Innovation and Employment: A Firm Level Study of Indian Industries[1]

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Abstract

This study based on the firm level data for eleven industries for the period ranging from 1998 through 2010 makes an attempt to capture the effect of R&D on employment in the backdrop of the debate on possible tradeoffs between innovation and labour absorption. It also estimates the firm specific time variant total factor productivity growth and technical efficiency and assesses the impact of R&D on these performance indicators. Though the findings are not supportive of a positive relationship between R&D and productivity, the elasticity of employment with respect to R&D is seen to be positive in a number of industries. Even when R&D does not mean actual innovation of technology, it involves processing of byproducts and efforts pursued to bring in an improvement in product quality and efficiency which may be resulting in employment gains.

Keywords: innovation, R&D, employment, TFPG, technical efficiency.

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1. Introduction

Innovation is endemic to economic growth. Growth in output which is more than proportionate increase in inputs is attributed to total factor productivity growth (TFPG), after controlling for returns to scale. TFPG in turn is a combination of technological progress and change in technical efficiency and an important determinant of total factor productivity growth, particularly the technological progress component, is linked to innovation. Endogenous growth models urge that research and development (R&D) expenditures taken as a broad proxy for innovative moves contribute directly to firms' productivity enhancement, and indirectly through their industry-wide spill-over effects (see Grossman and Helpman, 1990b; Romer; 1986).

However, the effect of innovation on employment is an important concern: whether innovation tends to reduce employment or it can be conducive to employment growth is a pertinent issue. If innovation means lesser utilisatiion of all the factors of production for the same level of output to be produced, then naturally it tends to reduce employment per unit of output. However, if innovation reduces the utilization of some of the factors of production and not labour, then both innovation and employment can go hand in hand. In support of this latter view it may be argued that output growth can be faster than the growth of some of the inputs such as capital but not labour because the labour contracts may involve rigidity. Labour might have been hired on a long term basis, which can be treated as a sunk cost (fixed or variable) - a retrospective cost that has already been incurred and cannot be recovered. Besides, the operation of the new technology is not necessarily automated that involves labour displacement.

A related point is also of great interest. Even if innovation leads to lesser utilization of all the factors (including labour) for a given level of output, the rise in the quantum of production certainly contributes to employment generation, i.e., the scale effect. Modernisation of technology may lead to its large scale application in various sectors of the economy and hence, the quantum of production and employment both may increase simultaneously even when the new technology gets more capital intensive. These issues of employment increase at the aggregate level due to wider application of the advanced technology prompted by the profit motive are certainly of great relevance, particularly in the context of the developing economies confronted with the compulsion of maximizing growth and generating employment opportunities for the vast supplies of labour.

However, there can be is a negative effect of innovation on employment. Since technological innovation largely takes place in developed countries they are made to suit these economies and their factor endowments. Incidentally these countries are primarily labour scarce and thus the new technology tends to become increasingly labour saving (Pack and Todaro, 1969). Import of such technology by the developing countries reduces their employment growth, particularly in the high productivity formal sector. However, there could be a counter-argument to this as well. The inter-linkages between the formal and the informal sectors are of great significance. Ancillary activities which are undertaken in the informal sector may contribute to substantial employment generation and thus, at the aggregate level there could be employment gain. But this view can again be contested by arguing that employment in the informal sector is of residual type, which raises the vulnerability of the workers. On the whole, a thorough review of literature both on theoretical and empirical aspects needs to be pursued before turning to the empirical analysis.

2. Various Viewpoints: Existing Studies

Schumpeter (1931, 1961) initiated the concept of "innovation". In his postulation innovation is a new production function, displaying a new combination of factors of production or production conditions. Innovation is a continuous process of creative destruction, old being replaced by the new. The combination of capital, labor and other factors of production is optimized in the process of innovation and its impact on total employment and employment structure is cyclical. In the initial stages, total employment grows sluggishly or even declines, while employment structure does not change significantly; at a later stage, there are rapid increases in total employment and marked changes in employment structure; and in the final stage of innovation, changes both in total employment and employment structure gradually diminish until the next innovation comes through (Guangrong and Yuanyuan, 2009).

If the new technology enhances productivity as well as promotes employment, the choice is clear. Such a possibility, though empirically difficult to materialize, exists at least theoretically. For example, technological progress brings in upward shift in the production frontier, which would mean higher levels of output for the given levels of inputs. In such a situation if the new technology becomes labour intensive, the rise in value added and employment both will be witnessed. However, the value added growth will be more than the rise in employment, and hence, labour productivity can actually shoot up[4]. Conversely, the new technology can dampen employment and improve productivity by adopting capital-deepening process.

Choi, Yub and Jin (2002) analyze the implications of Hicks-neutral technical progress for a small Harris-Todaro economy with variable returns to scale. The analysis demonstrates that the welfare effects of technical progress consist of three components, i.e., the primary growth effect, the returns-to-scale effect and the employment effect. This type of decomposition is indeed useful as it deciphers the effects of technical progress into various components. Besides, the study works out the possibilities under non-constant returns to scale which is a much stronger possibility in the real world than a constant returns to scale situation. Under constant returns to scale the possibility of non-immiserizing exists and one may conclude that technical progress will be beneficial. But with the introduction of non-constant returns to scale, technical progress can lead to the returns-to-scale effect, which can be of any sign, and the sum of the primary growth effect and the employment effect again can be of any sign which creates the possibility of immiserizing growth. In other words, growth without employment generation is possible as technical progress tends to reduce labour absorption.

Technical progress and rising capital intensity in the literature are almost synonymous. On the other hand, innovations in the line of labour intensive technical progress is a difficult proposition as these innovations are not easy to pursue. The capital intensive technical change also has important implications for rates of industrialization and capital accumulation even when the economies, particularly in the developing world, are characterised by a dual economic structure. Kelley, Williamson and Cheetham (1972)

[4] However, when output is fixed, the shift in technology from being capital intensive to labour intensive would result in deterioration in labour productivity.

noted that increases in the bias may tend to inhibit the rate of industrialization and reduce the rate of capital accumulation without appreciable changes in per capita GNP growth. Related to these results is the extent to which labour absorption in the industrial sector is affected: the study observes an important retarding influence that accumulates over time. It questions the wisdom of introducing labour saving technology in the industrial sector in order to enhance per capita growth. The authors rather note that per capita income is mostly insensitive to the technological bias introduced in the industrial sector of the developing countries. Hence, the outcome is neither an increase in per capital income nor a rise in employment in the industrial sector in response to adoption of capital intensive technology.

