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Economic reforms and manufacturing productivity: Evidence from India

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Abstract

Using data on 2-digit industry for 1981-2004, the study examines the association between growth in total factor productivity and economic reforms. Accordingly, we first compute industry-level productivity growth using advanced econometric techniques and thereafter ascertain the time frame over which economic reforms impact productivity. The evidence suggests that productivity growth is not reliably higher after reforms than prior to reforms. In addition, the findings indicate that it is primarily the interest rate channel that is important in explaining changes in productivity. Among macroeconomic policies, trade reforms and industrial delicensing appear to be instrumental in explaining productivity changes.

JEL classification: D24, L60, O47

Keywords: economic reforms; total factor productivity; Levinsohn Petrin; Indian manufacturing.

1. Introduction

A major focus of any structural reforms program is to put the country on a higher growth trajectory on a sustainable basis. A key component of achieving sustainable growth is to register consistent improvements in productivity. In fact, a significant body of literature has confirmed that the gap in income per capita between rich and poor countries is associated with large cross-country differences in total factor productivity (Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Howitt, 2000; Klenow and Rodriguez-Clare, 2005). Whether and to what extent such productivity differences can be traced to differences in manufacturing productivity remains an area of ongoing debate. Evidence on this count is far from unambiguous: some studies report manufacturing productivity as an important factor for differential economic growth across nations (Van Bart, 1993; Van Bart and Pilat, 1993; Dollar and Wolff, 1993), others find it to be much less relevant (Caves *et al*., 1982; Harrigan, 1999).

We employ the natural experiment of the economic reforms to examine the interface between economic reforms and total factor productivity (TFP) growth of industries at the two-digit level, using India as a case study. The production function is estimated following the methodology suggested by Levinsohn and Petrin (2003) so as to control for endogeneity problems that emanate from the simultaneous choice of inputs and productivity by the industry.

Studies on this aspect for India report changes in productivity (either improvement or declines) in the post-reform period, but do not quantify the period over which such productivity gains occur. Following from Aghion *et al.* (2005), since the pre-reform productivity (and consequently, the technological capability) of industries is expected to differ significantly, it seems likely that economic reforms would further magnify the productivity differentials. Accordingly, we explore the time period over which changes in productivity accrue to industries. In addition, we also introduce a set of industry-level variables to ascertain which set of factors play an important role in influencing productivity.

The choice of India as a case study rests on three considerations. First, India is presently one of the most important emerging economies with a rich history of industrial controls. These controls were introduced in the aftermath of independence in order to dovetail investment into desirable areas within a mixed economy framework through a process of industrial licensing. Second, like most developed economies, India has a large and diversified manufacturing sector. Over time, industries have tended to develop distinct characteristics, driven by a combination of regulatory policies as well as factors internal to the organization. The question therefore, remains as to what extent productivity varies across industries. Third, India has a rich history of industry-level database. The cross-sectional and time series variation in the data makes it amenable to rigorous statistical analysis and provides an ideal laboratory to examine the factors affecting growth in TFP and its interaction with economic reforms.

The study contributes to the extant literature in a few important ways. First, it expands the literature on industrial productivity in the context of an emerging economy.

The study of productivity is relevant because productivity is a catch-all measure of performance. Thus, productivity analysis may be pertinent to those involved in mergers and acquisitions issues, like industry practitioners and competition authorities. Also, to the extent that low productivity can act as an early warning signal, policy practitioners can utilize productivity measures as an additional monitoring instrument.

Second, the study is also related to the channels of monetary transmission. Following from the literature, we distinguish between the financial accelerator channel, in addition to the traditional interest rate channel, by constructing proxies that act as determinants of these channels. By regressing the productivity responses on a set of independent variables that acts as proxies for these channels, we are able to discern which sets of variables are influential in explaining the variation in manufacturing productivity response in the Indian case.

Third, the paper examines the role of institutions, focusing on labor laws in general and industry-level trade unionism, in particular. Besley and Burgess (2004), for instance, document that states with more pro-labor regulation had lower levels of manufacturing development. These states also exhibited higher levels of unionization. Sanyal and Menon (2005) also uncover evidence that state-level labor regulation variables such as number of labor courts, number of registered unions and number of mandays lost owing to labor disputes act as significant disincentives on firm location. Judged from this standpoint, it can be argued that the regulatory framework governing industrial disputes could be an important ingredient influencing industrial productivity, an aspect which the study seeks to explore.

Fourth, the paper also explores the micro and macroeconomic factors influencing productivity growth. Observers have highlighted the role of several factors, both at the microeconomic level such as industry size, capital intensity and leverage as well as macroeconomic level including trade, industrial and financial policies in influencing productivity growth, although none have considered these factors in a holistic fashion. By taking on board both the microeconomic (industry characteristics) as well as the macroeconomic factors, it provides a far more comprehensive picture of the reasons for productivity changes across industries than that considered by previous researchers.

The reminder of the analysis continues as follows. In Section 2, we provide an overview of the Indian industrial experience, as appropriate, and the position of this paper in that context. Section 3 describes the methodology to be applied in the empirical sections. Section 4 discusses data issues. Section 5 estimates the coefficients of the production function, from which the industry level productivity measures are calculated. Section 6 studies the determinants of manufacturing productivity and explores the interface between reforms and productivity. Contextually, it also highlights the role played by various industry-level factors. Section 7 concludes the paper.

