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Abstract

Purpose – It is essential to track the development of resource and pollution intensive industries such as textile, leather, pharmaceutical, etc., under burgeoning pressure of environmental compliance. Therefore, the purpose of this paper is to analyze the progress of Indian leather industry in terms of individual factors and total factor productivity.

Design/methodology/approach – This study applies and examines the various concepts of productivity such as labor productivity, capital productivity, material productivity and energy productivity. Further, it assesses and compares the performance of Indian leather industry in Tamil Nadu (TN), West Bengal (WB) and Uttar Pradesh (UP) based on productivity analysis, spatial variations determinants in productivity and technology closeness ratio.

Findings – The findings suggest that as per the productivity analysis, WB leather clusters have performed remarkably better in terms of partial factor productivity and technical efficiency (TE), followed by TN and UP. This can be attributed to shifting of leather cluster of WB to a state-of art leather complex with many avenues for resource conservation. Further, the findings reveal that the firm size and partial factor productivities have significant positive correlation with TE which supports technological theory of the firm.

Practical implications – The results of this study can be useful for the policy makers associated with the Indian leather industry especially to design interventions to support capacity building at individual firm level as well as cluster level to enhance the efficiency and productivity of overall industry.

Social implications – The findings also support the resource dependence theory of firm according to which the larger size firms should reflect on resource conservation practices, for instance the concept of prevention is better than cure based upon 3R (reduce, recycle and reuse) principles.

Originality/value – The paper gives an explanation of the productivity in the leather industry in terms of its factor productivity and TE.

Keywords Data envelopment analysis, Productivity, Indian leather industry, Technology closeness ratio, Grand efficiency

Paper type Research paper

1. Introduction

Industrial revolution is considered as one of the landmark events in the history of social evolution. Over the years, the revolution has not only increased the production capacity but also intensified the competition among the manufacturing firms based on their performance in resource productivity (Marisa *et al.*, 2008; Ferioli *et al.*, 2010; Roulet *et al.*, 2010; Oo and Lim 2011). Additionally, in order to achieve the competitive advantage in the market, along with the existing price, speed, best delivery services, the manufacturers are compelled to supply products with innovative and sustainable designs (Clark and Fujimoto, 1991; Ulrich and Eppinger, 2004; DeBrito *et al.*, 2008; Michael, 2008; Unger and Eppinger, 2009, Meybodi, 2013; Dubey and Gunasekaran, 2016; Geng *et al.*, 2017; Papadopoulos *et al.*, 2017).

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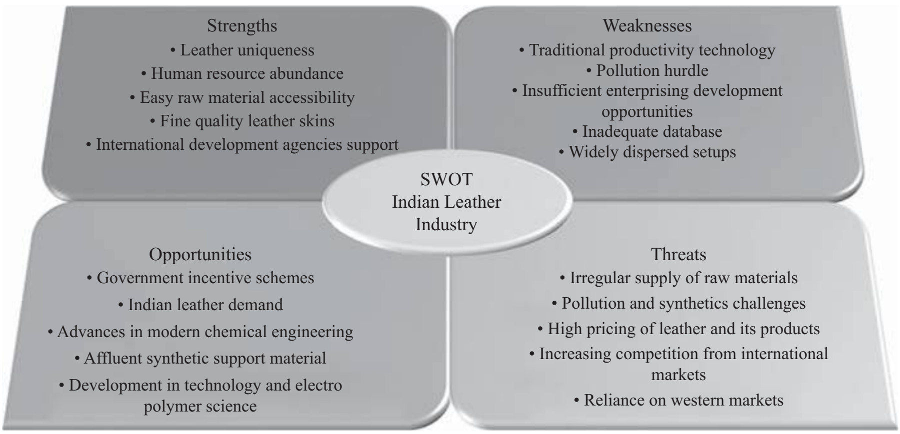
Initially, the definition of productivity used to focus on consumption or requirement of single input for producing a unit of output. Labor hour, as an input, was very widely considered for this purpose. The present literature defines it as partial factor productivity or labor productivity (LP). However, mechanization of industry has propagated the need to include other inputs in the form of capital, material and energy as the important factors of production (Blackburn, 1991; Jacobs and Chase, 2011). The existing literature (Hilmola, 2007; Wu, 2009; Grieco and McDevitt, 2012; Jola-Sanchez *et al.*, 2016; Tang, 2017; Tsionas and Izzeldin, 2018) defines this as total factor productivity (TFP) or multifactor productivity (MFP) or total productivity. The factors which influence TFP are numerous that includes useable knowledge (Kuznets, 1966; Lovell, 2003; Xue *et al.*, 2008; Wang *et al.*, 2013; Kapelko *et al.*, 2014), difference in technological advances, resistance to the use of better technologies (Mokyr, 1990; Pinto and Prescott, 1990), differences in working environment and practices, firm size and age (Little *et al.*, 1987; Lundvall and Battese, 2000; Cheng and Lo, 2004; Dubey *et al.*, 2017; Duman and Kasman, 2018). There are many techniques to assess the TFP of a business unit. However, technical efficiency (TE) is one of the very commonly used measures to assess relative productivity of a business unit. Mahajan *et al.* (2014) opined that the purest form of TE implies the effective proportion of input–output ratio on a predefined scale. Farrell (1957) introduced the concept of TE which recommends exploring the frontier of best performing firms. The frontiers are also known as efficient frontier or curve which is made up of various combination of inputs and outputs. There are predominantly two approaches for measuring the distribution of TE of a group of firms – data envelopment analysis (DEA) (Charnes *et al.*, 1978, Banker *et al.*, 1984) based on linear programming methods and stochastic frontier analysis (Aigner *et al.*, 1977; Meeusen and Vanden, 1977) based on econometric methods. These methods have been widely used for manufacturing (Goldar, 1985; Little *et al.*, 1987; Bhavani, 1991; Bhandari and Maiti, 2007; Odeck, 2009; Brkić and Putnik, 2013; Foresight, 2013; Putnik, 2012; Putnik *et al.*, 2013; Gunasekaran *et al.*, 2017) as well as for the service sector (Athanassopoulos, 1995; Barros and Dieke, 2008; Avkiran, 2009, 2011; LaValle *et al.*, 2011, Tweney, 2013; Langley, 2014; Lazaroiu *et al.*, 2017). In tune with the other researchers, Coelli (1996) confirmed the availability of different deterministic and stochastic production frontier models to facilitate productivity of decision-making units to covert inputs into outputs. Mahajan *et al.* (2014) explored the TE of large Indian pharmaceutical firms through DEA while setting benchmark for inefficient firms and suggested some alternative measures to improve their efficiency levels. We have applied DEA to our analysis because it provides information related to return on scale for a particular firm (Banker, 1984; Banker *et al.*, 1984; Sufian, 2011; Wang *et al.*, 2017).

