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Innovation and Employment: A Study of Indian Manufacturing Sector

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Abstract

While innovation is widely acclaimed as an important source of productivity and growth, its relationship with employment remained largely ambiguous. The debate assumes importance as the recent past has witnessed economic growth with falling or stagnant employment growth in a large number of countries. The loss of additional employment resulted in widespread inequalities and poverty that put the issue of economic growth in jeopardy. Moreover, there is a need to understand the relationship between innovation, employment and economic growth. This paper is an attempt towards deciphering this relationship to find the way-out for higher economic and employment growth using the case of Indian manufacturing sector. With the motive to find the impact of innovation on employment in different technological-intensive industries, four industries, namely pharmaceuticals (high technology), transport (medium–high technology), ferrous metals (medium–low technology) and textiles (low technology), for the period 2000–2001 to 2013–2014 are examined. It was found that the impact of 'product innovation' is positive on employment for different industries. Therefore, there is a need to build the 'system of innovation' in such a manner that radical innovations could be produced for long-term growth and employment.

Keywords

Technology, employment, process innovation, product innovation, Indian manufacturing firms, evolutionary growth theories, generalized least square regression, system of innovation

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I. Introduction

The aim of the present paper is to assess the impact of innovation on employment. The effect of innovation on employment has gained intense disagreement from different scholars, employers, employees and general public. The debate is augmented with technical progress resulting in lowering the labour per unit of output that could be counter-balanced through demand of new and quality products. It is unequivocally the fact that in the present knowledge world, no firm can survive without innovation. Therefore, deciphering the effect of innovation on employment could help in understanding the factors that could lead to employment generation.

The importance of innovation as a source of industrial growth is widely discussed in both theoretical and empirical literature, but the issue regarding the effect of technological change on employment remains controversial and ambiguous. The debate over the issue is characterized by two opposing views. On the one hand, the labour-saving innovations are feared to increase the rate of technological unemployment (Vivarelli, 2007). On the other hand, the theories propounded by classical and neo-classical economists presented the views that could counter balance the adverse effects of innovation on employment (Spiezia & Vivarelli, 2000; Vivarelli, 2012).[1] Divergent views also exist in the literature regarding the impact of 'product' and 'process' innovation on employment (Edquist, Hommen, & McKelvey, 2001; Pianta & Vivarelli, 2000) as well as regarding the impact of innovation for short-term and long-term employment dynamics (Pianta & Vivarelli, 2000). Substantially, the literature revolves around the issue of understanding whether there is any trade-off between innovation and employment. The 'new growth theories'[2] acknowledge 'innovation' as the important source of growth (Grossman & Helpman, 1991), structural transformation and competiveness (Lall, 2001). But, the impact of different technologies, their stages and types have different impact on employment generation in different firms, industries and countries. Although a huge literature exists that ascertained these issues from various angles (Pianta, 2005), dynamism in technology changes, advent of advanced means for information and communication technology, globalization of value chains and economic integration have retained the interest of scholars in particular field.

The interest for the issues also manifests due to slowdown of employment growth, both in developed and developing countries (ILO, 2014) with India not being an exception (Bhalotra, 1998; Das & Kalita, 2009; ILO, 2014; Kannan & Raveendran, 2009; Mehta, 2014a; Nagaraj, 2000; Sharma, 2000). Sharma (2000) found that the growth rate of employment particularly during 1990s was declining when the growth rate of GDP was accelerating. With the help of data, the study also found that the employment elasticity declined from 0.41 during 1983–1994 to 0.15 during 1999–2000. Goldar (2000), however, observed that there is an increase in the rate of growth of employment for most of the manufacturing industries during 1990–1991 to 1995–1996 when the growth of employment in organized manufacturing grew at 4.03 per cent per annum as compared to 0.53 per cent per annum between 1980–1981 and 1990–14991. Singh and Shergill (2015) found that the trend growth rate of employment from 1980–1981 to 1991–1992 was 0.40 that improved marginally to 0.63 per cent from 1992–1993 to 2004–2005.

As the present paper concerns India, we will discuss some of the arguments advanced by the scholars concerning the changing character of employment in India. Several studies (Das & Kalita, 2009; Panda & Ryou, 2007) blamed the inflexibility of labour laws as the main hurdle. Sharma (2006) asserted that the hurdle is not inflexibility of labour laws, but rather the complexity and ambiguity related to these laws that are creating the problem.

Insufficient economic incentives (Panda & Ryou, 2007), infrastructural constrains (Das & Kalita, 2009; Panda & Ryou, 2007) rising labour cost (Ghose, 1994), lack of skilled workforce (Das & Kalita, 2009) long working hours (Bhalotra, 1998) etc. were cited as some of the probable cause of stagnant employment growth in case of India in the literature. Some (Kumari, 2008; Panda, 2001) had also tried to analyze the impact of innovation on employment in case of Indian manufacturing industries. Kumari (2008) analyzed the employment growth in Indian engineering firms for the period 1985–1986 to 1994–1995. The study found that despite the increase in technology import intensity, research and development intensity, employment growth declined in the post-reform period as compared to pre-reform period. Panda (2001) examined how the technological shift affected employment growth in Indian automobile sector for the period 1960–1989. The study found that rate of growth of employment falls in majority of firms after liberalization.

Although the relation between economic growth, innovation and employment is very important, especially from the perspective of 'populated' developing country but still the literature on these issues is very scant and needs further analysis. Therefore, the present paper aims to fill this gap in the literature by examining the case of Indian manufacturing industries.

Thus, the specific aim of the present paper is to (1) examine the important factors that could lead to employment generation at the sub-sector level, using firm-level data for different technology-intensive industries in India. (2) The paper tries to decipher whether 'product innovation' and/or 'process innovation' lead to more employment growth in different technology intensive industries like high technology, medium–high technology, medium–low technology, low technology-intensive industry. (3) It addresses the questions: does a 'low-technology' industry or 'high-technology' industry lead to more employment growth in manufacturing sector in India.

