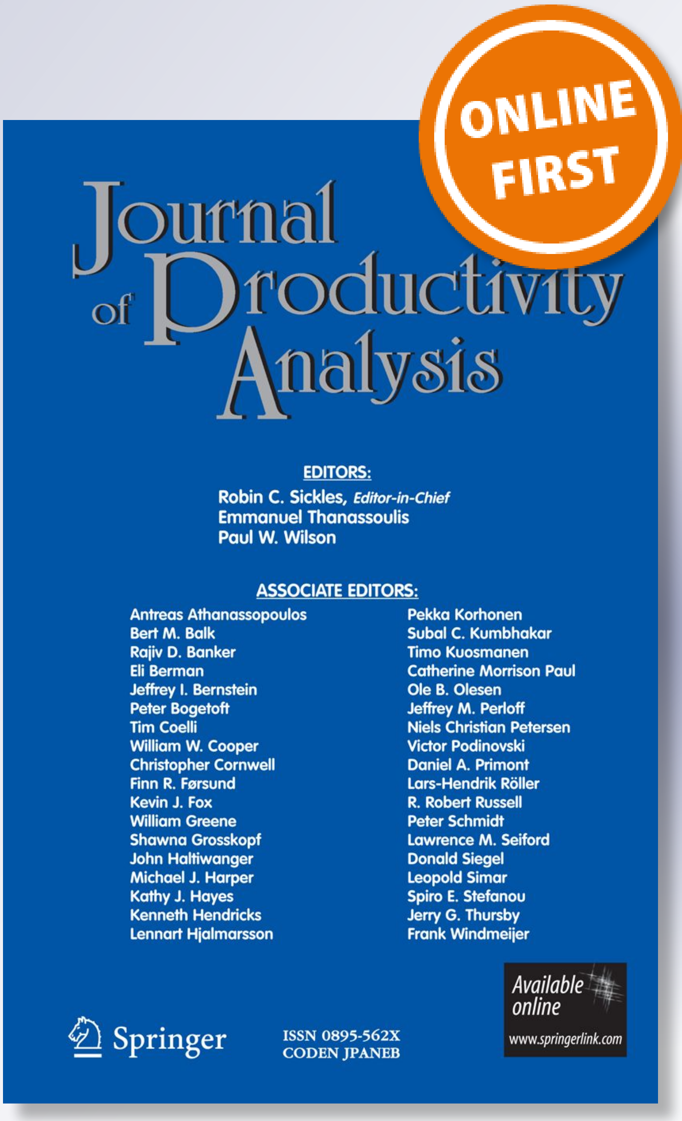
Market imperfections, trade reform and total factor productivity growth: theory and practices from India

Dibyendu Maiti

Journal of Productivity Analysis

ISSN 0895-562X

J Prod Anal
DOI 10.1007/s11123-012-0313-z



Springer

J Prod Anal
DOI 10.1007/s11123-012-0313-z

Market imperfections, trade reform and total factor productivity growth: theory and practices from India

Dibyendu Maiti

Abstract The study investigates how market imperfections distort the impact of trade reform on productivity growth. As the trade expands it influences both product and factor prices and if the distortions arise due to these market imperfections are not eliminated, the usual estimate of total factor productivity growth, using the growth accounting method, would be misleading. Theoretically, it shows that the usual estimate tends to be overestimated in the export competing sector and underestimated in the import competing sector. A modified approach of Olley–Pakes and Levinsohn–Petrin methods involving three-digits industries over the fifteen major Indian states during the period 1998–2005 has been used to deal with the simultaneity issue of factor choice and market distortions for the better estimate. A positive and significant impact of openness on the productivity growth has been observed only when the market imperfections are eliminated. Moreover, the modified productivity growth, after controlling market imperfections, has turned out to be lower than that of the usual estimate in India.

Keywords Trade reform · Solow residual · TFPG · Union bargaining · Mark-up

JEL Classification D24 · F16 · L11

D. Maiti (✉)
School of Economics, Faculty of Business and Economics, The University of the South Pacific, Suva, Fiji
e-mail: mdibyendu@yahoo.com

D. Maiti
Institute of Economic Growth, University of Delhi, New Delhi, India

1 Introduction

Most of the countries in the world, irrespective of their developmental stages, have pursued more liberalized policies during the last couple of decades and, since then, academicians and policy makers have been pursuing research to understand the implications of such reforms on their respective growth and development. Total factor productivity growth (TFPG),[1] which represents a level of technological shift of production frontier in an economy, is considered to be the best proxy to account for the impact of such policy changes. The previous experiences show that an economy may register a low level of productivity growth even when the economy growth of the country is accelerating.[2] It seems to be suggesting that the growth of an economy is not necessarily driven by a shift of the technological level. India has witnessed a gradual removal of trade and industrial restrictions during the last two decades for the sake of deriving substantial gain in the efficiency, productivity, competitiveness, and diversification of Indian industries through various channels under more liberalized settings from closer contact with the foreign markets. The reforms have lifted up the growth rate from a lower level (i.e., known as the '*Hindu*' Rate) to a level nearer to two digits, particularly on the industrial front (Rodrik and Subramanian 2004). Then, the immediate question is—what is the true level of productivity growth

[1] It essentially means the residual growth that is not explained by the growth of inputs used in production, and the growth depends on the level of technological improvement, efficient and intense use of resource in the economic activities.

[2] For example, Young (1992) found a low level of TFPG in Singapore, using a growth accounting exercise, when the per capita income of the economy rose from third world levels to those of industrialized levels during 1970s and 1980s.

Published online: 12 September 2012

of Indian economy during the post-reforms period and did the trade reforms significantly contribute to the productivity growth? Intuitively, it is assumed that the trade reform raises productivity growth and the higher productivity growth plays an instrumental role in achieving a higher growth rate during this period. But, the empirical studies did not find a unanimous answer so far. This may be because of various traditional methods and techniques used in their estimations. A number of studies find that the productivity growth of the industrial sector has improved during the post-reform period initiated in the late 1980s and early 1990s. In contrast, there are other studies which do not find an encouraging figure of the growth during the same period. These contrasting results have motivated us to investigate the estimation procedure by looking into more disaggregated information and using better methodology.

