + \beta_3 \Delta OTR_{j,t-2} + \gamma \Delta X_{ijt} + u_{ijt} \ldots (3.4)$$

Equation (3.3) is similar to equation (3.2). The input tariff variable and the QR variable have been dropped because the focus in on the impact of nominal protection (also the results for input tariff variable and QR variable presented above were not encouraging). The output tariff variable has now been introduced with one year lag. This helps to some extent in addressing the issue of tariff endogeneity raised above. Further, by taking the tariff variable with one year lag some allowance is made for possible lagged effect on productivity. Topalova and Khandelwal (2011), Mukherjee (2014) and Gupta and Veeramani (2014) have used a model specification similar to that in equation (3.3).

In equation (3.4), the model is estimated in difference form. This helps in eliminating unobserved firm heterogeneity. In this case, a three-period difference is taken. Thus, $\Delta^3 lnTFP_t = lnTFP_t - lnTFP_{t-3}$. Similar differencing has been done for the tariff variable and the firm characteristics. This specification is similar to one used by Amiti and Konings (2007).

In equation (3.5), the lagged productivity term has been introduced and the explanatory variables are taken in difference form (one period difference). The change in tariff rate in years t, t-1 and t-2 over the corresponding previous years have been taken.

Regression equations (3.3) and (3.4) have been estimated by the fixed effects model. Regression equation (3.5) has been estimated by the system GMM (generalized method of moments) estimator (two-step procedure). The three models in (3.3), (3.4) and (3.5) have been estimated separately for GO_TFP (gross output function based TFP estimates) and VA_TFP (value added function based TFP estimates). The results are reported in Tables 5, 6 and 7.

In all the three specifications of the model, a significant negative relationship is observed between nominal rate of protection (output tariff rate) and TFP in manufacturing firms, confirming the main finding emerging from the analysis presented in Sections 3.1 and 3.3. The estimates presented in Tables 5 and 7 indicate that changes in tariff have an impact on TFP with a lag. This is consistent with the findings of Das (2016) who has looked into the issue of lagged response.

Considering the empirical results presented in Sections 3.1 and 3.2 and those presented in this section, it may be inferred that lowering of tariff on manufactured products has a positive effect on productivity in Indian manufacturing. The effects seem to be occurring through the pro-competitive effects of tariff reductions.

Table 5: Output Tariff and TFP, Manufacturing Firms, 2001-2010, Regression Results

Explanatory variables	Value added function based TFP	Gross output function based TFP
	Regression-13	Regression-14
NRP (output tariff rate) lagged	-0.0045 (-5.30)***	-0.0010 (-3.18)***
Small firm dummy	-0.190 (-7.69)***	-0.057 (-7.52)***
Medium firm dummy	-0.018 (-1.08)	-0.011 (-2.24)**
Import intensity	0.169 (2.24)**	0.003 (0.13)
Export intensity	0.002 (0.03)	-0.016 (-0.86)
R&D capital stock share in total capital stock	0.374 (1.50)	0.237 (2.33)**
Royalty-sales ratio	0.446 (1.44)	0.137 (1.21)
FDI firm dummy	0.189 (2.49)**	0.046 (2.01)*
Constant	-0.463	0.011
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
R-squared	0.031	0.038
F value and (Prob.>F)	74.3 (0.00)	67.4 (0.00)
No. of observations	36281	36281

Note: Dependent variable: ln TFP. t-values in parentheses. Robust standard errors, corrected for clustering at firm level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

Table 6: Changes in Output Tariff and TFP, Manufacturing Firms, 1998-2010, Regression Results

Explanatory variables	Value added function based TFP	Gross output function based TFP
	Regression-15	Regression-16
Change in NRP (output tariff rate) (three year change)	-0.0051 (-2.35)**	-0.0017 (-2.69)**
Change in Import intensity (three year change)	-0.091 (-1.26)	-0.072 (-2.73)***
Change in Export intensity (three year change)	0.035 (0.50)	-0.015 (-0.62)
Change in R&D capital stock share in total capital stock (three year change)	-0.326 (-0.56)	0.007 (0.04)
Change in Royalty-sales ratio (three year change)	0.408 (2.98)***	-0.099 (-2.22)**
Constant	0.065	-0.004
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
R-squared	0.016	0.023
F value and (Prob.>F)	10.3 (0.00)	11.8 (0.00)
No. of observations	26816	26816