The structure of the paper is as follows. Section 2 presents the review of both theoretical and empirical literature concerning the issue of 'innovation' and 'employment'. The database and construction of variables is presented in Section 3. Section 4 discusses the methodology used in the paper. The trends and patterns of employment from manufacturing sector are discussed in Section 5. The results of econometric exercise are presented in Section 6. The role of public policies and its impact on employment in Indian manufacturing sector is presented in Section 7 followed by summary of the paper in Section 8.

2. Innovation and Employment: Review of theoretical and Empirical Literature

Conventional economic theories considered unemployment to be the result of labour rigidity (classical economics), restrictive monetary policies (Keynesian economics) and institutional drawbacks (labour economics) (Pianta & Vivarelli, 2000). Since Industrial Revolution, unemployment was said to be traceable to technological change (Gourvitch, 1940). The necessity and complexity of the issue is manifested in the inter-relationship of innovation, growth and employment (Edquist et al., 2001). Although huge literature[3] acknowledged innovation as a source of growth, little could be stated with precision regarding the relation of innovation and employment. Innovation could displace labour from particular firm or industry or nation that could be compensated by various mechanisms raising the point of disputation between 'pessimists' and 'optimists' (Spiezia & Vivarelli, 2000). Compensation theory as propounded by Classical economists suggests that market mechanism could compensate for initial job losses through various mechanism including introduction of new machines, decrease in prices, new investment, decrease in wages, increase in income and introduction of new products (ibid.). A contagious effort in this direction was done by a study by Simonetti, Taylor and Vivarelli (2000) wherein using the data for four developed countries, namely US, Italy, France and Japan, for the years 1965–1993, the authors estimated the strength of some 'compensation mechanism' to counter balance the initial loss of jobs due to innovation. The study emphasized that both history and institutional factors are important for determining the strength of compensation mechanism, based on which specific job creation policies should be framed. Hall, Lotti and Mairesse (2007) also tried to disentangle the role of displacement and compensation effects of innovation on employment using the firm-level data for Italian manufacturing sector.

Moreover, unemployment could also result due to skill-biased technologies,[4] product innovation and process innovation.[5] But the issue is whether the employment displacement effect of innovation is short lived or it get mitigated behind high growth rate in the long run. As in the present knowledge economies, backed by the evolutionary theoretical perspective (Nelson & Winter, 1982), innovation is a continuous process and finding and distinguishing the initial and final impact of innovation on employment is a serious task before researchers. Although a lots of serious effort in this regard has been done in the past but still given the complexity involved a huge gap persists in the literature wherein the present study could act as a small contribution.

It is pertinent to emphasize that the world economies including Europe were observing persistently high unemployment rate when economic growth was passing through advantageous phase of business cycle[6] (Lundgren, 2000). This has again aroused the attention of scholars towards the issue of understanding the relationship between innovation and employment.

Berman, Bound and Griliches (1994) found that the labour-saving technological change within US manufacturing sector during the 1980s lead to 15 per cent drop in the employment of production workers for the period 1979–1989.

Subsequently, the demand for skilled workers increased and the labour demand saw a reallocation of industries towards industries with higher share of skilled labours. But, using firm-level data for British Industries, Reenen (1997) found positive and significant effect of innovation on employment. Bogloacino, Piva and Vivarelli (2011) after discussing the theoretical literature on the relationship of technological change and employment, tried to assess it empirically using the data from 677 European manufacturing and service firms over the period 1980–2008. The estimation using the least square dummy variable corrected model show that the labour-friendly research and development (R&D) investment turned out to be statistically significant, although with a low magnitude. The study further found that the impact of R&D expenditure on employment is positive and significant for the services and high-tech manufacturing but is absent in traditional manufacturing. Berman and Machin (2000) regarded that technology imports by the developing countries from developed countries lead to unemployment in former countries. They argued that during the last half a century, the technological change in the developed countries was predominantly employment saving and are biased towards skilled labour. Adoption of these technologies by developing and emerging countries changed the structure of employment and labour market conditions in these countries, resulting in unemployment and inequalities. They further emphasized that indigenous innovation in these developing countries is relatively labour augmenting as these technologies were developed according to the resource endowments in their respective countries.

Moreover, the studies (Edquist et al., 2001) dealing with the relationship of innovation and employment tried to classify innovation into product and process innovation so as to compare their impact on employment. Hall et al. (2007) using data from Italian manufacturing firms for the period 1995–2003 found that process innovation does not have significant effect in displacing the employment in these firms. The study (ibid.) also found that about half of the employment growth in Italy during the period 1995–2003 is contributed by product innovation. Using the panel dataset for German manufacturing firms for 20 years, Lachenmaier and Rottmann (2007) tried to find the impact of innovation on employment. Using dynamic GMM model the paper found robust impact of both product and process innovation on employment. Stucchi and Giuliodori (2010) studied the effect of both process and product innovation on creation of jobs in Spanish manufacturing sector over the period 1991–2005 and found that both of process and product innovation created jobs in the sector.

Similarly, a number of studies also emerged that take up the issue from the perspective of developing countries. Karaomerlioglu and Ansal (2000) tried to decipher the dynamics of the impact of innovation on employment for developing countries. Emphasizing the importance and inevitability of investing in innovation, the author elaborated on the policy framework that could generate employment in these countries. Crespi and Zuniga (2012) examined the impact of innovation strategies on employment growth in four Latin American countries including Argentina, Chile, Costa Rica and Uruguay. Using the micro-data for manufacturing firms, the study found that the firms that conduct in-house innovation activities have the greatest impact on employment that signifies that investment in R&D not only promotes innovation but also generates employment. In another study Crespi and Tacsir (2013) examined the impact of process and product innovation on employment growth and composition in four Latin American countries (Argentina, Chile, Costa Rica and Uruguay). Based on the model of Harrison et al. (1998), their study found that employment growth is also related to process innovation along with product innovation. Further, the study also did not saw the evidence of skill biased-ness in employment composition due to innovation.