In fact, Mureithi (1974) elucidates this point with great lucidity. The rising capital-labour ratio means that each job creation is becoming more capital-expensive. Of course it must not be supposed that rising capital intensity is bad per se. It is likely that a large part of the capital formation could be devoted to the building of infrastructure like roads, public works, communications, etc. In addition, as the author argues, it is pertinent to realize that production actually takes place in stages: l) material handling, 2) material processing, 3) material handling among processes, 4) packaging, 5) storage of the finished products. Of the five stages, only the second, i.e., the central processing, need be capital intensive because at this stage the finer precision of temperature, pressure, ingredients combination, etc, is important. But there are many other stages where factor substitutability is technically possible and thus the entrepreneurs have a choice to select the technology. The desirability of a technology has to be judged not merely by its scientific or technical sophistication, but rather by its appropriateness in the context of the society in which it will be used. It requires innovative ideas to reduce the labour-saving elements of a technology while maintaining or improving quality and efficiency. In other words, labour-intensive technological progress which can improve performance and employment both is something that needs to be pursued by the developing countries. Even after accounting for the fact that there could be stages where capital intensive technology is absolutely necessary, innovation and employment can move in a positive direction in many other stages which then can offset the negative effect on employment as conceived in certain specific stages.

The “compensation theory” as Vivarelli (2013) points out, argues that technological unemployment is a temporary phenomenon. The labour saving effects of technology can be offset through: “(1) additional employment in the capital goods sector where new machines are being produced, (2) decreases in prices resulting from lower production costs on account of technological innovations, (3) new investments made using extra profits due to technological change, (4) decreases in wages resulting from price adjustment mechanisms and leading to higher levels of employment, (5) increases in income resulting from redistribution of gains from innovation, and (6) new products created using new technologies" (Vivarelli, 2013)[5].

Another interesting point emerges in relation to the preference for new technology (James, 1993). If new technology is not adopted it may affect the quality of products and thus exports may suffer, resulting in employment loss. On the other hand, adoption of new technology which is capital intensive in nature can cause employment to fall. Hence, one has to verify if employment loss due to drop in exports prompted by the traditional

[5] Also see Vivarelli (1995) and Pianta (2005).

labour intensive technology or employment loss due to adoption of capital intensive technology is greater in magnitude. Further, the speed of production, product flexibility and locational factors need to be considered in assessing the total effect of technology on employment. If certain products are manufactured in the low cost countries labour intensive technology can still be pursued. Hence, the factor price ratio is an important determinant of technology choice and decision about location of production base, which eventually impact on employment. The idea of enlarging the production base across the globe is embed in the study by James (1993). While the low labour cost countries can specialize in the production of certain goods or certain components of the composite goods using the labour intensive methods, the developed countries may specialize in certain other components that require very high levels of capital and skill. Thus, the newer and innovative ways would mean that technical progress would not only suit the labour market situation of the developing and the developed countries both but also bring in a positive relationship between innovation and employment at large.

A positive relationship between innovation and employment has been conceptualized in a novel way by Saviotti and Pyka (2004). Interpreting economic development as synonym for new goods, services or sectors Saviotti and Pyka (2004) view their emergence as a result of increasingly systematic use of innovation - a component of economic development which amounts to a process of qualitative change within the economic system. It is quite natural that as the old product or services matures employability declines. This could be due to a number of reasons. For example, with learning by doing total factor productivity growth takes place and hence, to produce the same magnitude of goods/services labour requirement may decline sizably. Thus, to improve the level of employment in a continuous manner, innovation has to go on and new goods and services have to be produced. In this sense innovation and employment can go hand in hand. The ability to reap variety is a manifestation of economic development, which in turn can create employment steadily. Also, on the productivity front its growth may not take place indefinitely implying upper bounds on sectoral productivity growth. In order to augment the productivity growth at the country level efforts have to be pursued to create new sectors. On the whole, the possibility of a positive relationship between innovation, employment and growth is not inconceivable.

However, having said this we may turn to another set of argument which suggests that the developed countries are faced with a severe shortage of labour ready to pursue mechanical jobs, and thus the innovations relating to technical progress are usually pursued with an objective of reduction in labour requirement in the production process. So technical progress and rising capital intensity proceed synonymously, which do not conflict with the labour market situation in the developed countries. However, with import liberalization if the developing countries import this type of technology at a cheaper cost it restricts their employment growth. Thus the labor-saving technical change is a definite disadvantage to developing economies (Kelley, Williamson and Cheetham, 1972.

As Azeez (2006) points out distinctly, a new technology gets embodied in capital goods, and therefore, import of capital goods is often considered as import of technology. Once imported capital good is put into operation, the technological progress realized in the country of origin will be incorporated into the production process (UNIDO, 2005). Though UNIDO (2005) argues that it is still cheaper for a latecomer to buy the technology already invented by others than to re-invent the wheel, there can be serious implications in terms of employment loss. Chakravarty (1987) noted that with imports of capital goods on a significant scale, domestic costs of production are unlikely to come down since developing countries might be importing expensive capital goods. Further, imports of capital goods can act as substitutes for domestic production of capital goods, imposing a social cost in the form of unutilized capacity making the domestic firms operate at high unit cost of production (Chandrasekhar, 1992).

The adoption and adaptation of these international technologies are indeed costly because of tacit knowledge and circumstantial sensitivity of technology (Evenson and Westphal 1995). Unless an importing country has significant technological capability, it cannot fully utilize the imported technology**.** Besides, imported technology may require more skilled than unskilled workers while developing countries are usually have an abundant supply of the latter type. Acemoglu and Zilibotti (2001) argue that due to the difference in skill scarcity, technology in developed countries tends to be skill intensive and is inappropriate for developing countries. Thus the potential productivity of imported technology cannot be realized in developing countries.

Next, one may pose the question in relation to product and process innovation. The interaction between economic integration, product and process innovation, and relative skill demand is an important aspect, which Braun (2008) analyses in a model of international oligopoly. Lowering of trade barriers increase the degree of foreign competition which may have effects on the incentives of firms to undertake R&D investment and also the firms' demand for skilled relative to unskilled workers. Increased competition following economic integration induces firms to bring down production costs by investing more aggressively in process R&D. At the same time, competitors expand their investments in product innovation in order to reduce the substitutability of their products. However, all this would require highly skilled human labour which can initiate newer ways of introducing cost efficient production processes and bring down the product differentials between the imported goods and the domestically produced goods. On the whole, economic integration and innovation are inter-linked resulting in an increase in the relative demand for skilled workers[6] and not the unskilled or semi-skilled variety of labour force which is in excess supply in most of the developing countries. Innovation and skill intensity usually go together – hence, even if innovation is not always labour displacing it benefits only those who are relatively in short supply. This tends to indicate that wage inequality is likely to increase in the process of innovation and increased trade.

