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What explains the productivity decline in manufacturing in the nineties in India?

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Table of Contents

List of Tables

Abstract

This paper uses the data envelopment analysis (DEA) based Malmquist productivity index to estimate total factor productivity growth (TFPG), technical change, and efficiency change for a panel of firms during the period 1991 to 2001 in 26 Indian manufacturing industries. The paper then analyses the factors explaining productivity growth, technical change and efficiency change using a Tobit regression for each industry. The results reveal that TFPG declined for all the sectors during the period. The most significant factor affecting efficiency change, technical change and productivity growth is RD intensity, either recurring or capital: this variable is significant in sixteen industries. Vintage of capital is significant in eight of the industries. Exports intensity and imports of capital intensity are significant in four industries.

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1 Introduction

During the nineteen sixties and seventies, many developing countries had embarked on their development process by adopting a protectionist trade regime. The justification for such regimes had been based partly on the infant industry argument and partly on the chronic balance of payments problems faced by these economies. These regimes, however, subsequently came in for a lot of criticism. Critics pointed out that the barriers instituted by the developing countries often caused inefficiencies and vitiated the business environment in these countries. Several problem areas that were cited in this regard included price controls, regulations on foreign trade, foreign currency regulations, tax regulations, etc.

In the specific context of Indian business, industrial licensing and labor laws have also been thought to constitute a major problem prior to the reform initiated in 1991. These characteristics of the Indian industrial sector made the firms uncompetitive with respect to international markets. As is well known, India liberalized domestic and external policies following the balance of payments crisis in 1991. These reforms included import liberalization, reduction of high tariff rates and the abolition of quantitative restrictions on international trade, reduction of barriers to entry in foreign direct investment, abolition of industrial licensing, allowing private initiative in erstwhile public sectors, reduction in taxes and simplification in tax structure, and reforms in the banking and financial sectors. The reforms undid some of these problems by bringing in less protective and more market friendly measures.[1]

Despite these reforms, the growth of the Indian economy remained lower than 6 percent in the nineties, whereas it had risen by almost 2 percent in the eighties even without the reforms. Some authors like Virmani (2005) have suggested that the structural transformation of the economy resulting from the initiation of reforms caused the low growth rate in the nineties. Goldar (2000), Balakrishnan et al. (2000), and Trivedi et al. (2000) have shown that productivity slowed down in India in the nineties. According to Virmani (2005), this was due to the transition from the old, globally inefficient system of production to a more efficient structure. This, he suggests was due to obsolescence of product lines and the capital used to produce it.

Productivity change has two components: first, movements at the frontier of production denoted by technical change, and, second, movements of firms towards the frontier, known as efficiency change. As Ahluwalia (2011) points out, in the early stages of the reform, rates of TFPG might have reflected not only pure productivity growth but also that the economy was moving from a position well inside the production possibility frontier to a position closer to

[1] This has been documented in Joshi (1994), Bhattacharya (1999) and Mammen (1999).

the frontier, reflecting the efficiency changes. As argued by Jerzmanowski (2007), it is important from the point of view of developing countries to understand which policy to devote resources to: should resources be spent on enforcing intellectual property rights or should they be devoted to enforcing greater gains from improvements in efficiency? It is germane, therefore, to examine the factors explaining productivity growth, technical change, and efficiency change.

In this paper, we provide yet another insight into the productivity slowdown in India. The paper, firstly estimates total factor productivity growth (TFPG), technical change and efficiency change of firms in 26 manufacturing industries during the period 1991 to 2001 using the data envelopment analysis (DEA) based Malmquist productivity index. The results reveal that TFPG declined for all the sectors during the period. Technical efficiency change was positive in most of the industries; however, technical change declined in all the industries.

Secondly, the paper analyses the factors explaining productivity growth, technical change and efficiency change of a panel of these firms. The factors explaining technical efficiency, technical change and productivity growth in the 1990s throw some light on the strategies followed by the firms to become more competitive in the globalised world. Factors that affect productivity are factors that push the frontiers of knowledge and hence are the factors that aid the process of diffusion across countries and industries. The most significant factor affecting efficiency change, technical change and productivity growth is RD intensity, either recurring or capital: for in sixteen industries, this variable is significant. Vintage of capital is significant in eight of the industries. Export intensity and imports of capital intensity are significant in four industries.

This paper is organized as follows: In the next section we present the literature on the impact of liberalization on efficiency and productivity of firms. In Section 3 we present the empirical model that we have estimated, discuss the variables and the data that has been used in the estimation. The results of the exercise have been discussed in Section 4. The final section sums up the paper.

2 Literature survey

The determinants of productivity growth hold the key to understanding growth rates since productivity differences largely explain differing income and growth rates in countries (Klenow and Rodriguez-Clare, 1997). In the growth literature, a distinction has been made between the 'deep determinants' of growth, which include factors such as trade integration, institutions and geography, and the 'proximate' determinants which include policies to increase capital formation, and improve resource allocation, etc. While the former determinants are viewed as long term, the latter are associated with the medium term, though it is recognized that in some instances policies for the medium term cannot be completely dissociated from those in the long term: for example, policies that improve TFP (in the medium term) will work in an environment with good institutions (which can be achieved in the long term). The determinants in the growth literature have been grouped into four categories: creation, transmission and absorption of knowledge; factor supply and efficient allocation; institutions, integration and invariants; and competition, social dimension, and environment (Isaksson, 2007). Some of these determinants are also relevant for understanding productivity growth, and are discussed below. However, the empirical evidence linking structural change, social dimensions and the environment are inconclusive in explaining TFP growth (Isaksson, 2007) and hence these last two categories are not discussed here.

The productivity of a country could be improved by the diffusion of knowledge, which is facilitated by improved absorptive capacity as human capital reaches higher levels (Lucas, 1988, Romer, 1990). An alternative route for the same could be through increasing the variety or quality of intermediate inputs that are generated through research and development (R&D). The effects of growth and trade liberalization can occur through an increase in growth or through improvements in productivity. There is a large literature on gains from productivity enhancing effects of trade liberalization. Trade liberalization leads to economic growth through the static gains from trade in the medium term or through long term gains from access to technology, intermediate and capital goods, benefits of scale and competition, etc. (Grossman and Helpman, 1991, Lucas, 1988). Romer (1992) suggests that there are unlimited possibilities for an economy with the introduction of new goods: while developed countries can discover the new goods, developing countries can import them. According to Acemoglu et al. (2006) a country's level of development determines the relative role of innovation versus imitation/adoption and is dependent on the distance from the global technology frontier.

The theoretical literature has recognized the importance of both imitation and innovation to the development process. Starting from the work of Vernon (1966) on product cycles, Krugman (1979) has shown the rate of innovation in the North is exogenous and the costless diffusion of this to the South occurs with a lag. Grossman and Helpman (1991) discuss how this phenomenon occurs and analyze a model whereby imitation by the South introduces "clones" in the North which leads to further innovation in the North. van Elkan (1996) develops an open economy model in which the stock of human capital may be augmented by innovation or imitation. This, she argues, is consistent with Maddison's observation that late developing countries tend to catch up more rapidly due to the larger imitation opportunity from abroad.

Theoretical models of industry evolution have shown that regulatory conditions have impeded efficiency improvements. Hopenhayn (1992) has shown that high entry costs not only reduce the amount of entry but that it also encourages incumbents with lower efficiency to remain in the market. This increases the efficiency dispersion in the market. In Jovanovic's (1982) model, market interventions such as artificial entry barriers, severance laws or policies that prop up dying firms are detrimental to the industry. Policies that inhibit expansion or contraction have similar consequences. Hopenhayn and Rogerson (1993) have simulated the effects of severance laws to show this effect. The empirical validation of this phenomenon has been to show the extent of dispersion with respect to the efficiency frontier. Bernard and

Jones (1996) study productivity performance comparisons across countries and find that manufacturing shows little evidence of labour or multifactor productivity convergence. They argue that work on industry productivity in developing countries is needed to reveal more about the underlying process of convergence and growth and also to separate the role of capital accumulation and technological change.

Turning to the empirical literature: the dynamic effects of liberalization are thought to enhance learning, technological change and economic growth. The relationship between protection and poor technological performance has been shown in the literature by cross country studies of economic growth; cross industry studies of technical efficiency and productivity change; and firm level case studies.[2]

Some studies, such as that by McMillan and Rodrik (2011), have examined this issue at the level of the economy and say that despite liberalization in several developing countries, not many countries have witnessed structural change in which high productivity employment opportunities have expanded. Developing economies are characterized by large productivity gaps between different parts of the economy. They find that for most economies that they study, the most productive sector is the public utilities while the least productive sector is agriculture. For India too, the above is true and the productivity of the manufacturing sector is in between that of these two sectors. This suggests that gaps in productivity exist between the sectors and such gaps also exist among firms and plants in the same industry. If removed, this can be an important engine of growth.

The cross country studies construct indices of total knowledge capital (measured by accumulated investment in R&D) in a country and use the import of capital goods to understand the effect of trade liberalization on productivity. Coe, Helpman and Hoffmaister (1997) use observations from 77 developing countries over 1971-1990 to examine the effect of trade on total factor productivity (TFP) and find that using import weighted sums of industrial countries' knowledge stock (as an indicator of developing countries' access to foreign knowledge) when interacted with openness has a significantly positive effect on TFP. However, this study has been criticized on the grounds that the authors do not consider competing explanations of access to knowledge capital, and imply an excessive bilateralism in access to knowledge. Another problem with studies in this literature is the measurement of TFP and the assumption of perfect competition that is made in the growth accounting exercise.

Griffith, Redding and Van Reenen (2004) use industry data of 12 OECD countries from 1974-1990 and show a positive effect of R&D expenditures on TFP growth. However, while innovation and R&D are important for TFP growth in industrialized countries, there is little evidence of the importance of these variables in developing countries (Isaksson, 2007).

[2] The empirical evidence on trade and growth based on the cross country studies has shown that increased trade has improved growth. These studies suffer from many problems according to Rodrik (1995) including endogeneity of the trade regime variable, causality between the relationships specified, failure to specify the mechanism which leads to growth and measurement problems in the sense that trade regime variables are confused with macroeconomic variables.