Note: Dependent variable: three period change in ln TFP. t-values in parentheses. Robust standard errors, corrected for clustering at 3-digit industry level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

Table 7: Changes in Output Tariff and their impact on TFP, Manufacturing Firms, 1998-2010, Regression Results

Explanatory variables	Value added function based TFP	Gross output function based TFP
	Regression-17	Regression-18
Lagged TFP	0.697 (50.92)***	0.785 (64.25)***
Change in NRP (output tariff rate) over previous year	-0.0012 (-1.12)	-0.0013 (-4.29)***
Change in NRP (output tariff rate) lagged by one year	-0.0016 (-1.89)*	-0.0008 (-2.94)***
Change in NRP (output tariff rate) lagged by two years	-0.0024 (-3.44)***	-0.0003 (-1.32)
Change in Import intensity	-0.146 (-3.06)***	-0.084 (-4.85)***
Change in Export intensity	-0.056 (-1.15)	-0.016 (-1.14)
Change in R&D capital stock share in total capital stock	0.426 (1.34)	0.217 (1.65)
Change in Royalty-sales ratio	0.224 (2.17)**	0.090 (1.59)
Change in firm size	0.717 (39.50)***	0.218 (34.59)***
Constant	-0.178	-0.009
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Wald chi-square (p-value)	4939.7 (0.000)	7211.9 (0.000)
No. of instruments	118	118
AR(1) (p-value)	-13.5 (0.000)	-15.7 (0.000)
AR(2) (p-value)	-1.32 (0.187)	0.52 (0.606)
Sargan test of over-identifying restrictions, statistic and p-value	194.2 (0.000)	140.7 (0.004)
No. of observations	29602	29602

Note: Dependent variable: ln TFP. For explanatory variables representing firm characteristics, one period change is taken. t-values in parentheses. Model estimation done by two-step system GMM. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' computations

In Table 7, the coefficient of firm size variable is positive and statistically significant. This is in agreement with the estimated coefficients of dummy variables for small and medium size variables in Table 5 and in Tables 1-4. These results indicate a positive relationship between firm size and TFP.

3.4 Does the Initial Level of Technical Efficiency Influence the Impact of Tariff Cuts?

This section is devoted to the question whether the initial period technical efficiency (TE) level of a firm influences how its TFP is impacted by trade liberalization. As argued in the introductory section of the paper, the beneficial effect on TFP may be lesser for a firm that has relatively low technical efficiency in the initial period because the observed low level of technical efficiency might be an indication of lack of managerial capabilities or other handicaps being faced by the firm. However, there is the other possibility that a firm with low technical efficiency may have to make greater efforts to meet the challenges of import competition and therefore the increase in TFP achieved following trade liberalization may be greater for such a firm than that a firm which had a relatively higher technical efficiency in the initial period.

To investigate this issue, technical efficiency has been estimated for the years 1995, 1996 and 1997 using stochastic frontier production function using the two-input (value added) model. The average of technical efficiency of the firms for this period is taken (some cases of average of three years, some other cases average of two years or the figure for only one year for which estimate could be made, depending on the availability of data). The firms for which technical efficiency could be computed for the period 1995 to 1997 have been considered for further analysis. Thus, the firms that enter later in the dataset are excluded.

For the select set of firms mentioned above, equation (3.3) given in the previous section has been estimated. The bottom one-third and top one-third of the firms ranked in terms of initial period technical efficiency are considered for the analysis. The results are shown in Table 8.