The most popular way of TFPG estimation, like the Solow residual, rarely pays attention to the market conditions of the concerned sectors, and, hence, a bias is expected to be observed in the estimated figures. Trade reforms promote competitiveness both in the national and international markets as well as produce spillover effects within a liberalized environment of an economy and thereby it may lead to a rise in residual growth driven by a technological change in the industrial sector. But, such reforms could change the residual growth by artificially influencing the market price without changing a true level of technology and this issue is grossly ignored in the literature. If so, the estimated figure of TFPG after reforms cannot be unbiased. For example, the foreign competition usually reduces the product market price of an import competing sector and, thus, the residual growth is expected to be declining in the sector. Such change in product market conditions would likely to transmit further to the labor market, leading to a change in the bargaining position of workers. Such logical link and explanation are available in Rodrik (1997) and Blanchard and Giavazzi (2003). These factors would influence the rate of residual growth on opposite directions and the net effect would ultimately depend on the relative strength of these two forces. If a loss from the drop of mark-up in the product market exceeds a gain from wage rent due to a reduction of bargaining power in the labor market, the residual growth of a production unit would decline without making any change on the technological front. The effect of competition on productivity growth, therefore, will be underestimated and the impact of trade reform would be misleading. This issue pins down to a problem of eliminating market distortions from the productivity estimation. To the best of my knowledge, two existing works have dealt with the market imperfections empirically till to date and have shown the implication of trade reforms on productivity growth in the Indian context (Krishna and Mitra 1998; Balakrishnan et al. 2006). According to the later one, in particular, the trade reforms made a significant reversal of competitiveness in the industrial sector, resulting in an improvement of productivity growth in Indian industries. But, they have failed to account for the labor market imperfections and its implication on the residual growth in response to the increased foreign competition. This is more important to study when the Indian labor market in the organized sector is known to be highly protected and unionized. *Second*, the trade reform might enhance competitiveness in the import competing sector, but not necessarily in the export competing sector. Therefore, the reform on the residue of these two sectors might work exactly on opposite directions. Unless these distortionary effects are controlled neither the estimate of productivity growth would be true nor the effect of trade reform on it would be correct. The present work attempts to address these two issues, theoretically and empirically, based on the contemporary Indian experiences. An attempt here is made to estimate an unbiased productivity growth by eliminating the market distortions from residual change and to study whether the trade reform significantly raises the productivity growth.

Theoretically, a single domestic firm is assumed, for simplicity, to produce a commodity using unionized workers. If both producer and worker have economic power over their respective payoffs, the firm pushes up the mark-up in response to an export sector reform and, thereby, raises the demand for labor. This increased demand offers a scope to the union to raise their wage rent. These two factors would work on opposite directions on the residual growth. As the expansion of exports impacts the labor market indirectly, through the product market changes, the benefit of workers from wage rent tends to be lower than that of the producer. If so, the usual TFPG would be overestimated. On the other hand, in response to the withdrawal of trade restrictions, if a foreign firm enters into the domestic market and competes with the domestic firm using a simple Cournot game in the product market, it reduces the producer's gain, followed by a drop of wage rent due to a decline in the market share of domestic firm. If the producer cannot shift the entire burden of product market competition to the labor market, the residue would surely decline and the usual productivity growth would be underestimated.

This paper empirically estimates a modified TFPG after controlling market imperfections. In a recent work, Abraham et al. (2009) developed a methodology to decompose the cost-price margin of Belgium firms into mark-up and wage rent. But, the paper provides neither a modified estimate of productivity growth nor sound reasons for distortions due to trade reforms therein. Although the simultaneity issue in the productivity estimation with the input choices has appeared to be an important concern in the contemporary literature, the above-mentioned paper has only dealt with this traditionally by using an investment proxy. However, this has been criticized by several scholars in the recent period (e.g., Levinsohn and Petrin 2003) on the ground that the investment figure is always underreported by firms and is practically zero for a sizeable number of firms in a sample of any country. Levinsohn and Petrin (2003) instead used the intermediate input as a substitute of the investment proxy for the same. With a bit of modification of both the methods, this paper has estimated the corrected TFPG using disaggregated industry data, at the three-digits level, over the fifteen major Indian states for the period 1998–2005. We observe that the trade openness does significantly influence market conditions and, therefore, the conventional estimates have been found biased. Moreover, the modified TFPG is found to be much lower than the usual estimates. We find an insignificant impact of trade openness on the usual productivity growth when market distortions are not eliminated. Controlling these market distortions, we observe that the trade openness has influenced the productivity growth positively and significantly. The rest of the paper is organized as follows: in Sect. 2, a brief account of literature on the productivity growth in Indian context is presented and the Sect. 3 develops a theoretical framework. Empirical methods and results have been reported and discussed respectively in Sects. 4 and 5. Section 6 ends up with concluding remarks.

2 Literature

According to the Classical view, the gains from trade lay on the allocation of resources in which the country has comparative advantages. It, therefore, accepts that the trade can improve efficiency in resource use, leading to a gain in productivity growth. Some trade theories often criticize that such gain does not exist in the long-run on a continuous basis, because trade reform usually appears as one time policy shock in an economy. However, Grossman and Helpman (1990) show how trade reforms can continuously expedite innovation and technical diffusion and, thereby, promote the long-run growth on a sustainable basis. Competition is considered to be the prime source of the innovation (Aghion et al. 2005). Following this line of argument, a number of researches reveal that the reforms benefit productivity growth through various channels of spill-over effect, technology transfer and factor movement. But, the competition does not necessarily confine into the import sector. An exportable firm also faces competition in the international market which essentially helps innovation and product differentiation, leading to a productivity gain in the sector (Pla-Barber and Alegre 2007). Ultimately, this has become an empirical issue as to see now how the relationship between trade and productivity growth would work under a specific situation of any country. It is interesting to note that a positive relationship has not been always observed in the existing empirical works (Bhagawati 1988; Nishimizu and Page 1990; Tybout 1992).

Empirically, the productivity growth estimated by using various methods (both parametric and non-parametric) in the Indian context has not shown a uniform pattern. A number of studies find that the productivity growth is surged in the industrial sector after 1980s in India (Ahluwalia 1991; Unel 2003; RBI 2004). In particular, Unel (2003) argues that the productivity has grown at a higher rate in the post-reforms period than that in 1980s. Ray (2002) also finds similar pattern by using a non-parametric linear programming technique. This study applies Data Envelope Analysis (DEA) to construct the Malmquist productivity index. Kumar (2006) and Balakrishnan et al. (2006) further support this evidence later on. The improvement in allocative efficiency as well as technical change, in response to the competitiveness, is the responsible factor for the productivity growth from pre-reforms to the post-reforms period. Milner et al. (2007) uses a range of methods to see the effect of economic liberalization at the two-digit industry level and also finds an increase in TFPG on an average in all the major industries. According to these literature, a rise of competitiveness is directly and indirectly found to be the most influential factor behind the productivity rise. Recently, Madsen et al. (2009) estimate that TFPG rate increases annually from 1960–1990 to 1991–2005 in India by 1.1 percentage points. Li and Treichel (2012) rather find a moderate improvement of TFPG in India during the last three decades from an approximate level of 1 % in 1980 to 1.5 % in 2008.

On the other hand, there are some studies which do not find an encouraging figure of TFPG in the post-reforms period. The productivity growth of Indian industries reported in the studies undertaken by Goldar (2004) and Goldar and Kumari (2003) registers a drop in the post-reform period compared to the pre-reform period and this has been observed during the period when the economy has maintained consistently a higher growth rate, particularly in the industrial sector which has never happened in Indian economic history. The suboptimal uses of capacity and decreasing returns to technology have been considered some responsible factors behind this phenomenon in these literature.