2. Industrial policy and growth

The introduction of the concept of a socialist economy in the 1960s with its concomitant focus on poverty reduction, egalitarianism and social equality meant that the Federal government pursued highly restrictive policies with respect to trade, industry and finance. The process of transition towards self-reliance, driven to an overarching extent by concerns of 'export pessimism' amongst developing nations nested on the logic of heavy-industry oriented industrialization within a closed economy framework. Such a policy engendered the need for industrial licensing whereby firms had to apply for a license for setting up new units or for capacity expansion. In effect, the policy exerted multiple controls over private investment that limited areas in which private investors were allowed to operate and also determined the scale of operations, the location of new investments and even the technology employed. This was buttressed by a highly protective trade policy, often providing tailor-made protection to each sector of industry. The costs imposed by these policies have been extensively studied (Bhagwati and Desai, 1965; Bhagwati and Srinivasan, 1971; Mookherjee, 1995), and by 1991, a consensus emerged on the need for greater liberalization and openness.

The structural break engendered by economic reforms laid strong emphasis on enabling markets and globalization coupled with lower degree of direct government involvement in economic activities. The list of industries reserved solely for the public sector was gradually scaled down and reduced to three: defense aircrafts and warships, atomic energy generation and railway transport. The process of industrial licensing by the Federal government was abolished, except for a few hazardous and environmentally-sensitive industries. The requirement that investment by large houses need a separate clearance under the *Monopolies and Restrictive Trade Practices Act* to discourage the concentration of economic power was replaced by a new competition law that focused on regulating anti-competitive behavior.

The net effect of these measures was a modest improvement in industrial growth. From an average of 4% in the 1970s and around 6.5% in the 1980s, industrial growth averaged around 6% during 1991-2004, perhaps reflecting the effect of liberalization of various controls. Over the entire period beginning 1980 through 2004, industrial growth has been roughly of the order of 6.1% (Kohli, 2006).

Concomitant with the process of deregulation, there have also been attempts to ascertain when economic reforms have led to any perceptible changes in manufacturing productivity. Studies on this aspect are inconclusive, at best. Early studies documented a decline in growth in TFP during the 1970s and a turnaround (driven primarily by an increase in labor productivity) in the first half of the 1980s (Ahluwalia, 1991). These findings were echoed in several other studies (Ray, 2002; Krishna and Mitra, 2003; Pattanayak *et al*., 2003; Unel, 2003) which also reported improvements in TFP, post reforms. Others (Goldar and Kumari, 2003) have, however, uncovered evidence that economic reforms adversely impacted productivity. By way of example, Goldar and Kumari (2003) indicate a fall in the growth rate of TFP in Indian manufacturing from 1.9% per annum during 1981-1991 to 0.7% during 1991-98. Balakrishnan *et al*. (2000) and Srivastava (2001) also identify a slowdown in TFP growth in Indian manufacturing in the post-reform period. Contextually, using data on a sample of over 3500 firms covering both the pre- and post-liberalization period, Balakrishnan *et al.* (2006) find limited evidence in support of a move to a more competitive market structure.

The methodology of TFP computation in several of these studies however, exhibits certain shortcomings. To address this deficiency, we employ advanced econometric techniques to compute productivity and subsequently relate it to the set of factors, both at the industry and economy-wide level, to ascertain the factors influencing them.

The analysis which comes closest to the spirit of the present paper is Aghion *et al.* (2005). Using data on 3-digit manufacturing industries for 16 major Indian states covering 1980-97, they address the issue as to how technological capability of industries affects their response to a 'shock', defined as the trade liberalization in 1991. Although this shock was common across firms in the same industry; however, firms in different states in the same 3-digit industry varied in terms of their level of pre-reform productivity, which were taken as a proxy of their technological capability. The results demonstrated that state-industries with higher pre-reform technological capability exhibited greater increases in total factor productivity (TFP), following reform. The present analysis also seeks to decipher the response of industries to a shock. In contrast to Aghion *et al*. (2005) however, the 'shock' in the present case is the economic reforms program initiated in 1992.[2] Unlike their analysis however, our focus is on the productivity change across industries.

To anticipate the results, the evidence suggests that productivity improvements are reliably lower after reforms than prior to reforms. In addition, the findings indicate that both interest rate channel as well as financial accelerator channel is important in explaining productivity, although the relative importance of the various channels varies markedly. Besides, several macroeconomic factors such as trade policy and credit availability are found to be important in explaining productivity changes.

3. Methodology for productivity computation

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[2] The economic reforms program was initiated following measures announced in the Union Budget on July 24, 1991. Given that the Indian financial year spans from first day of April of a given year to the last day of March of the following year, the year 1991-92 has been taken to represents 1992, and likewise for other years.

The traditional approach for productivity measurement estimates a production function and subsequently utilizes the residuals not explained by the factor inputs (capital, labor) as a proxy for total factor productivity. However, when estimating the production function, it is important to account for the correlation between input levels and productivity, as profit maximizing firms respond to increase in productivity by increasing use of factor inputs. Therefore, methods that ignore this endogeneity such as OLS or the fixed effects estimator could provide inconsistent parameter estimates.

To address this deficiency, we employ a modification of the semi-parametric approach. This framework was originally suggested by Olley and Pakes (1996) and subsequently modified by Levinsohn and Petrin (2003). The methodology by Olley and Pakes enables consistent estimation of the coefficients of a production function, taking on board the two possible sources of bias, sample selection bias and a simultaneity bias.[3] The former problem is handled by modeling the exit decision.[4] The latter, on the other hand, is solved by inverting an investment function, which is affected by unobserved productivity (See, for instance, Petrin and Levinsohn, 2008).