On the empirical front Berman and Machin (2000) showed the skill-bias of technological change especially in middle-income countries. Pianta (2005) emphasizes that innovation-based growth and job creation may operate in drastically different ways during different phases of the cycle, implying that the employment dynamics are not affected by the same factors and in the same ways during the upswings and the downswings. Piva (2003) presents a critical comparison of the positive implications of technology transfers (such as positive spillovers, technological catching-up, growing complementarities with domestic firms) with the negative ones (displacement of workers, negative welfare implications, competitive effects with domestic firms). Also, the author considers the nature of transferred technologies (labour-saving and/or skill-bias, embodied or not embodied in capital), together with the different institutional 'absorptive capacities' and

[6] Vivarelli (2011) argues that innovation has a strong skill-bias.

sectoral specializations of both middle-income and low-income developing countries. Lee and Vivarelli (2006) suggest that import of capital goods may imply an increase in inequality via skill-biased technological change. Imports of capital goods, - embodying technological innovations - are important both because of the role they play in contributing to capital upgrading and more generally to the economic growth of the developing countries. In fact, even without necessarily assuming that developed countries transfer their “best” technologies, transferred technologies are relatively skill-intensive, i.e. more skill-intensive than those in use domestically before trade and FDI liberalization. Thus openness – via technology – should imply a counter-effect to the SS theorem prediction, namely an increase in the demand for skilled labour, an increase in wage dispersion and so an increase in income inequality. However, using data on 33 Indian manufacturing industries in India for the period, 1992 through 2001, Pandit and Siddharthan (2006) further showed that technology imports, through joint ventures and MNE participation, influence employment positively. They noted that employment growth, production of differentiated products, skill intensity of the work force and technological up-gradation go hand in hand. On the other hand, Mitra (2009) observed a decline in employment to value added ratio with a rise in manufacturing imports including technology. .

Castellani and Zanfei (2006) present an in-depth theoretical and empirical analysis of the key issues underpinning the relationship between innovation and multinational companies. The authors argue that neither every foreign firm is a good source of externality nor every domestic firm is equally well placed to benefit from multinationals. Spillovers from multinationals differ according to the technological profiles, embeddedness and linkage creation of both foreign and domestic firms. Hasan (2002) presented evidence from panel data on Indian manufacturing firms in favour of a significant effect of imported technology on productivity. The empirical literature on R&D, using cross-sectional data, reports strong evidence in favour of its positive effect on productivity while the time series estimates are less conclusive (Crespi and Pianta, 2006).

With this background the rest of the paper is organized as follows. In section 3 we estimate technical efficiency (TE) and total factor productivity growth (TFPG) of firms using panel data for each of the eleven manufacturing industries and Section 4 examines the impact of R& D on some of these indicators. The impact of locational factor has also been controlled for. In section 5 we assess the impact of RN D and other firm specific factors on employment. This is pursued with and without considering the simultaneous impact of efficiency and productivity on employment. Finally the findings are summarized in section 6.

Two working hypotheses are pertinent:

1. Innovation leads to technology creation with higher efficiency and TFPG.
2. The productivity gains could be more in relation to capital than labour as the former is more expensive, which means innovation and employment both are positively associated.

Alternately, one may argue that expenditure on R&D has no effect on technology up-gradation since technology is mostly imported from the western developed countries. But this can be further contested on the ground that innovation is pursued by firms to attain product efficiency (quality), process other by-products and create ancillary products without any proportionate rise in investment in capital. This may require additional labour and thus the total employment of the firm may increase.

Using the firm level data in the manufacturing sector, compiled by ACCEQUITY for the period 1998 through 2010, the estimation has been carried out for eleven industries. The number of firms in many of these industries is substantial covering most of the existing ones with the exception of the very small ones[7]. However, the panel is not balanced as the information on all the variables is not available for all the firms and for each of the years. As regards the TFPG estimation the possibility of a strong relationship between TFPG and other inputs is low because we have considered an output function in which material and energy other than capital and labour (which are included in a value added function) are also considered. In other words TFPG estimated from a value added function may have strong relationship with inputs compared to TFPG estimated from an output function.

3. Estimating TE and TFPG

It may be useful at the outset to place a precautionary note in relation to the research and development expenditure (R&D) of the Indian firms, which is used as a proxy for innovation expenditure. First of all it does not necessarily mean technology creation. Funds are shown under R&D expenditure to derive tax benefits. After acquiring most parts of the technology from abroad firms have a tendency to show them as their own innovations. Similarly foreign personnel are invited to undertake R & D related activities rather than being pursued by the regular Indian employees. The employees are sent

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[7] The number of firms is as follows : Consumer Durables (Domestic Appliances) : 15, Consumer Durables (Electronics): 12, Chemical : 119, Electric Equipment: 51, Electronics Component: 36, Engineering: 79, Engineering Construction: 46, Engineering (Industrial Equipments): 38, Household and Personal Products: 23, Leather: 18, Pharmaceuticals and Drugs: 158

abroad for training which is again then indicated under the broad head of R&D expenditure. Indian enterprises import technology from abroad through the employment of consultants (Mani, 2008, 2009). In India, in-house R&D expenditures have increased tremendously since 1991 and so also the importation of technologies from abroad. The informal channels of technology imports have become very pronounced during the period of liberalization (Mani 2008, 1009).

Though the use of R&D is taken as a proxy for innovation it might be weak, especially in developing countries. Even if some MNEs have located their R&D headquarters in developing countries, computationally it does not take into account all the transfer of technologies embodied in machines which generally accounts for the most of the innovation dynamics. No information is available in this context from the companies' annual reports.

As Mani (2009) points out there is a strong view that India has now become a growing destination for innovative activities by MNCs, showing growing presence of foreign R&D centres in the country. Also FDI from India is steadily increasing and there have been a number of high profile take-over of Western technology-based companies by Indian corporates. All these indicators tend to suggest that India has become more innovative since 1991. Also, the TFPG growth in manufacturing and services is attributed to innovation. However this sort of an optimistic picture is an exaggeration. Though the technology oriented ventures are on the rise, Mani (2008, 2009) points out that most of the US patents that are assigned to India are actually owned by MNCs. The IT sector is well-known for obtaining patents but only foreign enterprises are specializing in IT related patents. On the whole, foreigners have taken more patents in India than Indians at the India Patent Office. He observed that the private sector enterprises are the most important inventors and among the ones who are active in obtaining patents are in the pharmaceutical sector. In fact, most of the domestic patents are in chemicals and pharmaceuticals only. So the view that India is becoming more innovative is rather difficult to be substantiated with evidence. Rather there is a severe shortage of skilled manpower, particularly in the Engineering sector (Mani, 2008, 2009).

A critical review of the company reports also tends to support some of these views as they spend mostly for improvement in product quality by refining operational parameters in order to meet consumers' aspirations. Also they pursue processing of by-products, introduce new products and improve the existing product efficiencies. Technology absorption and adaptation, improvement in marketability of products with improvement in the quality and flexibility of the products are some of the important items. How R&D can help negate the effects of squeezed margins in the competitive markets in terms of new models, new versions, business growth is an important objective of the firms. However, the reports also mention the possibility of upgrading the technology and development of alternative low cost raw materials and optimization of energy consumption. Table 1 on R&D expenditure as a percentage of sales suggests that most of the industries correspond to a very low magnitude. Only pharmaceutical and drugs show a figure of 2 percent; in the rest of the industries it is substantially lower than 1 per cent. In terms of rate of growth, however, R&D expansion is enormously large which could be due to a low initial base[8].

Table 1: R&D as a percentage of Sales (%)

Industry	RND/SALES%

[8] As for example, Whirlpool Of India Ltd. registered a R&D growth of 28.41%.