Productivity growth has played an instrumental role in the development process of many developing countries including India and China during their take-off periods. In a recent study, Nin-Pratt et al. (2010) compare agricultural TFP growth and its components, using non-parametric techniques, between China and India. The study shows that the agricultural TFP growth started accelerating in China after 1979 and while in India after 1974. But, the Chinese sector clearly outperforms India's performance in the later period. The principle reason is that the agriculture in China has been benefited from more fundamental institutional and policy reforms in agriculture than that of India. Manufacturing growth has also helped to absorb labor and left a lower employment burden for agriculture, creating incentives for capital investment and technical change, which kept output per workers in agriculture growing at high rate.

The above-mentioned studies have not paid any attention to the market imperfection. In recent years, however, there has been growing interest to see the influence of market distortions on the TFPG (Hall 1988; Domowitz et al. 1988; Harrison 1994; Konings et al. 2001, 2005; Dobbelaere 2004) and they point out that the productivity growth, using the methodology invented by Solow (1957), has been found biased due to the product market imperfections. In the Indian context, Balakrishnan et al. (2006) have accounted for such influence of product market competition in the productivity calculation for the industrial sector. The study is of the opinion that there has been an improvement in the productivity growth in response to a rise in competition after trade reforms. But, they consider only a partial story of market imperfections and ignore simultaneity issues in the estimation.

3 Theoretical framework

Protection assigns a cost to produce and the reform would essentially relax such cost, leading to a different set of costs and benefits for the agents engaged in the production process. Thereby, it could change the residual growth of a production unit by influencing the market conditions without making any notable technological change. The growth accounting method (i.e., known as Solow Residual or *SR*) accounts for the unexplained part of output growth that is not contributed by the factors of production. The use of simple factor share multiplied by a change in the factor has been the tradition to deduct the explained part from the output growth, ignoring the market conditions. We shall now theoretically investigate how the trade reform impacts on the residual growth, separately in the export and import competing sectors, due to change in the market conditions which is not linked to any technological change.

3.1 Export sector reform

Let us assume a simple possible situation where a single domestic firm produces an output Q for an export market at the price $P = (a - Q)$. One unit of labor produces αQ units of output (i.e., $L = \alpha Q$) in the firm where α is the labor-output ratio. Moreover, a subsidy (i.e., τ) is received by the firm for each unit of exports. The firm produces with the use of domestic workers who usually form a union for better wage. In the labor market, the wage is determined by the Nash bargaining solution between the union and the firm. If the wage paid to each laborer is w and no other costs are observed, the equilibrium output and price are solved by using a two-stage game. The wage is determined in the first stage and output is solved by the firm in the next stage. It can be solved by using backward induction method.

The reform in the export sectors means a removal of export barriers (both tariff and non-tariff) and this leads to a rise in the export demand (i.e., rise of a). Moreover, the current discussion of WTO has been recommending a reduction of direct and indirect subsidy on exports (i.e., drop of τ per unit of output). While the former relates to a shift in demand, the later relates to a shift in supply. Given these assumptions, we can write the profit function of the exporting firm as follows:

$$\pi_{\max Q} = (a - Q + \tau - w\alpha)Q \quad (1)$$

Maximizing Q, we find that:

$$Q = \frac{(a + \tau - w\alpha)}{2} \quad \text{and} \quad L = \frac{\alpha(a + \tau - w\alpha)}{2} \quad (2)$$

If the wage bill represents the utility function of trade union given their bargaining power β, the Nash bargaining function can be written as $\Omega = (\mathrm{wL})^{\beta}(\pi)^{1-\beta}$. Substituting the values of Q and L and talking derivatives with respect to w, we get:

$$w^E = \frac{\beta(a + \tau)}{2\alpha} \quad (3)$$

The expression suggests that the union wage rises directly with the bargaining power. Moreover, it is also directly related to parameters of the export sector reform. While an export expansion would raise the union wage, a drop in export subsidy would reduce it.

Now, substituting (3) into (2), we find:

$$Q^E = \frac{(2 - \beta)(a + \tau)}{4} \quad \text{and} \quad L^E = \frac{\alpha(2 - \beta)(a + \tau)}{4} \quad (4)$$

In equilibrium, the output and employment are inversely related to the bargaining power. It is also interesting to note that both of them are directly related to either a or τ. Then, the price of the final good in the market will be:

$$P^E = \frac{2(a - \tau) + \beta(a + \tau)}{4} \quad (5)$$

The final price is inflated by the bargaining power of the union. More importantly, the price is directly related to a and τ. In other words, an export expansion increases production and also raises the price of product. On the other hand, a drop of export subsidy works on the price exactly in the opposite direction. Substituting these results, the *SR* can be represented as follows:

$$SR^E = \frac{2(a-\tau) - \beta(a+\tau)}{2(a-\tau) + \beta(a+\tau)} \frac{\Delta(2-\beta)(a+\tau)}{(2-\beta)(a+\tau)} \quad (6)$$

Now, we can write the following proposition:

Proposition 1: *(a) If* $\tau = 0$*, then* $\frac{\partial SR^E}{\partial a} > 0$ *and (b) for a given a, if* $\tau > 0$*, then* $\frac{\partial SR^E}{\partial \tau} \gtrless 0$ *iff* $\left(\frac{2-\beta}{2+\beta}\right) \gtrless \frac{\tau}{a}$.

Proof: From (6), we get:

$$SR^E = \frac{2(a-\tau) - \beta(a+\tau)}{2(a-\tau) + \beta(a+\tau)} \frac{(\Delta a + \Delta\tau)}{(a+\tau)} \quad (7)$$

(a) If $\tau = 0$, we find that $\frac{\partial SR^E}{\partial a} = \frac{(2-\beta)}{(2+\beta)a}$. As $\beta < 2$, then $\frac{\partial SR^E}{\partial a} > 0$.

Due to a reduction of export barriers, the overall export demand for the products rises. This pushes up the product price and mark-up. On the other hand, the increased demand for the product must raise the demand for labor. Thus, it essentially pushes up the union wage and, thereby, reduces the residue of firm. The net effect of these two forces on the residual growth would appear to be positive, because the export sector reform affects the product market at first and then it transmits to the labor market. As the bargaining power of workers is a fraction, they cannot derive the entire benefits generated from the export growth and, therefore, the wage benefit cannot exceed the producer benefit. Hence, the export growth after reform in the sector leads to an overestimation of the productivity growth, even if no technological change has taken place.

(b) For a given level of a, if $\tau > 0$, we find that $\frac{\partial SR^E}{\partial \tau} = \frac{(2-\beta)a-(2+\beta)\tau}{2(a-\tau)+\beta(a+\tau)} \frac{1}{(a+\tau)}$, where $\frac{\partial SR^E}{\partial \tau} \gtrless 0$ iff $\frac{\tau}{a} \lessgtr \frac{(2-\beta)}{(2+\beta)}$

If the subsidy received by the domestic firm declines per unit of exports, the marginal cost curve will be shifted upward, resulting in a rise of market price and, thereby, a drop of production. The reduction in production leads to a drop in the labor demand as well. This results in a wage decline. The price rise and wage fall together would raise the residue for each unit of production, but the drop of exports volume would hurt the producer because of a production decline. The net effect of subsidy cut, therefore, is ambiguous. However, if the share of subsidy relative to the overall demand is substantially small (i.e., lower than a critical value), the *SR* would decline in response to a subsidy cut.