2. Literature review

Indian manufacturing industry has seen rapid development after the implementation of the New Industrial Policy of 1991 (Joshi and Little, 1996; Tendulkar *et al.*, 2006). The reform initiatives of the policy have led to improvements in TFP for most of the industries (Krishna and Mitra, 1998; Unel, 2003; Ray, 2002, 2011; Pattnayak and Thangavelu, 2005; Moktadir *et al.*, 2018; Xing *et al.*, 2018). During the initial year of industrialization, government has given priority to small-scale industries which contribute significantly to gross domestic products, employment generation and export (Nagesha and Balachandra, 2006; Melo *et al.*, 2018). However, many studies also highlighted the negative aspect of small-scale industries such as inefficient use of resource, poor environmental compliance (Gaudin, 2008; Chakraborty, 2011; European Commission, 2013; Venkatesh *et al.*, 2014; Longoni and Cagliano, 2015; Adebanjo *et al.*, 2016; Zhou and Kohl, 2017; Gangopadhyay *et al.*, 2018) and sub-standard working conditions (Chakraborty and Chakraborty, 2007; Hubacek *et al.*, 2007) which has direct bearing on productivity performance of a firm. While for a large firm, it is easier to exploited economies of scale to enhance its productivity. Mukherjee and Ray (2004) and Babu and Natarajan (2013) have found variation in TE across states which could be attributed to difference in infrastructural development such as access to power, transport and communication facilities (Mitra *et al.*, 2002). The leather industry in India has faced many challenges and bans since 1990s (Gupta *et al.*, 2018). This is because of its undoubting contribution toward environmental degradation (Sankar, 2006a, b). Roy (2012) discussed three stages for leather processing to receive the end/finished leather product. First, the hides and skins of animals (sheep, goat, etc.) are used which are available domestically for production purpose. This stage is also called as pre-tanning stage. Second, the collected hides and skins are converted into leather which releases immense pollution. It can also be said that this stage produces the maximum pollution in leather industry. In the third stage, all labor intensive and highly value added tasks takes place. It is also named as post-tanning stage. In the environmental context, the researcher (Roy, 2012) opined that India derives an ample income from in the form of foreign exchange earnings since early 1970s. Copeland and Taylor shared mix opinion that on the one side, the high scope of export and on the other side, the pollution producing intensity of this industry has made its distinct identity in India. Now in this twenty-first century, Government of India (GoI) would like to project India as manufacturing hub with "Make in India"[1] as a brand. As of now, the goal seems to be quite ambitious, the Indian manufacturing industry has a long way to go in terms of its performance improvement[2]. The focus should be on productivity enhancement with no compromise on products' quality while keeping in mind the SWOT analysis (see Figure 1) of Indian leather industry (Italian Trade Commission, 2010). There are many studies conducted to analyze the productivity performance in the context of Indian leather industry[3] (NPC, 2010; Ray, 2011; Bhandari and Maiti, 2012; AERB, 2015; Irani *et al.*, 2017).

However, in this paper we have analyzed the progress of Indian leather industry, which is one of the oldest and also part of "Make in India" project. The leather industry in India is made up of mainly tiny and small size units where efficient uses of inputs like water, various chemicals and fuels with access to advance technology can play a vital role in productivity improvement. The objective of this paper is to measure and compare TE of Indian leather firms for selected years by using DEA. The study also applied the concepts of metafrontier and technology closeness ratio (TCR) (Rao *et al.*, 2003; Battese *et al.*, 2004) to compare the performance of the selected leather clusters. Further, it analyzed the determinants of spatial variations in the productivity to understand the system of interdependency which drives the performance of a firm.