Engineering (construction)	0.0073
Engineering	0.0309
Leather	0.0324
Chemical	0.0549
Consumer Durables (electronics)	0.0624
Electronic Components	0.0636
Engineeing Industrial Equipment	0.11645
Consumer Durables (domestic appliance)	0.17181
Electrical Equipment	0.2547
Household and Personal Products	0.2653
Pharmaceutical and Drugs	2.1651

Time variant TE and TFPG from firm specific panel data: Methodology

Total factor productivity growth encompasses technological progress (regress) and the change in technical efficiency (TE) over time. Technological progress may be defined as advances in knowledge relating to the art of production, which may take the form of new goods, processes or new modes of organization (Goldar 1986). On the other hand, technical efficiency is the efficiency with which factors of production are combined to generate output. Technological change can be conceptualized in terms of shifts in the production function (Solow, 1957), whereas technical efficiency measures the distance between the actual and the frontier or maximum attainable levels of output (Bettesse, 1990). Some of the earlier studies that estimated the total factor productivity growth in the Indian context did so mostly under the assumption of constant return to scale and perfect competition in the factor market (Goldar, 1986). Without essentially considering these assumptions, the present study, based on the time series and cross-section poled data for fifteen major states in India, employs a frontier production approach to estimate technological change and the time varying technical efficiency, on the basis of which total factor productivity growth for each of the 17 two-digit level industries is estimated.

The methodology followed here is that of Cornwell, Schmidt and Sickles (1990), and has been applied in other studies as well (Krishna and Sahota 1991; Fecher and Pestiean1993; and Wu 1995).

As mentioned above the firm level data is extracted from ACCEQUITY. Since we do not have information on output/value added, total sales have been taken as a proxy. The log of sales is regressed on log of employment, and expenditure on capital, material and fuel and a time trend (t), the coefficient of which captures the technological progress (regress). Since companies reported only wages and salaries bill and not the number of employees, the industry specific emolument per person has been taken from the Annual Survey of Industries to divide the wages and salaries bill and deduce the number of total employees, inclusive of floor workers[9]. Consumer price index for the industrial workers is used to deflate the nominal wages. Capital (gross asset) is deflated by the prices of machinery and machinery tools. Energy is deflated by prices of methanol. Sales and materials (raw) are deflated by the respective industry specific product prices (wholesale price index –WPI).

The equation for gross sales is estimated for each of the eleven industries applying the standard panel data methods. From the three versions of the model (OLS, FE and RE) the appropriate one is chosen on the basis of the Lagrange Multiplier statistic and the Hausman statistic. The results are presented in Table 2: most of the variables are statistically significant and among the significant ones all have positive coefficients.

Table 2: Regression of Sales on Various Inputs

Dependent variable- LnSales

[9] This procedure assumes that each firm in a given industry is paying the same wage rate which may not be the case in reality.

Industry	Model	lnAssets	lnMaterial	lnEnergy	lnEmployment	Time	Constant	R^2	N
Consumer Durables-Domestic Appliances	FE	-0.036 (-1.35)	0.787** (45.50)	0.073 ** (4.37)	0.169** (8.14)	0.008 ** (3.78)	1.684** (7.64)	0.99	214
Consumer Durables-Electronics	FE	0.076 (1.34)	0.632** (21.55)	0.036 (1.01)	0.351** (5.80)	0.004 (1.04)	1.307** (3.05)	0.96	175
Chemical	FE	0.059** (4.05)	0.699** (65.35)	0.125** (10.98)	0.080** (5.05)	0.003** (2.22)	1.634** (13.00)	0.96	1579
Electric Equipment	FE	-0.042 (-1.32)	0.559** (28.02)	0.025 (1.13)	0.257** (7.96)	0.042** (10.30)	3.749** (13.60)	0.95	624
Electronics Component	RE	0.044 (1.43)	0.696** (32.85)	0.059** (2.28)	0.252** (6.95)	0.012** (3.41)	1.274** (5.82)	0.97	473
Engineering	RE	0.153** (6.02)	0.285** (20.83)	0.158** (7.12)	0.354** (7.12)	0.040** (10.79)	2.612** (13.71)	0.90	1010
Engineering Construction	RE	0.997** (288.74)	0.0003 (0.16)	0.002 (1.33)	-0.001 (-0.55)	0.013** (18.45)	-0.029* (-1.74)	0.99	463
Engineering –Industrial Equipments	FE	0.063 (2.78)	0.612 (30.39)	0.115 (5.55)	0.120 (4.71)	0.026 (7.01)	2.321** (14.28)	0.96	485
Household & Personal Products	FE	0.139** (4.24)	0.512** (14.57)	0.149** (5.04)	0.284** (7.36)	0.004 (1.17)	1.372** (4.32)	0.98	296
Leather	FE	-0.049 (-0.95)	0.758** (29.58)	0.164** (5.35)	0.044 (1.35)	0.010** (2.63)	2.022** (4.69)	0.97	249
Pharmaceuticals & drugs	FE	0.046** (2.89)	0.591** (65.82)	0.105** (8.41)	0.140** (9.58)	0.008** (4.21)	2.466** (20.64)	0.96	2061

ln stands for logarithmic transformation.
Figures in parenthesis are t- values for FE model and z-value for RE model
FE denotes fixed effect model and RE denotes random effect model. Based on LM and Hausman statistics the appropriateness of the model is chosen. ** and * denote 5 and 10 % level of significance, respectively.

In the next step the residuals are regressed on time t, i.e, time trend and t^2 for each of the company separately and the estimated values of the regressand are derived. Then pooling the data across firms over time the best performing firm and the year in which its performance is seen at the top is identified. This helps us estimate the efficiency level of the best performer for all other years and of all other firms for all the years. From the time varying technical efficiency and TFPG estimates at the firm level we have calculated the average estimates for each firm based on which the industry averages have been derived (Table 3). Consumer Durables (Domestic Appliances) and Engineering Construction are the two industries in which the average efficiency is over 60 per cent. Leather shows an efficiency of a little below 50 per cent and Consumer Durables (Electronics) and Engineering (Industrial Equipment) are at around 30 percent level. Chemical, Electronics Component and Household and Personal Products are also close to 30 percent. The rest of the three industries, i.e., Electric Equipment, Engineering, and Pharmaceutical, show a poor efficiency level of around 10 per cent or so. However, in Consumer Durables (Electronics) the average TFP growth has been exceptionally high (22.6 per cent) notwithstanding a moderate technical efficiency. Except the other three industries namely, Electric Equipment, Engineering, Engineering (Industrial Equipment) which experienced a TFPG of around 3 to 4 per cent the rest shows a sluggish growth of less than 1 per cent per annum.

Table 3: Average Efficiency and Total Factor Productivity Growth (%)

Industry	Efficiency	TFPG (%)
Consumer Durables-Domestic Appliances	0.6	0.808
Consumer Durables-Electronics	0.384	22.576
Chemical	0.262	0.613
Electronics Component	0.279	0.328
Electric Equipment	0.096	4.098
Engineering Construction	0.880	1.175
Engineering	0.123	3.847
Engineering- Industrial Equipment	0.344	2.667
Household and Personal Products	0.289	0.408
Leather	0.479	1.19
Pharmaceutical	0.101	0.74

Source: Authors' calculation.