The coefficient of tariff rate is found to be negative for both groups of firms. However, the coefficient is statistically significant for only one group, viz. the firms that had relatively low technical efficiency during 1995-97. Also, the numerical value of the coefficient is greater for this group of firms. Thus, the results indicate the effect of tariff cuts on TFP was greater for the firms with low initial period technical efficiency. The implication is that trade liberalization has a bigger productivity enhancing impact on firms which had a relatively lower productivity in the initial period than the firms which had relatively higher technical efficiency. In other words, trade liberalization had an effect that will work towards productivity convergence among manufacturing firms.

Table 8: Output Tariff and TFP, Manufacturing Firms, 2001-2010, Regression Results

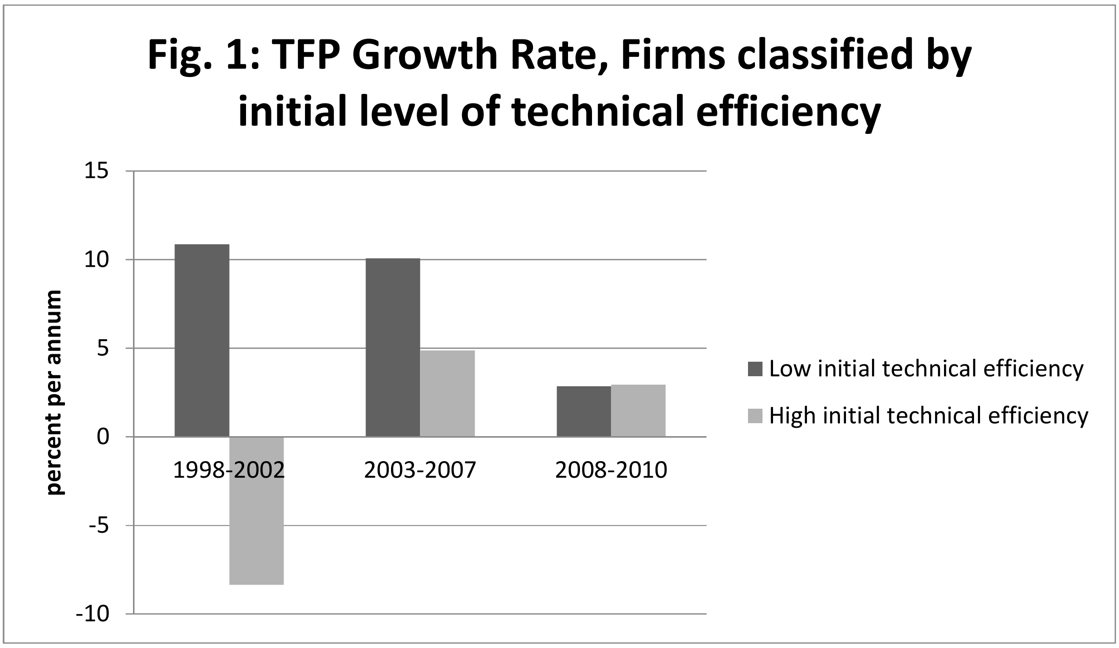
Explanatory variables	Value added function based TFP	
	Firms with relatively low technical efficiency in the initial period: Regression-19	Firms with relatively high technical efficiency in the initial period: Regression-20
NRP (output tariff rate) lagged	-0.0048 (-2.96)***	-0.0026 (-1.42)
Small firm dummy	-0.146 (-2.61)***	-0.249 (-2.67)**
Medium firm dummy	-0.030 (-0.72)	-0.086 (-2.06)**
Import intensity	0.253 (1.51)	0.401 (2.16)**
Export intensity	0.183 (1.29)	0.114 (0.71)
R&D capital stock share in total capital stock	0.727 (1.00)	0.460 (0.93)
Royalty-sales ratio	0.263 (0.92)	-2.054 (-1.32)
FDI firm dummy	0.236 (2.43)**	0.128 (0.92)
Constant	-0.349	0.087
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
R-squared	0.033	0.016
F value and (Prob.>F)	22.4 (0.00)	10.4 (0.00)
No. of observations	6565	6565

Note: Dependent variable: ln TFP. t-values in parentheses. Robust standard errors, corrected for clustering at 3-digit industry level. *** p<0.01, ** p<0.05, * p<0.1.