As far as technology transfer is concerned, there seem to be positive effects of inward investment for industrialized countries, but this is not necessarily the case for developing countries. The trade channel is more promising for technology transfer; the efficiency of the transfer depends on the absorptive capacity of the recipient country which, in turn, depends on human capital and capital intensity. In the context of developing countries, the absorptive capacity needs to be strengthened before technology transfer can be fully exploited. According to Isaksson (2007), the link between TFP and knowledge is weakened by factors such as institutional quality and the degree of openness of a country.

While macro based studies reveal that total trade is positive and significant in explaining growth, this literature has been criticized for not addressing endogeneity problems and for omitting institutions and geography. Adjustments for endogeneity and inclusion of institutions and geography, however, tend to render the trade variable statistically insignificant. Imports are strongly associated with productivity. There is a lot of heterogeneity which is masked by macro studies: trade liberalization had a greater impact on large plants and industries where competition was low.

The efficiency costs of trade protection and industrial regulation have been documented in the studies of Little, Scitovsky and Scott (1970), Balassa (1971), Bhagwati (1978) and Krueger (1978). These studies have evaluated trade regimes and demonstrated that the existing policies (of protection) had encouraged the development of industries that were high cost and did not show a rise in productivity over time. This issue has been examined across countries (Nishimizu and Page, 1982, Coe et al., 1997), at the level of sectors (Nishimizu and Page, 1991) and the level of firms or plants (Tybout et al., 1991, Pavcnik, 2002). Havrylyshyn (1990) surveys the literature on the evidence of the link between trade policy and efficiency or productivity gains in developing countries. Firstly, studies that measure technical efficiency gains and correlate these gains with the degree of protection, find (with the exception of Moran (1987) for thirty two countries) that there is evidence of a positive effect of trade policy liberalization on efficiency, for example, Nishimizu and Page (1982) for Yugoslavia, and Page (1984) for India. Jerzmanowski (2007) examines two alternative explanations of total factor productivity (the inefficiency and the appropriate technology) and concludes that inefficiency appears to be the main explanation for low incomes in the world.

Second, some studies like Hay (2001) for Brazil, and Jonsson and Subramanian (2001) for South Africa, link trade liberalization and productivity in cross sectoral studies for individual countries, and which show that reductions in trade barriers have led to increases in productivity through import competition. These studies generally find a strong positive relationship between productivity and openness and suggest that TFP advances are due to compression of margins and economies of scale. The role of technology in improving productivity is not strong in these studies as is the case of Sharma, Jayasuriya and Oczkowski (2000) for Nepal. This paper highlights the importance of complementary policies such as investment in infrastructure.

Most of the studies examine the effect of trade liberalization on industrial productivity changes. Tybout (2000) reports that the mean technical efficiency levels in developing countries are around 60 to 70 per cent of the best practice frontier in developed countries.

Tybout et al. (1991) analyze changes in the industrial sector performance accompanying the Chilean trade liberalization of the 1970s. They find very little evidence in overall productivity improvements. They construct industry specific indices of the changes in returns to scale, average efficiency level and dispersion in efficiency levels between 1967 and 1979. Cross firm variance in productivity levels are high in developing countries as shown by Pack (1988), Blomstrom and Kokko (1997), etc.

The third group of studies which are at the firm level, suggests a link between lowering of trade barriers and increase in competition, which would lead to increase in productivity. Such a link has been suggested by Esfahani (1991), Feenstra et al. (1997) and Tybout and Westbrook (1995). The latter study finds that exit of inefficient firms, cheaper intermediates, and competition from imports stimulate increases in productivity and the effect is strongest in industries that are open. Bigsten et al. (2000) find evidence of exports leading to productivity increase in Africa, while Kraay (1997) finds ambiguous results for China, and Tybout and Westbrook (1995) find little evidence of this in Latin America.[3] Muendler (2004) shows a small contribution of foreign material and investment goods in output for Brazil. Van Biesenbroeck (2003) finds that productivity improvements do not happen through advanced inputs in Colombia.[4] Tybout (2000) reviews the literature on trade liberalization and efficiency and concludes that the improvement in efficiency is probably due to intra plant improvement and unrelated to internal or external scale economies.

Finally, firm level case studies of technological change reported in studies by Katz (1987), Lall (1987) and Pack (1987) for example, do not lead to any generalizations regarding the extent to which trade regimes affect the pace of learning. Nelson (1981) has emphasized the importance of technological change on a firm's productivity growth. To understand how technology affects efficiency one has to examine how it diffuses through the economy. The impact of technological changes on productivity and efficiency depends on whether these changes are incremental or paradigmatic.[5] Incremental changes are movements along the trajectories while paradigmatic changes involve changes in the frontier itself. Paradigmatic changes lead to increased efficiency for the firms adopting the technology, but this may raise

[3] There is a problem of causation in this explanation: are firms that are productive exporting more or is it that exporting makes firms more productive (Aw et al., 2001)? The timing of the changes in exports must be carefully modeled to extricate the direction of the link.

[4] One distinction that has been made in the literature in recent times is the distinction between exogenous versus endogenous changes in productivity associated with exporting. Exogenous changes in productivity need to be tested using the timing decision of firms (Lopez 2004) or, simply put, whether the firms became productive prior to the exporting decision. The endogenous change in productivity suggests from the growth accounting exercise, that if investment increases while output remains the same, productivity falls unless there are reductions in other inputs. However, this is nothing short of changes in efficiency and the two effects needs to be disentangled. Baldwin and Gu (2004) have combine micro data with questionnaires about export behaviour and find that changes in scale increased efficiency and increased innovation as a result of exporting.

[5] See Dosi (1988)

the distance between the frontier and the average firms, causing a decline in average efficiency of the industry. Thus the effect of technology on efficiency is ambiguous (see Caves 1992). Technology usage also has complementarity with skill. As Lall (1999) and Parker et al. (1995) show open trade is not associated with increased productivity per se, if other factors such as appropriate policy environment are not present. This may explain the absence of a positive relationship between openness and productivity at the firm level that is generally found in sectoral studies. Hence, as noted by Pavcnik (2002) and Bailey et al. (1992) it is important to examine plant level changes to understand changes in aggregate productivity.

3 Methodology

This paper uses panel data to estimate productivity growth, technical change and technical efficiency in the period 1991-2001 in firms in 26 manufacturing industries in India. The main focus of this paper is an analysis of the factors that explain productivity differences, technical and efficiency change for firms in 26 manufacturing industries. The Malmquist productivity index has been used to decompose productivity growth into technological change and efficiency improvements over the period. These productivity measures are then used as the dependent variable in a Tobit regression to analyze the factors affecting TFPG in each of the 26 sectors.

Total factor productivity (TFP) is defined as the residual growth of output not explained by growth in inputs. Changes in the total factor productivity or total factor productivity growth (TFPG) reflect the ability to produce more and more output per bundle of inputs. Productivity changes occur due to technological change, change in technical efficiency and changes in allocative efficiency.[6] Technological changes reflect the creation of knowledge and lead to shifts in the frontier production function. Changes in technical efficiency represent movement towards the frontier as all producers are not using the best practice and the use of fewer inputs to produce the same output results in greater technical efficiency. According to Fare et al. (1994), this represents diffusion of technology. Technical change can be interpreted as evidence of innovation.

Changes in productivity can be measured using the growth accounting approach. Using this approach, the contributions to growth are the residual of the growth of output due to the growth of the factor inputs such as labor and capital. However, using this approach, makes it possible to separate out the effect of technological change,[7] but does not allow decomposing growth in total factor productivity to changes in technical efficiency or allocative efficiency. Moreover, this approach assumes that factors are paid the value of their marginal product under the assumption of perfect competition and marginal cost pricing.

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[6] Allocative efficiency changes results in resource reallocation as changes in output composition occur due to the right input mix being used in production and hence also contribute to overall productivity changes.

[7] The correlation between the components of output growth and measured productivity is known as Verdoon's law and is taken to reflect the embodiment of new technologies during periods of rapid investment and economies of scale.

There are two alternative ways of estimating the frontier and compute the changes in productivity: the first is the stochastic frontier approach (SFA) and the second is data envelopment analysis (DEA).[8] We have used the latter approach, or the Malmquist index of productivity change, which is based on Shepard's distance function. Fare et al. (1994) decomposed this index into two components, changes in technical efficiency and technological change. The Malmquist index is calculated as:

$$m(u_t, x_t, u_{t+1}, x_{t+1}) = \left[\frac{d_0^t(u_{t+1}, x_{t+1})}{d_0^t(u_t, x_t)} \times \frac{d_0^{t+1}(u_{t+1}, x_{t+1})}{d_0^{t+1}(u_t, x_t)} \right]^{1/2} \tag{1}$$

where, m refers to the Malmquist productivity index, u refers to output, and x to input. $d^t{}_0$ (ut, xt) represents the distance function for a firm in the first technological period t, while $d^{t+1}{}_0$ (ut, xt) represents the distance function of the same firm in the second technological period t + 1 evaluated at inputs and outputs at time period t. The productivity index can be decomposed into efficiency change and technical change as follows:

$$m(u_t, x_t, u_{t+1}, x_{t+1}) = \frac{d_0^{t+1}(u_{t+1}, x_{t+1})}{d_0^t(u_t, x_t)} \left[\frac{d_0^t(u_{t+1}, x_{t+1})}{d_0^{t+1}(u_{t+1}, x_{t+1})} \times \frac{d_0^t(u_t, x_t)}{d_0^{t+1}(u_t, x_t)} \right]^{1/2} \tag{2}$$

where the first part of the equation is the efficiency change while the part within parentheses is the technical change. The efficiency change is the output oriented measure of Farell's technical efficiency change between periods t and t +1 and indicates the magnitude of the efficiency change from period t to t + 1. The technical change measures the shift in the technology frontier between the two periods. The productivity growth between the two periods is the product of the geometric mean of the technical change and the efficiency change. This provides a measure of change in total factor productivity from year to year.