However, there are some country-specific studies also concerning the impact of innovation and employment. For Argentinean manufacturing firms, de Elejalde, Giuliodori and Stucchi (2013) using the data from the second National Innovation Survey for the period 1998 to 2001 found that the product innovation generates employment while the process innovation has no effect on employment generation. Moreover, the study emphasized that the contraction in employment is due to non-innovators.

On similar issue of innovation and employment, *The Economist* (2006) published an article citing the report of ADB authored by Jesus Felipe and Rana Hassan. The report found that in the year 2000 due to new technology, the jobs created in China for each unit of labour growth was less than a quarter of what it was in 1990. However, Joseph Stiglitz (2014) theoretically analyzed the relationship between innovation and employment while examining the equilibrium of different factor bias innovation in the model of induced innovation. The model depicts the different levels of factor substitution and their impact on employment level.

In an elaborated study, Coad and Rao (2007) prepared the 'innovativeness index' of the four manufacturing industries using NBER and Compustat database to find the sectoral effect of innovation on employment. Using the weighted least square analysis, the paper found that the firm-level innovative activity lead to employment creation.

Thus, the brief and selective presentation of literature shows that although the issue of assessing the impact of innovation on employment is not a new field of study, the present scenario regarding the employment growth has revived the issue. The importance of such study grew in importance for a populous country like India to draw the policy framework for generating employment opportunities.

2.1 Database and Variables

The Prowess 4.0 package of the Centre for Monitoring Indian Economy (CMIE) is used as main database for this paper. Prowess covers all the firms listed in Bombay Stock Exchange. The choice for the database is made as it collects data from the annual reports of the firms. The data are collected for the firms that provide the data for the chosen variables (as discussed in Section 5).[7] As the aim of the paper is to decipher the impact of various variables on level of employment for different technology intensive industries, we have used the OECD (2007) technology-based classification to make a choice for the industries. From the high-technology sub-group firms from pharmaceutical industry was chosen. The choice was made because of the fact that Indian pharmaceutical industry has witnessed a tremendous growth over the past few years and is recognized as one of the leading global players with holding globally 4th position in terms of volume and 13th in term of value of production (Mehta, 2014b; National Pharmaceutical Policy, 2006). According to Annual Survey of Industries (ASI) Central Statistical Organisation (CSO) data, the share of pharmaceutical industry in terms of employment was highest in the high-technology-intensive sub-group of industries. During 2000–2001 to 2002–2003, its share was 2.9 per cent of the total manufacturing employment that stood to be around 54 per cent of the total employment being generated by high-technology industries. Its share further rose to 3.07 per cent of the total manufacturing employment during 2003–2004 to 2005–2006 (Mehta, 2012).

From the medium–high-technology-intensive industries, firms from transport industry were chosen. During 2000–2001 to 2002–2003, ASI data show that around 5.33 per cent of employment was generated by this industry out of the total manufacturing employment. This share rose to 6.2 per cent during 2003–2004 to 2005–2006 (ibid.).

Firms from the ferrous metals were chosen from the medium–low technology industries. This industry includes basic iron ore, steel and other non-precious metals. Again according to ASI data, the share of this industry in terms of employment is highest in the sub-group of medium–low technology industries. The importance of these firms was also manifested as after independence, India laid special emphasis on building up these basic industries for self-reliance and sustainable growth in the country.

Further from the low-technology-intensive sub-group, firms from the textile industries were chosen. The employment share of this industry is about 14.22 per cent for the trillium 2003–2004 to 2005–2006 according to ASI database (ibid.).

As it is evident the choice of those industries was made that contribute a relatively high share of employment generation in their respective technology-intensive sub-group. The dataset used in the present study thus is composed of only 17 firms from pharmaceutical industry, 30 firms from transport industry, 21 firms from ferrous metals industry and 18 firms from the textile industries were chosen for the analysis, since the choice is made of the firms that provide information about 'number of employees' for continuous five years. Therefore, in all 86 firms were chosen for the years 2000–2014.

2.2 Choice of Variables

2.2.1 Dependent Variable

Log employment: Prowess database presents the data on 'number of employees' in individual firms. As the motive of the present paper is to examine the impact of various variables on the quantum of employment generated in different technology-intensive industries, the variable 'number of employees' in each firm concern seem relatively appropriate for inclusion as a dependent variable.

2.2.2 Independent Variables

Log sales: Total sales for the firm i at time t could have an impact on total number of employees in year $t + 1$. It could be the case that if there is an increase in products sales in year t, the inclusion of total employees could increase in the subsequent year to exert a pressure on production, given the constant level of efficiency. On the other hand, if the quantum of total sales remained less in year t, the employer would be discouraged to employ more employees in the subsequent year. But the issue is to examine what would be the magnitude of impact exerted by sales on 'number of employees' for different technology-intensive industries. It is assumed that the coefficient of 'sales' would be positive.

Log capital stock: The relationship of capital and labour is very peculiar. The positivity of relationship depends upon the nature of both labour and capital. On the one hand, other things remain constant; the labour-saving technology would dampen the employment opportunities for labour as compared to labour augmenting technologies. On the other hand, the 'compensation effect' can augment the employment. Thus, it is an issue of analysis to determine the effect of capital stock on the quantum of employment for different technologies.

Log product development expenses: Product development expenses include expenditure on R&D, royalty and technical know-how fees paid, etc. by the firm. Being important for the firm's survival and sustainability, these expenses are seen with scepticism from the employees. But the alternative literature (Crespi & Tacsir, 2013; Crespi & Zuniga, 2012; de Elejalde et al., 2013) exists that describe these expenses as an important factor generating employment opportunities. Thus, it is assumed that impact of 'product innovation' would be positive for generating employment. But the issue is to examine whether the 'product innovation' augment employment opportunities for different industries, irrespective of their technological proximities.