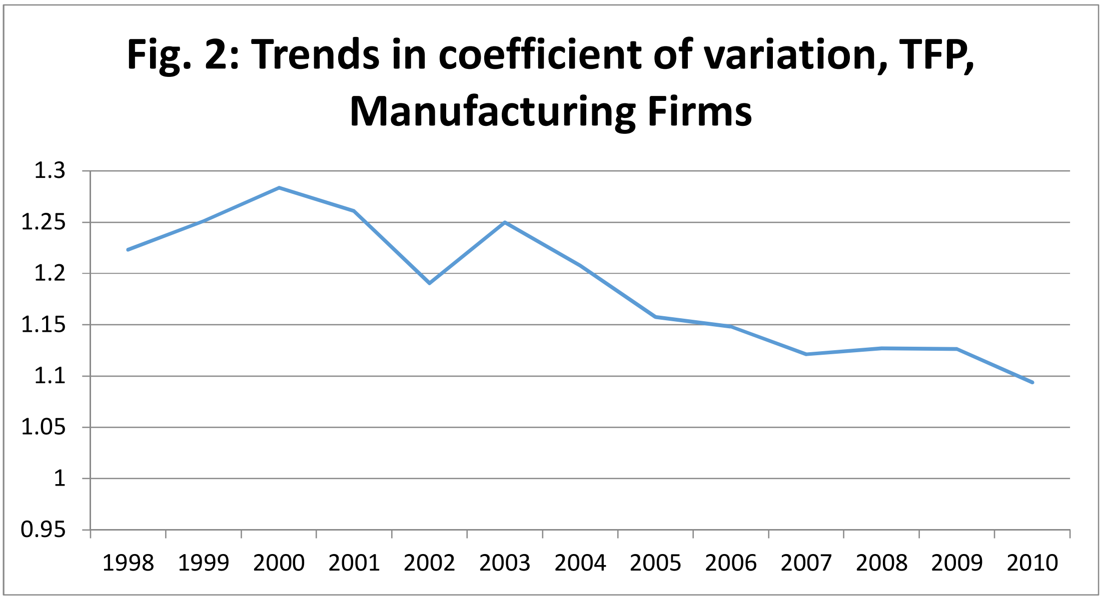
Source: Authors' computations

It may be pointed out here that the average rate of TFP growth during 1998 to 2010 was relatively higher among those firms that had relatively lower technical efficiency in the initial period of 1995-1997. This may be seen from Figure 1. A comparison is made between the bottom one-third and top one-third of firms ranked according to technical efficiency during 1995-1997.

Because the average growth rate in TFP was relatively higher among firms that had relatively lower technical efficiency in the initial period, this has led to a fall in inter-firm dispersion in the level of TFP. The coefficient of variation had a downward trend. This may be seen from Figure 2.



Note: TFP estimates based on value added function are used.
Source: Authors' computations.



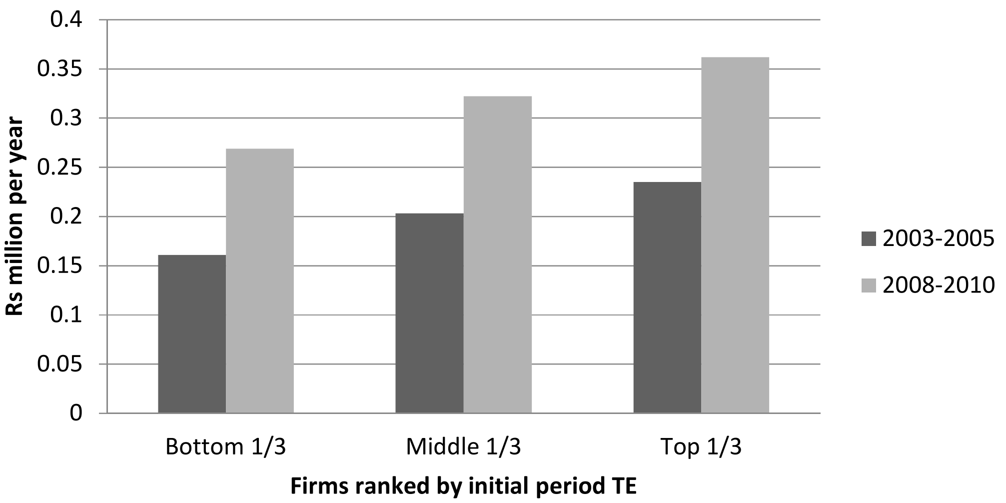
Note: TFP estimates based on value added function are used. Analysis is confined to those firms for which technical efficiency for 1995-1997 has been estimated.