Having obtained the productivity change, technical change and the changes in the efficiency in the first stage of the exercise, the second stage of the exercise uses the efficiency, technical change and the productivity scores regressing them as dependent variables to understand the factors explaining productivity growth and efficiency change in India during the nineties. This has been explained in the econometric model below. The factors explaining efficiency change, technical change and productivity growth in the 1990s throw some light on the strategies followed by the Indian firms to become more competitive in the globalised world.

Data

We have data on the firms for the period 1991 to 2001 from the Capitaline Ole′ database provided by Capital Markets (I) Pvt. Ltd. Information on firms is available for 26 industry

[8] For a discussion on the relative merits and demerits of the SFA and other methods see Van Biesebroeck (2003). It is not possible to separate out the components of productivity growth using SFA. The demerits of DEA have been documented in Johnes (2006).

groups for the years 1991 to 2001.[9] For each year, after cleaning the data,[10] we estimated productivity growth, technical change and efficiency change using the DEA approach with value added [11] as output and capital [12] and labor [13] as inputs. Hence equation (2) has been estimated separately for each of the firms in each of the 26 industry groups for each year and is reported in Table 1.[14] Table A1 in Appendix A shows the number of firms in each industry, and the average capital, labor and value added used in the estimation of total factor productivity, technical change and efficiency change for each industry.

Econometric model and estimation

In the second stage of the exercise we regressed the productivity, efficiency change and technical change scores obtained as dependent variables in the following equations. The regression has been at the level of the firm based on the balanced panel of firms,[15] separately for each of 26 industry groups over the period 1991- 2001:

$$TE_{i,t} = \alpha_0 + \alpha_{jt} \text{(independent variable)} + \alpha_k T_t + \upsilon_{it} \qquad (i \neq j, j \neq k) \qquad (3)$$

$$TC_{i,t} = \beta_0 + \beta_{jt} \text{(independent variable)} + \beta_k T_t + \xi_{it} \qquad (i \neq j, j \neq k) \qquad (4)$$

$$TFP_{i,t} = \gamma_0 + \gamma_{jt} \text{(independent variable)} + \gamma_k T_t + \varepsilon_{it} \qquad (i \neq j, j \neq k) \qquad (5)$$

9 The data used hence reflects data for registered manufacturing. Registered or Organized manufacturing includes all factories covered under Sections 2m (i) and 2m (ii) of the Indian Factories Act, 1948. This includes factories employing 10 or more workers and using power or 20 or more workers but not using power on any day of the preceding 12 months. The unregistered manufacturing sector covers all residual units which are not covered under the registered manufacturing and is engaged in manufacturing / repairing activities. It includes Own Account Manufacturing Enterprises (OAME) (run without any hired workers) and Establishments (run with at least one hired worker) which are further subdivided into two categories: Non-directory Manufacturing Establishments (NDME) and Directory Manufacturing Establishments (DME). While the NDME units employ less than six workers (including household workers), DMEs employ more than six workers (including household workers). As per the National Accounts Statistics, the average contribution of the registered manufacturing to India's GDP was 10.1% in 2000-05, while that of unregistered manufacturing was 5 % during the same period.

10 We have cleaned the data by omitting firms not belonging to manufacturing and then those with value added, salaries, employee cost or capital equal to or less than zero.

11 Value added has been defined as gross profit plus depreciation plus excise duty plus interest plus employee cost.

12 Capital is obtained by adding depreciation, 15% of fixed assets and inventories. This definition of capital is common and has been used extensively: e.g. Basant and Fikkert (1996).

Capital in the efficiency literature has been measured by the sum of assets and inventories or by average tangible assets per plant. This is given by tangible fixed assets + (acquisition of tangible fixed assets – removal of tangible fixed assets – depreciation of tangible fixed assets) /2 + (initial total inventory + final total inventory)/ 2. Since data on all the components of the formula is not available it has not been used.

13 We do not have data on employment and so some proxy has to be used. One alternative is to obtain a value of labor using the wages and wage bill for that industry group from the Annual Survey of Industries (ASI). However the assumption underlying this method is that the wages are the same in the entire industry which may not be true. Hence we have used employee cost of the firm. Compensation has been used by Caves (1992).

14 This is necessary since in the DEA approach the construction of the benchmark depends on the observations included which are considered to belong to a certain set – in this case, the industry. The benchmark has been constructed for the unbalanced panel for all observations belonging to an industry for the year.

15 This rules out the possibility of studying the role of entry and exit. However, exit is still difficult in the Indian context given that the labor laws have not been amended yet. See Ahluwalia (2002).

where TE stands for efficiency change, TC for technical change and TFP for total factor productivity. T stands for time.

Variables

Efficiency change, technical change and total factor productivity growth form the dependent variable in the regression exercise as shown by equations (3) - (5) above. Due to the efficiency change, technical change and productivity growth scores being bound at zero, censored normal Tobit was used. Though we have data for eleven years, one year was lost in estimation of the Malmquist index and so the panel regression has been run for ten years. Year dummies are added to account for differences in productivity and hence nine year dummies were given.

The independent variables are taken from the literature survey. Caves (1992) has discussed the factors in the context of inter industry and inter country differences in efficiency and productivity and these variables have been explained in Appendix B along with their expected signs. The variables that have been used in this paper are those where inter firm differences are likely to matter.

Caves (1992) has classified the independent variables into five different groups: these categories are: a) competitive conditions, b) organizational factors, c) structural heterogeneity, d) dynamic disturbances, and e) regulation. The first group of factors includes market structure conditions such as concentration, import competition and export intensity. The organizational factors or the second group include scale of plant, diversification, multiplant operation, extent of subcontracting, prevalence of foreign investment, extent of unionization and use of part time employees. The third group of factors or structural heterogeneity factors are those related to capital intensity, vintage of capital, product differentiation, fuel intensity, regional dispersion, inter plant dispersion of material labor ratio, diversity of industry product, diversity of plant scale and the proportion of non production workers. The dynamic disturbances, or the fourth group, include intensity of R&D expenditure, technology import payment, technology export receipts, rate of productivity growth, the rate of output growth and the variability of output growth. Finally, among the regulatory policies affecting efficiency are tariff protection and the regulation of entry. Strict regulation is a hindrance to innovation, reduces competitive pressure, technology spillovers and the entry of newer and high-tech firms. Due to data constraints all the above factors have not been used. Robust Huber/White covariance and standard errors were obtained in the regression exercise.

4 Results

Trends in productivity growth and its components

Table 1 shows the estimates of efficiency change, technical change and TFPG obtained from the Malmquist index as explained by equation (2).

[Table 1 about here]

From the table we see that over the period 1991 to 2001, the total factor productivity (last column) has declined in all the industries.[16,17] This has been documented by Goldar (2004), Srivastava (2001) and Trivedi et al. (2011) using different approaches. [18,19] On the other hand, technical efficiency and technical change has been different for different industries: while technical efficiency change (column 2) has declined in textiles, aluminum, metal products, plastics, steel, cables, electrical equipment, fertilizers, electronics, and telecom, it has increased for the other industries except breweries where it has remained constant. So on balance, the technical efficiency change has been positive in most of the industries and no generalizations can be made about increases/declines in terms of the various industries. This is not surprising since other authors have pointed out the low levels of efficiency of India.[20] Technical change has declined in all the industries, leading to the conclusion that it has been dragging down TFPG in all the sectors. What can be the explanation for the decline in total factor productivity in Indian manufacturing in the 1990s?

Productivity is a composite measure of performance and which can increase either through efficiency changes or technical change or through both. Clearly in the Indian manufacturing context, while the former seems to have largely improved in the 1990s, the latter declined. However, is this sufficient to cause a decline in TFP? Changes in technical efficiency could have offset some of the losses due to technical change. A reason is therefore needed to explain why technical progress declined in this period. The factors explaining productivity growth, efficiency change and technical change are analyzed below to shed some light on this aspect.

Factors explaining productivity growth, efficiency change and technical change

Table 2 summarizes the results for the determinants of total factor productivity growth in all the industries based on estimation of equation (3), (4) and (5) (for details of results see Appendix C1- A26).

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[16] The industries are automobiles, breweries, cement, chemicals, electronics, food, fertilizers & pesticides, non electrical machinery, steel, paper, pharmaceuticals, plastics, glass & ceramic tiles, textiles, paints, petrochemicals, personal care, engineering, sugar, cables, metal products and parts, aluminum, electrical equipment, auto ancillaries, solvent extraction and telecom.

[17] As pointed out by Hsieh and Klenow (2009), resource misallocation can lower TFP. By hypothetically reallocating capital and labour across plants in India to equalize marginal product as observed in the United States, they show that the TFP gains could be as much as 40-60 percent. Tamura et al. (2012) construct new human capital per worker for 168 countries and show that 66-90 percent of the variation in long run growth can be explained by the variation in the growth of inputs per worker.

[18] Srivastava (2001) has estimated the technical efficiency of Indian manufacturing firms for the period 1980-81 to 1996- 97. He finds that mean technical efficiency has gone down in the nineties (the period of liberalization) compared to the eighties. Nataraj (2011) examines the impact of liberalization on the productivity of small and informal firms in India and finds that trade reforms have increased productivity for such firms. However, Bollard et al. (2013) report an increase in productivity during the period.

[19] As noted in Goldar, the difference in TFP estimates in his study and that of Unel's (2003) comes from the estimation of benchmark capital.

[20] Jerzmanowski (2007); Ray (2004)

[Table 2 about here]

Discussion

From the table we see that that in eight of the twenty six industries, the same factors (highlighted in bold) affect technical change, efficiency change and productivity growth. These industries are auto, electronics, food, metal products, non electrical machinery, paints, pharmaceuticals and plastics.

In the *automobiles* industry capital expenditure on R&D intensity is significant in explaining technical change, efficiency change and productivity growth. Capital expenditure on R&D is significant in explaining efficiency change only in the presence of the year dummies and advertising intensity (which is insignificant but has the right sign).

In the *electronics* industry, exports intensity explain efficiency change, technical change as well as productivity growth. Year dummies explain efficiency change and technical change.