Log efficiency: The inclusion of this variable could help us in deciphering the impact of 'product' versus 'process' innovation on employment. A huge literature (Crespi & Tacsir, 2013; Harrison et al., 1998; Stucchi & Giuliodori, 2010) exists that take up the issue. Whereas some studies (Crespi & Tacsir, 2013; Crespi & Zuniga, 2012; de Elejalde et al., 2013) regard product innovation to augment employment, some (Lachenmaier & Rottmann, 2007) also emphasize the similar results for process innovation. However, Edquist et al. (2001) regarded that 'process innovation' could have negative impact on employment generation. Thus, it is assumed that the impact of 'process innovation' would be negative on employment. But again the issue is to examine whether the negative impact of 'process innovation' on employment exists for all HT, MHT, MLT and LT industries.

3. Methodology

The standard linear model can be expressed as

$$Y_{it} = X^{d}{}_{it}\beta \qquad (1)$$

where the dependent variable (Y_{it}) for the cross-section industry *i* at time *t* depends *d*th explanatory variable(s) (X^{d}_{it}). Since, for the present analysis, we considered four explanatory variables; the linear model takes the form as:

$$\text{EMP}_{it} = \text{SALES}_{it}^{\beta s} . \text{CAPITAL STOCK}_{it}^{\beta cs} . \text{PRODDEV}_{it}^{\beta pd} . \text{EFFICIENCY}_{it}^{\beta ef} \quad (2)$$

where EMP (dependent variable) is 'number of employees' in firm *i* and time *t*. The explanatory variables include

SALES is total sales done by firm *i* and time *t*,

CAPITAL STOCK is the stock of capital constructed by cumulative addition of 'change in stock';

PRODDEV is product development expenses, which include the expenditure on R&D and royalties and technical fees paid;

EFFICIENCY is the variable that capture the 'efficiency in using fixed assets' by firm *i* at time *t*.

A logarithmic transformation of equation (2) yields

$$\text{emp}_{it} = \alpha + \beta_s \,\text{sales}_{it} + \beta_{cs} \text{capitalstock}_{it} + \beta_{pd} \text{proddev}_{it} + \beta_{ef} \text{efficiency}_{it} + \mu_{it} \quad (3)$$

where lower case indicates logs of the same variables, α is the constant term while μ_{it} is the random disturbance term.

For empirical proximity, the lagged model is estimated where the dependent variable (emp_{it}) depends upon the lagged values of explanatory variables. Thus, the model takes the following form:

$$\text{emp}_{it} = \alpha + \beta_s \,\text{sales}_{it-1} + \beta_{cs} \text{capitalstock}_{it-1} + \beta_{pd} \text{proddev}_{it-1} + \beta_{ef} \text{efficiency}_{it-1} + \mu_{it-1} \quad (4)$$

The study uses panel dataset, where the total number of observations $N*T$ consists of the number of observations (t = 1, ..., T) on each cross-section unit (i = 1, ..., N) (Johnston & DiNardo, 1997). The double-log model began by assuming $\mu_{it} \sim \text{iid}(0,\sigma^2)$ for all *i* and *t*, that is the errors are homoscedastic and serially uncorrelated.

To check the consistency of the estimators, Breush–Pagan statistics is undertaken to identify whether pooled estimator is consistent or not. If the estimated test produces significant χ^2, it reject the null hypothesis of homoscedasticity. Further, auto-correlation was also tested. In the present analysis, for all the models, both heteroscedasticity and auto-correlation exists. Therefore, the generalized least square model was used after controlling for both of these discrepancies.

4. Trends and Patterns of Employment across Different Manufacturing Firms

In this section, a descriptive analysis is carried out to understand the basic pattern and trend of employment in the firms form different technology intensive manufacturing industries. Based on the various issues of ASI published by CSO available at the website of Ministry of Statistics and Programme Implementation (MOSPI), it was found that for the years 2001 to 2012 the trend growth rate of employment in pharmaceutical industry was 9.42 per cent, 11.18 per cent for transport industry, 7.61 per cent for ferrous metals and 1.82 per cent for textiles industries. Thus it is evident that the relatively high-technology-intensive industries are able to generate more employment opportunities as compared to the low-technology industries for the years 2001–2012. Amongst the chosen industries, transport, followed by pharmaceuticals from the high-technology-intensive industries and ferrous metals from medium–low technology industrial sub-group were able to generate employment. This signifies that the employment generation is no longer confined only to low-technology labour-intensive industries. For further analysis and to understand the underlying mechanism, we have taken the firm-level data for these four industries (pharmaceuticals, transport, ferrous metals and textiles) so as to understand the impact of various variables, especially innovation —product and process innovation on employment. It is, however, evident that (Table 1) the product development expenses as a percentage of sales were highest for pharmaceuticals, followed by textiles, ferrous metals and textiles. This is in proximity with the technological complexities of these industries. Thus, it is considerable that the Indian firms are simultaneously earmarking higher proportion of their sales proceeds towards product development expenses. Whereas in early 2000, firms from pharmaceutical industry earmarked around 1.75 per cent of their sales on product development, they raised it to around 5 per cent during 2012–2014. For the same period, transport industry earmarked 1.1 per cent during 2000–2003 and 2.3 per cent during 2012–2014. Similar is the case with firms from ferrous metals as they increase the product development expenses from 0.5 per cent during 2000–2003 to 1.4 per cent during 2012–2014. But for the low-technology-intensive firms from textile industries the rate was marginally increased from 0.08 per cent of sales during 2000–2003 to 0.14 per cent during 2012–2014. But the major issue of concern that emerges from the descriptive variables (Table 1) is the lower level of average efficiency for all these firms. For pharmaceuticals, average efficiency has reduced by half from 1.19 in early 2000 to 0.54 in the mid-2010s. For textiles, the average efficiency remained comparatively high and almost intact during the two and half decades of 2000. Similar is the case with other two industries. For the firms from ferrous metals, the average efficiency was around 0.6 and for textiles it was 0.9 for the period 2000–2003 to 2012–2014.