Source: Italian Trade Commission (2010)

Figure 1. SWOT analysis: Indian leather industry

3. Research methodology

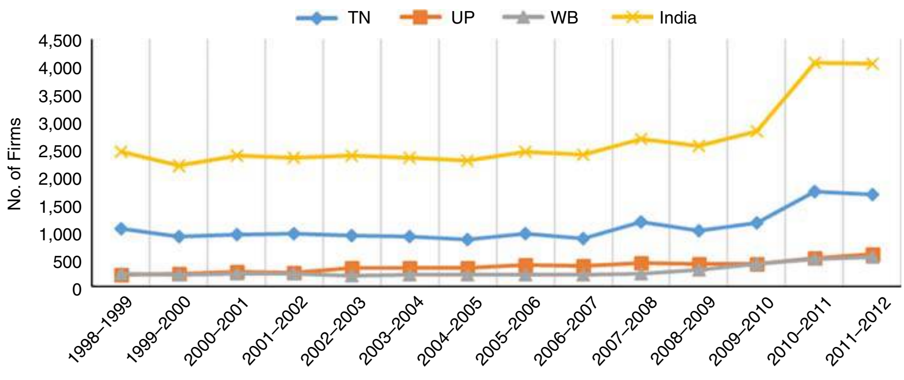
This study applied the various concepts of productivity, i.e., LP, capital productivity (CP), material productivity (MP) and energy productivity (EP) to assess and compare the performance of the leading states of Indian leather industry – Tamil Nadu (TN), West Bengal (WB) and Uttar Pradesh (UP). DEAP 2.1 application software developed by Tim Coelli has been used for DEA analysis (Coelli, 1996). With reference to the consulted literature, the technique of DEA can be used in two ways, i.e., input approach and output approach. Input approach implies the minimized use of inputs/resources to receive/fetch the desired or same level of output. In contrast, output approach of DEA signifies that how much output can be enhanced while keeping a constant approach toward the amount of input. The output approach is more crucial and important because it directs to achieve same level of output with minimized/constant inputs (Singh *et al.*, 2000; Uri, 2000, 2001, 2003; Facanha and Resende, 2004; Resende, 2008; Sreekumar and Mahapatra, 2011). According to Cooper *et al.* (2000), the technique DEA has gained a lot of momentum and has managed to grow as one of the powerful analytical tool for measuring and evaluating performance, that too, in a very short period of time. To capture the variation in performance, statistical parameters like median (the middle value or the middle score in a statistical analysis is termed as the median. In case here are two even values, then we take the average score of the two middle values, Ramsey and Schafer, 2012) and inter-quartile range (IQR) have been evaluated (IQR explains the extent of diffusion among/within the given data sets while reflecting its relationship with the already calculated median value, Groebner *et al.*, 2004). Further, to test the influence of various attributes of industry, significance of correlation coefficients has been tested with *t*-statistics (this test is placed under the umbrella of inferential statistics. It confirms the existence of significant difference between two groups with a normal distribution, Carpenter *et al.*, 2007). For the present study, the market share in India's export is 37.8, 25.17 and 13.56 percent for TN, UP and WB, respectively (CLE, 2015; Gupta and Racherla, 2018). We have analyzed Annual Survey of Industry (ASI)[4] data from 2007–2008 to 2011–2012 for firm-wise productivity analysis, whereas, from 1998–1999 to 2011–2012 for aggregate state-wise analysis.

4. Results and discussion

4.1 Analysis based on aggregate data

This section analyzed the productivity performance based on aggregate time series data of the selected states. In the words of Bernolak (1997), productivity is derived as a result of relationship between input and output in a process/system in quantifiable terms, where time is considered as one of the important performance indicator (De Toni and Tonchia, 2001; Weyer 2011). The trend of number of firms in these states and India as a whole has been demonstrated (see Figure 2). The sudden increase in number of units in TN during 2009–2011 can be attributed to relative competitive advantage gained with the development of export-oriented leather industry corridor in TN.

Labor productivity (LP). The LP must reflect the optimum use of human resources deployed to produce results in a production/manufacturing set up (Czumanski and Lödding, 2016). The input (human capital) must produce the desired output (goods/services). According to Kuhlang *et al.* (2011), in order to enjoy the high LP, the proportion of processes that contributes highly toward output must be kept on a higher side, and in contrast the time frame for such processes shall be kept on a lower side. Grünberg (2004) stated that to reduce LP losses in any production/manufacturing unit, high transparency and with desired corrective measures must be implemented to eliminate the problem from its roots. Moges Belay *et al.* (2014) opined that the manufacturing concerns which are using more labor in comparison to the capital are called as highly labor intensive units. This type of set ups are

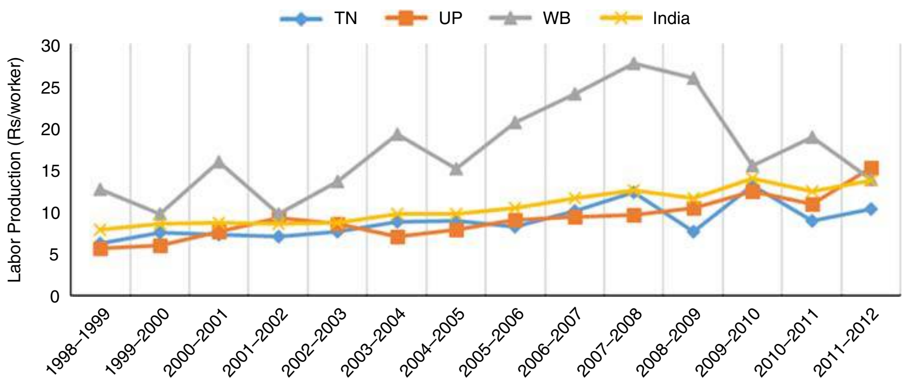


Source: ASI (2014)