Source: Authors' computations.

An interesting issue to be examined next is how these developments have impacted the wage rate in manufacturing firms. One difficulty in analyzing this issue is that data on actual employment is available only for a small sub-set of firms. For those firms, wage rate has been computed for different years by dividing total compensation paid to employees by total number of employees. Average wage rate during 2003-2005 and 2008-2010 (at current prices) in three groups of firms classified according to their initial period level of technical efficiency is shown in Figure 3. It is seen from the figure that the firms that have higher level of technical efficiency are paying higher wage rate to their workers. A positive correlation between the two variables is indicated.

It should be pointed out that wage rate has increased over time in all the three group of firms – bottom one-third, middle one-third and top one-third according to the initial period technical efficiency (TE). The growth in wage rate was slightly higher in the firms with low initial period technical efficiency, leading to a slight decline in wage inequality among firms. Wage rate in the top one-third firms as a ratio to the wage rate in bottom one-third firms was 1.46 during 2003-2005, which came down to 1.35 during 2008-2010.

Fig. 3: Wage rate, manufacturing firms



Note: Analysis is confined to those firms for which technical efficiency for 1995-1997 has been estimated. Only a small portion of these firms have reported actual employment data. Wage rate has been computed for those firms and average wage rate has been obtained.

Source: Authors' computations.

4. Conclusion

Using firm-level data for about 6000 manufacturing firms drawn from *Prowess* of the CMIE, the paper analyzed the impact of trade liberalization on productivity of manufacturing firms in India. A good deal of care was taken in the measurement of TFP. Based on Levinsohn and Petrin (2003) methodology, and two specifications of the production function (namely, gross output and value added, estimated separately for each two-digit industry), estimation of firm-level TFP estimation was done, with care taken in the measurement of output and inputs.

Econometric models were estimated to examine the impact of changes in tariff and non-tariff barriers on TFP in manufacturing firms in India. Estimation followed the fixed effects model, and the system GMM estimator for the dynamic version. The main explanatory variables considered for the econometric models are output tariff rates, input tariff rates, and quantitative restrictions. Control variables included several firm characteristics such as firm size, FDI and import intensity.

The results revealed a significant negative effect of tariff rate on TFP (corroborating the findings of a large number of earlier studies on the topic in question undertaken for India in the past, including Topalova and Khandelwal, 2011 and Das, 2016), implying thereby that import liberalization in India had a positive effect on TFP of Indian manufacturing firms. Also, it appears from the results that lowering of output tariff had greater beneficial impact on TFP of Indian manufacturing firms than the lowering of tariff on inputs. This finding is at variance with the findings of several earlier studies undertaken for India. An explanation of the divergence in findings might lie in the fact that the present study covers a more recent period when the QRs have been almost entirely removed and tariff rates have been brought to very low levels.

The analysis presented in the paper revealed that the firms that had relatively low technical efficiency during 1995-1997, experienced in the subsequent period, i.e. during 1997-2010, a bigger beneficial, productivity enhancing impact of trade liberalization. This had a dampening effect on the inter-firm dispersion in TFP and in wage rate.

Some of the other findings are: (a) import intensity of firms is found to have a positive effect on firm productivity, and (b) a positive effect of R&D, royalty expenditure and FDI on firm productivity is found.

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