In the *food* industry, efficiency change is explained by product differentiation and imports of capital and capital expenditure on R&D (intensity) which is significant only in the presence of the year dummies, which are themselves insignificant. Technical change is explained by capital expenditure on R&D (intensity) and the year dummies. Productivity growth is explained by imports of capital and capital expenditure on R&D (intensity).

In the *metals* industry, efficiency change is explained by foreign ownership of more than 10 percent which is significant in the presence of the year dummies, though the year dummies are insignificant themselves. Foreign ownership of more than 10 percent and year dummies also explain technical change and productivity growth. Productivity growth is also explained by fuel intensity but has the wrong sign.

R&D expenditure (sum of recurring and capital expenditure) intensity and foreign ownership of more than 10 percent explains efficiency change in the *nonelectrical machinery* industry, though the latter is significant only in the presence of year dummies. The year dummies are themselves insignificant. Technical change is explained by vintage of capital, foreign ownership of more than 10 percent, recurring expenditure on R&D intensity and year dummies. Vintage of capital is significant only in the presence of year dummies. Productivity growth is explained by foreign ownership of more than 10 percent, year dummies and expenditure on R&D (intensity). The latter is significant only when year dummies are included in the regression.

In the *paints* industry, imports of capital and capital expenditure on R&D (intensity) are significant in explaining efficiency change. Technical change is explained by imports of capital, recurring expenditure on R&D intensity, foreign ownership of more than 10 percent and year dummies. In the presence of year dummies, only imports of capital and recurring expenditure on R&D (intensity) are significant. Productivity growth is explained by imports of capital intensity, foreign ownership of more than 50 percent and year dummies.

In the *pharmaceutical* industry, exports are significant in explaining efficiency change, technical change as well as productivity growth. In the case of both, technical change and productivity growth, exports are significant if included in the regression along with the year dummies. Foreign ownership of more than 50 percent is significant in explaining technical change and foreign ownership of more than 10 percent is significant in explaining productivity growth.

Capital intensity, exports, product differentiation, recurring expenditure on R&D intensity (when regressed along with year dummies) are significant in explaining efficiency change in the *plastics* industry. The year dummies are themselves not significant. Technical change is explained by product differentiation; recurring expenditure on R&D intensity and year dummies. Productivity growth is explained by product differentiation and year dummies.

In twelve industries the same factors explain technical change and productivity growth. These are aluminum, auto ancillaries, breweries, cables, electrical equipment, engineering, fertilizers, glass, paper, petrochemicals, steel, and textiles. As we have noted earlier, technical efficiency in the majority of the following industries: aluminum, cables, electrical equipment, fertilizers, steel, and textiles, has declined over the period.

In the *aluminum* industry, the age of plant and machinery is significant in explaining both technical change and productivity growth. Royalty payments intensity has the right sign but is insignificant in explaining efficiency change.

In *auto ancillaries*, while recurring expenditure on R&D intensity explains efficiency change, capital expenditure on R&D intensity explains technical change and productivity growth.

In *breweries*, vintage of capital is significant in explaining technical change and productivity growth, while there is no variation in efficiency change and so the regression is not reported.

In the *cables* industry, efficiency change is explained by recurring expenditure on R&D (intensity), while technical change and productivity growth are explained by capital expenditure on R&D (intensity) and year dummies.

In the *electrical equipment* industry efficiency change is explained by vintage of capital while technical change and productivity growth are explained by foreign ownership of more than 10 percent and the year dummies.

In the *engineering* industry, imports of raw materials explain efficiency change. However, this is insignificant. Vintage of capital, expenditure on R&D (which is the sum of recurring expenditure and capital expenditure) intensity, and ownership of more than 50 percent are significant in explaining technical change, as are year dummies. Vintage of capital and year dummies are significant in explaining productivity growth.

The explanatory variable in the *fertilizers* industry is vintage of capital for efficiency change. This is significant only in the presence of the year dummies, though the year dummies are not significant and some have the wrong sign. Technical change and productivity growth are explained by capital expenditure on R&D, royalty payments intensity and foreign ownership of more than 10 percent and year dummies.

The variable explaining efficiency change in the *glass* industry is recurring expenditure on R&D (intensity), while technical change is explained by capital expenditure on R&D (intensity) and foreign ownership of more than 10 percent and year dummies. Productivity growth is explained by foreign ownership of more than 10 percent and year dummies.

Vintage of capital, foreign ownership of more than 10 percent and year dummies are significant in explaining technical change as well as productivity growth in the *paper* industry. Imports of raw material intensity has the right sign but is insignificant in explaining efficiency change.

In the *petrochemicals* industry efficiency change of firms was explained by capital expenditure on R&D (intensity), while technical change and productivity growth were explained by foreign ownership of more than 10 percent and year dummies.

In the *steel* industry, technical change is explained by vintage of capital, exports intensity and capital expenditure on R&D (intensity) in the absence of the year dummies. Foreign ownership of more than 50 percent is significant only when included with the vintage of capital. Productivity growth is explained by vintage of capital and foreign ownership of more than 10 percent which, with the inclusion of the year dummies, become insignificant. Vintage of capital has the right sign in the regression for efficiency change though it is not significant.

In the *textile* industry technical change is explained by exports, imports of raw material and foreign ownership of more than 50 percent. The inclusion of the constant term in the regression results in a near singular matrix. Efficiency change is explained by the vintage of capital which is near significant with the inclusion of fuel intensity and the significance increases with the year dummies. Productivity growth is explained by import of raw materials and foreign ownership of more than 50 percent. Inclusion of the age of plant and machinery are needed to render the import of raw materials significant but it itself has the wrong sign.

In three industries, personal care, solvent extraction, and telecom, productivity growth is explained by the same factors as efficiency change. These industries (barring telecom) are all characterized by increases in efficiency change during the period.

In the *personal care* industry, efficiency and productivity growth was explained by capital intensity and the age of plant and machinery. In case of productivity growth, the variables were significant only with the inclusion of the year dummies in the regression. Technical change was explained by vintage of capital and year dummies.

In the *solvent extraction* industry, the age of plant and machinery is significant in explaining efficiency change and productivity growth. In the former, the age of plant and machinery is significant only with the inclusion of the year dummies, capital intensity and product differentiation. Capital intensity has the wrong sign and though product differentiation has the right sign, it is insignificant. In case of productivity growth, capital expenditure on R&D

is also significant if regressed along with exports (which has the wrong sign and is insignificant). Technical change is explained by imports of capital which is significant only with inclusion of the year dummies.

In the *telecom* industry efficiency change is explained by capital expenditure on R&D (intensity) but not year dummies, while technical change is explained by vintage of capital. Imports of capital and also explain technical change only when regressed with year dummies. Capital expenditure on R&D has the wrong sign. Productivity growth is explained by capital expenditure on R&D (intensity) and year dummies.

For the rest of the industries, cement, chemicals, and sugar, different factors affect technical change, efficiency change and productivity growth.

In the *cement* industry, recurring expenditure on R&D is nearly significant in explaining efficiency change of firms while technical change is explained by imports, which is significant only with the inclusion of the year dummies in the regression. Productivity growth is explained by capital expenditure on R&D intensity and foreign ownership of more than 10 percent as well as year dummies.

In the *chemicals* industry, efficiency change is explained by recurring expenditure on R&D intensity (which is significant only in the presence of foreign ownership of more than 10 percent dummy), while technical change is explained by vintage of capital, which is significant in the presence of the year dummies. Productivity growth is explained by foreign ownership of more than 10 percent and the year dummies.

In the *sugar* industry technical change is explained by recurring expenditure on R&D intensity in the presence of year dummies and without year dummies, has the wrong sign. Foreign ownership of 10 percent as well as the year dummies are significant in explaining productivity growth. The age of plant and machinery is significant in explaining efficiency with the year dummies but has the wrong sign. Imports of raw materials has the right sign but is insignificant.

The most significant factor affecting efficiency change, technical change and productivity growth is RD intensity, either recurring or capital: this variable is significant in sixteen industries. Vintage of capital is significant in eight industries. Exports intensity and imports of capital intensity are significant in four industries. Differences in physical capital or capital intensity ratio are not significant in most cases and do not explain differences in efficiency change, technical change or productivity growth.

5 Conclusions

This paper uses the data envelopment analysis (DEA) based Malmquist productivity index to estimate total factor productivity growth (TFPG), technical change and efficiency change for a panel of firms during the period 1991 to 2001 in 26 Indian manufacturing industries. The results reveal that TFPG has declined for all the sectors during the period. Technical efficiency change has been positive in most of the industries indicating the diffusion of technology (as argued by Fare et al., 1994) in those sectors. However, technical change has declined in all the industries. This also highlights the point made in the literature survey about the differences in shifts of the productivity frontier and movement towards the frontier. Efficiency change and technical change are two components of productivity growth and change in productivity growth could come from either (or both). This has implications for the industrial policy of a developing country: improving efficiency may bring about significant productivity change (as also emphasized by Nishimizu and Page, 1982). Also given that shifting the frontier is resource intensive and is something many developing countries may not be able to bring about, there are obvious implications for technology policy in a developing country.

In the second stage, the productivity growth, efficiency change and technical change estimates have been used in a Tobit regression to compare the differential role of factors explaining them. The conclusion that emerges is that only in few of the industries do the same factors explain productivity growth, technical change and efficiency change. This paper provides an explanation for the slowdown of productivity growth: the importance of the RD intensity and the vintage of capital highlight the structural transformation underlying Indian manufacturing in the nineties.