Figure 2. Number of leather and leather products manufacturing firms

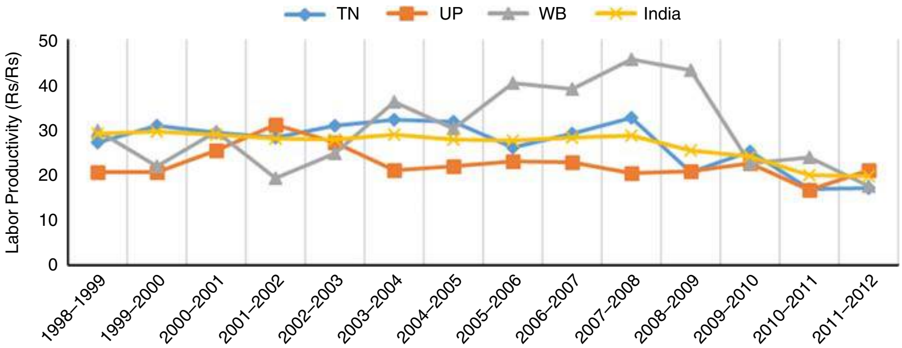
coming up as vacant research areas for the researchers. The results for this study reflect that all the states have demonstrated increase in LP of varying degree (see Figure 3). This can be the consequence of modernization/mechanization happening across every manufacturing sector which leads to replacement of workers with machines. GoI has introduced a scheme known as Integrated Development of Leather Cluster in the year 2000 to incentivize the process of leather industry modernization (DIPP, 2012). As the data confirm, WB has been consistently outperforming others with average LP as Rs17.31/- per worker. It is important to note that during the period when Calcutta Leather Complex (CLC) was coming up, i.e., 2005–2006 onward in WB, the state has seen an enormous growth in its LP. However, a sudden drop in the productivity, after 2009–2010, is quite mysterious which needs to be investigated that paves the path for the future researchers.

However, when we calculated LP as output value against the wage paid to workers, the performance of the clusters, except for WB, has demonstrated quite different scenario (see Figure 4). Both TN and WB followed negative trends. This can be attributed to increase in labor price due to shortage of skilled labor[5]. In our field survey, we found that other industries which have relatively better working conditions and growth dynamics have in turn offered a great deal of competition to leather industry in sourcing the skilled manpower.



Note: Labor productivity has been estimated as Output value/Number of workers

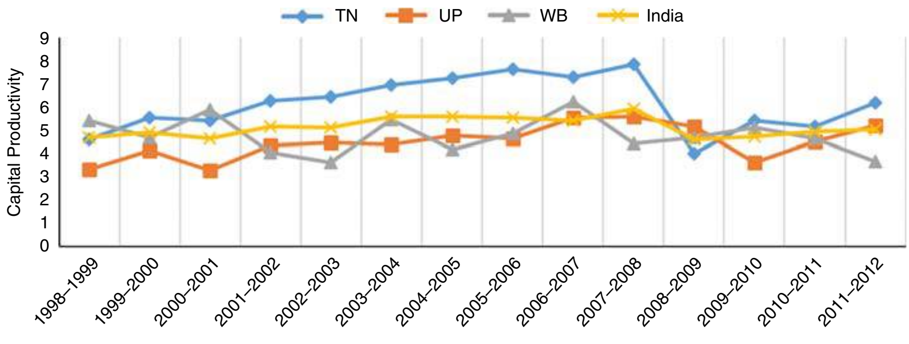
Figure 3. Labor productivity profile of leading states in Indian leather industry



Note: Labor productivity has been estimated as Output value/Wages paid

Figure 4.
Labor productivity profile of leading states in Indian leather industry

Capital productivity (CP). The RCBCI (Royal Commission Building and Construction Industry) has explained three types of productivities i.e. MFP, LP and CP (RCBCI, 2002). Gray (2006) made an addition to it by stating that the main target of CP is to measure the balance between industry outputs vs capital input. It also examines the level of flexibility as an added advantage. The excessive accumulation of capital with scarce productivity barely produces any desirable output (Allen, 2009). Ray (2002), Mukherjee and Ray (2004) and Trivedi (2004) confirm that capital is one of the factors of production which proves meaningful only when there is a difference between material and primary input. On the contrary, Pink (2007) demonstrated the case of Goods and Services Tax in Australia by saying that its implementation has reduced the industrial output which in turn affected the CP performance. Lowe (1987) and Yan and Chunlu discussed that the earlier researchers have significantly contributed and highlighted the development of capital productivity with respect to the construction industry. The capital units related to industrial investment with respect to equipments, building and machines can be very well identified from the capital productivity index (Goodrum and Haas, 2002; RCBCI, 2002; BFC, 2006). The results of the present study evidence that TN has been consistently doing better than others, except the sudden drop in 2008–2009 from which it has recovered the very next year. It might have happened either due to the dampening demands during financial crisis or due to enhanced competition with increasing number of firms (see Figure 5) or both. In case of leather industry, we along with the traces of literature noted that the firms run their operations with approx. 60–70 percent or even less capacity utilization[6].

