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Measuring the Performance of Small, Medium and Large Manufacturing in Punjab: A Bootstrapped Malmquist Index Analysis

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Abstract

The manufacturing sector has played a pivotal role for the development of the economies. It generates jobs, earn foreign reserves by exports and serves domestic economy as well. Given the importance of manufacturing sector, the performance measurement of this sector has been the main interest of economists, researchers and policymakers. The objective of the present study is to measure the performance of small, medium and large scale manufacturing industries. We utilized non-parametric approach to measure the performance by using survey panel data during 1995-2005. Further, for hypotheses testing, we use bootstrapping approach to test the null of insignificant change in the performance measures. We found that small and large scale manufacturing industries do not significantly change their technological frontier during the study period, while, both are highly efficient due to the better operation and management. Further, for high efficiency, the contribution of scale efficiency is larger as compare to the operation and management in case of large scale manufacturing industries. On the other hand, medium scale industries significantly shifted their technological frontier and adopted new technology or innovations, this sector is also efficient due to the better operation and management. However, the performance of all these manufacturing industries in terms of productivity change is not satisfactory. We conclude that by and large, the manufacturing industry has been endeavoring to improve its efficiency by expanding production with the help of available resources and administrative strategies. The conspicuous element is that the firms are reluctant to put resources into R&D which can shift production frontier upward.

Keywords: Small, Medium and Large manufacturing, Performance, DEA, Bootstrapping, Punjab

The manufacturing sector has been an essential source for raising the health of the economies. It is a historical fact that countries with vigorous manufacturing sector have experienced more economic progress magnification and development. Presently, the industries are undergoing rapid transmutations in the world due to the technological developments and processes that have empowered to engender incipient sorts of goods and services and new kinds of plan of actions for compliance (Behun*et al.* 2018; Tuček, 2016). The manufacturing sector also significantly affects all spheres of sustainable development of the economy. Then again, its accompaniment and improvement are controlled by the advancement of the availability of natural resources, required adeptness labor, energy, technology, international trade, and competition, etc. In these consistently transmuting conditions, there is a desideratum to discover successful strategies, methodology and ways that enable its adaptability to survive (Sachpazidu-Wójcicka, 2017 and Yang *et al.,* 2019).

At the time of independence, Pakistan had financial constraints and it was unrealistic for the government to set up manufacturing activities in the public domain. It was the private sector who initiated to invest in this sector. At that time, Pakistan was producing only low valued products. Later on, to develop the industries the government of Pakistan embraced various policies. Now, this sector is significantly contributing to the economy, job creation, competitiveness and trade development. Unfortunately, this sector is also suffering due to the energy outages, high input prices, inflation, political instability, low demand both in domestic and international markets.

It is in a great interest of policy makers to measure the performance of Pakistan's manufacturing sector to find out that which particular sector is underperforming. Few researchers attempted to measure the performance of industrial sector by utilizing various data sets of large scale manufacturing such as Ahmad *et al.* (2017) and Din *et al.* (2007) amongst others. However, existing literature has rather ignored the small and medium scale manufacturing. The present study is an attempt to measure the performance of small, medium and large-scale manufacturing industries at 4-digit industrial codes for the Punjab region of Pakistan by utilizing the survey data of the years 1995-96, 2000-2001 and 2005-06 gathered from the Punjab Bureau of Statistics (PBS).

The conception of industrial performance through productivity and efficiency has obtained substantial consideration in the recent past. Productivity and efficiency reflect overall performance of any DMU, which may enhance or cut investment in specific industries. Subsequently, professionals, economists and governments are apprehensive about characterizing and estimating these notions.

The performance scores can be assessed, if they are comparative across DMUs, which prompts relative scores. Efficiency is one of the most paramount issues for managers, researchers and policy-makers. This notion was first presented by Farrell (1957) and was then further developed by Charnes*et al.* (1978). Productivity can be quantified in terms a DMU's realized performance, i.e average production by one unit of input. Productivity is a quantitative association between inputs and output (Antle and Capalbo; 1988). Milgate*et al.* (1991) portrayed the concept of productivity as a ratio of production to the index of inputs utilized. However, efficiency is calculated either by the proportion of the actual production to the greatest possible production or by the proportion of least likely inputs to the actual inputs.

The present study contributes in the existing literature by i) considering all manufacturing industries (small, medium and large), and ii) carrying out hypotheses testing on the performance measures, which has rather ignored earlier particularly on small and medium manufacturing sector. We utilized a non-parametric methodology to compute performance measures in the framework of Malmquist productivity index (MPI). The productivity measure has also been divided into efficiency change and technological change, and the efficiency change further disintegrated to obtain scope efficiency change and pure efficiency change. This non-parametric approach is subject to the criticism that it does not allow to perform statistical hypotheses testing, consequently, the bootstrapping approach has been utilized to acquire confidence interval for statistical inferences on the mean scores of MPI and its different components.

Literature Review

The researchers have made perpetuating efforts to build up suitable methods to quantify technical efficiency and productivity. For quite a long time, the average labor productivity was generally utilized as a proxy for efficiency. Farrell (1957) elucidated that this isn't a copacetic measure. It ignores other inputs utilized in the production, and it may deceptively affect strategic planning and policymaking of an economy or an individual DMU. Djankov (1999) expounded that the growth of this traditional measure, perchance, represents a low caliber of initial efficiency. There were various attempts to build efficiency indices in which output is compared with a weighted average of inputs, however, it fizzled in light of the fact that this methodology contains glitches of index numbers (Kholegashvili, 2007).

Farrell (1957) made a substantial progress on the measurement of efficiency scores of DMUs that deal with all inputs and evades the quandaries linked with index number by decomposing efficiency scores into technical and allocative efficiencies. The overall efficiency as a result of technical and allocative efficiencies is based on the assumption that the most efficient output function is already identified (Farrell, 1957). He also expounded that the DMU's efficiency is with respect to the other DMUs and the efficient isoquant is measured with the help of all DMUs under consideration. As firms are heterogeneous, especially in terms of utilized inputs, which are generally arduous to estimate. On the discourse of Farrell's work, Winsten (1957) mentioned that Farrell did exceptionally significant work concerning the efficiency measurement of DMUs when compared with earlier work which utilized regression models to estimate average production function. Winsten (1957) further pointed out that regardless of the impediments of Farrell's methodology, his work is a remarkable contribution that encouraged the researchers for further work on these issues.