3.2 Import sector reform

Gradual withdrawal of tariffs and other barriers on importable goods can be considered a major form of import sector reforms. The implication of this reform would work on the residual growth of a domestic firm in a different way. We assume that a single domestic firm produces an import competing good and faces union in the labor market. One foreign firm potentially can enter into the domestic market after tariff cuts and plays a Cournot competition with the domestic firm in the product market. The foreign firm produces abroad but sells in the domestic market by paying t per unit of imports as a tariff. For simplicity, we do not consider any other costs. Therefore, if the domestic firm produces q_1, the foreign firm imports q_2 and the demand function is $P = (a - q_1 - q_2)$, the profit functions for domestic and foreign firms, respectively, can then be written as

$$\pi_1 = (a - q_1 - q_2 - w\alpha)q_1 \quad \text{and} \quad \pi_2 = (a - q_1 - q_2 - t)q_2 \quad (8)$$

Solving both outputs, we get:

$$q_1 = \frac{(a + t - 2w\alpha)}{3}, \quad L = \frac{\alpha(a + t - 2w\alpha)}{3} \quad \text{and} \quad q_2 = \frac{(a - 2t + w\alpha)}{3} \quad (9)$$

Here, the domestic firm alone creates a demand for workers in the economy and the wage would be solved by using Nash bargaining solution between the domestic firm and the union. Substituting the volume of employment and output, both the union utility and profit of firm can be derived easily. Then, the equilibrium wage would be:

$$w^M = \frac{(a+t)\beta}{4\alpha} \quad (10)$$

It implies that the union wage declines with a fall in tariff rate. Again substituting the equilibrium wage in (9), we find:

$$q_1^M = \frac{(2-\beta)(a+t)}{6}, \quad q_2^M = \frac{(4+\beta)a - (8-\beta)t}{12} \quad \text{and} \quad L^M = \frac{\alpha(2-\beta)(a+t)}{6} \quad (11)$$

The expressions (11) suggest that both output and employment at the domestic firm decline with the import tariff cuts and, hence, the import volume rises. It is to be noted that $t^* = (4 + \beta)a/(8 - \beta)$ is the prohibitive tariff rate. If $t > t^*$, the imports will be totally prohibited and the domestic firm would behave like a monopoly. If $t < t^*$, then the firm faces competition from the foreign firm. Substituting (11) into the demand function, the product market price can be written as follows:

$$P^M = \frac{(4+\beta)(a+t)}{12} \quad (12)$$

Here, the tariff cut increases competition in the domestic market and, thereby, depresses the product price.

Substituting all these figures, the residual growth can be written as:

$$SR^M = \frac{2}{(4+\beta)}\frac{\Delta(2-\beta)(a+t)}{(a+t)} \quad (13)$$

We can now write the following proposition.

Proposition 3: *If* $t < t^*$, *then* $\frac{\partial SR_M}{\partial t} > 0$.

Proof: When $t < t^*$, the foreign firm imports and SR changes can be represented as follows:

$$\frac{\partial SR_M}{\partial t} = \frac{2}{(4+\beta)}\frac{(2-\beta)}{(a+t)} > 0 \quad (14)$$

If $t < t^*$, the foreign firm enters into the domestic economy to sell the product and competes with the domestic firm. In the face of Cournot competition, the domestic firm is forced to reduce its market share. But, the total sale of the product would definitely rise by depressing the product price. On the other hand, a lower market share of the domestic firm leads to a decline in labor demand and resultant union wage. These two forces—lower product price and lower wage—together determine the residual growth of domestic firm, and the net effect of tariff cut appears to be negative on the residue. Similar to the previous explanation, as the producer cannot shift the entire burden of increased competition to the labor market, the producer's loss will be higher than that of workers. Therefore, the import competing sector seems to have a lower SR than a true technological growth.

4 Empirical framework

4.1 Estimation framework

The above theoretical conjectures are planned for investigation by using disaggregated level of information from Indian economy. A standard benchmark model with two production factors, labor and capital, is widely used in the literature. Let us consider a production function where value added Q_{ijt} of firm i over j th region and year t is produced using two inputs, namely labor L and capital K:

$$Q_{ijt} = A_{ijt}F(L_{ijt}, K_{ijt}) \quad (15)$$

If the production function is homogeneous of degree $1+\lambda$ for all input factors, the returns to scale would be $1+\lambda$. It would then exhibit, respectively, decreasing ($\lambda < 0$), constant ($\lambda = 0$), or increasing ($\lambda > 0$) returns to scale. By taking a total differential of (15) and log values, we get:

$$(q_{ijt} - k_{ijt}) - \varepsilon_{L,ijt}(l_{it} - k_{ijt}) = \lambda_{ijt}k_{ijt} + a_{ijt} \quad (16)$$

The left-hand expression in (16) represents the growth of output per unit of capital minus the product of labor elasticity and growth of labor per unit of capital. This essentially captures the residual growth which is the sum of capital growth explaining returns to scale ($\lambda_{ijt}k_{ijt}$) and unexplained random term (a_{ijt}). This unexplained term can be used as a proxy for the total factor productivity growth. Two practical problems for the estimation of a true TFPG from this equation arise here. *First*, the estimation of factor elasticity (i.e., labor) under imperfect market conditions is really difficult. In practice, the factor share is widely used as proxy of factor elasticity. Now, the question is: can we use the factor share, irrespective of market conditions in the product and labor markets, for the productivity estimation? *Second*, how to deal with a possibility of high correlation between random term and capital choice in the right-hand side of the equation that creates a simultaneity issue to find an unbiased estimate of productivity growth?