Levinsohn and Petrin (2003) contend that the monotonicity condition required for the inversion of the investment function may not be valid due to capital adjustment costs. The monotonicity condition for investment is replaced by an equivalent requirement for an intermediate input function.

4. Database and sample

The basic source of the data is the Annual Survey of Industries (hereafter, ASI) database. The *Economic and Political Weekly* (EPW) has created a systematic, electronic database using ASI results for the period 1973-74 to 2003-04. Concordance has been worked out between the national industrial classifications (NIC) used till 1988-89 and that used thereafter (NIC-1970, NIC-1987 and NIC-1998) and comparable series for

[3] The selection bias refers to the fact that many firms would have left the market during the sample period. It is, therefore, reasonable to imagine that the unobservable productivity variable and the decision to leave the market are correlated, causing a potential bias. The simultaneity problem is related to the correlation between the unobservable productivity variable and the amount of inputs chosen by the firm.

[4] Given the data is at the 2-digit industry level, the issue of sample selection bias cannot be directly factored into account, since the exit of firms is unobservable.

various two- and three-digit industries have been prepared. From the database, the series on output and input (undeflated) has been extracted for various two-digit industries, aggregating a total of 23 industries.[5] Data have been culled out on several variables: gross value added, total persons engaged in industrial units (number of workers), number of factories, net income, gross fixed capital formation, loan outstanding, working capital, interest payments and value of intermediate inputs (separate series constructed for materials as also power and fuel).

The empirical section estimates a Cobb-Douglas production function having a measure of output as dependent variable and thee inputs as explanatory variables. The inputs are labor, capital and intermediate inputs. Following Levinsohn and Petrin (2003), two intermediate inputs are used as proxy variables for productivity. These include expenses on fuels and raw material expenditures. Labor is taken as the total number of workers in the firm.

Following Levinsohn and Petrin (2003), a real capital stock series *K* was constructed using the perpetual inventory equation, as given by the expression:

$$K_t = (1-\delta)K_{t-1} + I_t \qquad \textbf{(1)}$$

where I_t is investment and δ is the depreciation rate. Following Caselli (2005), the initial capital stock K_0 is computed as $K_0=I_0/(\mu+\delta)$, where I_0 is the value of investment series in the first year of its availability and μ is the average geometric growth rate for the investment series between the first year with available data (i.e., 1974) and 1980. We assume the value for the depreciation rate, δ of 5%, following earlier evidence for India (Unel, 2003).

Output is measured as gross value added, consistent with the literature (Ahluwalia, 1991; Goldar, 1986; Balakrishnan and Pushpangadan, 1994; Unel, 2003). One advantage of using gross value added rather than gross output is that it allows

[5] The list of industries (along with industry code) include: Food and beverage (15), Tobacco (16), Textile (17), Wearing apparel (18), Leather and footwear (19), Wood and straw (20), Paper (21), Publishing and recording media (22), Coke, petrol and fuel (23), Chemicals (24), Rubber and plastic (25), Other non-metallic minerals (26), Basic metal (27), Metal products (28), Machinery and equipment (29), Office, accounting and computer machinery (30), Electrical machinery (31), Radio, TV, etc (32), Medical equipment etc. (33), Motor vehicles etc. (34), Other transport equipment (35), Furniture (36) and Electricity, gas and water supply (40),

comparison between industries that are employing heterogeneous raw materials (Grilliches and Ringstad, 1971; Verner, 1998). Another advantage is that gross value added accounts for differences and changes in the quality of inputs (Salim and Kalirajan, 1999). Constant values were obtained by deflating all nominal variables by the WPI for separate industry groups, obtained from the Office of the Economic Advisor, Ministry of Commerce and Industry, Government of India.

5. Estimation of manufacturing productivity

The first step of the algorithm involves the estimation of the following partially linear equation:

$$y_{it} = \gamma_o + \gamma_l l_{it} + \gamma_k k_{it} + \gamma_c c_{it} + \gamma_e e_{it} + h_t(c_{it}, k_{it}) + \varepsilon_{it} \quad \textbf{(2)}$$

where lower case letters represent natural logarithms; y is output, l is labor, c is communications, e is intermediate inputs, k is capital and ε is the random error term. The function h(.) is estimated by a polynomial series expansion where terms up to the fourth degree of c_{it} and k_{it} are utilized.

The first step in the estimation allows one to obtain consistent estimates of the variable factor coefficients, γ_i and γ_e. Once these parameters are obtained, we compute the term:

$$y_{it}^P = y_{it} - \hat{\gamma}_l l_{it} - \hat{\gamma}_e e_{it} \quad \textbf{(3)}$$

This term is then regressed on a polynomial series in {c_{it}, k_{it}}. The fitted value from the regression is denoted as $\hat{\psi}_t(c_{it}, k_{it})$.

In the second step, consistent estimates for γ_k and γ_e are obtained through non-linear least squares applied to expression (4) as under:

$$y_{it}^P = \gamma_o + \gamma_e e_{it} + \gamma_k k_{it} + g[\hat{\psi}_{t-1}(c_{it-1}, k_{it-1})] - \gamma_o - \gamma_c c_{it} - \gamma_k k_{it-1}] + \xi_{it} + \eta_{it} \quad \textbf{(4)}$$

where ξ_{it} is the innovation term in productivity.

Table 1 presents the production function coefficients estimated through the Levinsohn-Petrin (L-P) algorithm, alongside the coefficients obtained through OLS methodology.