The estimates of different efficiency scores found through frontier production function (FPF) are output-based which postulates maximum production from the given level of inputs and are not same as Farrell's (input-based - best practice inputs usage). The FPF incorporates technical inefficiency by assuming non-zero expected value of random error term (for detail see i.e Aigner, and Schmidt 1977; Battese and Corra 1977; Battese and Coelli 1993; Battese and Coelli 1995). However, Farrell's approach frontier models are characterized into two basic categories: non-parametric and parametric. These methods have few differences and similarities that lean towards a specific approach. Although, both approaches are not free from limitations. We carefully selected Data Envelopment Analysis (DEA) – a non-parametric approach which provides change in all performance scores between two time periods.

After the concise discussion of the literature regarding the development of methodologies of efficiency measurement, we now, turning into the selected empirical studies concerning the applications and findings which were carried out to measure the performance of DMUs.

Brada*et al.* (1997) analyzed the efficiency of Hungarian and Czechoslovakian enterprises by utilizing cross-section data for the year 1991 and 1990 respectively. They found insignificant role of ownership and a significant impact of managerial efforts (inverse) and firm size (positive) on the performance measures. The inverse impact of managerial efforts on the efficiency suggests that managerial staff who show substantial efforts to politick and less to propelling the technical efficiency for their organizations are led to influence objectives such that make it easier for them to meet these objectives and subsequently get higher rewards than managers who either unsuccessful to politick efficaciously or dedicate their energies to increase organizational performance (Blanchard and Kremer; 1997).

For the Italian manufacturing sector, Fiordelisi and Molyneux (2004) examine the performance measures by utilizing DEA for the duration of 1993-1997. Their findings revealed that mean cost inefficiency in Italian manufacturing elongated somewhere in the range of 14% and 22%. Such inefficiencies were mostly because of allocative as opposed to technical inefficiency. Moreover, minor changes transpired in TFP during 1993-1996, while a considerable rise in TFP occurred amid 1996-1997. Tsekouras*et al.* (2007) examined the role of scale and technical efficiency on a firm's likelihood to quit from the Greek market of rubber and plastic manufacturing. They found the significance of technical efficiency in decision making about the exit or remain in the business, while scale efficiency has a quadratic relationship with the possibility to leave.

It is well evident from the literature that large firms in general are efficient. This is probably due to the fact that large-manufacturers are the main stakeholders in the market (Diaz and Sanchez 2008; Badunenko 2010; amongst others). According to Schiersch (2012), in the case that this is valid, then policies ought to be made to create conducive business environment only for large organizations. Keeping in view this fact, Schiersch (2012) examined the performance of the German mechanical engineering sector by utilizing a large dataset of different firm sizes. The study revealed that on average, the most efficient firms are of small and large sizes, however, most of the medium-sized firms are inefficient.

Kim and Park (2006) investigated the role of foreign and local R&D in the performance of Korean manufacturing sector. The study revealed that the efficiency change is consequential to raise TFP as oppose to technological progress, moreover, both foreign and domestic R&D also help to raise efficiency and technology. Hashimoto and Haneda (2008) measured the efficiency for ten Japanese pharmaceutical firms and for the entire industry by utilizing a non-parametric approach (DEA based on MPI) during 1983-1992. In the DEA framework, they used total sales as output and three different costs (product innovation, patent or R&D and process innovation) as inputs to measure TFP change. They found that the efficiency change of pharmaceutical industry monotonically declined over the study period.

Mahadevan (2002) examined the TFP growth for the Malaysian manufacturing sector during 1981-1996. He found a sluggishly positive annual change in TFP about 0.8 percent. This unsatisfactory progress was possibly driven due to the slow technological changes. On the other hand, Mohamad and Said (2011) analyzed the relative performance of Malaysian government-associated manufacturing companies through output based DEA during 2003-2008. The results of performance indices showed that under constant return to scale only ten companies were on the best-practice frontier and under increasing return to scale twenty-one companies were on the favorable frontier. Some large companies showed decreasing returns to scale and were scale inefficiency. They further found that most of the companies acclimated technology rather than adopted new technological innovation. Ramli and Munisamy (2013) investigated the overall eco-efficiency and technical efficiency through DEA at state level manufacturing sector in Malaysia during 2001-2010. The study revealed that eco-efficiency scores were slightly lower in the states where industrial activities are restricted or limited as oppose to the states under Free Industrial Zone and technical efficiency was similar in both areas. Yang *et al.* (2019) found that technical change is significant for increasing capacity utilization in Chinese manufacturing industries by using DEA and bootstrap regression during 2007-2017.

Balcombe *et al.* (2008) applied DEA double bootstrap approach proposed by Simar and Wilson (2007) to look at the main impetuses of efficiency for Bangladeshi rice farms. They found that efficiency of forms improved considerably and determined by education level of farm owner, farm age, and credit availability.

On the Indian auto parts manufacturing, Saranga (2009) measured various performance indicators through DEA approach for the sample of 50 firms and found that largely firms were in the region of diminishing returns to scale and were not efficient. The empirical findings of the study revealed that, in the Indian environment, higher inventories and effective working capital management are the prerequisites for higher operational efficiencies. Moreover, the study emphasized on the reforms of labor laws, as these ineffective laws are the major cause of different inefficiencies. Tripathy*et al.* (2013) analyzed the performance of 81 Indian pharmaceutical firms. They found that during the product patent period, firms showed positive change in productivity and technical efficiency as compare to the process patent regime. Moreover, the firms' specific significant factors to improve technical efficiency were age, ownership, R&D intensity, foreign direct investment and capital imports.