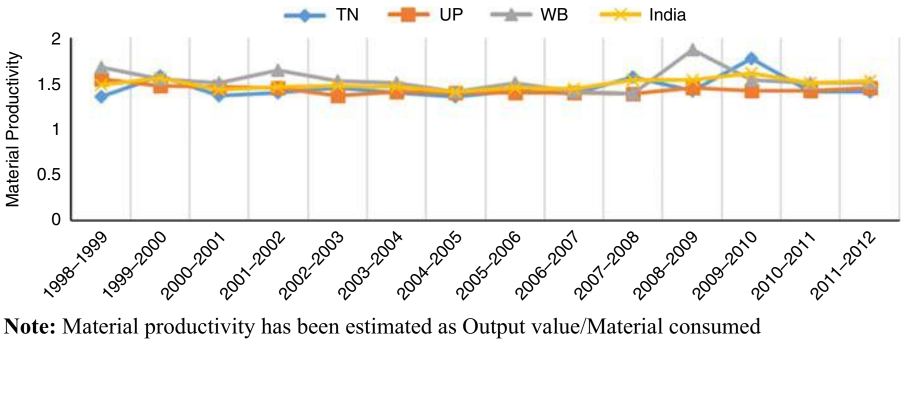


Note: Capital productivity has been estimated as Output value/Invested capital

Figure 5.
Capital productivity profile of leading states in Indian leather industry

Material productivity (MP). The enhancement in productivity is measured via decreased material handling activities including time and storage (Shian-Shyong *et al.*, 2011). The material handling constitutes a greater portion of overall productivity in industrial concerns. Yang *et al.* (2005) shares that the product cost is highly dependent on the MP. According to Kulak (2005), material handling occupies 30–75 percent of the total cost for MP, but an intelligent system/design can reduce it by 15–30 percent. The reduced cost and lead times act as important factors for MP in industrial units. The MP scores have shown quite flat trends across the clusters (see Figure 6). The underlying dynamics for this can be the modernization of industry which in turn would have given an upward push to MP due to minimized material wastage; in contrast with the increased prices of raw material (DIPP, 2012) might have pushed it down. As per the consulted literature, there a huge scope to lessen the consumption of material and energy in the Indian leather industry (Saravanabhavan *et al.*, 2007; DIPP, 2012). The initiatives such as implementation of an advanced technology for leather processing can bring down water usages by around 40 percent (Ludvik, 2000). Similarly, a better technique of tanning can increase the chromium fixation from 60–70 to 95 percent approximately (Suresh *et al.*, 2001). Further, during our field interviews we found that the techniques like recycling, recovery and reuse, which have already proved their importance for resource/material conservation (Sanja and Pattnayak, 2005) are not adopted by the leather firms. A consultant based in UP leather cluster reveals that whatever modernization tannery units have made, the only intention was to improve the quality of leather produced, and he mentioned that tannery owners hardly give any importance to resource conservation. However, some modernized techniques, like installation of ultra-modern drums with many advanced features, have led saving of valuable resources.

Energy productivity (EP). The existing literature confirms that productivity is one of the important indicators to measure enterprise competitiveness and industry growth. Cleveland *et al.* (1984) stated that there exists a strong correlation between EP and gross national product of an economy. Liu and Li (2001) opined that an industry must consider various factors to reduce energy deployment as compared to the return in the form of output. The energy production is an essential element in the economic production of any industry (Diao *et al.*, 2010; Hu and Liu, 2016). The productivity in relation to energy can be discussed in four ways, i.e., to measure total factor productivity while keeping energy as an input factor, deals with the partial factor energy, a type of single-factor productivity which is calculated as a ratio of gross product to energy consumption, focuses on the direct relationship between energy and productivity (Boyd and Pang, 2000) and presents the association of EP or efficiency in relation to TFP (Panesar and Fluck, 1993; Honma and Hu, 2009; Chang and Hu, 2010; Shibin *et al.*, 2016). Unlike previous studies that highlighted the energy-related



Note: Material productivity has been estimated as Output value/Material consumed

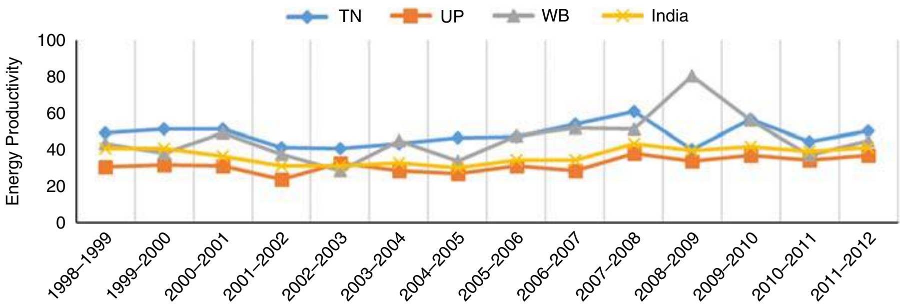
Figure 6. Material productivity profile of leading states in Indian leather industry

developments like carbon-dioxide emissions (Strazicich and List, 2003; Romero-Avila, 2008), energy use (Jakob *et al.*, 2012), electricity intensity (Maza and Villaverde, 2008; Liddle, 2009), this present study has considered EP has one of its main elements. The findings exhibit that TN and WB have performed noticeably better than UP and India's average value (see Figure 7). The average EP values were 48.43, 46.18 and 31.09 for TN, WB and UP, respectively. However, during our field trips to these clusters we got to know that UP' firms have been forced to pay higher energy bill due to the usage of private generator to accommodate the interrupted power supply.