If one replaces labor elasticity by its relative share to the total value addition, two types of market distortions can be seen to appear in the estimated residual growth due to product and labor market imperfection. In the presence of product market imperfection, if $\mu = P/MC$ or mark-up levied on the top of marginal cost of production and s_L is the cost share of labor, the labor elasticity can be represented by the product of mark-up and labor share, i.e., $\varepsilon_L = \mu s_L$. *Second*, in the presence of both product and labor imperfections if the labor union wants to maximize either employment or wage with a bargaining power θ, the Nash bargaining solution would then provide a different relationship between labor share and elasticity that would essentially include bargaining term as follows: $\varepsilon_L = \mu s_L + \mu(s_L - 1)\theta/(1-\theta)$. The first term of the left-hand side captures the product market imperfection (influenced by the mark-up) and the second term captures labor market imperfection (influenced by the bargaining power). While the first term raises the labor elasticity for a rise in market power, the second term deteriorates the same for a rise in union power. Combining these two terms with some manipulation, we find the following regression equation for its estimation (see "Appendix").

$$SR_{ijt} = \beta_{ijt}LER_{ijt} + \frac{\lambda}{\mu_{ijt}}k_{ijt} + \frac{\theta_{ijt}}{1-\theta_{ijt}}BAR_{ijt} + (1-\beta_{ijt})a_{ijt} \quad (17)$$

where, $SR_{ijt} = (q_{it} - k_{it}) - s_{L,ijt}(l_{ijt} - k_{ijt})$, $LER_{ijt} = (q_{it} - k_{it})$ and $\beta_{ijt} = (p_{ijt} - MC_{ijt})/P_{ijt} = 1 - (1/\mu_{ijt})$ is the Lerner index. Since μ and β are directly related, SR rises with LER, if β is positive. $BAR_{ijt} = (\alpha_{L,ijt} - 1)(l_{ijt} - k_{ijt})$ indicating a negative value and it rises with either wage share or employment. Therefore, if $\mu > 0$ then SR_{ijt} rises with LER_{ijt} and if $\theta > 0$, then SR_{ijt} declines with BAR_{ijt} The expression (17) is our basic equation to be used for further analysis and allows us to estimate mark-up and wage rent simultaneously, without using information on marginal cost, market price and the alternative wage.

4.2 Method of estimation

In principle, both pooled and fixed effect panel regressions can be applied for the estimation of regression parameters in (17), but they are often criticised on the endogenety ground. A firm usually observes a part of TFPG before the selection of investment and factor of production. This raises a problem of simultaneity in the estimation. Thus, a simple regression result using Ordinary Least Square method would be misleading. At first, Olley and Pakes (1996, hereafter OP) raised this issue and offered an alternative estimation method (applied in Abraham et al. 2009). Then, Levinsohn and Petrin (2003, hereafter LP) revised this further. The OP method used firm level investment as a proxy for productivity shocks. However, it has a potential drawback in the cases where firms report zero investment. Due to the invertibility condition, this proxy is valid only for non-zero investment. Pronounced adjustment costs force most firms in developing countries like India, Turkey, Columbia, Mexico, and Indonesia to report zero investment. Therefore, it reduces number of observations substantially in the regression. The LP method suggests, thereafter, an application of intermediate inputs as a proxy for productivity shocks. Firms generally do not report zero level of intermediate input usage.

In this study, we apply both methodologies for robustness checking with a bit of modification. As per the requirement of OP method, a dummy variable (i.e., exit) has been created here which takes value one for those whose profits are positive, and otherwise it is zero. Moreover, gross fixed capital formation has been used as a proxy for productivity change when the OP method is used. On the other hand, both material and fuel costs are used as proxies for the same when the LP method has been run.

The estimation procedure of both approaches involves three steps to deal with the simultaneity problem and market distortions. We want to estimate average figure of regression parameters. At first, the disturbance term of a standard revenue function is broken into two parts—observed and unobserved term.

$$SR_{ijt} = \beta LER_{ijt} + \gamma k_{ijt} + \eta BAR_{ijt} + w_{ijt} + u_{ijt} \qquad (18)$$

where, $\gamma = \frac{\lambda}{\mu}$ and $\eta = \frac{\theta}{1-\theta}$

ω_{ijt} is the observed part and u_{ijt} is the random disturbance term. The expectation of future realisation of productivity growth (i.e., observed term) increases in its contemporaneous values of stock (log-capital) and proxy variables (material costs and fuels in LP and gross capital formation in OP, denoted as m_{ijt}). In other words, an unknown function for optimal decision of m_{ijt} can be written as $m_{ijt} = m_t(w_{ijt},k_{ijt})$. Inverting this function, we can write further as $w_{ijt} = h_t(m_{ijt},k_{ijt})$ and therefore, $\phi_{ijt} = \lambda k_{ijt} + h_t(m_{ijt}, k_{ijt})$ where the third order polynomials in m and k including constant term would represent a proximate form of this unknown function. Denoting the estimated variables as $\tilde{\phi}_{ijt}$ and substituting this into (18), we find

$$SR_{ijt} = \beta LER_{ijt} + \eta BAR_{ijt} + \tilde{\phi}_{ijt} + u_{ijt} \qquad (19)$$

Note that this equation is slightly different from the one used in OP and LP methods. At the first stage, this equation will be estimated and after that in order to go into the second stage, we define another variable as $V_{ijt} = SR_{ijt} - \hat{\beta} LER_{ijt} - \hat{\eta} BAR_{ijt}$. Alternatively, this equation can be written as follows:

$$V_{ijt} = \gamma k_{ijt} + g(\tilde{\phi}_{ijt-1} - \gamma k_{ijt-1})_{ijt} + v_{ijt} + u_{ijt} \qquad (20)$$

Again, g appears to be an unknown function and is approximated to third order polynomials of the variables for the estimation of this equation. This is a bit more cumbersome than the first-stage and the estimated v_{ijt} provides our modified figures of TFPG. Since the inference is based on non-linear technique of estimation, we use bootstrapping by 250 times.

Third step undertakes a regression of a set of explanatory variables (X_{ijt}) on the estimated residue from the previous stage for the determinants of productivity growth. The regression equation is written as follows:

$$v_{ijt} = a + bX_{ijt} + \kappa_i + \varphi_j + \varepsilon_{ijt} \qquad (21)$$

where, κ, φ and ε are respectively industry specific error, regional specific error and normal disturbance. The above-mentioned two-stage regression will be run for simple productivity growth estimation and all three-stage will be applied for the determinants of productivity growth.

4.3 Data description

We have gathered information on two digit industries for fifteen major states and for 7 years from 1998 to 2005. This information has been collected mainly from the *Annual Survey of Industries*, Government of India. The database includes capital stocks, investments, factor uses, outputs, value added and types of workers, and such information is available for major 15 states of India. It is noteworthy to mention that a major change of industrial classification took place in 1998 and hence, a perfect matching of NIC classifications (1998) at the three digits level with the previous classifications has been really difficult. Altogether, total observarions in the study are approximately 4536. Thus, our industrial statistics vary over time, and across region and industry.

Moreover, industry-wise trade data has been drawn from the *World Bank Trade Data-base* (World Bank 2006). This provides exports and imports figure at the ISIC 3 digit level of classification, and this is matched with the 3 digit NIC classification of *the Annual Survey of Industries*. Thus, our import and export variables vary across industries and over time (but not across states). Import and export figures are first multiplied by the exchange rate and then deflated by WPI for converting into real figures.

4.4 Results and discussions

We begin our discussion on empirical analysis by presenting a set of summary statistics. The industrial sector in India has performed well during 1998–2005 (Table 1). The industry-wise average value addition, capital stocks, and employment have been observed to be on the rise during this period. It is noteworthy to mention that the use of contract workers has increased at a substantially higher rate during this period.