Further, regarding sales–labour ratio (ascribed as labour productivity) was presented for all four chosen industries. It was found that for firms from pharmaceutical industry was initially very high at 9.77 during 2000–2003 that subsequently fell to around 6.00 in later period. The rate for the same variable for transport was more than 8 during early 2000 and reached 18.39 during 2012–2014. For the industries from relatively low-technology intensity namely ferrous metals and textiles, this rate remained around 8 throughout. This signifies that for proportion of sales per unit of labour employed is relatively more in high-technology-intensive industries. This substantiate the opinion of development

Table 1. Descriptive Analysis of Firms from Different Industries in India

Industry Years	Variables					
	Sales Over Labour Ratio	Capital Labour Ratio	Compensation to Employees Over Sales Ratio	Managerial Remuneration as a Percentage of Compensation to Employees	Product Development Expenses as a Percentage of Sales	Average Efficiency
Pharmaceuticals (HT)						
2000–03	9.77	0.96	9.85	3.39	1.75	1.19
2010–12	6.00	0.75	12.16	3.81	4.68	0.70
2012–14	6.44	0.88	13.63	0.18	4.87	0.54
Transport (MHT)						
2000–03	8.29	0.49	8.09	1.55	1.12	1.16
2010–12	13.86	1.55	5.98	1.78	2.12	1.03
2012–14	18.39	2.05	6.05	0.28	2.39	1.07
Ferrous metals (MLT)						
2000–03	1.84	0.13	12.80	0.13	0.52	0.59
2010–12	8.37	0.69	8.49	0.08	0.92	0.64
2012–14	9.73	1.03	9.13	0.09	1.42	0.59
Textiles (LT)						
2000–03	8.11	0.56	0.09	2.07	0.08	0.86
2010–12	7.33	0.61	0.06	2.23	0.10	0.95
2012–14	8.11	0.74	0.06	0.83	0.14	0.95

Source: CMIE Prowess.
Note: Product development expenses includes royalties, technical know-how fees and research and development (R&D) expenses.

theorist like Lall (2001), Rodrik (2008) and Sutcliffe (1971) who emphasized the structural transformation of economy to relatively high-technology-intensive industries to generate income, resources, employment and sustainable high growth.

Another variable of interest was capital–labour ratio that was estimated for firms from the four chosen industries. For pharmaceuticals, the ratio was 0.96 during 2000–2003 and 0.88 during 2012–2014. This signifies that the capital investment was moderate, probably due to the complex and expensive assets required in high-technology-intensive sector. But for the transport industry, it was found that capital–labour ratio has increased substantially from 0.49 during 2000–2003 to 2.05 during 2012–2014. The change in the ratio could reflect two possibilities: (1) labour remained constant and capital was raised; (2) capital remained constant and labour intake reduced. But, to reiterate the findings from the ASI data, it was found that labour intake had increased in the industry. Therefore, it became evident that both labour intake and capital accumulation have increased in transport sector with the higher proportion of capital accumulation. This relationship between capital and labour is also further analyzed using econometrics techniques in the next section.

Capital–labour ratio for the low-technology-intensive industries like ferrous metals and textiles also showed a rising trend, but the magnitude of the ratio is somewhat less than the high-technology and medium–high-technology industries.

Table 1 also presents the ratio of compensation to employees over sales for different firms from four industrial subgroups. It was found that the variable has shown an upward trend for pharmaceutical industries as the ratio increased from 9.8 during 2000–2003 to 13.63 during 2012–2014. On the other hand, it was found that for transport and ferrous metals industries, the ratio of compensation to employees over sales has decreased. Next the ratio for textiles industries remained meager. This clearly shows that the share of employees from the sales proceeds is found relatively more in high-technology industries as compared to low-technology industries. The share of employees from high-technology industries could be high on account of the skilled possessed by them as compared to employees from low technology industries. Similar is the case for managerial compensation as a percentage of compensation to employees. The high proportion for early 2000 was found for the pharmaceuticals followed by textile industries.

Thus, it could be infer based on the descriptive analysis presented in Table 1 and the discussion based on ASI data that in pharmaceuticals, investment in product development through expenditures in R&D, payment of royalty, technical fees etc. has not deterred the employment in this high-technology industry. Although the sales–labour ratio has undoubtedly decreased initially from 2000–2003 to 2010–2012, but revived later during 2012–2014. But the ratio of compensation to employees over sales has increased during the period. On the other hand, the investment in product development in textiles remained less.

Thus, few points emerge from the discussion presented above. First, the investment in product development was undertaken more in relatively high-technology industries. Second, these high-technology industries are more labour intensive according to ASI data. Third, the 'compensation to employees' over sales is also high in high-technology industries as compared to low-technology industries.

Fourth, 'managerial remuneration' as a percentage of 'compensation to employees' is also high for high-technology industries as compared to low-technology industries. To delve more on the issue of finding the impact of innovation on employment in different technology-intensive industries, the econometric estimation is done and the results presented in the next section.