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Tables

Table 1: Technical efficiency change, technical change and total factor productivity

	Δ TE	Δ TC	TFPG
Aluminium	0.998	0.797	0.796
Auto	1.001	0.788	0.788
Auto ancilliaries	1.010	0.790	0.794
Brew	1.000	0.804	0.804
Cables	0.998	0.785	0.783
Cement	1.006	0.795	0.799
Chemicals	1.004	0.794	0.797
Electrical equipment	0.999	0.798	0.797
Electronics	0.998	0.917	0.919
Engineering	1.010	0.795	0.796
Fertilizers	0.999	0.796	0.795
Food	1.002	0.808	0.809
Glass	1.004	0.792	0.795
Metal products	0.992	0.806	0.804
Non electrical machinery	1.005	0.802	0.810
Paints	1.009	0.793	0.801
Paper	1.002	0.798	0.799
Pharma	1.005	0.787	0.790
Plastics	0.972	0.831	0.818
Personal care	1.005	0.816	0.811
Petrochem	1.011	0.815	0.824
Solvent extraction	1.025	0.798	0.818
Steel	0.999	0.787	0.787
Sugar	1.002	0.795	0.795
Telecom	0.976	0.802	0.783
Textiles	0.998	0.793	0.793

Source: author's calculations based on equation (2)

Note: Δ TE: change in technical efficiency, Δ TC: technical change, TFPG: change in total factor productivity. TFPG, efficiency change and technical change has been computed using the DEA approach with value added as output and capital and labor as inputs.

Table 2: Summary of results

	Determinants of TC	Determinants of TE	Determinants of TFPG
Aluminium	MACH (-) with Y**,** Y (+), OWN 10 (+) without Y dummies		MACH (-) with Y, Y (+)
Auto	**RDCAP (+)** , Y (+)	**RDCAP (+)** only with Y and PRODIFF (-)	**RDCAP (+)**, Y (+)
Auto ancilliaries	RDCAP (+),Y (+)	RDREC (-) (only without Y),	RDCAP (+),
Brew	CAPVINT (-),Y (+)	No variation in efficiency	CAPVINT (-),Y (+)
Cables	RDCAP (+), Y (+)	RDREC (-),	RDCAP (+), Y (+)
Cement	IMPORTS (+) only if Y included,Y (+)		RDCAP (+), OWN 10 (+), Y (+)
Chemicals	CAPVINT (-) only if Y included, Y (+)	RDREC (-) only if OWN 10 included	OWN 10 (+), Y (+)
Electrical equipment	OWN 10 (+), Y (+)	CAPVINT (-)	OWN10 (+), Y (+)
Electronics	**EXP (+),** Y (+)	**EXP (+),** Y (+)	**EXP(+),** Y (+)
Engineering	RD (+), CAPVINT (-), OWN 50 (+), Y (+)		CAPVINT (-), Y (+)
Fertilizers	ROYAL (+), RDCAP (+), OWN 10 (+), Y (+)	CAPVINT (-) only if Y included	ROYAL (+), RDCAP (+), OWN 10 (+), Y (+)
Food	**RDCAP (+),** Y (+)	IMPC (+), PRODIFF (-), **RDCAP** (+) only if Y included,	**RDCAP** (+), IMPC (+), Y (+)
Glass	RDCAP (+), OWN 10 (+), Y (+)	RDREC (-),	OWN 10 (+), Y (+)
Metal products	**OWN 10 (+)**, Y (+)	**OWN 10 (+)** only if Y included	**OWN 10 (+)**, Y (+)
Non electrical machinery	CAPVINT (-) only if Y included, RDREC (-), **OWN 10 (+),** Y (+)	RD (+), **OWN 10 (+)** only if Y included,	RD (+) only if Y included, **OWN 10 (+),** Y (+)
Paints	**IMPC (+),** RDREC (-), OWN 10 (+), Y (+)	**IMPC (+)**, RDCAP (+) without Y (+),	**IMPC (+),** OWN 50 (+), Y (+)
Paper	CAPVINT (-), OWN 10 (+), Y (+)		CAPVINT (-), OWN 10 (+), Y (+)
Pharma	**EXP (+)** only with Y (+), OWN 50 (+),	**EXP (+),**	**EXP (+)** only with Y (+), OWN 10 (+)
Plastics	RDREC (-), **PRODIFF (-)**, Y (+)	CAPINT (+), EXP (+), **PRODIFF (-)**, RDREC(-) only with ROYAL and Y	**PRODIFF (-),** Y(+)
Personal care	CAPVINT (-),Y (+)	CAPINT (+), MACH (-),	CAPINT (+) only if Y included , MACH (-) only if Y included, Y (+)
Petrochem	OWN 10 (+), Y (+)	RDCAP (+),	OWN10 (+), Y (+),
Solvent extraction	IMPC (+) only with Y,	MACH(-) with PRODIFF and CAPINT and Y (+)	MACH (-) only if Y included, RDCAP (+) with EXP but not with Y , Y (+)
Steel	CAPVINT (-), EXP (+), RDCAP (+), OWN 50 (+) only when CAPVINT included, Y (+)		CAPVINT (-), OWN 10 (+), Y (+)
Sugar	RDREC (-) only if Y included,Y (+)		OWN 10 (+), Y (+)
Telecom	CAPVINT (-), IMPC(+) only with Y, Y (+)	RDCAP (+),	RDCAP (+), Y (+)
Textiles	EX (+), IMPR (+), OWN 50 (+), Y (+), no intercept and Y11	CAPVINT(-)	IMPR (+),OWN 50 (+), Y (+),

Source: Author's calculations

Note: only variables that are significant and with the expected sign are reported in the table.

Appendix A

Table A1: Industry wise Descriptive statistics

Industry	No. of firms in a year*	TFPG #	Capital (Rs. Crore)	Labor (Rs. Crore)	STO** (Rs. Crore)
Aluminum	7	0.796	285.55	39.69	624.12
Auto ancillaries	42	0.794	20.77	7.05	94.67
Automobiles	17	0.788	273.19	92.32	1150.74
Breweries	4	0.804	29.85	15.20	245.02
Cables	9	0.783	39.07	6.75	167.56
Cement	22	0.799	92.45	19.62	306.24
Chemicals	45	0.797	28.92	6.59	152.33
Electrical equipment	20	0.797	124.65	63.96	386.56
Electronics	26	0.919	72.07	15.82	236.37
Engineering	41	0.796	32.27	10.51	76.13
Fertilizers	16	0.795	178.98	27.39	554.45
Food	18	0.809	27.66	21.20	135.22
Glass	12	0.795	27.53	5.92	65.81
Metal products	11	0.804	32.64	9.10	95.63
Non electrical machinery	15	0.810	42.74	13.27	149.98
Paints	15	0.801	54.55	10.53	185.29
Paper	17	0.799	60.11	15.84	199.41
Personal care	10	0.811	52.22	7.89	254.88
Petrochemicals	10	0.824	207.00	37.28	583.58
Pharmaceuticals	26	0.790	43.00	13.95	143.76
Plastics	12	0.818	12.99	3.18	69.03
Solvent extraction	6	0.818	42.70	3.74	333.66
Steel	28	0.787	213.36	38.12	481.62
Sugar	12	0.795	109.57	11.21	188.82
Telecom	5	0.783	184.28	64.10	411.41
Textiles	90	0.793	52.79	10.80	161.09

Source: Author's calculations
* The number of firms refers to the number in that industry in each of the eleven years.
# computed using equation (2) and also reported in Table 1
** STO –Sales Turnover
Rs. Crore = Rs. 1, 00, 00, 000

Appendix B

Table B1: explanatory variables

	Variable	**Category as in Caves (1992)**	**Definition used**	**Expected sign of the coefficient in the regression**
1	IMPORTS (imports intensity)	Competitive Conditions	Total imports / STO	(+)
2	IMPC (imports of capital intensity)	Competitive Conditions	Capital (plant and machinery) imported /STO	(+)
3	IMPR (imports of raw materials intensity)	Competitive Conditions	Raw materials imported /STO	(+)
4	EXP (exports intensity)	Competitive Conditions	Total exports / STO	(+)
5	OWNER 10	Organizational factors	Dummy 1 if foreign ownership exceeds 10%	(+)
	OWNER 50	Organizational factors	Dummy 1 if foreign ownership exceeds 51%	(+)
6	CAPINT (Capital intensity)	Structural Heterogeneity	Capital /Employee Manufacturing Cost (EMC)	(+)
7	CAPVINT (vintage of capital)	Structural Heterogeneity	Depreciation allowance /value of plant and machinery	(-)
8	MACH (age of machinery)	Structural Heterogeneity	Accumulated depreciation /capital	(-)
9	PRODIFF (advertising intensity)	Structural Heterogeneity	Advertisement expenditure /STO	(-)
10	FUELINT (fuel intensity)	Structural Heterogeneity	Power and fuel cost / STO	(-)
11	RDCAP (R&D capital intensity)	Dynamic disturbances	R&D expenditure (capital) /STO	(+)
12	RDREC (R&D recurring intensity)	Dynamic disturbances	R&D expenditure (recurring) /STO	(-)
13	ROYAL (royalty payments intensity)	Dynamic disturbances	Royalty payments / STO	(+)
15	Y	Dynamic disturbances	Year dummies	(+)

Note: STO = sales turnover, EMC = employee cost

Appendix C

Table C1: Determinants of Technical change and productivity growth (TFPG) in Aluminum industry

Panel data regression: Dependent variable: Technical change and productivity growth

	Technical change	**Technical change**	**Technical change**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3	0.13 (3.22) ***	0.13 (3.23) ***		0.13 (3.27) ***
Y4	0.23 (5.27) ***	0.23 (5.22) ***		0.22 (5.32) ***
Y5	0.20 (4.10) ***	0.20 (4.13) ***		0.22 (4.86) ***
Y6	0.29 (7.33) ***	0.29 (7.18) ***		0.27 (6.51) ***
Y7	0.32 (8.08) ***	0.31 (7.78) ***		0.32 (8.02) ***
Y8	0.35 (8.54) ***	0.34 (8.03) ***		0.35 (8.27) ***
Y9	0.38 (8.03) ***	0.37 (7.64) ***		0.38 (7.77) ***
Y10	0.36 (9.38) ***	0.35 (8.80) ***		0.38 (9.24) ***
Y11	0.38 (9.76) ***	0.36 (9.06) ***		0.38 (9.57) ***
MACH	-0.02 (-1.83) ***			-0.01 (-1.74) ***
OWN 10			0.11 (6.74) ***	
S.E of regression	0.06	0.06	0.12	0.05

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 107.33 (for technical change) and 111.86 (for productivity change), Total number of observations = 70 of which uncensored = 70, ***-1 % significant, ** - 5% significant, * - 10% significant
No. of firms: 7, No. of years: 10