4.5 Mark-up, bargaining power and TFPG

In order to estimate the mark-up and bargaining term of union at the industry level, the required variables like *SR*, *LER*, *BAR* and *k* have been constructed. Then, the model described in (20) has been run by using OP and LP methods separately and the results have been reported in Table 2. The estimated coefficients of these variables would provide the values of mark-up, bargaining power, and return to scale in Indian industries on an average combining all industries during 1998–2005. In both regressions, the coefficient of *LER* has been positive and statistically significant. From this estimated value, we derive the average value of mark-up (μ) over all industries and states, and they are 2.128 and 3.205, respectively, in OP and LP regressions. Hence, we can safely infer that the product market price in Indian organized industrial sector tends to be 2–3 times higher than their marginal cost of production, on an average. The coefficient of *BAR* has been negative and statistically significant in both regressions (see Table 2). From the estimated values, we derive the bargaining power of union and it registers almost 0.50 in both regressions. Therefore, we can conclude that the

Table 1 Summary Statistics

Heads	1998		2005	
	Mean	SD	Mean	SD
Output (Rs.)	5,717	1,260.6	8,426	1,776.7
GVA (Rs.)	1,445	387.8	1,844	415.0
Fixed capital (Rs.)	3,397	1,054.3	3,196	793.9
Workers (nos.)	8,078.0	2,1741.3	8,169.9	2,0524.5
Contract workers (nos.)	1,253.2	3,746.2	2,188.9	9,736.2

Figures in millions

Table 2 Mark-up and bargaining power in Indian manufacturing during 1998–2005

Variables	OP	LP
LER	0.535***	0.688***
BAR	−0.991***	−0.993***
k	0.811***	0.705***
Number of obs.	4246	4472
Wald-statistic	–	70.58
Estimation	Two-stage	Two-stage
Mark-up	2.128	3.205
Bargaining power	0.50	0.50
Return to scale	1.725	2.26

$SR_{ijt} = (q_{it} - k_{it}) - s_{L,ijt}(l_{ijt} - k_{ijt})$, $LER_{ijt} = (q_{it} - k_{it})$, $BAR_{ijt} = (\alpha_{L,ijt} - 1)(l_{ijt} - k_{ijt})$ and $y_{ijt}, k_{ijt}, l_{ijt}$ are respectively log value of value added, fixed capital and number of workers used. Methods used in variable constructions as well as calculation of mark-up, bargaining power and return to scale have been discussed on Sect. 4 at length. *** represents significant at 1 %, ** represent significant at 5 % and * represent significant at 10 %; *OP* Olley–Pakes method, and *LP* Levinshon–Petrin method

workers in the Indian organized industrial sector, on an average, combining all industries during 1998–2005, are almost equally powerful as the employer.

The estimated coefficient of *k* (i.e., log of capital) has been positive and statistically significant in both regressions, and from the coefficient one can easily derive the average value of return to scale in the Indian manufacturing Sector (i.e., λ). The returns to scale are 1.725 and 2.26, on an average, covering all industries and over all regions, respectively, in OP and LP regressions. This result clearly suggests that Indian firms in the organized sector exhibits an increasing return to scale during 1998–2005.

4.6 Trade, mark-up, and bargaining power

Now, we shall explore whether trade significantly influences the mark-up and wage rent of union in Indian industries. Building on our theoretical exercises, two interaction terms of *LER* variable and *BAR* variables, respectively, with log value of exports and imports have been added to the model. The interaction term of *LER* with exports would essentially account for a change of mark-up with the growth of exports. If the esitmated coefficient is positive, the growth of exports must have added to the mark-up. Similarly, the interaction term of *BAR* with log value of exports captures its impact on wage rent of the union. If the esitmated coefficient is negative, the growth of exports must have added to the union wage. The similar explanation is also applicable for imports as well. Two sets of regressions have been run for robustness checking—one with the interaction terms and another with control variables along with these interaction terms. The regressions

Table 3 Impact of exports and imports on mark-up and wage bargaining in Indian manufacturing during 1998–2005

Variable	Olley–Pakes method		Levinshon–Petrin method	
(1)	(2)	(3)	(4)	(5)
LER	−0.073	−0.120	−0.02	0.009
BAR	−1.044***	−1.048***	−1.062***	−1.055***
K	0.779***	0.821***	0.698***	0.734***
Export*BAR	−0.007***	−0.007***	−0.004	−0.006***
Export*LER	0.049**	0.046*	0.071***	0.049***
Import*BAR	0.013***	0.0134***	0.0122***	0.013***
Import*LER	0.026	0.034	0.018	0.037*
Export	–	–	–	–
Import	–	–	–	–
Contract labors	–	0.053**	–	0.077***
Share of managers	–	0.002***	–	0.002***
Wald statistic	–	–	41.59	22.10
Number of obs.	4246	4246	3829	3183
Estimation	Two-stages	Three-stages	Two-stages	Three-stages

Same as in Table 2

results have been presented in Table 3. At first, these four interaction terms have been incorporated in the regressions and the results are reported respectively in columns (2) and (4). It shows that the estimated coefficient of interaction terms of *LER* with exports has been postive and statistically significant in both regressions. In other words, the growth of exports raises the residue of the concerned industries by pushing up its market price and that has resulted in a rise of the mark-up in the sector. Moreover, the estimated coefficients of interaction term of *BAR* with the exports have also been statistically significant and negative. It indicates that the exports expansion rasies demands for more workers and, thereby, the increased demand of workers has raised their wage rent, leading to a reduction of the residuals in the sector. Therefore, the export competing sector has gained surplus through a rise in the mark-up and lost a bit by paying higher wages to the workers.

On the other hand, if we look at the import competiong sector, the results have been quite different. The estimated parameters of interaction term of *LER* variable with imports have been statistically insignificant in both regressions. Hence, the impact of imports on mark-up is uncertain. However, the estimated coefficient of interaction term of *BAR* variable with imports has been positive and statistically significant. Thus, we can safely infer that the growth of imports increases competion for the domestic firm and reduces demand for workers. The lower demand has resulted in a reduction of wages paid to the workers in the concerned sector and led to a rise in the residue of the sector. But, the effect of the competition in the sector on price has been uncertain.[3]

Table 4 Growth of GVA, solow residual and revised total factor productivity in Indian manufacturing during 1998–2005

GVA	7.2
Workers	0.76
Fixed capital	3.12
TFPG	
1. Usual SR	1.04
2. OP method	0.46
3. LP method	0.58

Growth rate has been calculated by running simple trend regression controlling industry and state effects

Then, we include other two important factors, the contract workers and the share of entrepreneurs/managers, which are known to be robust explanatory factors for productivity growth in the contemporary world, in the regressions. Flexibility of the labor choices and growth of entrepreneurs/managers would definitely improve the productivity growth by creating condusive environment for technological improvement and skill formation. Incorporating these two additional explanatory variables, we run both OP and LP regressions, and the results have been reported respectively in columns (3) and (5). The sign and the significance level of the estimated parameters derived in the previous equation have not changed, even after controlling these two variables. The results discussed previously relating to the effect of trade reforms on mark-up and wage bargaining, therefore, stand valid. It can be concluded that unless the distortions due to the product and labor market imperfections are eliminated from the residual growth, a true TFPG cannot be estimated.