5. Econometric Analysis

As the aim of the paper is to deciphering the impact of innovation, both product and process on employment, the panel regression analysis was done. The panel dataset was created by taking the data for firms from four different technology-intensive industries—HT, MHT, MLT and LT. The data were collected for 14 years from 2000 to 2014. As already discussed for product innovation, the expenditure on R&D, royalty paid and technical fees paid are taken and for process innovation, PROWESS provides the data on 'efficiency in use of assets'. Appendix I(a–d) presents the correlation tables and summary statistics of the various variables used for the analysis. The correlation matrix shows that for all the industries the log of efficiency has a negative relation with almost all the variables, except for transport industry. The pair-wise correlation for other variables is moderately correlated. Further, Table II (Appendix I) shows that the standard deviation was highest for log employment (dependent variable) for all the industries. Regarding the pharmaceutical industry, the variable for sales and efficiency shows a high kurtosis signifying that for most of the firms, sales are high and efficiency is low. For the various variables for other industries, the low level of kurtosis is there.

In Table 2, the attempt is made to decipher the impact of product and process innovation on employment. Log of employment was taken as the dependent variable with two independent variables, one for product innovation (lnproddev) and other for process innovation (ln efficiency). The estimation was done for the firms for the four technology intensive industries. To begin with, the tests for heteroscedasticity and serial auto-correlation were done for all the four industries and both the problems were found in the dataset. Therefore, the panel datasets were estimated after controlling for both heteroscedasticity and auto-correlation using generalized least square (GLS) method. All these four models show a significant Wald χ^2 that signifies that the model is best fit. It is important to highlight that irrespective of the industry concern, the impact of product innovation was significant and positive. For pharmaceuticals, Table 2 shows that one unit increase in product innovation led to 0.37 units increase in employment. Similarly the rate for transport was 0.43 units increase in employment. This rate differential could be due to the complexity of skill requirement in the former industry as compared to the latter. Moreover, Table 1 shows that compensation to employees is relatively more in pharmaceutical industry. This indicate that even if the pace of employment generation is relatively of less magnitude in pharmaceuticals as compared to transport, the stability and sustainability are promising due to greater share of employees in sales proceeds. Therefore, it became evident that product innovation

Table 2a. Innovation and Employment: Product versus Process Innovation

Type of Industry	***HT***	***MHT***	***MLT***	***LT***
Specific Category	*Pharmaceutical*	*Transport*	*Ferrous Metals*	*Textiles*
Model	GLS	GLS	GLS	GLS
	Dependent Variable: ln Employment			
Independent Variable	Coefficient (z-value)	Coefficient (z-value)	Coefficient (z-value)	Coefficient (z-value)
ln proddev	0.37*** (4.73)	0.43*** (5.18)	0.81*** (13.01)	0.79*** (5.36)
ln efficiency	–0.23 (–0.64)	0.06 (0.21)	0.01 (0.04)	–0.17 (0.69)
Constant	5.50*** (13.93)	3.99*** (12.68)	4.18*** (12.38)	5.19*** (13.46)
AR(1) coefficient	0.64	0.53	0.69	0.63
Wald χ^2	20.11***	28.84***	195.3***	28.83***
Number of observations	238	420	294	252

Source: CMIE Prowess.

Notes: 1. Cross-sectional time series generalized least square (GLS) method is estimated after controlling for auto-correlation and heteroscedasticity in the panel dataset.
2. *, ** and ***Values are significant at 10 per cent, 5 per cent and 1 per cent level.
3. B–P test means the Breusch–Pagan/Godfrey Test for heteroscedasticity. *lnproddev*, product innovation. *ln efficiency*, process innovation.

can generate employment opportunities even in developing countries like India in high-technology industries. But regarding the impact of process innovation, the coefficient of log efficiency for both the models concerning pharmaceuticals and transport was insignificant. But for pharmaceuticals the coefficient was negative signifying that the impact of process innovation was detrimental for employment generation. Here, it should be mentioned that the Indian pharmaceutical industry is basically 'generic' in nature signifying that it is producing the low-cost substitute of available 'drugs' in the market, the production of which itself requires substantial investment in R&D and are thus understood in term of 'product innovation'.

For transport industry, although the coefficient of process innovation was insignificant but its magnitude was positive showing a positive impact of process innovation on employment. Thus, this shows that for relatively high-technology industries, product innovation has a positive impact on employment and the impact of process innovation is not always negative.

The perusal of relatively low-technology industries—ferrous metals and textiles—shows that the impact of product innovation is significant and relatively high as compared to high-technology industries. On the other hand, the impact of process innovation is insignificant but positive for ferrous metals industries and insignificant but negative for textile industries. This again signifies a very important aspect of innovation, that product innovation has a positive impact on employment, whereas also for the low-technology industry, the impact of process innovation remained inconclusive.

Table 2b. Innovation and Employment: Panel Data Regression Analysis

Type of Industry	***HT***	***MHT***	***MLT***	***LT***
Specific Category	*Pharmaceutical*	*Transport*	*Ferrous Metals*	*Textiles*
Model	*GLS*	*GLS*	*GLS*	*GLS*
		Dependent Variable: log Employment		
Independent Variable	Coefficient (z-value)	Coefficient (z-value)	Coefficient (z-value)	Coefficient (z-value)
ln sales	0.79***	0.36**	0.30**	0.74***
	(8.66)	(2.25)	(2.25)	(5.33)
ln capital stock	0.09*	0.22*	–0.03	0.01
	(1.80)	(2.50)	(–0.97)	(0.02)
lnproddev	–0.12	0.13	0.64***	0.38**
	(–1.19)	(1.24)	(5.80)	(2.80)
ln efficiency	–0.55	–0.32	–0.03	–0.52
	(–1.64)	(–0.96)	(–0.09)	(–1.16)
Constant	0.31	1.16	2.20***	–0.52
	(0.52)	(1.13)	(2.33)	(–0.46)
AR(1) coefficient	0.42	0.54	0.65	0.55
Wald χ^2	146.17***	53.13***	261.7***	69.02***
Number of observations	238	420	294	252

Source: CMIE Prowess.

Notes: 1. Cross-sectional time series generalized least square (GLS) method is estimated after controlling for auto-correlation and heteroscedasticity in the panel dataset.