4.2 Analysis based on firm-wise data

Productivity analysis. In this section, we have analyzed the firm-wise data of leather and leather products firms which has been compiled by ASI. The selected samples of three clusters have been compared on parameters like median and IQR to avoid the problem of extreme values associated with average value and standard deviation. In the LP analysis, we found that WB has certainly scored the highest value profile with the sudden dip in 2009–2010 (see Table I), which is also reflected in aggregate data analysis (see Figures 2 and 3). However, in ISR profile UP has received the lowest values which indicate that the cluster is made up of firms with similar technology, while in WB cluster firms have been using very conventional to advanced level of technology.

The firm-wise analysis of capital productivity data reveals that TN has been consistently performing better than others (see Table II), as we found in aggregate data analysis (see Figure 4). However, TN's IQR values, which reflect spread in firm composition, are also highest among the selected clusters. Further, MP has demonstrated almost flat trends within and across the clusters with average median value as 1.4 (see Table III). WB and TN



Note: Energy productivity has been estimated as Output value/Fuel cost

Figure 7. Energy productivity profile of leading states in Indian leather industry

Table I. Comparative analysis of labor productivity based on firm-wise data

	Labor productivity (LP)[a]					
	UP		TN		WB	
	Median	IQR	Median	IQR	Median	IQR
2008	11.853	15.39	14.091	14.4	27.556	39.16
2009	10.913	13.68	13.253	15.87	18.19	29.18
2010	10.309	16.09	12.175	13.61	16.489	21.2
2011	9.497	13.75	10.397	14.21	15.898	25.24
2012	9.763	13.99	9.669	14.82	na	na

Note: [a]Labour productivity = Output value/Wages paid to workers have surely marked higher EP than UP during 2008–2012 (see Table IV). The average of median values are 74.2, 59.54 and 46.5 for WB, TN and UP, respectively. In TE, WB has demonstrated the best performance among all the selected clusters. This might be the consequence of shifting of WB cluster to a new location during 2005–2006. As we discussed earlier, CLC in WB can be attributed to better capital productivity, higher labor and EP which has resulted in overall upgraded TE (Table V).

Determinants of spatial variations in productivity. The correlation analysis of productivity parameters with control variables, such as size of a firm (Y), age of a firm (Age), ISO 14000 certification (ISO), organization type (OrgT), reveals following important facts (see Table VI), namely, TE is strongly and positively correlated with all partial productivity parameters; TE is strongly and positively correlated with size of a firm and has been well supported by the literature (Little *et al.*, 1987; Bhandari and Maiti, 2012), whereas partial productivity parameters have not shown any consistent relationship with size of firm; ISO certification has significant and positive correlation with TE only in UP cluster,

	Capital productivity (CP)[a]					
	UP		TN		WB	
	Median	IQR	Median	IQR	Median	IQR
2008	5.552	7.31	9.013	10.76	6.378	9.71
2009	6.073	6.91	6.75	9.6	7.544	8.25
2010	5.521	5.85	6.83	10.15	6.236	9.75
2011	5.773	5.23	7.312	9.57	4.889	7.62
2012	5.759	5.72	7.694	10.29	na	na

Note: [a]Capital productivity = Output value/Invested capital

Table II. Comparative analysis of capital productivity based on firm-wise data

	Material productivity (MP)[a]					
	UP		TN		WB	
	Median	IQR	Median	IQR	Median	IQR
2008	1.437	0.33	1.421	0.4	1.429	0.4
2009	1.465	0.34	1.42	0.45	1.349	0.33
2010	1.469	0.34	1.502	0.45	1.471	0.42
2011	1.517	0.47	1.432	0.44	1.489	0.48
2012	1.488	0.45	1.414	0.37	na	na

Note: [a]Capital productivity = Output value/Cost of material consumed

Table III. Comparative analysis of material productivity based on firm-wise data

	Energy productivity (EP)[a]					
	UP		TN		WB	
	Median	IQR	Median	IQR	Median	IQR
2008	44.747	43.7	60.967	56.48	78.062	104.24
2009	44.207	46.77	61.953	56.42	104.466	132.65
2010	49.259	39.03	59.718	60.88	53.101	133.46
2011	45.266	34.38	53.496	51.32	61.175	76.63
2012	49.058	45.66	61.575	54.98	na	na

Note: [a]Energy productivity = Output value/Cost of fuel consumed

Table IV. Comparative analysis of energy productivity based on firm-wise data whereas it has demonstrated no association with partial productivity parameters; in TN cluster, CP has significant and positive relation with LP, which is always expected from a progressive cluster; CP has shown significant and negative association with MP in UP cluster; CP's strong and positive relationship with EP across all the clusters highlights the