4.7 Trade and TFPG

In the previous section, we observe that the trade expansion after reforms has significantly affected the market conditions. During 1998–2005, the industry has grown in the economy on an average at 7.2 %, but the employment growth is very low. The usual TFPG has been found to be 1.04 % for the period (Table 4). The modified figures should not necessarily be lower than that of the usual TFPG. It could be greater or lower depending upon the relative strength of the mark up and wage rent. We find that the modified TFPGs have been 0.46 and 0.58 %, respectively, in OP and LP methods after controlling the market imperfections in the product and labor markets for the same

[3] The domestic firms in some sectors receive favorable treatment from other non-tariff barriers (like Anti-Dumping initiatives) in India (Maiti 2012). As a result, the domestic price is perhaps not reduced significantly with the rise of import competition. .

period. It is interesting to mention that the revised productivity growths in both methods have been almost half of the usual estimate. Therefore, the usual TFPG actually overstates the true level of technological change. As the mark-up in the export competing sector has increased significantly and has not declined in the import sector, the price rise dominates the overall effect in the economy. Hence, the elimination of these mark-ups has resulted in a decline of the residual growth, which represents the true level of the productivity growth.

In order to show the effect of trade reform on productivity growth, we create openness variable—the ratio of total trade (exports and imports) relative to total production. At first, the openness variable is regressed on the residual growth without considering interaction terms of market imperfections with exports and imports. The regression results have been reported in columns (2) and (3) in the Table 5. The openness has turned out to be statistically insignificant to explain the residual growth. When the same variable has been regressed on residual growth after controlling the interaction terms of *LER* and *BAR* variables, respectively with log value of exports and imports, the effect of openness (after the above-mentioned three stage regression) has turned out to be positive and statistically significant in both regression (see column (4) and (5) in Table 5). Therefore, the impact of openness on the productivity growth has been positive because of increased competition in domestic and export markets. This improvement takes places through the increased technology transfers, technical diffusion and other spill-over effects in the economy.

Table 5 Impact of openness on total factor productivity in Indian manufacturing during 1998–2005

(1)	OP (2)	LP (3)	OP (4)	LP (5)
LER	0.539***	0.701***	−0.073	−0.02
BAR	−0.991***	−0.99***	−1.044***	−1.062***
K	0.834***	0.71***	0.779***	0.698***
Export * BAR	–	–	−0.007***	−0.004
Export * LER	–	–	0.049**	0.071***
Import * BAR	–	–	0.013***	0.0122***
Import * LER	–	–	0.026	0.018
Openness	0.0008	0.0001	0.003***	0.083***
Wald statistic	–	61.04	–	61
Number of obs.	4,246	4,246	4,246	4,246
Estimation	Three-stages	Three-stages	Three-stages	Three-stages

Same as in Table 2

5 Conclusion

The present study develops a theoretical framework to see how trade reforms mislead the usual productivity growth (i.e., Solow residual) by simply changing the product and labor market conditions. The export expansion after reforms would likely to overestimate the usual productivity growth and the import sector reform leads to underestimate the same. Since the effect of trade reform hits the product market directly and then transmits to the labor market, the producers retain a larger benefit from the expansionary export sector reform and cannot shift the entire burden in the face of increased import competition.

The paper empirically investigates the impact of trade reform undertaken in Indian economy on the productivity growth during the last two decades. A simple modified method of the approaches provided by Olley and Pakes (1996) and Levinsohn and Petrin (2003) have been employed on disaggregated industrial data at the thee-digits level over 15 major Indian states during 1998–2005 to deal with both the issues of simultaneity and market imperfections in the productivity estimation. We find that the trade reform significantly raises mark-up and wage rent in the export competing sector and reduces wage rent in the import competing sector. The existing studies, therefore, provide wrong estimates of productivity growth because of the presence of significant market distortions in the economy. It is observed that while the usual estimate of productivity growth is 1.04 %, the modified estimates, after controlling the market distortions, account for almost half of that in both approaches. Moreover, the openness explains productivity growth significantly when the market imperfections due to the trade reform are controlled. It thus follows that the trade openness changes the market conditions and increases the productivity growth as well in the economy.

This paper adds to the literature in several ways. It theoretically shows how trade reforms affect the residual growth simply by changing market conditions which has nothing to do with technological change. The usual estimate of TFPG is likely to be overestimated in the export competing sector and under-estimated in the import competing sector. *Second*, the paper deals with both the simultaneity issue and market imperfections jointly to discover a modified estimate of productivity growth. *Third*, the true productivity growth appears to be almost half of the usual estimate. *Fourth*, the trade openness positively contributes to productivity growth only when imperfections have been controlled. The study has particular relevance to the current discussions on the reform policies relating to FDI flow into retail trading sector in India. This policy might increase the competition in the downstream market where the competition would likely to raise the producer's innovation effort and resultant productivity growth. On the other hand, such reform might also raise a bargaining position of corporate traders at the downstream market over suppliers and/or producers who rely on the existing and traditional marketing channels. The relative strength of buyer's power and vertical competition would effectively determine the actual level of innovation efforts. The net effect on innovation or productivity growth could, therefore, be theoretically ambiguous and is an interesting matter of further empirical investigation.

Acknowledgments I sincerely acknowledge the research grant (ref.: RP02/001/2008/RP) sponsored by the Indian Council of Social Science Research that helped in preparing this paper. I am grateful to Biswanath Goldar and D N Bhattacharyya for insightful suggestions in the previous version of the paper and also thankful to Poulomi Dasgupta for research assistance in this work. My sincere thanks also go to the editor and the anonymous referees of this journal for giving me some insightful comments in the earlier draft. Usual disclaimers apply.

Appendix

Let us consider the Cobb-Douglas production function where value added Q of a firm using labor L and capital K:

$$Q = AF(L, K) \tag{22}$$

The production function is homogeneous of degree $1 + \lambda$ for all input factors. By taking a total differentiation of (22) and logarithmic values we get:

$$(q - k) - \varepsilon_L(l - k) = \lambda k + a \tag{23}$$

Under perfection competition, the wage is paid according to the value of marginal product, i.e., $w = PMP_L$. Re-arranging the terms, we get that $\varepsilon_L = \frac{\Delta \ln Q}{\Delta \ln L} = \frac{wL}{PQ} = s_L$. Then, we get:

$$(q - k) - s_L(l - k) = \lambda k + a \tag{24}$$

Now, $(q - k) - s_L(l - k)$ is defined as SR.