[Table 1. Estimation of production function parameters]

The estimates reveal that the coefficient on the freely variable input, labor, is higher under OLS method as compared to L-P procedure. Illustratively, under OLS, the coefficient on worker equals 0.241; the same under L-P method is 0.228, confirming the theoretical and empirical observations of Levinsohn and Petrin (2003). The bias in the coefficient on capital depends on the extent of correlation among the inputs and the productivity shocks. In this case, the estimates under OLS estimate are higher than that under L-P methodology.

Industry-level (natural log of) total factor productivity is computed as the difference between actual and fitted output, according as:

$$\omega_{it} = y_{it} - \hat{\gamma}_l \, l_{it} - \hat{\gamma}_k \, k_{it} - \hat{\gamma}_c \, c_{it} - \hat{\gamma}_e \, e_{it} \qquad \textbf{(5)}$$

Akin to Topalova (2007), we construct an index of productivity as the logarithmic deviation of an industry from the reference industry's productivity in the base year. More specifically, we subtract the productivity of the industry with the median log output in the base year from the estimated firm-level TFP.

Table 2 reports the summary statistics for the measure of TFP growth according to their status with regard to industry. Average productivity growth appears to be the highest in coke and the lowest for textiles; as many as 11 industries have average productivity growth in excess of the overall industry-wide productivity growth figure. Without loss of generality, the productivity growth numbers appear to be consistent with previous studies for India.

[Table 2. Descriptive statistics for productivity scores]

6. Determinants of productivity

6.1 What factors drive industry productivity?

This section examines the determinants of productivity. We classify the set of possible factors under three heads: the interest rate channel (IRC), the financial accelerator channel (FAC) and labor market characteristics (LMC). Table 3 provides the empirical definitions of the variables and the data source.

[Table 3. Variable description]

Under the first channel, we consider three variables: interest cost, investment and the fact as to whether an industry is in the traded sector. High (interest) cost industries are likely to be more sensitive to interest rate changes. If such costs act as a brake on investment, this is likely to manifest itself in lower productivity, indicating a negative coefficient on this variable. Second, investment-intensive industries will have higher capital stock in relation to output and the more sensitive will be the industry with respect to an increase in the cost of capital, which could dampen productivity. Finally, industries in the tradable goods sector might have better placed to access to foreign currency earnings. If diversification of sources of revenue impels them to raise productivity, this would suggest a positive coefficient on this variable.

The second channel is based on the financial accelerator theory. The first indicator is *leverage*. Levered industries are likely to encounter greater difficulties in obtaining new funds from the market. Based on this conjecture, we expect a negative influence of *leverage* on productivity. On the other hand, to the extent that leverage ratio is an indicator of borrowing capacity, more levered industries might be able to obtain loans at better terms, suggesting a positive coefficient on this variable. Second, industries with high *coverage* are expected to be more creditworthy and therefore, likely to exhibit higher productivity. Industries with higher working capital requirements have higher short-term financing requirements. If higher short-term financing requirements translate into higher (resp., lower) productivity, the coefficient on this variable is expected to be positive (resp., negative).

Finally, the size of an industry (*size*) is often used as an indicator for the degree of asymmetric information problems in lending relationships. Agency costs are usually assumed to be smaller for large industries because of the economies of scale in collecting and processing information. As a result, such industries are able to finance themselves directly through financial markets and are less dependent on banks. To control for the fact that size varies significantly across industries, we normalize this variable by defining it as the ratio of total number of workers in an industry divided by the number of factories.

The final variable is related to labor market features. If an industry is highly unionized, retrenchment could prove difficult. Trade union membership represents an important constituent of bargaining power of workers and it seems likely that highly unionized industries could exhibit lower productivity. To address this aspect, we include a variable *union*. A major limitation of this variable is that the number of trade union members is reported only from unions submitting returns. Moreover, submission of these returns is purely voluntary. As a result, these numbers could be under-estimates, since it does not take cognizance of the members of non-reporting unions. Notwithstanding these deficiencies, trade unionism is an important component of bargaining power of workers that helps steer the course of negotiations along a defined path.

Accordingly, we estimate the following equation for industry *s* at time *t* as given by (6):

$$TFPG_{s,t} = \alpha_1[IRC]_{s,t} + \alpha_2[FAC]_{s,t} + \alpha_3[LMC]_{s,t} + \alpha_4[YD]_t + \alpha_5[ID]_s + \nu_{s,t} \quad \textbf{(6)}$$

where *TFPG* is the industry-specific, time-varying measure of total factor productivity growth, obtained using the L-P algorithm; *IRC*, *FAC* and *LMC* are the set of variables under these three channels, as elucidated earlier. The inclusion of industry fixed effects (ID) absorbs unobserved heterogeneity in the determinants of productivity that are industry-specific, while the year dummies (YD) control for macroeconomic shocks common to all industries, although neither YD nor ID are reported in the regressions. Finally, ν is the error term.

[Table 4. Effect of industry characteristics on change in productivity]

Table 4 reports the results. We have, on average, data for 27.7 years for each industry, hence the maximum number of industry-years is 523. To ascertain the relative importance of each of these channels, models (1) through (3) sequentially incorporate the three channels before combining them together in Model 4. Throughout, the reported standard errors take on board the serial correlation in the data by keeping all observations that belong to the same industry together (i.e., clustered standard errors).