4. Impact of R&D on TE and TFPG

The impact of R&D on performance, particularly TFPG, is a well-documented view. Nadiri (1993) found a positive and strong relationship between R&D as an index of technological change, and TFPG in the developed countries' context. Singh and Trieu (1996) also noted a positive impact of expenditures on basic, applied and experimental research on TFPG in Japan, South Korea and Taiwan. However, we noted in the text earlier that RND expenditure may not be always linked to technological change. In the next step we make an attempt to assess the impact of R&D as a percentage of sales on TE and TFPG. This is pursued in two ways. First, based on the firm-specific average figures the impact of R&D to sales ratio is examined after controlling for loactional characteristic such as population base of the city/town where the firm is located. This is pursued keeping in view the literature on agglomeration economies (for a detailed review see Mitra, 1999). Second, based on the panel data the R&D to sales ratio is taken to measure its impact on time varying-firm specific TE and TFPG. In this regression the effect of locational characteristic could not be considered due to the lack of time series data.

On an average employment in most of the industries seems to be expensive in terms of capital requirement as the employment per 100 thousand rupees of sales turns out to be quite low. In relative sense it is high, out of eleven industries, only in four, such as Leather, Engineering Construction, Electronic Components and Pharmaceutical and Drugs (Table 4).

The regression results show that the R&D to sales does not have a positive impact either on technical efficiency or TFPG in any of the industries considered in our analysis (Tables 5 and 6). Rather TFPG in Chemical is negatively related to R&D. Similarly the agglomeration variable also does not indicate any significant effect which could be due to the fact that we have taken the firms registration office address in the absence of plant address. Only two industries namely Engineering (industrial equipments) and Pharmaceutical and Drugs show a positive impact of population size on efficiency.

However, based on the panel data we are able to see a positive effect of R&D to sales ratio on technical efficiency in four industries (Chemical, Engineering (Industrial Equipments), Leather, Pharmaceuticals & Drugs), a negative effect in three other industries (Consumer durables-electronics, Electric equipment, Electronics component, and a statistical insignificance in the rest of the four groups (Table 7). In the case of TFPG the evidence is even scanty – two groups show a positive effect, i.e., Consumer Durables (Domestic Appliances), Engineering (Industrial Equipments), one negative, i.e., Pharmaceutical, and the rest are statistically insignificant (Table 8). Incidentally the Pharmaceutical industry reported the maximum innovation (as noted by Mani, 2008 and also in Table 1). The negative coefficient in the equation for TFPG could be because of the fact that R&D expenditure is actually incurred to improve product quality etc. which has nothing to do with technological progress as such. Rather too much of experimentation may reduce performance in terms of TFPG. However, the extent of the available technology used, which is measured in term of technical efficiency, is positively associated with RND in this industry. This differential impact of RND on TE and TFPG becomes very distinct as we change the regressor to log of R&D instead of R&D to sales ratio. The positive effect of lnR&D on TE is noted in a number of industries whereas the negative effect is evident in the case of TFPG (Tables 8 and 9). This is indicative of the fact that given the technology firms are able to improve the performance (TE) by spending more on R&D. However, R&D is not able to contribute to overall TFPG as technology is often imported from abroad. We have not controlled for other variables in these equations mainly to examine the gross relationship between R&D and the performance indicator and also because of the lack of information on variables which may be relevant from the point of view of the firm[10]. A similar attempt is also made in the paper by Singh and Trieu (1996).

Table 4: Employment per Sales (measured in 100,000 Rs)

Size Classes	Industry
0-10	Chemical
10-20	Consumer Durables (Domestic Appliances) Chemical, Household and Personal Products Electrical Equipment
20-30	Consumer Durables (Electronics), Engineering (Industry Equipment) Engineering
30-40	Pharmaceutical and Drugs
40-50	Leather Engineering Construction Electronic Components

[10] Though it is an omitted variable model it clearly indicates the lack of a relationship. If the impact were significant then there was a reason to consider other variables before highlighting the result.

Table 5: Average Technical Efficiency and R&D/Sales
Dependent Variable- Average Efficiency : OLS

Industry	Avg RND/Sales	Population	Constant	Adj-R sqr	N
Consumer Durables- Domestic Appliances	24.897 (1.79)	1.07e-08 (1.01)	0 .460** (5.77)	0.13	9
Consumer Durables- Electronics	-59.364 (-1.33)	6.31e-09 (0.37)	0 .533** (5.39)	0.13	5
Chemical	-0.875 (-0.63)	3.96e-10 (0.32)	0 .250** (26.56)	-0.02	66
Electric Equipment	-1.010 (-0.64)	-1.48e-09 (-1.04)	0 .095** (7.50)	-0.02	32
Electronics Component	2.312 (0.76)	-1.18e-09 (-0.22)	0.258** (6.97)	-0.11	15
Engineering	-14.499 (-1.66)	-1.32e-09 (-0.30)	0.180** (4.73)	0.02	27
Engineering Construction	0.258 (0.30)	2.60e-11 (0.03)	0.878** (108.44)	-0.15	15
Engineering – Industrial Equipments	-2.523 (-0.51)	8.34e-09 * (1.87)	0 .346** (12.55)	0.19	13
Household & Personal Products	-4.930 (-1.64)	-2.78e-09 (-0.74)	0.329** (9.32)	0.05	13
Leather	-34.693 (-1.01)	-9.40e-09 (-0.27)	0 .562** (4.90)	-0.17	7
Pharmaceuti-cals & Drugs	0.008 (0.38)	1.26e-09* (1.87)	0.092** (18.80)	0.01	118

Note: Figure in parenthesis are t- values. ** and * denote 5% and 10% level of significance, respectively.

Table 6: Average TFPG and R&D/Sales
Dependent Variable- Average TFPG: OLS Estimates

Industry	RND/Sales	Population	Constant	Adj-R sqr	N
Consumer Durables- Domestic Appliances	0.267 (0.16)	-1.10e-09 (-0.84)	0.0110 (1.13)	-0.13	9

Consumer Durables-Electronics	159.700 (0.75)	-6.86e-08 (-0.84)	.0470 (0.10)	-0.45	5
Chemical	-1.602** (-3.03)	-3.32e-10 (-0.71)	0.01** (2.79)	0.11	66
Electric Equipment	-3.25 (-1.78)	1.53e-09 (0.93)	0.050** (3.48)	0.08	32
Electronics Component	-1.80 (-0.70)	-2.05e-09 (-0.46)	0.036 (1.25)	-0.12	13
Engineering	1.28 (0.20)	-1.27e-09 (-0.45)	0.051** (2.28)	-0.06	29
Engineering Construction	0.226 (0.37)	-2.31e-10 (-0.39)	0.011** (2.18)	-0.09	19
Engineering – Industrial Equipments	-2.429 (-1.00)	-4.21e-09* (-2.13)	0.042** (2.94)	0.21	13
Household & Personal Products	-0.223 (-0.18)	-1.22e-09 (-0.78)	0.013 (0.92)	-0.13	13
Leather	-8.112 (-1.57)	-1.10e-08 (-2.08)	0.043* (2.54)	0.30	7
Pharmaceuti-cals & Drugs	-.0071545 (-0.27)	-1.33e-10 (-0.15)	.009228 (1.53)	-0.0165	118

Note: Figure in parenthesis are t- values. ** and * denote 5% and 10% level of significance, respectively.