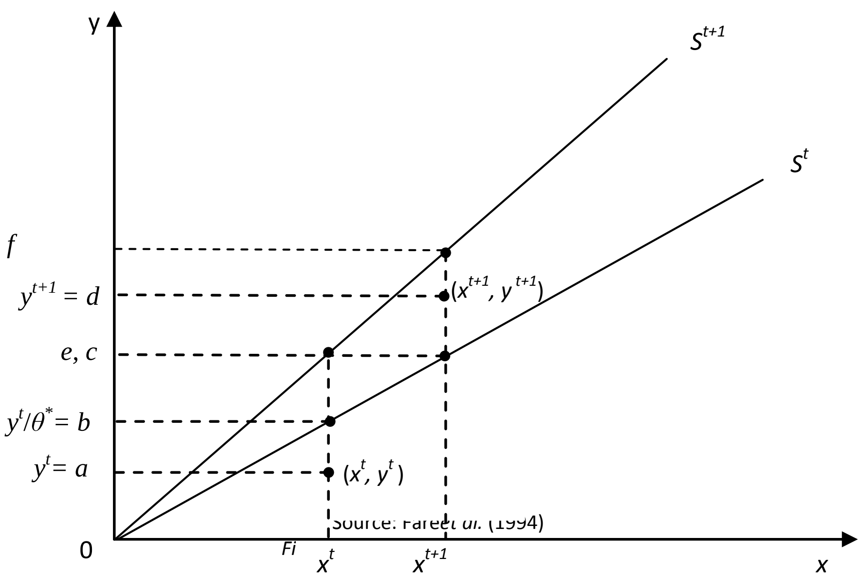
Al-Refaie*et al.* (2016) conducted a study to assess the TFP growth and energy efficiency through DEA approach in the Jordanian industrial sector during 1999-2013. They analyzed three five-year energy plans and revealed that TFP was less than one in the third plan (2009–2013), which shows a decline in TFP growth. On the evaluation of the performance of UAE's non-financial sector, Majumdar (2017) conducted a study via doing DEA analysis on the 27 listed corporations of UAE over the period of 2007-2014. The breakdown of MPI revealed that the technological improvements (capital investments, embracing new technology and production process) enhanced the performance of the top-efficient corporations. In addition, the study also found that after crisis food and beverages, pharmaceuticals and telecommunication were the most efficient industries, while, construction, real estate, services and cements sectors were badly beat down by the financial crisis.

Din *et al.* (2007) determined the performance through non-parametric and parametric approaches for Pakistan's large scale manufacturing establishments during 1995-2001. Their results by using both approaches showed that there is a little increase in efficiency level throughout the under-investigating period. Ahmad *et al.* (2017) examined the role of working capital management in explaining the efficiency of the Pakistan's 37 manufacturing firms by applying DEA approach and Tobit regression during 2009-2014. The DEA measures revealed that fifteen firms are required to increase inputs to reach at efficient level, six firms are utilizing excess quantity more inputs as required, while, sixteen firms are operating on the best practice frontier and need to maintain present ratio of inputs. In addition, findings of the Tobit regression indicates the significance of current ratio, working capital management and financial leverage in determining efficiency.

Methodology

Malmquist Productivity Index (MPI). To evaluate performance of the manufacturing sector, the present study exploits MPI – a linear programming and non-parametric approach based on DEA, was developed by Caves *et al*. (1982) (CCD) and amplified by Färe*et al*. (1994), Simar and Wilson (1999, 2000), Löthgren (1999), Mahadevan (2000) among others. The MPI allows to measure TFP change, which can further be divided into technical efficiency change (EFC) and technological change (TC). The non-parametric approach is also appropriate in case of small-size data (Chu and Lim 1998) and is preferred due to the number of reasons as discussed by Lovell (1996), Coelli*et al.* (1998), Mahadevan (2000) and Iqbal (2011) among others: *first*, it is not required to have prior information about input prices, *second*, the assumption that all DMUs are fully efficient is relaxed, *third*, it is free from the usual assumptions of error term as in the case of parametric models, *fourth*, it is free from the measurement error and statistical noise, *fifth*, the consideration of any new DMU in the data set does not alter the efficiency scores of the existing DMUs, *sixth*, the addition of any new output or input also does not affect efficiency scores of DMUs and *seventh*, it can be utilized even in the existence of several outputs and inputs.

We closely followed Färe*et al*. (1994) to measure different performance indicators. For this purpose some distance function are to be estimated such as $D_o^t(x^t, y^t)$, $D_o^t(x^{t+1}, y^{t+1})$ $D_o^{t+1}(x^{t+1}, y^{t+1})$ and $D_o^{t+1}(x^t, y^t)$ by utilizing linear programming. Where *x*, *y* and *D*s are the vectors of inputs, outputs and output oriented distance functions respectively at one time period (*t*) or from one point of time to another (*t*+1)[1]. The distance function of a DMU - $D_o^t(x^t, y^t) = 1$ (technically efficient) if and only if (x^t, y^t) exists on the production frontier, if $D_o^t(x^t, y^t) < 1$ (technically inefficient) if and only if (x^t, y^t) exists below the production frontier (Farrell; 1957). In a similar way, $D_o^{t+1}(x^{t+1}, y^{t+1})$ can be described for the production frontier at *t*+1. The observed output y^t at time *t* exists under the frontier of production technology S^t at time t (see figure 1)[2], the input-output combination (x^t, y^t) of a DMU is not optimum (technically inefficient). At the same point of input x^t, a DMU needs the highest reciprocal of proportional increase in y^t to obtain an optimum level of production - at x^t, the feasible output is (y^t / θ^*) (see figure 1).



Source: Fareet al. (1994)

The input-output combination (x^t, y^t) in terms of distances of technology S^t can be written as $0a/0b$ or $\|y^t\| / \|y^t / \theta^*\|$, that is less than 1, therefore, shows inefficient input-output proportion. The best practice output or the highest possible level of productivity under CRS can be achieved if average productivity (y/x) is maximized which also represents observed TFP change (Färe*et al.*; 1994). The MPI (TFP change) is measured as:

$$MPI = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \times \sqrt{\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right) \times \left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)} \quad ..... \quad (1)$$

[1] For further methodological details see Färe*et al*. (1994) and Iqbal (2011)
[2] Figure 1 taken from Färe*et al.* (1994)

where the first term in (1) is a relative efficiency change (*EFC*)(*catching-up effect*) from one period (t) to other (t+1) that figures out the gap between the actual output and the potential output (Färe*et al.*;1994). The shift in the technology (*TCH*)(*innovation*) between t to t+1. Moreover, *EFC* can be break-down into pure technical efficiency change (PEC) and scale efficiency (SEC). Following Färe*et al.* (1994), the Malmquist index in terms of distances is reproduced as (see figure 1):

$$MPI = \frac{(0d/0f)}{(0a/0b)} \times \sqrt{\left(\frac{0a/0b)}{0a/0c}\right) \times \left(\frac{0d/0e}{0d/0f}\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where first expression is technical efficiency rate from t to t +1 and rest of the expression shows the shift in the frontier (TCH), while the product of all expressions on the right had side of (12) is MPI. All above performance indicators are censored at 1. The value of any indicator greater than unity shows improvement and less than unity indicates decline in the performance (Färe*et al.* 1994). After having the results of MPI and its components, we utilize bootstrapping approach to compute the confidence intervals and bias-corrected score of MPI for hypothesis testing.[3]

Data Source. The estimation of MPI and its components are based on survey level panel data gathered from PBS. The Pakistan Bureau of Statistics conducts survey with the gap of five years on the manufacturing industries through the coordination of provincial Bureau of Statistics and publish aggregate data in the Census of Manufacturing Industries (CMI). The survey data for the Punjab province is available only for the years 1995-96, 2000-01 and 2005-06. The last survey of 2005-06 is the latest year for which the data is available.