2. *, ** and ***Values are significant at 10 per cent, 5 per cent and 1 per cent level.

3. B–P test means the Breusch–Pagan/Godfrey Test for heteroscedasticity. *lnproddev*, product innovation. *ln efficiency*, process innovation.

Further, the similar estimations are done after controlling for some of the important variables and the results of which are presented in Table 2b. The impacts of product and process innovation on employment are examined after controlling for the quantum of sales (ln sales) and capital stock (ln capital stock). Again the models are estimated using the GLS models after controlling for heteroscedasticity and auto-correlation. The four models are again found to be significant due to the high value of Wald χ^2.

Perusal of Table 2b shows that all the four models are highly significant. For pharmaceuticals, it was found that the coefficient of sales (ln sales) was highly significant and it shows that the impact of one unit increase in sales lead to 0.79 units increase in employment. However, the coefficient of product innovation and process innovation was insignificant. This shows that the effect of sales is positive for employment generation. But it is fairly evident that in the industries like pharmaceuticals where the technological frontiers are fast moving rightwards, increasing sales are not possible without innovations. Similarly for transport industry, it was found that the impact of sales is again positive and significant. In both pharmaceuticals and transport, the impact of capital stock was also positive on employment. Again on these high-technology industries, the investment in capital again results to embodied technological spillovers. Thus, this again signifies that investment in innovation either directly or through purchase of new capital goods lead to more sales that in turn could lead to increase investment.

The next two models examine the impact of various variables on employment in ferrous metals from MLT industry and textiles from LT industries. Table 2 shows that in ferrous metals the impact of investment in product development on employment is highly significant and positive (0.64) followed by the impact of sales (0.30). This signifies that innovation plays a very important role in employment creation for the firms in this industry. Although the impact of process innovation was found to be negative on employment, but the coefficient is insignificant in nature.

In textile industry, again the impact of sales (0.74) and product innovation (0.38) was found to be significant and positive. This signifies that innovation plays an important role in employment generation even in low-technology industry like textiles. Thus, as in the other industries, innovation helps in increasing sales that result in high employment generation in subsequent year.

Thus, the result shows that innovation helps in augmenting employment in industries, irrespective of technology intensity. Innovation helps in increasing sales that helps positively in increasing employment. Therefore, the results refute the dogma involving the negative impact of innovation on employment.

6. Public Policy: Innovation and Employment

The last part of the twentieth century was dominated by market fundamentalists that confine the role of public policy for improving the functioning of the market (Cimoli et al., 2009). But the literature (Cimoli et al., 2009; Dosi, 1988; Lall, 2001; Maio, 2009; Rodrik, 2008) has widely acknowledged that 'public policy'[8] played a dominant role during the development process of most of the now developed countries. The 'firm' is the main actor and government should play an important role through public policy for achieving the specific objectives of industrial growth for nation states. Growth and employment generation are two specific objectives before Indian policy makers. It was found from the analysis that innovation could generate employment in different industries. However, the growth literature has also emphasized the role of innovation in augmenting and sustaining economic growth. Therefore, for both the objectives 'innovation' should be emphasized.

But the issue is what should be the specific policies that could lead to high economic growth and also generate employment. From the econometric exposition in the last section, it was found that 'product innovation' plays a dominant role in augmenting employment. Therefore, the policies should emphasize 'product innovation' that has a general positive effect on employment as compared to 'process innovation' as has been also discussed in Edquist et al. (2001) and Pianta (2005). But sometimes apparent delineation between product and process innovation become distorted as both these are simultaneously taking place.

Therefore, the key issue is at what rate process innovation are eliminating jobs as compared to the product innovation that are creating jobs (Pianta, 2005).

Process innovation is characterized as 'incremental' or 'marginal' innovation as opposed to 'radical' product innovations. Whereas the former could be achieved through 'learning by doing' and 'learning by using', the latter requires a consistent effort involving various actors and inter-linkages between them. Asheim and Gertler (2005) citing Crevoisier argued that the reliance on incremental innovation would mean that quick exhaustion of technical paradigm on which they were founded. Therefore, incremental innovation could be important for short run, but for long-run economic growth and employment generation, product innovation is widely accepted.

Evolutionary growth theories regarded technological paradigms could lead to product innovation that consists of various feed-back mechanisms and better inter-linkages between different firms, university–industry relationships under constructive institutional frameworks (Edquist, 1997; Edquist & Johnson, 1997). Thus, the public policy should revolve around the means and mechanism that could lead to radical innovation through encouraging firms to innovate, have a inter-link between different firms, linkages between producers, suppliers and users, encourage linkages between technology producers and technological users, greater association between research institutes, universities and industry along with encouraging institutional and organizational innovation. Thus, the public policy should transform the 'system of innovation' (Fagerberg, 2005) in such a manner that radical innovations could be produced for long-term growth and employment.

7. Summary and Conclusions

The paper undertakes to understand the important relationship between 'economic growth', 'innovation' and 'employment'. Growth theories highlight the significance of innovation for long-run economic growth, but subsumed the impact of innovation on employment. The impact of innovation on employment could vary from short run to long run; it also varies for different firms/industries within and between nations. The impact could also be different for different technology intensities of firms/industries. The aim of the present paper is to present and discuss the impact of 'innovation' on employment of those manufacturing industries that has shown a significant growth, both in value and employment terms. It was to determine the impact of various variables on the quantum of employment generated by these industries. However, the technological intensity of different firms could vary significantly both in context of other firms and industry, the technological intensity could also vary inter-temporarily. Thus, for the analysis, the choice of the industries was made based on technological-based classification (OECD, 2007) of manufacturing industries.