In the first set of regression, investment bears a negative sign, supportive of the fact that the interest rate channel plays an important role in affecting productivity. The coefficient on investment indicates that a rise in investment by 10% lowers productivity by around 1.5 percentage points. The magnitude is statistically significant at the 0.01 level. The coefficient on *interest,* conforming to *a priori* expectations.

On the other hand, the financial variable that seems to work more consistently with the financial accelerator hypothesis in explaining productivity growth is *coverage* and *size.* Illustratively, industries exhibiting higher coverage ratios are better able to contain the costs of capital, which is manifest in higher productivity. The coefficient on *size* is positive. The result is consistent with previous findings which suggests that productivity is higher in large firms (Snodgrass and Biggs, 1995; Lee and Tang, 2001; Nucci *et al*., 2006).

The third model examines the role of institutions, in particular, the role of trade unionism. The coefficient on the variable *union* is negative and statistically significant. The finding is in contrast with previous results for India, which report limited impact of institutional factors on productivity (Topalova, 2007), but is consistent with the contention that more unionized firms are less likely to exhibit productivity improvements in the long-run (Hirsch, 1997),

The final model (4) combines all the explanatory variables together in a single specification. Most of the earlier results carry over in this case as well. As well, in the fully augmented model, *leverage* bears a negative and significant sign, implying that levered industries could be constrained in accessing funds, which could adversely impact their productivity. The fit of the model is highest in this case: model (4) explains roughly 17% of the variation in the dependent variable.

6.2 Do economic reforms matter for productivity?

A significant body of literature in India notes that Indian manufacturing witnessed significant productivity gains, post-reforms, although several others report to the contrary. It does not, however, explore the time frame over which such changes occur at these enterprises. Illustratively, studies which report improvements in productivity after reforms simply note that productivity tended to be substantially higher after reforms than in the period prior to reforms. Others ((Srivastava 2001; Das 2003a; Kaur and Kiran, 2008) uncover evidence of a decline in TFP. Srivastava (2001) for instance report decline in TFP during the period 1990-91 to 1997-98 to 2% per annum as compared to 3.6% during 1980-81 to 1990-91. The estimates by Das (2003a) also suggest that TFP growth in post-1991 reform period to be either negative or in the range of 0-2% for most industries.

To investigate this further, table 5 presents the results of formal tests for changes in TFPG by industry around the time when economic reforms occurred. Two sets of results are reported. In one, the average levels of TFPG over one to five years following reforms [*POST* (5,1)] are compared with the average levels during the period of one to five years before reforms [*PRE*(1,5)]. In another, the average levels of TFPG over the period of one to ten years following reforms [*POST*(1, 10)] are compared with the average levels over the period one to ten years prior to reforms [*PRE*(10, 1)]. Since the pre-reform technological capability of different industries is expected to be significantly different, this would suggest that the time frame over which productivity gains accrue to industries could differ as well.

[Table 5. Univariate tests of productivity change: Pre- *vs*. post-reforms]

The evidence suggests that in the short-run, growth in productivity, on average, is higher after reforms as compared to that obtaining prior to reforms. In the small window case, across most of the industries, the TFPG in the one-to-five years after reforms exceeds that in the one-to-five years prior to reforms. The results are reversed in the long window case, wherein it is observed that TPFG after reforms is typically lower as compared to that obtaining in the pre-reform period. In neither the short nor the long window case are these differences statistically significant. Consider, for instance, basic metals industry. The TFPG in the one-to-five years prior to reforms is 0.082. This rises to 0.103, post reforms. In case of the long period, these corresponding numbers are 0.061 and 0.038, respectively. None of these differences are however, significant at conventional levels.

On balance, the evidence in table 5 appears to indicate that, over a long time span, productivity growth for key industries declines after economic reforms. The evidence however, does not control for the general level of economic activity before and after the economic reforms. They are therefore, not capable of distinguishing between changes in industry attributes arising from ordinary fluctuations in economic activity and those due to changes in attributes intrinsic to the industry.

To investigate this further, we perform a series of multiple regressions that enable us to detect changes in industry attributes occurring during economic reforms, while controlling for the economic environment. Accordingly, we include three indicator variables. The variable *PRE* equals one if the observation is one or five years prior to the year of reforms, else zero. The *Year0* variable equals one in 1992 (year of reforms) and zero, otherwise.[6] Finally, the variable *POST* equals one if the observation is for one to five years after the year of reforms, zero otherwise. Finally, we include the set of observable industry-level controls, as also industry dummies. We repeat the analysis

[6] The statement on industrial policy tabled in the Indian Parliament in July 1991 laid the framework for deregulation of the industrial sector. The comprehensive set of reforms were initiated over the next one-and-a-half years. Following from this logic, we consider the year 1992 (corresponding to the period 1991 April to 1992 March) as the year of reforms. The *Year0* dummy variable is based on this consideration.

using both the short and long window to ascertain the time span over which productivity gains accrue to industries.

[Table 6. Regression results: Productivity change and economic reforms]

As Table 6 shows, productivity growth does not exhibit any perceptible rise prior to economic reforms. The coefficient on *PRE* is not significant in Models (1)- (4). The evidence to suggest that productivity growth improves after reforms, at least in the short-run, is much more compelling, since the coefficient on *POST* is strongly significant in two of the four cases. The differences between the coefficients of *PRE* and *POST* are however, not statistically significant. Since all regressions control for industry dummies, this indicates that productivity changes are not reliably higher post economic reforms than during the period prior to reforms.