Table C2: Determinants of Efficiency change, Technical change and productivity growth (TFPG) in Auto industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3	0.01 (0.88)	0.16 (20.18)***		0.17 (22.68) ***	
Y4	0.01 (0.85)	0.24 (41.63)***		0.24 (52.42) ***	
Y5	0.01 (1.21)	0.28 (40.21)***		0.28 (46.65) ***	
Y6	0.01 (0.97)	0.30 (27.96)***		0.31 (29.47) ***	
Y7	0.01 (1.08)	0.34 (60.60)***		0.34 (77.09) ***	
Y8	0.00 (0.67)	0.37 (44.59)***		0.37 (48.82) ***	
Y9	0.01 (0.94)	0.38 (48.56)***		0.38 (54.14) ***	
Y10	0.01 (1.03)	0.38 (52.91)***		0.38 (60.52) ***	
Y11	0.02 (1.65)	0.39 (43.44)***		0.39 (55.82) ***	
RDCAP	0.12 (1.95)***		0.89 (2.28) ***		0.94 (2.23)***
S.E of regression	0.02	0.02	0.12	0.12	0.12

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 462.03 (for efficiency change), 398.87 (for technical change) and 405.10 (for productivity change), Total number of observations = 170 of which uncensored = 170, ***-1 % significant, ** - 5% significant, * - 10% significant, No. of firms: 17, No. of years: 10

In auto

Table C3: Determinants of Efficiency change, Technical change and productivity growth (TFPG) in Auto ancillaries industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**Technical change**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3		0.17(49.75) ***		
Y4		0.23 (43.04) ***		
Y5		0.27 (41.42) ***		
Y6		0.31 (45.05) ***		
Y7		0.35 (143.08) ***		
Y8		0.40 (49.24) ***		
Y9		0.41 (33.12) ***		
Y10		0.38 (91.19) ***		
Y11		0.44 (17.41) ***		
RDREC	-0.66 (-1.73)***			
RDCAP			4.16 (5.86)***	4.06 (5.72)***
S.E of regression	0.07	0.06	0.14	0.14

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 505.28 (for efficiency change), 222.85 (for technical change) and 223.45 (for productivity change), Total number of observations = 420 of which uncensored = 420, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 42, No. of years: 10

Table C4: Determinants of Technical change and productivity growth (TFPG) in Breweries industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3		0.15 (4.99) ***		0.14 (5.28) ***
Y4		0.26 (5.27) ***		0.26 (5.79) ***
Y5		0.27 (10.72) ***		0.26 (10.56) ***
Y6		0.30 (12.02) ***		0.29 (11.63) ***
Y7		0.33 (12.91) ***		0.31 (12.76) ***
Y8		0.31 (9.07) ***		0.29 (8.39) ***
Y9		0.36 (14.08) ***		0.34 (13.60) ***
Y10		0.39 (12.09) ***		0.37 (11.42) ***
Y11		0.43 (8.05) ***		0.41 (8.58) ***
CAPVINT	-1.39 (-2.30)***		-1.39 (-2.30)***	-0.48 (-2.20)***
S.E of regression	0.12	0.06	0.12	0.06

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 28.94 (for technical change) and 28.94 (for productivity change), Total number of observations = 40 of which uncensored = 40, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 4, No. of years: 10

Table C5: Determinants of Efficiency change and productivity growth (TFPG) in Cables industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			0.14 (3.50) ***		0.19 (3.16) ***
Y4			0.33 (9.16) ***		0.33 (8.21) ***
Y5			0.31 (8.04) ***		0.30 (7.22) ***
Y6			0.33 (9.41) ***		0.34 (7.75) ***
Y7			0.44 (11.78) ***		0.43 (10.27) ***
Y8			0.70 (4.73) ***		0.57 (4.87) ***
Y9			0.41 (10.78) ***		0.43 (10.77) ***
Y10			0.44 (12.86) ***		0.44 (12.63) ***
Y11			0.44 (12.96) ***		0.45 (13.01) ***
RDCAP		113.34 (3.76) ***		116.32 (4.22) ***	
RDREC	-62.28 (-2.07) ***				
S.E of regression	0.12	0.23	0.15	0.20	0.14

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 62.47 (for efficiency change), 4.81 (for technical change) and 16.90 (for productivity change), Total number of observations = 90 of which uncensored = 90, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 9, No. of years: 10

Table C6: Determinants of Efficiency change and productivity growth (TFPG) in Cement industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3
Y3	0.15 (11.69) ***		0.17 (5.52) ***
Y4	0.23 (25.90) ***		0.23 (12.62) ***
Y5	0.28 (26.79) ***		0.27 (14.39) ***
Y6	0.31 (33.25) ***		0.31 (16.44) ***
Y7	0.32 (27.67) ***		0.31 (15.03) ***
Y8	0.35 (35.76) ***		0.38 (9.31) ***
Y9	0.39 (29.06) ***		0.38 (12.11) ***
Y10	0.41 (23.15) ***		0.41 (14.62) ***
Y11	0.38 (31.62) ***		0.38 (19.52) ***
IMP	0.10 (2.12) ***		
RDCAP		0.36 (1.73) ***	
OWN 10		0.10 (7.38) ***	
S.E of regression	0.04	0.15	0.09

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 226.44 (for efficiency change), 397.53 (for technical change) and 215.54 (for productivity change), Total number of observations = 220 of which uncensored = 220, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 22, No. of years: 10

Table C7: Determinants of Efficiency change and productivity growth (TFPG) in Chemicals industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**TFPG**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3		0.15 (13.25) ***		0.17 (37.33) ***
Y4		0.24 (19.37) ***		0.25 (33.74) ***
Y5		0.29 (25.45) ***		0.30 (81.25) ***
Y6		0.29 (20.60) ***		0.33 (26.70) ***
Y7		0.36 (26.41) ***		0.35 (37.95) ***
Y8		0.37 (27.51) ***		0.39 (36.41) ***
Y9		0.36 (29.25) ***		0.39 (41.19) ***
Y10		0.42 (24.84) ***		0.41 (35.83) ***
Y11		0.44 (14.38) ***		0.59 (3.55) ***
CAPVINT		- 0.00 (-2.83) ***		
OWN 10			0.10 (4.83) ***	
RDREC	-2.74 (-1.75) ***			
S.E of regression	0.16	0.07	0.39	0.36

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 123.96 (for efficiency change), 501.50 (for technical change) and -283.47 (for productivity change), Total number of observations = 450 of which uncensored = 450, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 45, No. of years: 10

Table C8: Determinants of Efficiency change and productivity growth (TFPG) in Electrical equipment industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**Technical change**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	
Y3			0.16 (12.83) ***	
Y4			0.24 (19.35) ***	
Y5			0.28 (22.18) ***	
Y6			0.30 (23.94) ***	
Y7			0.38 (9.24) ***	
Y8			0.33 (17.65) ***	
Y9			0.38 (30.14) ***	
Y10			0.38 (30.16) ***	
Y11			0.41 (28.83) ***	
CAPVINT	-0.06 (-1.75) ***			
OWN10		0.10 (8.09) ***		0.10 (8.29) ***
S.E of regression	0.08	0.14	0.07	0.14

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 516.75 (for efficiency change), 116.10 (for technical change) and 108.70 (for productivity change), Total number of observations = 200 of which uncensored = 200

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 20, No. of years: 10

Table C9: Determinants of Efficiency change and productivity growth (TFPG) in Electronics industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Efficiency change	Technical change	Technical change	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3		0.01 (0.87)		0.19 (9.03) ***	
Y4		0.03 (1.60)		0.28 (8.16) ***	
Y5		0.02 (1.59)		0.30 (19.40) ***	
Y6		0.05 (3.05) ***		0.34 (9.25) ***	
Y7		0.03 (2.20) ***		0.31 (13.04) ***	
Y8		0.03 (1.88) **		0.39 (11.51) ***	
Y9		0.04 (2.80) ***		0.36 (23.40) ***	
Y10		0.02 (1.48)		0.40 (22.32) ***	
Y11		0.3 (2.01) ***		0.40 (23.16) ***	
EX	0.03 (1.81) ***		0.28 (2.80) ***		0.33 (2.66) ***
S.E of regression	0.04	0.04	0.15	0.10	0.16

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 485.39 (for efficiency change), 125.57 (for technical change) and 107.85 (for productivity change), Total number of observations = 260 of which uncensored = 260

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 26, No. of years: 10

Table C10: Determinants of Efficiency change and productivity growth (TFPG) in engineering industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3	0.03 (3.05) ***		0.17 (10.76) ***	
Y4	0.01 (1.57)		0.24 (44.64) ***	
Y5	0.01 (1.19)		0.30 (26.95) ***	
Y6	0.01 (0.94)		0.32 (36.70) ***	
Y7	0.01 (0.76)		0.35 (53.42) ***	
Y8	0.03 (1.65)		0.38 (58.69) ***	
Y9	-0.00 (- 0.38)		0.39 (63.32) ***	
Y10	0.01 (2.17) ***		0.40 (54.56) ***	
Y11	0.00 (0.09)		0.41 (59.19) ***	
CAPVINT		-0.13 (-3.69) ***		-0.13 (-3.55) ***
OWN 50		0.10 (14.07) ***		
RD		0.15 (2.70) ***		
S.E of regression	0.06	0.13	0.05	0.14

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 540.45 (for efficiency change), 258.73 (for technical change) and 210.20 (for productivity change), Total number of observations = 410 of which uncensored = 410