Table 1. *Description of output and inputs*

Output/ Inputs	**Variable**	**Description**
Output	Sales	Total sales of industrial sector at 4-digit level in terms of million rupees (Rs.).
	Labor	The average number of daily persons employed during the surye year which consist of both regular and contractual employees.
Inputs	Fixed Assets	Total value of fixed assets at the end of fiscal year in million Rs. It consists of land value, building, plant, machinery transport, and other assets i.e. furniture, equipment etc.
	Industrial Cost	It consists of total cost incurred on raw materials, energy, repairing and maintenance etc.

The number of firms in the three survey years are 2364, 2357 and 3528 respectively and these include small, medium and large scale manufacturing industries. The small sized firms have up to 50 employees, medium sized firms have 51-250 employees and LSMIs have greater than 250 employees (State Bank of Pakistan, 2007). As the panel of firms is unbalanced in observations across the three surveys, we aggregated the data to the 4-digit industry level. A brief description of the output and inputs variables utilized to calculate MPI is presented in Table 1.

Empirical Results

The present study utilizes MPI – a non-parametric approach to measure the various performance indicators for small, medium and large manufacturing industries at 4-digit level in the Punjab province of Pakistan during 1995-2005. The DEAP 2.1 program has been used to estimate distance functions through linear programming that are additionally availed to compute MPI and its components. As discussed earlier that the score of any performance indicator of MPI equal to one shows no transmutation from time t to t+1, the value less than one indicates deterioration, and it's score bigger than one implicatively insinuates upswing of a performance measure. Thence, subtracting one from any MPI component demonstrates a percentage increase or decrease from one point of time to another.

After having the results of MPI, in the next step, we did bootstrap simulations on MPI and its components. During bootstrapping, 2000 replications were accomplished for hypotheses testing on the different performance measures of industries. This approach allows testing the null

[3]For methodological issues see Atkinson and Wilson (1995).

hypothesis of insignificant change in MPI and its components by utilizing lower and upper critical boundaries at 95% confidence intervals. The null hypothesis of insignificant change in corresponding performance measure cannot be rejected if interval encompasses the unity which suggests that no change occurred.

Performance of Small Manufacturing Industries. Table 3 reports annual mean values of MPI estimates for the small scale manufacturing industries. The overall mean (geometric mean) value of TFP on average declined annually by 14.3 percent, while TCH was 0.644 during the whole time frame (1995-2005). This deterioration happened mainly because of the absence of innovations or frontier shift. The efficiency change was 1.331 which infers that small manufacturers were remarkably efficient. The positive increase in efficiency was due to both PEC and SEC. Moreover, PEC has larger effect on the efficiency change. We also found that during 1995-2000 and 2000-2005, 41 (71 percent) and 37 (64 percent) small industries were efficient respectively (Table 2).

On average, during the entire under investigating period, the best ten efficient small industries were Carpets and Rugs (1722), Dairy Products (1520), Pulp Paper and Paperboard (2101), Musical Instruments (3692), Electric Domestic Appliances (2930), Spinning & Weaving of Textiles (1711), Other Rubber Products (2519), Motor Vehicles (3410), Other Products of Wood (2029), and Footwear (1920). The annual means of Malmquist indices suggest that the efficiency of all top ten small industries was high due to PEC and SEC while all these industries were highly inefficient in terms of innovations. The most inefficient industries include Soaps & Detergents (2424), Grain Mill Products (1531), Soft Drinks Mineral Waters (1554), Watches & Clocks (3330), Other Food Products n.e.c. (1549), Printing & Publishing of Books etc. (2211), Bakery Products (1541), Refined Petroleum Products (2320), Lead Zinc Tin & Products (2723), and Finishing of Textiles (1713). All these small manufacturing industries also registered a decline in productivity growth, mainly due to the decline in both EFC and TCH.

Table 2. *Description of MPI Estimates - Small Scale Manufacturing*

Period	Number of Industries at 4-digit level (percentage)					
	EFC	TCH	PEC	SEC	TFP	Score
	2 (3%)	--	5 (9%)	26 (45%)	--	equal to 1
1995/2000	41 (71%)	3(5%)	36 (62%)	30 (52%)	25 (43%)	greater than 1
	15 (26%)	55(95%)	17 (29%)	3 (5%)	33 (57%)	less than 1
	4 (7%)	--	4 (7%)	40 (69%)	--	equal to 1
2000/2005	37 (64%)	7 (12%)	35 (60%)	15 (26%)	20 (34%)	greater than 1
	17 (29%)	51(88%)	19 (33%)	--	38 (66%)	less than 1

Source: Authors' Calculations

Table 3. *Performance of Small Manufacturing Industries – Malmquist Summary (Mean of all years)*

4-DigitIndustry Code	EFC	TCH	PEC	SEC	TFP Change
Ten Most Efficient Small Manufacturing Industries					
1722	2.113	0.621	2.028	1.042	1.312
1520	1.905	0.535	1.967	0.969	1.019
2101	1.815	0.574	1.810	1.003	1.042
3692	1.797	0.485	1.808	0.994	0.872
2930	1.782	0.520	1.461	1.220	0.927
1711	1.777	0.581	1.248	1.424	1.032
2519	1.773	0.766	1.772	1.001	1.359
3410	1.745	0.696	1.431	1.219	1.214
2029	1.738	0.467	0.777	2.237	0.812
1920	1.729	0.461	1.717	1.007	0.796
Ten Least Efficient Small Manufacturing Industries					
2424	1.058	0.607	1.058	1.000	0.642
1531	1.042	0.953	1.003	1.038	0.993
1554	1.000	0.624	1.000	1.000	0.624
3330	0.997	0.605	0.928	1.075	0.604