In the longer run, the evidence does not provide any conclusive evidence. Consider for instance Model (8). Although the coefficients on both *PRE* and *POST* are positive and statistically significant, the differences between these coefficients are not statistically significant, indicating that productivity improvements in the post-reform period are not statistically higher as compared to the pre-reform regime.

6.3 Reforms and productivity: A disaggregated look

A major focus of the reforms process in India has been the issue as to which set of reforms exerted a perceptible impact on productivity growth. A significant body of literature attributes the same to trade reforms (Krishna and Mitra, 1998; Chand and Sen, 2002; Das, 2003b; Topalova, 2007), whereas others focus on the importance of reoriented industrial policies (Kalirajan and Bhide, 2004); yet others point to the ease of credit availability as a crucial ingredient for improved productivity performance (Reddy, 2005). To explore this further, we examine the impact of each of these policies on productivity growth.

We include three sets of measures to capture the impact of the respective policies. Under trade policy, following Pursell (2007), we employ the nominal rate of protection (*NRP*) which captures the effect of lowering tariffs on output and intermediate inputs. If lowering NRP raises productivity growth, the coefficient on this variable would be negative.[7] Under industrial policy, following Aghion *et al*. (2008), we employ a dummy variable which equals one beginning from the year in which an industry was delicensed (*delicensed*), else zero. To the extent that delicensing of an industry is associated with improved productivity, a positive coefficient on this variable is expected. Finally, under financial policies, we employ the ratio of gross bank credit as a ratio to GDP (*credit*), with an expected *a priori* positive sign.[8] Data on gross bank credit are obtained from the Reserve Bank of India database (RBI, 2007). All regressions control for industry-specific features as also dummies to account for industry-level and business cycle considerations that are otherwise not accounted for in the analysis.

[Table 7. Regression results: Productivity change and macroeconomic policies]

The results are set out in Table 7. The coefficient on *NRP* is negative and significant at the 0.10 level with a point estimate of -0.005. In other words, higher protection rate lower productivity growth: a 10 percent rise in *NRP* lowers TFPG by roughly 0.05. The evidence concurs with studies on Indian manufacturing by Sivadasan (2006) and Topalova (2007), which indicates a beneficial impact of trade liberalization on productivity.

Next, we examine whether industrial policies have had a salutary impact on TFPG. In the second specification, the coefficient on *delicensing* is positive and strongly significant. This is in conformity with recent research which shows that delicensing played a major role in increasing productivity in India's formal manufacturing sector, resulting in significant productivity gains (Chari, 2009). The *credit* variable displays an observed positive sign, but is not statistically significant.

[7] Estimates of nominal rates of protection (NRP) for 1993, 1995, 2001 and 2004 have been extracted from Pursell (2007). It is assumed that the NRP remain unchanged during intervening years. See also Nouroz (2001)

[8] The data on deployment on gross bank credit (GBC) across industries does not exactly correspond with the industry names, since the data sources are different. As a result, it is not possible to obtain the GBC/GDP ratio for certain industries; hence the number of industries/ observations are lower when *credit* is employed as an independent variable.

Summing up, the analysis testifies that economic reforms have not had any perceptible influence on the growth in manufacturing productivity; the conventional interest rate variables besides the financial accelerator variables are relevant in explaining productivity differentials across industries. Importantly, among major economic policies, trade liberalization and delicensing seems to have been instrumental in productivity growth.

7. Summary and conclusions

The reforms exercise in India, undertaken as part of the overall restructuring since the early 1990s, was aimed at improving the growth prospects of the economy. Central to the process was improving the productivity in the manufacturing sector. Most studies on industrial productivity fail to account for the sample selection and simultaneity bias and therefore, arrive at misleading conclusions of productivity changes.

In this context, the present study employs advanced econometric techniques to compute productivity of Indian manufacturing sector since 1980 that encompasses the economic reforms program. Industry-level productivity measures were obtained as the difference between actual and expected output, where the latter is the fitted value from the estimation of a production function. The estimated production function follows from the strategy suggested by Levinsohn and Petrin (2003) to account for endogeneity problems.

In the second stage of the investigation, we evaluate the factors affecting manufacturing productivity. The evidence indicates that both interest rate channel as well as financial accelerator channel is important in explaining productivity change, although the relative importance of the various factors under each of the channels varies markedly. In particular, across these two channels, the investment and interest cost variables seem to exert a notable impact on productivity growth. The results indicate that among major economic policies, trade liberalization and delicensing seems to have played the most significant role in explaining productivity change.

We evaluate the period over which economic reforms are manifest in productivity changes. Here again, the evidence suggests that improvements in productivity are not reliably higher after reforms than prior to reforms. The results are remarkably robust. It is apparent in simple univariate comparisons as well as in multivariate regressions that control for industry and year effects. Judged thus, there seems to be a role for macroeconomic policies in impacting productivity in the post-reforms period. The Indian case is a testimony to this fact.