Table 7: Technical Efficiency and R&D/Sales
Dependent Variable- Efficiency, Panel data

Industry	Model	RND/ Sales	Constant	R^2 / Adj R^2	N
Consumer Durables-Domestic Appliances	RE	8.065** (5.91)	0 .550** (16.15)	0.23	78
Consumer Durables-Electronics	OLS	-27.054** (-4.18)	0 .453** (20.53)	0.36	30
Chemical	RE	0.684* (1.87)	0 .243** (37.42)	0.004	586
Electric Equipment	RE	-0.422** (-2.54)	0.084** (12.16)	0.003	220
Electronics Component	RE	-1.669* (-1.81)	0.271** (12.45)	0.0001	103
Engineering	RE	0.361 (0.22)	0.142** (7.13)	0.03	185
Engineering	OLS	-0.114	0 .878**	-0.01	83

Construction		(-0.03)	(186.99)		
Engineering – Industrial Equipments	RE	1.482** (2.85)	0 .334** (12.25)	0.02	97
Household & Personal Products	RE	-0.475 (-0.35)	0 .279** (20.67)	0.02	64
Leather	RE	2.765* (1.78)	0 .491** (17.62)	0.03	54
Pharmaceuti-cals & Drugs	RE	0.165** (6.76)	0 .096** (30.21)	0.04	1176

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

Table 8: TFPG and R&D/Sales
Dependent Variable- TFPG; Panel Data

Industry	Model	RND/ Sales	Constant	R^2 / Adj R^2	N
Consumer Durables-Domestic Appliances	RE	3.292** (6.37)	-0.004 (-0.77)	0.17	78
Consumer Durables-Electronics	OLS	-32.55 (-0.64)	0.506** (2.90)	-0.02	30
Chemical	RE	0.025 (0.06)	0.008 (1.57)	0.005	586
Electric Equipment	RE	-0.766 (-1.06)	0.062** (4.68)	0.0001	220
Electronics Component	RE	2.013 (1.60)	-0.0006 (-0.04)	0.01	99
Engineering	RE	0.163 (0.07)	0.050** (2.72)	0.001	185
Engineering Construction	OLS	-3.517 (-1.06)	0.011** (2.42)	0.001	83
Engineering – Industrial Equipments	RE	1.320** (2.68)	0.010 (1.16)	0.003	97
Household & Personal Products	RE	1.950 (1.21)	-0.009 (-0.75)	0.04	64
Leather	RE	-1.145 (-1.07)	0.022** (2.56)	0.02	54
Pharmaceuti-	RE	-0.425**	0.012**	0.03	1176

cals & Drugs		(-6.10)	(2.69)		

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

Table 9: Technical Efficiency and lnR&D
Dependent variable- Efficiency: Panel Data

Industry	Model	Lnrnd	Constant	R^2 /Adj R^2	N
Consumer Durables- Domestic Appliances	RE	0 .023** (6.56)	0 .484** (13.52)	0.36	78
Consumer Durables- Electronics	RE	-0.021** (-4.76)	0.465** (10.05)	0.46	30
Chemical	RE	0 .007** (6.39)	0 .219** (29.62)	0.11	585
Electric Equipment	RE	0 .002** (4.36)	0 .069** (12.52)	0.55	220
Electronics Component	RE	0 .0003 (0.08)	0 .261** (10.39)	0.0002	101
Engineering	RE	0 .018** (5.16)	0.093** (4.14)	0.02	184
Engineering Construction	OLS	0 .002 (1.36)	0 .866** (96.09)	0.01	80
Engineering – Industrial Equipments	FE	0 .007** (3.66)	0 .307** (30.63)	0.33	96
Household & Personal Products	FE	0 .0104** (2.27)	0 .194** (6.78)	0.17	60
Leather	RE	0 .017** (2.63)	0 .432** (13.97)	0.39	54
Pharmaceuti-cals & Drugs	FE	0 .003** (7.66)	0 .079** (28.24)	0.33	1170

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

Table 10: TFPG and lnR&D
Dependent variable- TFPG: Panel Data

Industry	Model	Lnrnd	Constant	R^2 /Adj R^2	N
Consumer Durables-Domestic Appliances	FE	0 .008** (5.09)	-0.022** (-3.98)	0.15	78
Consumer Durables-Electronics	OLS	-0.002 (-0.08)	0 .429* (1.90)	-0.03	30
Chemical	FE	-0.007** (-4.44)	0 .034** (5.39)	0.02	585
Electric Equipment	RE	-0.0004 (-0.18)	0 .061** (3.43)	0.0003	220
Electronics Component	FE	0 .012 (1.41)	-0.018 (-0.72)	0.11	97
Engineering	RE	-.010* (-1.93)	0.080** (3.37)	0.03	184
Engineering Construction	OLS	-0.004** (-2.18)	0.025** (2.86)	0.04	80
Engineering – Industrial Equipments	FE	-0.007** (-3.74)	0.056** (5.77)	0.001	96
Household & Personal Products	RE	0.0001 (0.03)	-0.008 (-0.38)	0.04	60
Leather	FE	-0.013** (-2.77)	0 .0707** (3.72)	0.001	54
Pharmaceuticals & Drugs	FE	-0.005** (-3.34)	0 .035** (3.93)	0.0003	1170

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

5. Impact of R&D on Employment

Employment to sales ratio perceived as a rough proxy for labour requirement per unit of output has been regressed on R&D to sales ratio, exports to sales ratio, imports to sales ratio, assets to sales ratio and efficiency (or TFPG). In an alternative specification employment to sales ratio has been replaced by log of employment, without changing the determinants. This is pursued mainly to capture the view that labour per unit of real output (approximated by real sales) may not increase in response to R&D though the overall employment may[11]. The performance indicator is included to test if TFP growth, for example, results in higher output growth relative to input growth including labour or alternately employment does not drop though the use of other factor inputs may decline.

In the equations with technical efficiency as one of the determinants the following three industry groups unravel a positive effect of R&D to sales ratio on employment: Engineering (Industrial Equipment), Household and Personal Products, Pharmaceutical and Drugs (Table 11). In the rest of the industries R&D to sales ratio remains insignificant. Technical efficiency itself shows a negative effect on employment to sales ratio in the case of Electronics Component and a positive effect in engineering (industrial equipments) and remains insignificant in the rest of the industries.