1549	0.995	0.946	0.927	1.074	0.942
2211	0.982	0.667	0.968	1.014	0.654
1541	0.959	0.727	0.948	1.012	0.697
2320	0.844	0.850	0.846	0.998	0.717
2723	0.817	0.799	1.000	0.817	0.652
1713	0.382	0.715	0.246	1.554	0.273
Other Small Manufacturing Industries					
2722	1.709	0.595	1.707	1.001	1.017
1810	1.708	0.612	1.253	1.363	1.045
1721	1.702	0.638	1.814	0.938	1.086
2899	1.677	0.611	1.214	1.381	1.024
2520	1.656	0.587	1.308	1.266	0.972
2610	1.651	0.779	1.596	1.034	1.287
2413	1.645	0.659	0.966	1.702	1.084
2411	1.645	0.576	1.040	1.582	0.949
3120	1.554	0.682	1.576	0.987	1.060
2109	1.553	0.742	0.988	1.571	1.151
2021	1.538	0.494	1.538	1.000	0.760
2921	1.535	0.669	1.237	1.241	1.028
2919	1.535	0.549	1.537	0.999	0.842
2926	1.482	0.531	1.487	0.997	0.787
2711	1.452	0.861	1.073	1.353	1.250
2693	1.398	0.508	1.616	0.865	0.710
2893	1.396	0.650	1.396	1.000	0.907
2691	1.381	0.592	1.382	0.999	0.818
2423	1.365	0.552	0.876	1.558	0.753
1543	1.361	0.644	1.362	1.000	0.877
1513	1.354	0.629	0.706	1.919	0.851
1723	1.331	0.578	1.217	1.094	0.770
3693	1.292	0.750	1.169	1.105	0.969
3592	1.277	0.491	1.225	1.042	0.627
2429	1.256	0.738	1.250	1.005	0.927
2811	1.255	0.697	1.197	1.048	0.874
1730	1.203	0.513	0.946	1.272	0.617
2421	1.196	0.817	1.141	1.048	0.977
3430	1.196	0.597	1.195	1.000	0.713
2422	1.190	0.625	1.181	1.007	0.743
1729	1.183	0.543	1.182	1.001	0.643
1911	1.171	0.737	1.046	1.120	0.863
1533	1.139	0.946	1.143	0.997	1.077
3610	1.138	0.649	1.136	1.002	0.739
3699	1.125	0.539	1.124	1.000	0.606
2911	1.109	0.600	1.108	1.001	0.666
2724	1.101	0.806	1.103	0.998	0.888
1514	1.083	1.063	1.000	1.083	1.151
Overall Mean of small industries during 1995-2005	1.331	0.644	1.189	1.119	0.857

Source: Authors' Calculations

Note: See appendix for industrial classification codes and industry name.

Table 4. *Bootstrapped MPI Mean Scores – Small Manufacturing Industries*

Performance Indicator	Period/ Average	Actual Scores	Bias	Bias Corrected Scores	Bias Corrected Std. Err.	Lower CV at 95%	Upper CV at 95%
EFC	1995/2000	1.583	-0.002	1.584	0.100	1.399	1.767
TCH	1995/2000	0.647	-0.001	0.649	0.033	0.596	0.726
PEC	1995/2000	1.437	-0.016	1.453	0.099	1.257	1.596
SEC	1995/2000	1.248	-0.005	1.253	0.084	1.078	1.437
TFP Change	1995/2000	1.031	0.017	1.015	0.104	0.895	1.266

EFC	2000/2005	1.454	-0.009	1.463	0.111	1.311	1.749
TCH	2000/2005	0.703	0.001	0.702	0.025	0.646	0.751
PEC	2000/2005	1.258	-0.004	1.262	0.777	1.134	1.408
SEC	2000/2005	1.173	-0.015	1.188	0.076	1.070	1.398
TFP Change	2000/2005	0.954	0.002	0.952	0.059	0.833	1.079
EFC	Overall Mean	1.376	0.008	1.368	0.046	1.296	1.467
TCH	Overall Mean	0.656	0.001	0.655	0.019	0.620	0.699
PEC	Overall Mean	1.241	0.001	1.240	0.044	1.140	1.318
SEC	Overall Mean	1.143	0.000	1.142	0.036	1.096	1.254
TFP Change	Overall Mean	0.884	0.002	0.882	0.028	0.828	0.935

Source: Authors' Calculations

Table 4 reports the findings of bootstrapping on the performance measures for the period of 1995/2000, 2000/2005 and overall mean of small scale manufacturing industries. The null hypothesis of insignificant change cannot be accepted in all cases as the lower and upper critical boundaries do not have unity. The bootstrapped confidence interval suggest that all performance scores significantly changed except TFP change for the period of 1995/2000 and 2000/2005. This approach additionally allows to obtain the magnitude of biasness in the actual scores and bias-corrected performance scores. The overall mean of bias-corrected score of TFP change is 0.882 which implicatively insinuates that the growth in productivity declined by 11.8 percent during 1995-2005. The fundamental reason behind for such a disappointing performance in growth is due to the absence of innovations or non-shifting of frontier technology. The bias-corrected score of EFC suggests that during the study period, on average, efficiency of small industries improved by 36.8 percent and this transpired because of better operations and management performance and, production at relatively large scale.

Performance of Medium Manufacturing Industries. The mean values of different MPI performance measures for the medium scale manufacturing industries are reported in Table 6. The overall mean value of TFP shows that the productivity growth increased by 3 percent, while EFC declined by 12.8 percent during the study period. The shift of production frontier is the only factor for increase in overall productivity growth. However, the reason of inefficiencies are due to the bad operations and management and, not increasing the production at large scale. It was also found that during 1995-2000 and 2000-2005, 37 (93 percent) and 18 (45 percent) medium scale industries were inefficient respectively (Table 5). Surprisingly, all medium industries, during 1995/2000, shifted their production frontier due to the innovation or adoption of new technology, while during 2000/2005 only three industries (8 percent) shifted their production frontier (i.e Starches and Starch Products, Prepared Animal Feeds , and Agricultural and Forestry Machinery).