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Table 1. Estimation of production function parameters

	OLS	LP
Constant	1.570 (0.147)***	
Ln (workers)	0.241 (0.027)***	0.228 (0.077)***
Ln (fuel)	-0.100 (0.043)**	
Ln (raw materials)	0.358 (0.026)***	
Ln (capital)	0.443 (0.051)***	0.190 (0.049)***
Time period	1981-2004	1981-2004
Industry, N.Obs	23; 547	23; 547
Wald test:	21.86	14.66
Constant Returns to Scale	(0.00)***	(0.00)***

Standard errors in parentheses
***, ** and * indicate significance at the 1, 5 and 10% level, respectively

Table 2. Descriptive statistics for productivity scores

	N. Obs	Mean	Median	SD	Minimum	Maximum	25 percentile	75 percentile
All industries								
TFPG	523	0.046	0.041	0.202	-0.839	0.917	-0.056	0.151
TFPG by industry								
Basic Metals	23	0.052	0.060	0.197	-0.391	0.353	-0.100	0.170
Chemicals	23	0.057	0.051	0.119	-0.176	0.282	-0.024	0.118
Coke	23	0.099	0.097	0.413	-0.839	0.917	-0.008	0.386
Electricity	17	0.079	0.064	0.176	-0.043	0.391	-0.301	0.391
Electrical Machinery	23	0.023	0.020	0.157	-0.065	0.290	-0.065	0.290
Food	23	0.045	0.019	0.105	-0.100	0.288	-0.052	0.140
Furniture	23	0.043	0.070	0.326	-0.461	0.615	-0.302	0.615
Leather	23	0.032	0.043	0.298	-0.548	0.825	-0.074	0.134
Machinery & eqpt.	23	0.028	0.020	0.083	-0.158	0.254	-0.012	0.071
Medical eqpt.	23	0.038	0.034	0.189	-0.507	0.448	-0.047	0.448
Metal products	23	0.033	0.038	0.085	-0.140	0.233	-0.006	0.063
Motor vehicles	23	0.052	0.053	0.161	-0.230	0.412	-0.073	0.155
Office, accounting etc.	23	0.054	0.091	0.310	-0.664	0.760	-0.158	0.211
Other non-metallic min.(NMM)	23	0.042	0.041	0.148	-0.267	0.286	-0.039	0.149
Other transport eqpt.	23	0.045	0.049	0.178	-0.341	0.426	-0.026	0.162
Paper	23	0.024	-0.010	0.204	-0.371	0.400	-0.154	0.165
Publishing etc.	23	0.057	0.030	0.152	-0.156	0.556	-0.056	0.556
Radio, TV, etc	23	0.059	0.032	0.200	-0.363	0.477	-0.083	0.477
Rubber	23	0.071	0.051	0.142	-0.175	0.535	0.004	0.535
Textile	23	0.006	0.020	0.108	-0.182	0.269	-0.075	0.080
Tobacco	23	0.057	0.042	0.234	-0.446	0.829	-0.039	0.149
Wearing apparel	23	0.064	0.061	0.175	-0.140	0.566	-0.109	0.157
Wood	23	0.012	0.002	0.197	-0.605	0.388	-0.082	0.081

Table 3. Variable description

Variable	Notation	Empirical definition	Obs.	Mean	Std. Dev.
Interest rate channel (IRC)					
Capital intensity	Investment	Gross fixed capital formation/ gross value added	547	0.361	1.037
Tradable	Traded	Dummy=1, if an industry is in the traded goods sector, else zero	552	0.304	0.461
Interest cost	Interest	Interest payments/ gross value added	547	0.195	0.085
Financial accelerator channel (FAC)					
Leverage ratio	Leverage	Outstanding loans/ capital	547	0.965	0.501
Coverage ratio	Coverage	Net income/ interest payments	547	4.572	4.132
Working capital ratio	Working	Working capital/ gross value added	547	0.793	0.529
Average factory size	Size	Ln (Number of workers/ Number of factories)	547	4.009	0.796
Labor market channel (LMC)					
Trade unionism	Union	Number of employees listed as trade union members/ number of workers	547	0.201	0.195

Table 4. Effect of industry characteristics on change in productivity

	(1)	(2)	(3)	(4)
Constant	0.599 (0.091)***	0.173 (0.118)	0.041 (0.022)*	0.687 (0.305)**
Investment	-0.159 (0.055)***			-0.149 (0.058)***
Interest	-1.132 (0.180)***			-0.916 (0.219)***
Traded	0.329 (0.248)			0.374 (0.291)
Leverage		-0.042 (0.047)		-0.027 (0.014)*
Coverage		0.014 (0.005)***		0.004 (0.003)
Working		-0.045 (0.029)		-0.027 (0.034)
Size		0.053 (0.028)*		0.020 (0.011)*
Union			-0.121 (0.049)**	-0.084 (0.059)
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
R-squared	0.158	0.111	0.068	0.173
Period, industry	1981-2004	1981-2004	1981-2004	1981-2004
N. Obs; industry	523; 23	523; 23	523;23	523;, 23

Standard errors (clustered by industry) in parentheses
***, ** and * indicate significance at the 1, 5 and 10% level, respectively