Firstly, the aim of the paper is to examine the factors that lead to employment generation at the firm level in different (high-tech, medium-high tech, medium–low tech, low tech) industries. Second, the aim was to find the impact of 'product' innovation and 'process' innovation on the quantum of employment generation in these four industries from different technological intensive sub-groups. Third, the aim was to find whether employment generating capacity of different industries varies. Based on the industry-level data, it was found that the trend growth rate of employment in relatively high-technology industries (pharmaceuticals and transport) was relatively more than that of the relatively low-technology industries (ferrous metals and textiles) for the years 2001–2012. Secondly, it was found that 'sales' have an important impact in determining the quantum of employment generated in these four chosen industries. This clearly signifies that 'sales' a proxy of growth has an important impact in generating employment irrespective of the industry chose. It was also found that the impact of innovation, specifically 'product innovation' is significant and positive on employment for different manufacturing firms. Thus, it could be emphasized that innovation is necessary not only for growth and sustainability of firms, 'product innovation' also could generate more employment opportunities.

Thus, as a policy implication, the need is to frame the policies in a manner that could encourage firms in different industries to accumulate technology. Although there could be various means for technology accumulation for a firm—ranging from 'generating' to 'buying' technology along with the complex inter-mix of two. But as a policy implication, the role of the government is very important for creating a conducive atmosphere for innovation-related activities. The government should incentivize innovation, try to inter-link the 'technology creators' and 'technology users', create awareness amongst the employees regarding the positive impact of investment in technology. To sum up, the need is to build the 'innovation system' by involving different actors including employees, firms, universities, governments etc. in such a manner that 'innovation' could produce long-term growth and employment.

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Appendix I[9]

Table Ia. Correlation Table for Variables from the Firms of Pharmaceutical Industry

	lnemp	ln sales	ln capitalstock	lnproddev	ln efficiency
lnemp	1.00				
ln sales	0.63	1.00			
ln capital stock	0.35	0.477	1.00		
lnproddev	0.35	0.68	0.57	1.00	
ln efficiency	–0.04	0.02	–0.09	–0.15	1.00

(Table Ia continued)

(Table Ia continued)

Table Ib. Correlation Table for Variables from the Firms of Transport Industry

	lnemp	ln sales	ln capital stock	lnproddev	ln efficiency
lnemp	1.00				
ln sales	0.39	1.00			
ln capital stock	0.36	0.67	1.00		
lnproddev	0.40	0.76	0.58	1.00	
ln efficiency	0.03	0.33	–0.02	0.08	1.00

Table Ic. Correlation Table for Variables from the Firms of Ferrous Metals Industry

	lnemp	ln sales	ln capital stock	lnproddev	ln efficiency
lnemp	1.00				
ln sales	0.52	1.00			
ln capital stock	0.12	0.35	1.00		
lnproddev	0.58	0.71	0.18	1.00	
ln efficiency	–0.09	–0.08	–0.06	–0.15	1.00

Table Id. Correlation Table for Variables from the Firms of Textile Industry

	lnemp	ln sales	ln capital stock	lnproddev	ln efficiency
lnemp	1.00				
ln sales	0.39	1.00			
ln capital stock	0.16	0.49	1.00		
lnproddev	0.37	0.41	0.26	1.00	
ln efficiency	–0.00	–0.00	–0.08	–0.19	1.00

Table II. Summary Statistics of Variables

Industry	Variables	Mean	Standard Deviation	Kurtosis	Skewness
Pharmaceutical					
	lnemp	5.81	3.22	2.57	–1.09
	ln sales	7.67	2.74	6.15	–0.97
	ln capital stock	3.73	2.80	1.70	–0.17
	lnproddev	3.23	2.39	2.66	0.31
	ln efficiency	0.02	0.54	6.35	–1.31
Transport					
	lnemp	5.33	3.62	–0.54	1.77
	ln sales	8.48	2.02	–0.82	6.13
	ln capital stock	4.10	2.83	0.05	2.26
	lnproddev	2.91	2.55	0.43	2.28
	ln efficiency	0.32	0.62	–0.11	5.13

Industry	Variables	Mean	Standard Deviation	Kurtosis	Skewness
Ferrous Metals					
	lnemp	5.02	3.69	–0.20	1.92
	ln sales	7.61	2.35	–0.45	5.42
	ln capital stock	3.21	2.65	0.22	2.15
	lnproddev	1.47	2.44	1.44	4.30
	ln efficiency	0.03	0.55	–0.69	3.87
Textiles					
	lnemp	5.62	3.63	–0.75	1.86
	ln sales	7.88	1.86	–2.01	10.84
	ln capital stock	2.97	2.74	0.13	1.51
	lnproddev	1.11	1.27	0.46	2.89
	ln efficiency	–0.07	0.44	–0.68	3.71

Notes

1. See Section 2 for detailed review of these issues.
2. See Mehta (2013) for detailed review of these theories.
3. Ruttan (2001) presented various theoretical discussions about the relationship of innovation and growth.
4. Lundgren (2000) argued that unemployment could be independent of business cycle and can, to a large extent, be explained by the mismatch between skill supplied and skill demanded.
5. To distinguish between product and process, innovation is the contribution of Schumpeter in 1911 publication *Theory of Economic Development* wherein he defined the former as 'the introduction of new good, ...or a new quality of the good', while the latter as 'the introduction of a new method of production' (Edquist et al., 2001; Pianta, 2000).
6. This phenomenon was regarded as 'jobless growth' (Lundgren, 2000).
7. The other important source for such an analysis is the three-digit industry-level data from ASI. But the choice is made for the firm-level data as the relevant information for the variables like royalty fees paid, R&D expenditure, managerial remuneration, compensation to employees, efficiency in using assets etc. were available at the firm-level data.
8. Cimoli et al. (2009) and Maio (2009) talked about public policy in terms of industrial policies that include innovation and technological policies, education and skill formation policies, trade policies, along with industrial support, competitiveness and competition–regulation policies.
9. Refer Section 4 for the discussion on variables.

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