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 41, No. of years: 10

Table C11: Determinants of Efficiency change and productivity growth (TFPG) in Fertilizers industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**Technical change**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	
Y3	0.01 (1.06)		0.15 (8.91) ***	
Y4	0.01 (0.60)		0.21 (9.92) ***	
Y5	-0.00 (-0.57)		0.26 (22.27) ***	
Y6	-0.00 (-0.38)		0.31 (26.63) ***	
Y7	-0.02 (-2.97) ***		0.36 (26.54) ***	
Y8	-0.01 (-1.20)		0.36 (25.02) ***	
Y9	-0.04 (-3.58) ***		0.41 (17.38) ***	
Y10	0.02 (1.30)		0.33 (16.25) ***	
Y11	-0.04 (-2.47) ***		0.47 (12.04) ***	
CAPVINT	- 0.01 (-1.91) ***			
OWN10		0.11 (5.42) ***		0.10 (5.02) ***
RDCAP		15.01 (2.83) ***		14.19 (2.79) ***
ROYAL		1.04 (5.59) ***		1.05 (5.73) ***
S.E of regression	0.03	0.15	0.07	0.14

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 316.84 (for efficiency change), 83.36 (for technical change) and 89.14 (for productivity change), Total number of observations = 160 of which uncensored = 160

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 16, No. of years: 10

Table C12: Determinants of Efficiency change and productivity growth (TFPG) in Food industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Efficiency change	Technical change	Technical change	TFPG
	Eq. 1	Eq. 2	Eq. 3		
Y3		-0.03 (-1.08)		0.19 (11.35) ***	
Y4		-0.03 (-0.86)		0.25 (13.24) ***	
Y5		0.01 (0.35)		0.25 (17.88) ***	
Y6		-0.06 (-1.71)		0.30 (38.93) ***	
Y7		-0.04 (-0.98)		0.34 (33.05) ***	
Y8		-0.02 (-0.62)		0.31 (32.51) ***	
Y9		-0.02 (-0.54)		0.36 (47.93) ***	
Y10		-0.05 (-1.65)		0.38 (40.01) ***	
Y11		-0.02 (-0.59)		0.39 (31.44) ***	
PRODIFF	-0.26 (-1.69)	-0.35 (-2.20) ***			
IMPC	0.86 (2.74) ***	1.07 (3.66) ***			0.90 (4.51) ***
RDCAP		14.83 (2.27) ***	33.76 (3.74) ***		37.22 (3.26) ***
S.E of regression	0.08	0.08	0.12	0.04	0.12

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 197.09 (for efficiency change), 130.42 (for technical change) and 119.48 (for productivity change), Total number of observations = 180 of which uncensored = 180,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 18, No. of years: 10

Table C13: Determinants of Efficiency change and productivity growth (TFPG) in Glass industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			0.17 (28.14) ***		0.17 (28.14) ***
Y4			0.27 (15.98) ***		0.26 (25.23) ***
Y5			0.28 (20.73) ***		0.22 (3.40) ***
Y6			0.33 (62.47) ***		0.33 (23.20) ***
Y7			0.34 (38.69) ***		0.35 (28.95) ***
Y8			0.41 (21.42) ***		0.39 (24.34) ***
Y9			0.37 (26.70) ***		0.43 (8.81) ***
Y10			0.41 (49.31) ***		0.41 (49.31) ***
Y11			0.45 (12.86) ***		0.44 (12.86) ***
OWN 10		0.11 (8.02) ***		0.11 (6.76) ***	
RDCAP		0.21 (1.70) **			
RDREC	-1.50 (15.87) ***				
S.E of regression	0.10	0.14	0.05	0.16	0.10

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 112. (for efficiency change), 70.65 (for technical change) and 43.78 (for productivity change), Total number of observations = 120 of which uncensored = 120

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 12, No. of years: 10

Table C14: Determinants of Efficiency change and productivity growth (TFPG) in Metal products industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3	0.05 (1.47)		0.13 (6.90) ***		0.17 (4.87) ***
Y4	-0.03 (-1.30)		0.29 (5.94) ***		0.25 (8.58) ***
Y5	-0.02 (-0.87)		0.40 (3.67) ***		0.37 (3.48) ***
Y6	0.00 (0.36)		0.26 (7.71) ***		0.26 (7.54) ***
Y7	0.00 (0.36)		0.31 (16.78) ***		0.31 (15.51) ***
Y8	0.00 (0.36)		0.34 (17.75) ***		0.34 (16.43) ***
Y9	0.00 (0.36)		0.36 (17.44) ***		0.36 (16.31) ***
Y10	0.00 (0.36)		0.36 (18.79) ***		0.36 (17.44) ***
Y11	0.00 (0.36)		0.37 (18.68) ***		0.38 (17.42) ***
OWN 10	4.5 E-17 (13.47) ***	0.09 (5.26) ***		0.09 (5.79) ***	
S.E of regression	0.06	0.19	0.15	0.18	0.15

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 207.19 (for efficiency change), 36.03 (for technical change) and 43.64 (for productivity change), Total number of observations = 150 of which uncensored = 150,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 15, No. of years: 10

Table C15: Determinants of Efficiency change and productivity growth (TFPG) in Non electrical industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6
Y3		-0.06 (-0.73)		0.15 (6.20) ***		0.11 (1.51)
Y4		-0.07 (-0.85)		0.20 (9.76) ***		0.16 (2.28) ***
Y5		0.03 (0.26)		0.19 (6.97) ***		0.21 (2.54) ***
Y6		-0.02 (-0.28)		0.27 (12.19) ***		0.25 (3.71) ***
Y7		-0.08 (-1.01)		0.38 (11.56) ***		0.32 (4.48) ***
Y8		-0.12 (-1.46)		0.40 (7.96) ***		0.28 (3.81) ***
Y9		0.26 (0.83)		0.35 (15.95) ***		0.60 (2.15) ***
Y10		-0.10 (-1.42)		0.32 (12.52) ***		0.27 (4.08) ***
Y11		-0.06 (-0.81)		0.36 (14.74) ***		0.35 (5.25) ***
CAPVINT				-0.27 (-1.81) ***		
OWN 10		0.05 (2.63) ***	0.09 (5.19) ***		0.09 (2.13) ***	
RDREC			-0.14 (-6.80) ***			
RD	0.29 (5.82) ***	0.27 (3.64) ***				0.28 (4.18) ***
S.E of regression	0.43	0.44	0.14	0.08	0.39	0.37

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: -86.56 (for efficiency change), 79.96 (for technical change) and -70.81 (for productivity change), Total number of observations = 149 of which uncensored = 149,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 15, No. of years: 10

Table C16: Determinants of Efficiency change and productivity growth (TFPG) in Paints industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6
Y3		0.04 (2.17) ***		0.14 (9.78) ***		0.17 (9.89) ***
Y4		0.00 (0.19)		0.16 (5.42) ***		0.17 (4.92) ***
Y5		0.04 (1.21)		0.25 (18.10) ***		0.28 (13.14) ***
Y6		0.04 (1.22)		0.25 (12.15) ***		0.30 (16.15) ***
Y7		-0.04 (-0.96)		0.37 (18.31) ***		0.36 (7.77) ***
Y8		0.05 (0.96)		0.29 (13.62) ***		0.32 (8.79) ***
Y9		0.13 (2.19) ***		0.36 (24.68) ***		0.47 (8.29) ***
Y10		-0.00 (-0.13)		0.46 (13.44) ***		0.44 (14.22) ***
Y11		0.07 (1.04)		0.46 (10.61) ***		0.54 (4.96) ***
IMPC	1.05 (1.70) **	1.28 (1.91) ***	0.63 (3.13) ***	0.34 (2.44) ***	1.63 (2.71) ***	
OWN 10			0.10 (7.08) ***			
OWN 50					0.08 (4.22) ***	
RDREC			-1.10E-06 (-4.03) ***	-1.58E-06 (-4.68) ***		
RDCAP	1.25 E-05 (6.39) ***					
S.E of regression	0.16	0.16	0.16	0.08	0.23	0.18

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 65.76 (for efficiency change), 61.74 (for technical change) and 6.25 (for productivity change), Total number of observations = 150 of which uncensored = 150

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 15, No. of years: 10

Table C17: Determinants of Efficiency change and productivity growth (TFPG) in Paper industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Technical change	**Technical change**	**TFPG**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3		0.16 (7.65) ***		0.15 (6.39) ***
Y4		0.22 (13.22) ***		0.21 (9.56) ***
Y5		0.26 (16.45) ***		0.27 (13.11) ***
Y6		0.30 (18.74) ***		0.29 (14.80) ***
Y7		0.38 (10.15) ***		0.37 (9.53) ***
Y8		0.35 (21.21) ***		0.35 (16.14) ***
Y9		0.37 (18.64) ***		0.36 (15.60) ***
Y10		0.38 (20.69) ***		0.37 (17.13) ***
Y11		0.38 (23.54) ***		0.37 (17.77) ***
CAPVINT	-1.94 (-4.95) ***		-1.98 (-4.94) ***	
OWN 10	0.18 (3.86) ***		0.18 (3.83) ***	
S.E of regression	0.12	0.06	0.12	

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 126.94 (for technical change) and 124.77 (for productivity change), Total number of observations = 170 of which uncensored = 170,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 17, No. of years: 10

Table C18: Determinants of Efficiency change and productivity growth (TFPG) in Pharmaceutical industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			0.18 (16.78) ***		0.17 (26.45) ***
Y4			0.24 (22.70) ***		0.24 (26.45) ***
Y5			0.29 (26.75) ***		0.28 (31.60) ***
Y6			0.33 (31.00) ***		0.33 (34.68) ***
Y7			0.34 (31.82) ***		0.35 (41.47) ***
Y8			0.37 (34.59) ***		0.37 (50.17) ***
Y9			0.38 (35.04) ***		0.36 (36.93) ***
Y10			0.42 (39.14) ***		0.56 (3.68) ***
Y11			0.38 (35.13) ***		0.40 (9.54) ***
EX	0.02 (3.36) ***		0.01 (1.72) **		0.03 (3.12) ***
OWN 10				0.10 (4.00) ***	
OWN 50		0.12 (5.00) ***			
S.E of regression	0.19	0.12	0.04	0.29	0.26

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 58.66 (for efficiency change), 181.28 (for technical change) and -53.93 (for productivity change), Total number of observations = 260 of which uncensored = 260, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 26, No. of years: 10