Table 5. *Description of MPI Estimates - Medium Scale Manufacturing*

Period	Number of Industries at 4-digit level (percentage)					
	EFC	TCH	PEC	SEC	TFP	Score
1995/2000	--	--	5 (13%)	15 (38%)	--	equal to 1
	3 (8%)	40(100%)	4 (10%)	25 (63%)	24 (60%)	greater than 1
	37 (93%)	--	31 (78%)	2 (5%)	16 (40%)	less than 1
2000/2005	1 (3%)	--	3 (8%)	20 (50%)	--	equal to 1
	21 (53%)	3 (8%)	21 (53%)	18 (45%)	11 (28%)	greater than 1
	18 (45%)	37 (93%)	16 (40%)	2 (3%)	29 (73%)	less than 1

Source: Authors' Calculations

The mean MPI score of all industries revealed that on average top ten productive medium-scale manufacturing industries were Cement lime and plaster (2694), Starches and Starch Products (1532), Prepared Animal Feeds (1533), Agricultural and Forestry Machinery (2921), Basic Iron and Steel (2711), Vegetable and Animal Oils and Fats (1514), Grain Mill Products (1531), Pesticides and Agrochemical Products (2421), Dairy Products (1520), and Motor Vehicles (3410). The fundamental reason for the satisfactory growth was the adoption of new technology that shifted production frontier particularly during 1995-2000. The most inefficient industries include

Other Rubber Products (2519), Plastics Products (2520), Soft Drinks (1554), Electric Domestic Appliances (2930), Non-Refractory Ceramic Ware(2691), Other Textiles n.e.c. (1729), Fruits, Vegetables and Edible Nuts (1513), Glass and Glass Products (2610), Footwear (1920), and Finishing of Textiles (1713). The production frontier of all these inefficient industries shifted may be due to the adoption of new technology while inefficiencies happened mainly as a result of production at a low scale and bad operations and management.

Table 6. *Performance of Medium Manufacturing Industries – Malmquist Summary (Mean of all years)*

4-Digit Code	EFC	TCH	PEC	SEC	TFP Change
Ten Most Efficient Medium Manufacturing Industries					
2694	1.355	2.208	1.000	1.355	2.992
2711	1.257	1.096	1.116	1.126	1.378
3120	1.196	0.925	1.193	1.002	1.107
1532	1.170	1.444	1.054	1.110	1.689
1531	1.116	1.120	1.043	1.071	1.251
2921	1.107	1.290	1.106	1.001	1.428
1520	1.095	1.117	1.093	1.002	1.223
2421	1.074	1.140	0.757	1.418	1.224
3693	0.996	1.129	0.890	1.119	1.124
1533	0.955	1.550	1.000	0.955	1.480
Ten Least Efficient Medium Manufacturing Industries					
2519	0.768	1.178	0.893	0.861	0.905
2520	0.768	1.175	0.774	0.992	0.902
1554	0.754	1.198	0.795	0.949	0.903
2930	0.744	1.175	0.754	0.986	0.874
2691	0.741	1.175	1.000	0.741	0.871
1729	0.735	1.175	0.750	0.980	0.864
1513	0.698	1.104	0.765	0.912	0.770
2610	0.653	1.175	0.663	0.986	0.767
1920	0.650	1.052	0.515	1.262	0.684
1713	0.431	1.037	0.504	0.856	0.447
Other Medium Manufacturing Industries					
1911	0.952	1.059	0.821	1.159	1.008
1722	0.938	1.181	1.002	0.937	1.108
1514	0.927	1.369	1.000	0.927	1.269
2101	0.916	1.162	0.914	1.002	1.065
3410	0.911	1.332	1.139	0.800	1.214
2422	0.910	1.174	0.923	0.987	1.069
1730	0.887	1.099	0.882	1.005	0.975
2109	0.886	1.236	1.017	0.871	1.094
1810	0.875	1.114	0.932	0.939	0.975
2919	0.868	1.045	0.867	1.002	0.907
1711	0.861	1.175	1.028	0.838	1.011
1541	0.855	1.122	0.903	0.947	0.960
2899	0.853	1.175	0.884	0.965	1.001
2423	0.852	1.095	0.879	0.970	0.933
2411	0.843	1.293	0.843	0.999	1.090
2429	0.835	1.100	0.867	0.964	0.919
3699	0.826	1.127	0.922	0.896	0.931
3592	0.785	1.175	1.000	0.785	0.923
2021	0.783	1.176	0.828	0.946	0.921
2424	0.777	1.044	0.778	0.998	0.811
Overall Mean of medium industries during 1995-2005	0.872	1.180	0.888	0.982	1.030

Source: Authors' Calculations

Note: See appendix for industrial classification codes and industry name.

The bootstrapping on the MPI and its components for medium-scale manufacturing industries are reported in Table 7 for testing null hypothesis of insignificant change. The results suggest that null hypothesis for EFC, TCH and PEC cannot be accepted as the confidence intervals do not contain unit value for the period of 1995/2000. It is also found that there is insignificant change in all components except TCH during 2000/2005. Moreover, the hypotheses testing on the overall mean values of performance indicators reveal that EFC, TCH and PEC were significantly different from unity. The change in frontier shift found significant unambiguously in all cases. The overall mean of bias-corrected score of TCH is 1.191 which implicatively insinuates that the growth in technological progress increased by 19.1 percent which helped medium-scale manufacturing industries to upswing their production frontier. While, overall efficiency significantly declined (11.3 percent) due to the unsatisfactory performance in operation and management.

Performance of Large-Scale Manufacturing Industries. The results of performance measures of large scale manufacturing industries are reported in Table 9. The annual mean value of TFP change suggest that large industries registered a very low growth about 0.7 percent during 1995-2005, the reason behind this low performance in terms of productivity was the lack of innovations and the non-shifting of technology frontier. However, large industries were highly efficient that was due to both production at a larger scale and better operation and management. On average, these manufacturing industries executed well in all performance indicators with the exception of TCH. This implies, during study period perhaps large industries were reluctant to resources into R&D and new technology due to the fear of political uncertainty, hike in input prices and energy outages. It was also found that during 1995-2000 and 2000-2005, 25 (78 percent) and 23 (72 percent) large scale manufacturing industries were efficient respectively (Table 8). The most striking fact is that none of these industries shifted their frontier of technology.