Table V. Comparative analysis of Technical efficiency based on firm-wise data

	Technical efficiency (TE)[a]					
	UP		TN		WB	
	Median	IQR	Median	IQR	Median	IQR
2008	0.269	0.243	0.326	0.276	0.384	0.445
2009	0.399	0.311	0.368	0.355	0.445	0.304
2010	0.307	0.295	0.356	0.372	0.4	0.45
2011	0.395	0.21	0.462	0.331	0.475	0.259
2012	0.057	0.046	0.07	0.1	na	na

Note: [a]Estimated from variable return to scale input-based DEA

Table VI. Relationship between productivity parameters and its control variables based on correlation coefficient

	UP	TN	WB	Comment
TE_CP	0.157**	0.288**	0.232**	Strongly positively correlated
TE_LP	0.348**	0.272**	0.312**	Strongly positively correlated
TE_MP	0.132**	0.074*	0.308**	Strongly positively correlated
TE_EP	0.096**	0.288**	0.428**	Strongly positively correlated
TE_Y	0.248**	0.261**	0.478**	Strongly positively correlated
TE_ISO	0.110**	0.022	0.079	Positively correlated
TE_Age	0.046	0.020	−0.006	No correlation
TE_OrgT	0.045	−0.047	0.084	No correlation
TE_Ex	−0.033	−0.082	−0.033	Very weakly negatively correlated
CP_LP	0.012	0.212**	0.031	Weakly positively correlated
CP_MP	−0.106**	−0.070	−0.008	Weakly negatively correlated
CP_EP	0.384**	0.175**	0.280**	Strongly positively correlated
CP_Y	−0.028	−0.061	0.031	No correlation
CP_ISO	−0.032	0.005	−0.065	No correlation
CP_Age	−0.045	−0.013	0.036	No correlation
CP_OrgT	−0.199**	−0.153**	−0.024	Moderately negatively correlated
CP_Ex	0.059	−0.034	0.302**	Not sure
LP_MP	−0.077*	−0.040	−0.057	Weakly negatively correlated
LP_EP	−0.075*	0.428**	0.093	Not sure
LP_Y	0.147**	−0.004	0.011	Not sure
LP_ISO	−0.063	−0.054	−0.071	Very weakly negatively correlated
LP_Age	−0.040	0.078*	−0.060	No correlation
LP_OrgT	0.087*	−0.137**	−0.052	Not sure
LP_Ex	−0.073	−0.111*	−0.144	Weakly negatively correlated
MP_EP	−0.053	−0.081*	0.154*	Not sure
MP_Y	−0.022	−0.105**	0.344**	Not sure
MP_ISO	0.019	0.020	−0.141	No correlation
MP_Age	0.026	0.076*	−0.006	Not sure
MP_OrgT	−0.014	0.013	0.068	No correlation
MP_Ex	−0.020	−0.171**	0.002	Weakly negatively correlated
EP_Y	0.058	0.141**	0.063	Weakly positively correlated
EP_ISO	−0.017	−0.012	0.012	No correlation
EP_Age	−0.020	0.035	0.014	No correlation
EP_OrgT	−0.231**	0.032	0.252**	Not sure
EP_Ex	0.195**	0.035	0.364**	Moderately positively correlated

Notes: *,**Significant at 5 and 10 percent level respectively need for efficient and optimum utilization of firms capacity; though OrgT has not depicted any consistency in relationship with TE, LP, MP and EP but its correlation with CP is significantly negative in UP and TN clusters. This reveals that private and public limited firms have lower CP as compared to proprietorship and partnership firms; overall, export intensity has shown insignificant and negative correlation with TE, LP and MP, however, strong and positive correlation with EP in UP and WB clusters.

These peculiar findings of the study do not fully relate with earlier observations according to which plant characteristics including size, wages, age, adoption of advanced technologies and export intensity are positively correlated with productivity (Baily *et al.*, 1992; Doms *et al.*, 1996; Bernard and Jensen, 1999; Van Biesebroeck, 2005; Wagner, 2007).

Technology closeness ratio (TCR). The process of evaluating TCR helps to highlight the inter-group deviations with respect to productivity and TE (Bhandari and Vipin, 2016). TCR permits to develop varied measures to estimate technological distances between firms and the products produced by them (Sakakibara, 2002; Bloom *et al.*, 2013). Gopalakrishnan *et al.* (2004) discussed different models for TCR, namely, CORELAP (Lee and Moore, 1967), ALDEP (Seehof and Evans, 1967), COFAD (Tompkins and Reed, 1976) and PLANET (Tompkins *et al.*, 1996). The present study followed DEA analysis (Coelli, 1996) approach. The grand or meta-frontiers calculated by using DEA reveals that grand efficiency score of WB has been consistently higher than other leading leather cluster states (see Figure 8). Also, TN and UP were on the second and third position, respectively, on grand efficiency profiles. This could be attributed to shifting of WB leather cluster to a state-of art leather complex.