Table C19: Determinants of Efficiency change and productivity growth (TFPG) in Plastics industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3	0.02 (0.54)		0.14 (2.99) ***		0.14 (2.19) ***
Y4	0.06 (2.12)		0.17 (3.65) ***		0.22 (5.24) ***
Y5	0.01 (0.72)		0.24 (5.03) ***		0.27 (6.02) ***
Y6	0.02 (0.96)		0.25 (6.30) ***		0.28 (8.17) ***
Y7	-0.02 (-0.64)		0.31 (6.78) ***		0.29 (7.33) ***
Y8	0.10 (1.51)		0.27 (6.95) ***		0.36 (6.54) ***
Y9	-0.10 (-0.19)		0.33 (6.54) ***		0.33 (7.50) ***
Y10	0.05 (1.69) **		0.35 (6.42) ***		0.39 (7.52) ***
Y11	0.05 (1.81) ***		0.36 (7.83) ***		0.42 (9.96) ***
CAPINT	0.00 (2.40) ***		0.00 (2.40) ***		0.00 (2.56) ***
EX	0.11 (1.77) **				
PRODIFF	-1.37 (-2.34) ***	-3.10 (-3.13) ***	-1.38 (-2.34) ***	-2.93 (-2.74) ***	
RDREC	-3.91 (-2.42) ***	-9.62 (-1.87) ***	-3.91 (-2.42) ***		
S.E of regression	0.10	0.14	0.10	0.16	0.13

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 106.68 (for efficiency change), 65.17 (for technical change) and 47.93 (for productivity change), Total number of observations = 120 of which uncensored = 120,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 12, No. of years: 10

Table C20: Determinants of Efficiency change and productivity growth (TFPG) in Personal care industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**Technical change**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3			0.16 (8.25) ***	0.19 (6.61) ***
Y4			0.27 (16.09) ***	0.28 (7.14) ***
Y5			0.29 (16.35) ***	0.30 (9.33) ***
Y6			0.61 (3.70) ***	0.47 (4.07) ***
Y7			0.26 (4.64) ***	0.37 (6.91) ***
Y8			0.40 (26.17) ***	0.49 (5.30) ***
Y9			0.47 (20.30) ***	0.57 (4.93) ***
Y10			0.56 (7.33) ***	0.50 (10.36) ***
Y11			0.65 (4.18) ***	0.55 (7.60) ***
CAPVINT		-0.73 (-1.76) **		
CAPINT	0.01 (1.85) ***			0.01 (2.41) ***
MACH	-0.08 (-2.05) ***			-0.12 (-2.59) ***
S.E of regression	0.25	0.32	0.26	

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit:, -2.07 (for efficiency change), -25.74 (for technical change) and 17.52 (for productivity change), Total number of observations = 97 of which uncensored = 97,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 10, No. of years: 10

Table C21: Determinants of Efficiency change and productivity growth (TFPG) in Petrochemicals industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**Technical change**	**TFPG**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			0.27 (10.46) ***		0.21 (6.37) ***
Y4			0.53 (5.36) ***		0.40 (4.32) ***
Y5			0.36 (18.02) ***		0.25 (8.26) ***
Y6			0.38 (18.78) ***		0.32 (13.17) ***
Y7			0.47 (14.33) ***		0.38 (11.20) ***
Y8			0.51 (15.77) ***		0.42 (10.82) ***
Y9			0.42 (18.07) ***		0.37 (15.41) ***
Y10			0.51 (13.57) ***		0.41 (14.21) ***
Y11			0.44 (20.00) ***		0.39 (15.65) ***
OWN 10		0.16 (2.35) ***		0.15 (4.35) ***	
RDCAP	11.94 (2.21) ***				
S.E of regression	0.11	0.19	0.12	0.17	0.12

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 80.55 (for efficiency change), 25.78 (for technical change) and 38.31 (for productivity change), Total number of observations = 100 of which uncensored = 100

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 10, No. of years: 10

Table C22: Determinants of Efficiency change and productivity growth (TFPG) in Solvent extraction industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**TFPG change**	**TFPG change**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Y3		0.40 (11.08) ***	0.21 (2.72) ***	
Y4		0.40 (10.09) ***	0.27 (2.43) ***	
Y5		0.51 (8.67) ***	0.27 (3.09) ***	
Y6		0.33 (11.56) ***	0.15 (1.53)	
Y7		0.47 (9.73) ***	0.26 (3.31) ***	
Y8		0.49 (24.86) ***	0.34 (4.35) ***	
Y9		0.36 (8.76) ***	0.41 (3.44) ***	
Y10		0.49 (23.30) ***	0.45 (4.59) ***	
Y11		0.55 (17.08) ***	0.30 (3.69) ***	
IMPC		2.97 (2.35) ***		
MACH	-0.40 (-1.92) ***		-0.33 (-2.09) ***	
RDCAP				204.74 (1.85) ***
S.E of regression	0.29	0.08	0.17	0.19

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: -7.49 (for efficiency change), 66.16 (for technical change) and 28.65 (for productivity change), Total number of observations = 60 of which uncensored = 60

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 6, No. of years: 10

Table C23: Determinants of Efficiency change and productivity growth (TFPG) in Steel industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Technical change	**Technical change**	**Technical change**	**TFPG**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			-0.03 (-1.05)		0.18 (13.54) ***
Y4			0.05 (1.91) ***		0.26 (19.87) ***
Y5			0.12 (3.32) ***		0.33 (12.63) ***
Y6			0.12 (4.28) ***		0.33 (25.27) ***
Y7			0.15 (5.05) ***		0.36 (22.57) ***
Y8			0.17 (6.16) ***		0.38 (30.69) ***
Y9			0.18 (6.17) ***		0.40 (27.65) ***
Y10			0.20 (7.19) ***		0.41 (29.88) ***
Y11					0.44 (15.40) ***
CAPVINT	-1.16 (-3.66) ***	-1.37 (-4.05) ***		-1.31 (-3.76) ***	
EX	0.21 (5.34) ***				
OWN 10				0.08 (6.09) ***	
OWN 50		0.10 (10.03) ***			
RDCAP	43.39 (4.88) ***				
S.E of regression	0.12	0.13	0.11	0.14	0.07

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 181.27 (for technical change) and 157.27 (for productivity change), Total number of observations = 280 of which uncensored = 280,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 28, No. of years: 10

Table C24: Determinants of Efficiency change and productivity growth (TFPG) in Sugar industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3
Y3	0.18 (11.98) ***		0.19 (9.06) ***
Y4	0.33 (8.39) ***		0.33 (6.60) ***
Y5	0.26 (8.23) ***		0.26 (9.11) ***
Y6	0.32 (22.75) ***		0.30 (16.97) ***
Y7	0.44 (8.92) ***		0.43 (8.87) ***
Y8	0.40 (20.20) ***		0.39 (9.54) ***
Y9	0.41 (13.09) ***		0.44 (7.52) ***
Y10	0.31 (9.76) ***		0.35 (9.53) ***
Y11	0.48 (19.52) ***		0.39 (14.00) ***
OWN 10		0.12 (3.74) ***	
RDREC	-0.63 (-4.37) ***		
S.E of regression	0.09	0.17	0.12

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 129.00 (for efficiency change), 117.25 (for technical change) and 84.85 (for productivity change), Total number of observations = 120 of which uncensored = 120,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 12, No. of years: 10

Table C25: Determinants of Efficiency change and productivity growth (TFPG) in Telecom industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	Technical change	Technical change	TFPG	TFPG
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			0.17 (3.16) ***		0.09 (1.44)
Y4			0.21 (5.31) ***		0.20 (5.77) ***
Y5			0.19 (3.95) ***		0.15 (2.08) ***
Y6			0.24 (6.52) ***		0.27 (7.70) ***
Y7			0.33 (6.81) ***		0.38 (7.32) ***
Y8			0.29 (7.55) ***		0.36 (6.34) ***
Y9			0.49 (6.40) ***		0.40 (7.60) ***
Y10			0.27 (6.39) ***		0.33 (8.25) ***
Y11			0.27 (6.05) ***		0.30 (7.27) ***
CAPVINT		-0.69 (-1.87) ***	-0.60 (-2.96) ***		
IMPC			0.39 (2.98) ***		
RDCAP	3.01 (7.30)***			2.20 (3.80) ***	1.40 (6.78) ***
S.E of regression	0.12	0.14	0.07	0.16	0.09

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 41.34 (for efficiency change), 29.63 (for technical change) and 52.94 (for productivity change), Total number of observations = 50 of which uncensored = 50, ***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 5, No. of years: 10

Table C26: Determinants of Efficiency change and productivity growth (TFPG) in Textiles industry

Panel data regression: Dependent variable: Efficiency change, technical change and productivity growth

	Efficiency change	**Technical change**	**Technical change**	**TFPG**	**TFPG**
	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
Y3			0.60 (47.41) ***		0.59 (44.61) ***
Y4			0.69 (53.91) ***		0.67 (55.87) ***
Y5			0.72 (45.06) ***		0.72 (58.47) ***
Y6			0.76 (48.16) ***		0.77 (26.98) ***
Y7			0.78 (54.03) ***		0.77 (52.75) ***
Y8			0.80 (54.89) ***		0.79 (51.99) ***
Y9			1.07 (7.25) ***		0.86 (14.30) **
Y10			0.79 (40.83) ***		0.77 (33.61) ***
Y11					0.79 (33.18) ***
CAPVINT	-0.04 (-1.73) ***				
EX		0.99 (23.88) ***	0.22 (4.66) ***		
IMPR		2.56 (9.80) ***	0.56 (3.37) ***	0.17 (2.61) ***	0.32 (3.28) ***
OWN 50		0.55 (4.26) ***	0.35 (1.95) ***	0.10 (10.21) ***	0.05 (3.49) ***
S.E of regression	0.15	0.60	0.48	0.17	0.25

Note: Censored Normal Tobit with Huber White standard errors and covariance. Other statistics: log likelihood for Tobit: 279.87 (for efficiency change), - 1095.58 (for technical change), and 193.12 (for productivity change), Total number of observations = 900 of which uncensored = 900,

***-1 % significant, ** - 5% significant, * - 10% significant

No. of firms: 90, No. of years: 10

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