On the basis of annual mean scores of individual industries, the most ten efficient industries were Other General-Purpose Machinery (2919), Non-Refractory Ceramic Ware (2691), Pharmaceuticals (2423), Other Chemical Products (2429), Sports Goods (3693), Tanning & Dressing of Leather (1911), Cement, Lime & Plaster (2694), Electric Domestic Appliances (2930), Bicycles & Invalid Carriages (3592), and Wearing Apparel, Except Fur Apparel(1810). While only four industries were inefficient such as Dairy Products(1520), Basic Chemicals(2411), Plastics and Synthetic Rubber(2413), and Carpets and Rugs(1722).

Table 7. *Bootstrapped MPI Mean Scores – Medium Manufacturing Industries*

Performance Indicator	Period/ Average	Actual Scores	Bias	Bias Corrected Scores	Bias Corrected Std. Err.	Lower CV at 95%	Upper CV at 95%
EFC	1995/2000	0.755	-0.003	0.758	0.035	0.697	0.833
TCH	1995/2000	1.670	0.014	1.656	0.116	1.538	1.984
PEC	1995/2000	0.803	0.001	0.802	0.032	0.747	0.875
SEC	1995/2000	0.955	-0.005	0.960	0.032	0.894	1.016
TFP Change	1995/2000	1.388	-0.016	1.405	0.275	1.084	2.122
EFC	2000/2005	1.143	0.004	1.139	0.093	0.994	1.370
TCH	2000/2005	0.876	0.003	0.873	0.019	0.828	0.903
PEC	2000/2005	1.134	0.010	1.124	0.097	0.966	1.303
SEC	2000/2005	1.089	-0.001	1.090	0.060	0.987	1.232
TFP Change	2000/2005	0.985	0.009	0.975	0.075	0.852	1.118
EFC	Overall Mean	0.890	0.003	0.887	0.029	0.842	0.961
TCH	Overall Mean	1.193	0.002	1.191	0.033	1.147	1.277
PEC	Overall Mean	0.902	0.002	0.900	0.025	0.854	0.947
SEC	Overall Mean	0.991	0.001	0.990	0.024	0.940	1.031
TFP Change	Overall Mean	1.077	0.000	1.077	0.054	0.973	1.176

Source: Authors' Calculations

Table 8. *Description of MPI Estimates - Large Scale Manufacturing*

Period	Number of Industries at 4-digit level (percentage)					
	EFC	TCH	PEC	SEC	TFP	Score
1995/2000	--	--	6 (19%)	--	--	equal to 1
	25 (78%)	--	16 (50%)	23 (72%)	17 (53%)	greater than 1

	7 (22%)	32 (100%)	10 (31%)	9 (28%)	15 (47%)	less than 1
	2 (6%)	--	7 (22%)	4 (13%)	--	equal to 1
2000/2005	23 (72%)	--	15 (47%)	22 (69%)	15 (47%	greater than 1
	7 (22%)	32 (100%)	10 (31%)	6 (19%)	17 (53%)	less than 1

Authors' calculations

Table 9. *Performance of Large Manufacturing Industries – Malmquist Summary (Mean of all years)*

4-Digit Industrial Codes	EFC	TCH	PEC	SEC	TFP Change
Ten Most Efficient Large Manufacturing Industries					
2919	2.075	0.756	1.238	1.675	1.567
2691	2.040	0.711	1.533	1.331	1.450
2423	1.949	0.727	1.048	1.859	1.418
2429	1.932	0.779	1.000	1.932	1.506
3693	1.910	0.643	1.902	1.004	1.228
1911	1.818	0.674	1.033	1.761	1.225
2694	1.762	0.651	1.044	1.689	1.147
2930	1.759	0.665	1.790	0.983	1.170
3592	1.751	0.700	1.187	1.475	1.226
1810	1.731	0.647	1.068	1.620	1.120
Ten Least Efficient Large Manufacturing Industries					
1514	1.299	0.728	1.343	0.968	0.946
1554	1.212	0.656	1.093	1.109	0.795
1533	1.152	0.761	1.146	1.005	0.877
2021	1.057	0.698	1.012	1.045	0.738
1711	1.051	0.723	1.000	1.051	0.760
2412	1.000	0.699	1.000	1.000	0.699
1520	0.989	0.777	0.799	1.238	0.768
2411	0.933	0.632	0.934	0.999	0.589
2413	0.920	0.726	0.934	0.986	0.668
1722	0.743	0.746	0.748	0.994	0.554
Other Large Manufacturing Industries					
1713	1.690	0.622	1.034	1.635	1.051
2711	1.675	0.624	0.934	1.792	1.046
3410	1.653	0.688	1.210	1.366	1.137
1920	1.652	0.635	1.169	1.414	1.049
1542	1.608	0.716	1.563	1.028	1.150
1600	1.608	0.658	1.000	1.608	1.058
2921	1.607	0.798	0.863	1.863	1.282
1730	1.582	0.644	1.017	1.555	1.019
2424	1.511	0.700	0.830	1.821	1.058
3699	1.509	0.632	1.110	1.360	0.954
2610	1.464	0.732	1.390	1.054	1.072
2101	1.442	0.662	1.202	1.199	0.955
Overall Mean of small industries during 1995-2005	1.455	0.692	1.104	1.318	1.007

Source: Authors' Calculations

Note: See appendix for industrial classification codes and industry name.

Table 10. *Bootstrapped MPI Mean Scores – Large Manufacturing Industries*

Performance Indicator	Period/ Average	Actual Scores	Bias	Bias Corrected Scores	Bias Corrected Std. Err.	Lower CV at 95%	Upper CV at 95%
EFC	1995/2000	2.022	0.034	1.988	0.170	1.658	2.284
TCH	1995/2000	0.656	0.004	0.652	0.021	0.617	0.696
PEC	1995/2000	1.307	-0.011	1.318	0.123	1.107	1.609

SEC	1995/2000	1.728	0.008	1.720	0.151	1.440	1.986
TFP Change	1995/2000	1.338	-0.001	1.339	0.132	1.079	1.575
EFC	2000/2005	1.265	0.001	1.265	0.063	1.173	1.408
TCH	2000/2005	0.744	0.000	0.744	0.010	0.726	0.763
PEC	2000/2005	1.062	0.004	1.058	0.043	0.970	1.144
SEC	2000/2005	1.215	0.004	1.210	0.052	1.100	1.313
TFP Change	2000/2005	0.939	-0.009	0.948	0.044	0.862	1.014
EFC	Overall Mean	1.503	-0.009	1.512	0.056	1.429	1.624
TCH	Overall Mean	0.694	0.000	0.694	0.008	0.683	0.712
PEC	Overall Mean	1.130	0.005	1.126	0.046	1.054	1.253
SEC	Overall Mean	1.357	0.000	1.357	0.055	1.237	1.462
TFP Change	Overall Mean	1.040	-0.003	1.043	0.045	0.958	1.122

Source: Authors' Calculations

Note: See appendix for industrial classification codes and industry name.