Table 5. Univariate tests: Productivity change pre- *vs.* post-reforms

Industry group	Summary statistics	Small window		Difference: POST = PRE (*t*-test)	Large window		Difference: POST = PRE (*t*-test)
		PRE (-5,-1)	POST (+1, +5)		PRE (-10,-1)	POST (+1, +10)	
Basic metals	Mean	0.082	0.103	-0.193	0.061	0.038	0.297
	SD	0.188	0.155		0.149	0.191	
Chemicals	Mean	0.053	0.088	-0.446	0.068	0.050	0.300
	SD	0.059	0.165		0.091	0.160	
Coke	Mean	0.013	0.153	-1.578	0.114	0.071	0.221
	SD	0.088	0.177		0.443	0.426	
Electricity	Mean	0.071	0.117	-0.438	0.066	0.126	-0.653
	SD	0.128	0.194		0.185	0.174	
Electrical mach.	Mean	0.115	0.023	1.039	0.051	0.005	0.604
	SD	0.126	0.154		0.189	0.150	
Food	Mean	0.051	0.069	-0.284	0.077	0.036	0.834
	SD	0.096	0.113		0.114	0.103	
Furniture	Mean	-0.176	0.096	1.339	-0.021	0.098	-0.807
	SD	0.267	0.367		0.326	0.335	
Leather	Mean	0.165	0.038	0.511	0.100	0.022	0.629
	SD	0.507	0.228		0.352	0.174	
Machinery & eqpt.	Mean	0.024	0.069	0.769	0.035	0.028	0.191
	SD	0.072	0.109		0.053	0.105	
Medical eqpt.	Mean	-0.033	0.062	-0.716	0.003	0.066	-0.701
	SD	0.275	0.112		0.207	0.191	
Metal products	Mean	0.053	0.040	0.153	0.042	0.017	0.623
	SD	0.133	0.132		0.090	0.094	
Motor vehicles	Mean	0.063	0.105	-0.407	0.057	0.022	0.503
	SD	0.117	0.199		0.112	0.193	
Office, accounting	Mean	0.031	-0.052	0.309	0.056	-0.004	0.403
	SD	0.243	0.548		0.190	0.427	
Other NMM	Mean	0.046	-0.089	1.816	0.071	0.006	0.993
	SD	0.134	0.026		0.118	0.170	
Other transport	Mean	0.112	0.074	0.663	0.049	0.042	0.082
	SD	0.100	0.081		0.134	0.239	
Paper	Mean	0.153	0.006	1.534	0.053	0.015	0.392
	SD	0.171	0.129		0.239	0.196	
Publishing etc.	Mean	0.046	0.065	-0.249	0.074	0.028	0.623
	SD	0.613	0.157		0.179	0.146	
Radio, TV, etc	Mean	0.070	-0.008	0.531	0.091	0.009	0.887
	SD	0.163	0.285		0.189	0.223	
Rubber	Mean	0.038	0.041	-0.059	0.122	0.039	1.257
	SD	0.083	0.108		0.177	0.111	
Textiles	Mean	0.067	0.040	0.331	0.019	0.003	0.326
	SD	0.125	0.128		0.110	0.105	
Tobacco	Mean	0.092	0.055	0.379	0.068	0.042	0.226
	SD	0.059	0.206		0.317	0.176	
Wearing apparel	Mean	0.179	0.029	1.099	0.116	0.009	1.339
	SD	0.044	0.303		0.123	0.219	
Wood	Mean	0.049	0.095	3.851***	0.028	0.004	0.249
	SD	0.129	0.195		0.110	0.282	

***, ** and * indicate significance at the 1, 5 and 10% level, respectively

Table 6. Regression results: Productivity change and economic reforms

	Small window				Large window			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.609	0.076	0.033	0.582	0.597	0.143	0.040	0.655
	(0.088)***	(0.088)	(0.012)***	(0.254)**	(0.094)***	(0.108)	(0.021)*	(0.297)**
Year 0	-0.004	-0.037	-0.050	-0.007	0.006	-0.009	-0.058	0.043
	(0.046)	(0.047)	(0.044)	(0.045)	(0.056)	(0.055)	(0.053)	(0.045)
PRE (-5, -1)	0.027	0.025	0.01226	0.028				
	(0.025)	(0.022)	(0.021)	(0.023)				
POST (+1, +5)	0.038	0.018	0.011	0.033				
	(0.016)**	(0.014)	(0.012)	(0.016)*				
PRE (-10, -1)					0.028	0.067	0.014	0.082
					(0.022)	(0.028)**	(0.021)	(0.031)***
POST (+1, +10)					0.026	0.016	-0.015	0.058
					(0.021)	(0.026)	(0.022)	(0.021)***
IRC	Yes	No	No	Yes	Yes	No	No	Yes
FAC	No	Yes	No	Yes	No	Yes	No	Yes
LMC	No	No	Yes	Yes	No	No	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
POST = PRE	0.15	0.10	0.27	0.03	0.01	4.05	5.23	0.85
F- test (p-Value)	(0.70)	(0.75)	(0.61)	(0.86)	(0.94)	(0.05)**	(0.00)***	(0.36)
R-squared	0.125	0.068	0.032	0.136	0.120	0.076	0.034	0.139
Period	1981-2004	1981-2004	1981-2004	1981-2004	1981-2004	1981-2004	1981-2004	1981-2004
N. Obs, industry	523; 23	523; 23	523; 23	523; 23	523; 23	523; 23	523; 23	523, 23

Standard errors (clustered by industry) in parentheses
***, ** and * indicate significance at the 1, 5 and 10% level, respectively

Table 7. Regression results: Productivity change and macroeconomic policies

	Trade policies	Industrial policies	Financial policies	Combined policies
Constant	0.519	0.762	0.275	0.262
	(0.284)	(0.293)***	(0.152)*	(0.383)
NRP	-0.005			-0.010
	(0.003)*			(0.005)*
Delicensing		0.060		0.139
		(0.029)**		(0.050)***
Credit			0.029	0.019
			(0.038)	(0.041)
IRC	Yes	Yes	Yes	Yes
FAC	Yes	Yes	Yes	Yes
LMC	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
R-squared	0.173	0.175	0.291	0.309
Period, industry	1991-2004	1981-2004	1991-2004	1991-2004
N. Obs, industry	506; 23	523; 23	315; 22	306; 23

Standard errors (clustered by industry) in parentheses
***, ** and * indicate significance at the 1, 5 and 10% level, respectively