Under imperfections in product market, the wage is paid according to their marginal revenue product, i.e., $w = MR.MPP_L$. If $\mu = P/MC$, then $\varepsilon_L = \mu s_L$. Assuming $\varepsilon_L + \varepsilon_K = 1 + \lambda$ and substituting then in (24), we can easily rearrange as follows:

$$(q - k) - s_L(l - k) = \left(1 - \frac{1}{\mu}\right)(q - k) + \lambda k + (1 - \beta)a \tag{25}$$

Under imperfections both in the product and labor markets, the labor union is assumed to have a bargaining power θ. $\bar{L}$ is the total workers and w_0 is the alternative wage for workers outside the firm. Nash bargaining equation is as follows:

$$\max_{w,L} \Omega = \left(Lw + (\bar{L} - L)w_a - \bar{L}w_a\right)^{\theta}(PQ - wL)^{1-\theta} \tag{26}$$

Differentiating with respect to wage and employment and then rearranging the terms, we get:

$$w = (1 - \theta)w_a + \theta\frac{PQ}{L} \tag{27}$$

$$w = \frac{\theta}{1 - \theta}\left(\frac{PQ - wL}{L}\right) + \frac{\partial(PQ)}{\partial L} \tag{28}$$

Now, we get $\frac{\partial(PQ)}{\partial L} = \frac{\partial(PQ)}{\partial Q}\frac{\partial Q}{\partial L} = \frac{P}{\mu}\frac{\partial Q}{\partial L}$ where $\mu = \frac{e_p}{e_p - 1}$ and $e_p = \frac{P}{Q}\frac{\partial Q}{\partial P}$.

Then, we find that

$$\varepsilon_L = \mu s_L + \mu(s_L - 1)\theta/(1 - \theta) \tag{29}$$

Combining (25) and (29), we find that

$$(q - k) - s_L(l - k) = \left(1 - \frac{1}{\mu}\right)(q - k) + \frac{\lambda}{\mu}k + \frac{\theta}{1 - \theta} \times (s - 1)(l - k) + (1 - \beta)a \tag{30}$$

References

Abraham F, Konings J, Vanormelingen S (2009) The effect of globalization on union bargaining and price-cost margins of firms. Rev World Econ 145(1):13–36

Aghion P, Bloom N, Blundell R, Griffith R, Howitt P (2005) Competition and innovation: an inverted U relationship. Q J Econ 20(2):701–728

Ahluwalia IJ (1991) Productivity and growth in Indian manufacturing. Oxford University Press, New Delhi

Balakrishnan P, Parameswaran M, Pushpangadan K, Babu SM (2006) Liberalization, market power, and productivity growth in Indian industry. J Econ Policy Reform 9(1):55–73

Blanchard O, Giavazzi F (2003) The macroeconomic effects of regulation and deregulation in goods and labor markets. Q J Econ 118(3):879–909

Dobbelaere S (2004) Estimation of price-cost margins and union bargaining power for Belgian manufacturing. Int J Ind Organ 22:1381–1398

Domowitz L, Hubbard RG, Peterson BC (1988) Market structure and cyclical fluctuations in U.S. manufacturing. Rev Econ Stat 70(1):55–66

Goldar BN (2004) Productivity trends in Indian manufacturing in the pre and post-reform periods. Working paper no. 137, Indian Council for Research on International Economic Relations, New Delhi. http://www.icrier.org/pdf/wp137.pdf

Goldar BN, Kumari A (2003) Import of liberalization and productivity growth in Indian manufacturing industries in the 1990S. Dev Econ 41(4):436–460

Grossman GM, Helpman E (1990) Trade innovation and growth. Am Econ Rev Papers Proc 80(2):86–91

Hall RE (1988) The relation between price and marginal cost in U.S. industry. J Polit Econ 96(5):921–947

Harrison AE (1994) Productivity, imperfect competition and trade reform: theory and evidence. J Int Econ 36:53–73

Konings JP, Cayseele V, Warzynski F (2001) The dynamics of industrial mark-ups in two small open economies: does national competition policy matter. Int J Ind Organ 19:841–859

Konings JP, Cayseele V, Warzynski F (2005) The effects of privatization and competitive pressure on firms' price-cost margins: micro evidence from emerging economies. Rev Econ Stat 87(1):124–134

Krishna P, Mitra D (1998) Trade liberalization, market discipline and productivity growth: new evidence from India. J Dev Econ 56:447–462

Kumar S (2006) A decomposition of total productivity growth: a regional analysis of Indian industrial manufacturing growth. Int J Product Perform Manag 55(3/4):311–331

Levinsohn J, Petrin A (2003) Estimating production functions using inputs to control for unobservables. Rev Econ Stud 70(1): 317–342

Li J, Treichel V (2012) Applying the growth identification and facilitation framework: the case of Nigeria. In: Li J (ed) New structural economics. The World Bank, Washington DC, pp 215–258

Madsen JB, Saxena S, James BA (2009) The Indian growth miracle and endogenous growth. J Dev Econ. doi:10.1016/j.jdeveco.2009.06.002

Maiti D (2012) Anti-Dumping, competitiveness and consumer welfare: a study on commodity prices with a special reference to India. SANEI Working Paper Series No. 12-07, South Asian Network of Economic Research Institutes, Dhaka, Bangladesh

Milner C, Vencappa D, Wright P (2007) Trade policy and productivity growth in Indian manufacturing. World Econ 30(2): 249–266

Nin-Pratt A, Yu B, Fan S (2010) Comparisons of agricultural productivity growth in China and India. J Prod Anal 33(3): 209–223. doi:10.1007/s11123-009-0156-4

Nishimizu M, Page JM Jr (1990) Trade policy and market orientation, and productivity change in industry. In: Melo J, Sapir A (eds) Trade theory and economic reform, North, South and East. Basil Blackwell, Oxford, pp 245–264

Olley S, Pakes A (1996) The dynamics of productivity in the telecommunication equipment industry. Econometrica 64(5): 1263–1297

Pla-Barber J, Alegre J (2007) Analysing the link between export intensity, innovation and firm size in a science-based industry. Int Bus Rev 16(3):275–293

Ray SC (2002) Did India's economic reforms improve efficiency and productivity? A non-parametric analysis of the initial evidence from manufacturing. Indian Econ Rev 37:23–57

Reserve Bank of India (2004) Report on currency and finance, 2002-03, New Delhi

Rodrik D (1997) Has globalization gone too far? Institute for International Economics, Washington D.C. http://bookstore.piie.com/book-store/57.html

Rodrik D, Subramanian A (2004) From 'Hindu Growth' to productivity surge: The mystery of the Indian growth transition. IMF Working Paper WP/04/77. International Monetary Fund, Washington DC

Solow R (1957) Technical change and the aggregate production function. Rev Econ Stat 39:312–320

Tybout JR (1992) Linking trade and productivity: new research directions. World Bank Econ Rev 6(2):189–211

Unel B (2003) Productivity trends in India's manufacturing sectors in the last two decades. IMF Working Paper, WP/03/22. International Monetary Fund, Washington DC

Young A (1992) A tale of two cities: factor accumulation and technical change in Hong Kong and Singapore. NBER Macroeconomic Annual. MIT press, Cambridge