To the check the significant change through hypotheses testing, we also performed bootstrapping on the Malmquist index and its different components for the large-scale manufacturing industries (Table 10). The results demonstrate that null hypothesis of insignificant change for PEC and TFP change cannot be rejected at 5% level of significance as the confidence intervals contain unit value for the period of 2000/2005. It was also found that overall mean value of TFP change showed insignificant change. The change in efficiency found significant unambiguously in all cases. The overall mean of bias-corrected score of EFC is 1.512 which indicates, large-scale industries were highly efficient and were successful to increase their efficiency by improving the production frontier of scale and better operations and management. Further, the contribution of scale of production frontier in improving efficiency is much larger as compare to the contribution of operations and management.

Summary and Conclusion

The present study utilizes MPI to measure the various performance indicators for small, medium and large-manufacturing at a 4-digit level in the Punjab province of Pakistan during 1995-2005. We also used a bootstrapping approach for hypotheses testing on MPI and its components. The prior literature on the manufacturing sector of Pakistan rather has ignored the small and medium scale manufacturing industries concerning the investigation of their performances. This study contributes in the existing literature to measure the performance of manufacturing industries by considering three different sized industries (small, medium and large scale).

The productivity index (MPI) has also been divided into efficiency change and technological change. Moreover, the efficiency change further decomposed to fetch scope efficiency change and pure efficiency change. The annual mean values of MPI estimates for the small scale manufacturing industries declined annually by 14.3 percent, mainly because of the absence of technological change. The efficiency change measure suggests that small manufacturers (i.e Carpets and Rugs, Dairy Products, Pulp Paper and Paperboard) were highly efficient primarily due to the better operations and management. During 1995-2000 and 2000-2005, 71 percent and 64 percent small industries were efficient respectively. The annual means of MPI for the medium scale manufacturing industries showed that the shift in production frontier increased productivity growth by 3 percent, however, most of these industries were inefficient (i.e Other Rubber Products, Plastics Products, Soft Drinks) as mean value of efficiency change declined by 12.8 percent. During 1995-2000 and 2000-2005, 93 percent and 45 percent medium scale industries were inefficient respectively and all industries shifted their production frontier during 1995/2000 due to the adoption of new technology. The large scale manufacturing industries were generally efficient and registered a small productivity growth about 0.7 percent during 1995-2005, the reason behind this low performance in terms of productivity was the lack of innovations. Moreover, during 1995-2000 and 2000-2005, 78 percent and 72 percent large scale manufacturing industries were efficient respectively.

Overall, this study found that the manufacturing sector has been trying to increase their efficiency only by increasing the scale of production and managerial techniques. The prominent feature of Punjab's manufacturing sector is that the industries are perhaps hesitant to invest in R&D which plays imperative role to shift the technological frontier. The policy suggestion for all sized industries is to increase R&D invest especially in medium and large-scale industries which is important to uplift production frontier. This investment is important to create research culture within the manufacturing sector. Such endeavors lead to elevate product innovations and developments that helps to increase the value of manufacturing goods which will further expand exports and reduce trade deficit. This investment can be increased if government provide fiscal incentives to encourage R&D activities. In addition, the banking sector can facilitate industries for such purposes by introducing various loan schemes. It is well evident in the literature that specialization has positive impact on the industrial productivity (Iqbal and Siddiqi, 2013). Another general suggestion for government or policy-makers is the implementation of such policies which help to promote specialization or create specialized industrial zones at specific locations or districts. This step may increase competition among firms that also encourage technological innovations and development.

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Appendix

Pakistan Standard Industrial Classification

4-digitIndustrial Codes	Industry Name	4-digitIndustrialCodes	Industry Name
1513	Fruits, vegetables and edible nuts	2422	Paints, varnishes, printing ink
1514	Vegetable and animal oils and fats	2423	Pharmaceuticals
1520	Dairy Products	2424	Soaps and detergents
1531	Grain mill products	2429	Other Chemical Products
1532	Starches and starch products	2519	Other rubber products
1533	Prepared animal feeds	2520	Plastics products
1541	Bakery Products	2610	Glass and glass products
1542	Sugar	2691	Non-refractory ceramic ware
1543	Cocoa, chocolate and sugar confectionery	2693	Structural clay and ceramic products
1549	Other food products n.e.c.	2694	Cement, lime and plaster
1554	Soft drinks; mineral waters	2711	Basic Iron and Steel
1600	Tobacco Products	2722	Aluminum and its products
1711	Spinning and weaving of textiles	2723	Lead, zinc, tin and products
1713	Finishing of textiles	2724	Copper Products
1721	Made-up textile articles; except apparel	2811	Structural metal products
1722	Carpets and Rugs	2893	Cutlery and general hardware
1723	Cordage, rope, twine and netting	2899	Other fabricated metal products n.e.c
1729	other textiles n.e.c.	2911	Engines and turbines
1730	Knitted and crocheted fabrics	2919	Other general-purpose machinery
1810	Wearing apparel, except fur apparel	2921	Agricultural and forestry machinery
1911	Tanning and dressing of leather	2926	Textile and leather production machinery
1920	Footwear (FW)	2930	Electric domestic appliances
2021	Plywood, panels and boards	3120	Electricity distribution and control apparatus
2029	Other products of wood	3330	Watches and clocks
2101	Pulp, paper and paperboard	3410	Motor vehicles
2109	Other articles of paper and paperboard	3430	Parts and accessories for motor vehicles
2211	Printing and Publishing of books etc	3592	Bicycles and invalid carriages
2320	Refined petroleum products	3610	Furniture
2411	Basic Chemicals	3692	Musical instruments
2412	Fertilizers and nitrogen compounds	3693	Sports goods
2413	Plastics and synthetic rubber	3699	Other manufacturing n.e.c
2421	Pesticides and agrochemical products		