The ratio of exports to sales is significant with a positive coefficient in three industries and negative only in one. Similarly the imports to sales ratio show a significant value only in three industries and among them two are positive. Based on this it is difficult to generalize that trade contributes to employment generation. However, some of the labour intensive sectors like Consumer Durables (Domestic Appliances) and Household and Personal Products show a positive effect of both export to sales and import to sales on employment to sales. While higher exports lead to increased employment, imported inputs also tend to create employment, suggesting possibilities of complementary relationship between the imported inputs and skilled labour. Not any major improvement

[11] If the rise in output is more than employment then labour per unit of output may decline in spite of an increase in overall employment.

in results is obtained by redefining the dependent variable as log transformation of employment[12].

Table 11: Employment/Sales and R&D/Sales with TE
Dependent variable: Employment/Sales

Industry	Model	RND/ Sales	Export/ Sales	Import/ Sales	Asset/ Sales	TE	Constant	R^2 / Adj R^2	N
Consumer Durables-Domestic Appliances	OLS	-60.906 (-0.33)	5.501* (1.96)	35.868** (4.03)	1.452 (0.40)	0 .988 (0.15)	7.307 (1.61)	0.37	29
Consumer Durables-Electronics	OLS	309.098 (1.55)	-32.785** (-2.91)	3.074 (0.98)	-10.741 (-1.77)	21.641 (1.49)	2.868 (0.50)	0.70	18
Chemical	RE	30.674 (1.23)	-1.045 (-1.00)	-0.837 (-0.66)	1.856** (4.44)	1.002 (0.24)	3.063** (2.36)	0.07	186
Electric Equipment	RE	203.766 (1.22)	-1.135 (-0.22)	-0.448 (-0.05)	1.484 (0.81)	-31.656 (-1.14)	9.350** (2.86)	0.03	96
Electronics Component	OLS	31.550 (0.18)	32.149** (2.94)	19.948 (1.66)	0 .172 (0.64)	-83.524** (-3.53)	29.970** (4.19)	0.41	32
Engineering	RE	161.433 (0.49)	-1.057 (-0.19)	-2.679 (-0.42)	8.776** (3.37)	-21.047 (-1.22)	10.140** (2.68)	0.40	45
Engineering Construction	OLS	3968.547 (1.21)	-4299.384 (-1.45)	17.053 (0.82)	0 .687 (0.10)	-40.983 (-1.12)	40.997 (1.20)	0.36	7
Engineering –Industrial Equipments	OLS	1431.894** (2.62)	2.444 (0.31)	-91.238** (-3.37)	8.080** (3.57)	104.567** (2.88)	-28.425** (-2.10)	0.68	31
Household & Personal Products	RE	374.736** (3.00)	18.092** (2.13)	41.933** (2.71)	2.105 (1.10)	-27.171 (-1.31)	14.116** (2.31)	0.02	46
Leather	RE	1799.993 (0.92)	15.840 (1.62)	-30.546 (-0.93)	-5.998 (-0.33)	-29.798 (-1.31)	27.965 (1.63)	0.31	26
Pharmaceuticals & Drugs	FE	56.842** (5.53)	-3.520 (-1.37)	1.738 (0.42)	8.696** (318.97)	-41.859 (-1.45)	11.692** (3.33)	0.97	499

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

[12] Results not reported.

When we replace technical efficiency by TFPG in the equation for employment to real sales ratio, the results relating to RND/Sales ratio remain unchanged except for Electronics Component which now turns out to be negative and significant (Table 12). TFPG itself is significant only in two industries with a negative coefficient, implying higher growth in output relative to input growth. Electronics Component and Household and Personal Products show a positive effect of both exports and imports. Even after changing the dependent variable to log of employment both these industries continue to indicate the positive effect of trade. Also, after changing the dependent variable to log of employment Electronics Component, Engineering (Industrial Equipment) and Leather show a positive effect of R&D to sales on employment with no negative effect in any of the other industries[13].

On the whole, the R&D/sales ratio is not significant in a number of industries; however the cases of positive impact are noteworthy.

Table 12: Employment/Sales and R&D/Sales with TFPG
Dependent Variable: Employment/Sales

Industry	Model	R&D/ Sales	Export/ Sales	Import/ Sales	Asset/ Sales	TFPG	Constant	R^2 / Adj R^2	N
Consumer Durables-Domestic Appliances	OLS	-49.604 (-0.26)	5.494 (1.68)	35.483** (4.04)	1.390 (0.38)	1.541 (0.05)	7.933** (4.69)	0.37	29
Consumer Durables-Electronics	OLS	119.961 (0.50)	-32.922* (-2.72)	-1.491 (-0.69)	-3.828 (-0.42)	-1.265 (-1.10)	10.801** (7.99)	0.67	18
Chemical	FE	25.810 (0.98)	-0.244 (-0.20)	-0.115 (-0.09)	1.964** (4.43)	-1.069 (-0.24)	3.216** (6.56)	0.03	186
Electric Equipment	RE	171.269 (1.03)	0.343 (0.07)	-3.024 (-0.37)	2.482 (1.45)	4.331 (0.37)	6.066** (2.76)	0.005	96
Electronics	RE	-425.871*	14.137*	22.107**	1.062**	-49.693**	5.626**	0.47	30

[13] Results not shown.

Component		(-1.92)	(1.94)	(2.24)	(3.22)	(-2.88)	(2.79)		
Engineering	RE	127.925 (0.38)	-1.050 (-0.19)	-5.082 (-0.78)	9.592** (3.92)	-14.093 (-1.08)	7.162** (2.73)	0.28	45
Engineering Construction	OLS	-1633.149 (-0.24)	1167.036 (0.27)	32.055 (1.49)	7.146 (1.05)	28.362 (0.69)	1.882 (0.64)	0.02	7
Engineering –Industrial Equipments	OLS	2076.12** (3.56)	10.245 (1.16)	-76.600** (-2.45)	4.745* (1.74)	-5.985 (-0.08)	8.787* (1.79)	0.58	31
Household & Personal Products	RE	403.708** (2.88)	19.146** (2.07)	38.48** (2.23)	2.055 (1.01)	-9.267 (-0.81)	6.910** (3.48)	0.02	46
Leather	OLS	1065.961 (0.65)	22.450** (2.64)	-28.044 (-1.04)	9.830 (0.62)	-128.113** (-3.22)	5.005 (0.44)	0.38	26
Pharmaceuticals & Drugs	RE	58.454** (5.93)	-5.212** (-2.29)	0.099 (0.03)	8.701** (323.13)	0.970 (0.10)	7.278** (5.09)	0.98	499

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

In the light of the second hypothesis we have dropped TFPG or technical efficiency from the employment equation. The effect of R&D/sales on employment to sales turns out to be positive and significant in the following four industries: Electric Equipment, Engineering (Industrial Equipments), Household and Personal Products, Pharmaceuticals & Drugs. In the rest of the industries the effect is statistically insignificant. As we redefine the dependent variable in terms of log of employment, the R&D to sales ratio takes a positive coefficient for Consumer Durables (Domestic Appliances) and negative for Consumer Durables (Electronics)[14].