In contrast, TCR has demonstrated mixed trends where WB has marked significant improvement in its score whereas TN has depicted relatively the best performer among all, except its recent dip during 2011–2012 (see Figure 9). The transition in TCR profile during

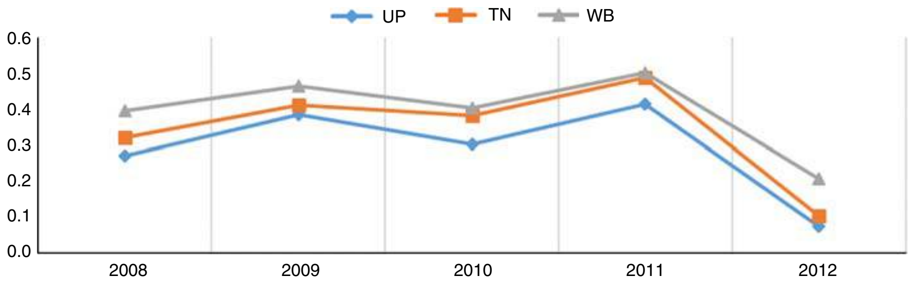


Figure 8. Grand efficiency profile of leading states in Indian leather industry

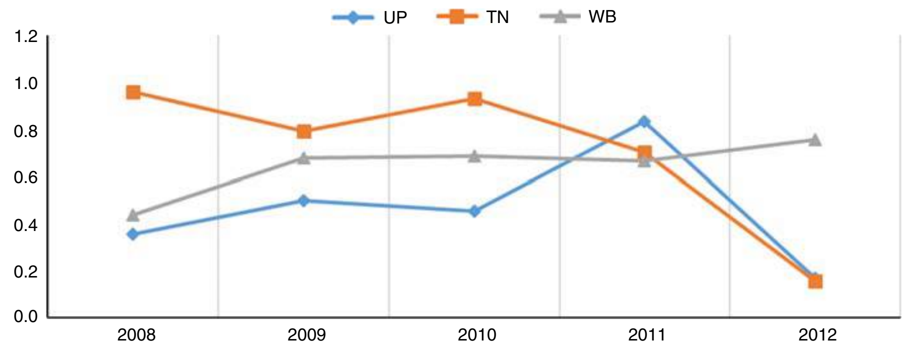


Figure 9. TCR profile of leading states in Indian leather industry

2010 and 2011 is quite mysterious where the states have converged abruptly. It can be attributed to state government interventions like non-compliance which led to the closer of many tanneries in UP and TN.

5. Key findings and practical implications

This study applied the various concepts of productivity to assess and compare the performance of the leading states of Indian leather industry, namely, TN, WB and UP. The productivity analysis reveals that WB leather clusters have performed remarkably better in terms of partial factor productivity and TE, followed by TN and UP. This can be definitely attributed to shifting of leather cluster of WB to a state-of art leather complex with many avenues for resource conservation. Further, the findings of the study suggest that firm size and partial factor productivities have significant positive correlation with TE which supports technological theory of the firm. Thus, government must monitor the progress of the clusters to ensure the optimum utilization of resources and implement the concept of prevention is better than cure with its policy measures. With respect to the implications of the present study, the existence of leather industry confirms environmental degradation which happens due by adopting environmental non-friendly technologies while its production. Another implication is related to end users of this industry, i.e., consumers who are in turn expected to choose products carefully and save environment.

The results of this study can also prove useful for the policy makers associated with the leather industry especially in India to enhance its efficiency and productivity by initiating the required level of inputs and have desired outputs by minimizing the deviations, if any. There is an urgent need to implement benchmarking practices for the local and export markets in order to provide accurate information to both, i.e., investors as well as policy makers in India. Another implication for this industry can be to remotely examine the benefits and risks associated with the collection and allocation of raw materials. This aspect can also be explained in relation to huge demand for leather and its products. The policy makers must put a check on the existing fashion and leather-oriented trends in the market. Another important contribution from policy makers' side can be the technological assistance to the involved labor in this industry. They must be trained to fight with the cut throat competition in this area. The government must focus so as to how to minimize the production cost with which the circulation of leather products shall happen more speedily in the local market, and small enterprises shall get a chance to operate independently. The findings also support the resource dependence theory of firm according to which the larger size firms should reflect on resource conservation practices, for instance the concept of prevention is better than cure based upon 3R (reduce, recycle and reuse) principles. The set-up and implementation of the business support centers to provide hand-on training on 3R principle based resource conservation practices can bring somewhat relief for the people associated with this sector. With this, the manufacturers can receive a real guidance to chase the global leaders in the leather industry.

6. Limitations and scope for future research

This study has considered secondary data related to resources consumption and output value till the year 2012 only due to non-availability of the updated data. In future, the productivity analysis could be extended to analyze the impact of changing policy paradigm, such as Zero Liquid Discharge, Pradhan Mantri Kaushal Vikas Yojana, Mega Leather Cluster scheme, etc., of new government regime in India. Moreover, we have also realized the need for micro assessment of the leading leather states (UP, TN and WB) separately in order to find out the influence of local business environment on various factor productivities. As Indian leather industry is mainly export oriented, so to remain competitive we recommend that a well-structured benchmarking protocol need to be developed to compare the performance of various productivity parameters with the leading countries, such as Italy, China, Vietnam, etc., in the leather sector.

Notes

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6. Informal communication with Project Implementation Unit of IDLS, CLRI, Chennai, India.

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