The export to sales ratio is positive in four industries and negative in two industries. Similarly the import to sales is positive in three industries and negative in only one. Interestingly all these three industries showing positive effect of imports, also show the

[14] Results not reported.

positive effect of exports (e.g., Consumer durables-domestic appliances, Engineering construction, Household & personal products). In five industries the asset to sales ratio shows a positive effect on employment (Table 13).

Table 13: Employment/Sales and R&D/Sales without Performance Indicator

Dependent variable- Employment/Sales

Industry	Model	Rnd/sales	Export/sales	Import/sales	Asset/sales	Constant	R^2 /Adj R^2	N
Consumer Durables-Domestic Appliances	OLS	-42.461 (-0.30)	5.834** (2.58)	36.029** (4.77)	0 .684 (0.25)	8.011** (5.44)	0.41	30
Consumer Durables-Electronics	OLS	254.966 (1.24)	-38.581** (-3.49)	-0.612 (-0.30)	-11.041 (-1.74)	11.256** (8.67)	0.67	18
Chemical	FE	25.097 (0.96)	-0.267 (-0.22)	-0.085 (-0.07)	1.961** (4.44)	3.224** (6.61)	0.03	186
Electric Equipment	RE	160.121 (0.98)	0.818 (0.17)	-4.441 (-0.59)	2.532 (1.57)	6.356** (3.17)	0.004	97
Electronics Component	RE	390.092** (2.58)	39.079** (2.43)	13.932 (1.13)	0.311 (1.08)	4.041 (0.86)	0.17	32
Engineering	RE	167.599 (0.52)	-1.038 (-0.19)	-3.338 (-0.54)	10.296** (4.40)	6.249** (2.55)	0.28	47
Engineering Construction	OLS	252.464 (1.28)	9.079* (2.49)	28.312** (2.92)	5.148 (1.58)	3.081** (3.20)	0.46	10
Engineering – Industrial Equipments	OLS	2068.919** (3.67)	10.132 (1.19)	-76.14** (-2.53)	4.861** (2.18)	8.708* (1.85)	0.60	31
Household & Personal Products	RE	355.182** (2.79)	15.870* (1.84)	44.558** (2.82)	2.594 (1.38)	6.597** (3.81)	0.03	47
Leather	FE	221.470 (0.25)	-0.415 (-0.05)	9.806 (0.54)	41.032** (4.75)	3.798 (0.46)	0.01	26
Pharmaceuti-cals & Drugs	RE	124.543** (113.87)	-10.507** (-4.02)	-6.449 (-1.50)	8.706** (266.35)	8.473** (5.75)	0.98	507

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

In several studies employment is taken to be a function of value added and wage rate to estimate the growth and wage elasticity of employment. Following the same logic we may regress log of employment on log of real sales, real wage rate (derived by deflating the nominal figures by the consumer price index for industrial workers), and in addition real RND (deflated by the price index for machinery). Since R&D/Sales ratio has a highly limited variation across companies and over time, log of R&D may be considered to be more suitable.

In this specification (Table 14), log R&D turns out to be significant with a positive effect in a number of industries (seven) and the elasticity of employment with respect to R&D is seen to be highest in Consumer Durables (around 0.3). In two other industries (Leather and Pharmaceutical) it is again a little above 0.1. In Electric Equipment, Electronics Component and Household and Personal Products also the estimate is closer to 0.1.

Table 14: Partial Elasticity of Employment with respect to Sales, Wages and R&D
Dependent variable- LnEmployment

Industry	Model	lnSales	LnR&D	lnWagerate	Constant	R^2 /Adj R^2	N
Consumer Durables-Domestic Appliances	RE	0.784** (15.03)	0.051** (2.02)	-0.470 (-1.40)	-2.36** (-2.78)	0.89	78
Consumer Durables-Electronics	OLS	0.498** (8.74)	0.297** (8.48)	-0.325 (-0.41)	-0.448 (-0.35)	0.95	33
Chemical	FE	0.497** (14.99)	0.015 (0.74)	-0.745** (-8.59)	1.180** (4.13)	0.71	586
Electric Equipment	FE	0.484** (10.34)	0.070** (3.98)	-0.821** (-4.61)	1.55** (4.49)	0.85	225
Electronics Component	RE	0.581** (14.03)	0.066** (2.38)	-1.348** (-6.79)	1.358** (2.69)	0.92	101
Engineering	FE	0.477** (11.79)	0.023 (0.96)	-1.051** (-16.56)	2.712** (7.37)	0.77	186

Engineering Construction	RE	0.825** (10.30)	0.007 (0.28)	-1.012** (-2.34)	-1.760** (-2.29)	0.73	83
Engineering – Industrial Equipments	RE	0.732** (17.16)	0.017 (0.67)	-0.861** (-8.28)	-0.559 (-1.40)	0.84	98
Household & Personal Products	RE	0.745** (12.07)	0.065** (2.62)	-0.904** (-5.30)	-0.476 (-0.70)	0.95	61
Leather	RE	0.802** (6.96)	0.153** (2.19)	0.124 (0.17)	-3.142** (-2.45)	0.67	54
Pharmaceuti-cals & Drugs	FE	0.443** (18.30)	0.117** (7.67)	0.007 (0.07)	0.811** (3.55)	0.82	1194

Note: Figure in parenthesis are t- values for FE model and OLS and z-value for RE model. ** and * denote 5% and 10% level of significance, respectively. FE denotes fixed effect model: RE denotes random effect model: OLS denotes ordinary least square. Adj R^2 is calculated only for OLS.

6. Conclusion

On the whole, we noted that R&D as a percentage of sales does not affect efficiency or TFPG significantly. However, in absolute terms its impact on efficiency turns out to be positive in a number of cases though in terms of TFPG the effect is negative. This is indicative of the fact that given the technology firms are able to improve the performance (TE) by spending more on R&D. However, R&D is not able to contribute to overall TFPG as technology is often imported from abroad. After netting out the change in efficiency the TFP growth is attributed to technology up-gradation, which is sought from the developed countries. Hence, R&D expenditure does not enable firms to attain better performance relating to new technology procured from abroad – rather it reduces the overall performance (TFPG) possibly because of high adaptation cost of the new technology and inability to operate it and reap its potentiality instantaneously.

The impact of R&D as a percentage of sales on employment is positive only in a few industries. This has been tested with and without controlling for the performance indicator, which does not show any strong effect on employment. The R&D to sales ratio is seen to have a very limited variation for which the log transformation of R&D has been tried to work out the partial elasticity of employment with respect to R&D. In this specification a number of industries reported a positive effect of R&D on employment in absolute sense. Also, some of the labour intensive industries revealed a higher elasticity of employment with respect to R&D. On the whole, R&D’s positive impact on employment in absolute sense if not employment content per unit of output, is noteworthy even when R&D does not mean actual innovation. Processing of byproducts and efforts pursued to bring in an improvement in product quality and efficiency are some of the striking features of R&D expenditure, which may be resulting in employment gains. Even when capital intensive technology is adopted by the firms R&D expenditure has the potentiality to generate employment as it means additional activities without involving additional capital.

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