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Measurement of Technical Efficiency of MSME Sector in India: An Application of Stochastic Frontier

Surender Singh
Department of Economics
BPS Women University, Haryana, India
Email: surendermor71@gmail.com

Abstract

The study measures the technical efficiency for Indian Medium and Small-Scale Sector using the longitudinal data pertaining to the period 1981-82 to 2014-15 by employing stochastic frontier model, which also incorporates a model for technical inefficiency effects as well. The mean technical efficiency of MSME in India turns out to be 86 per cent thereby pinpointing that the output/production of MSMEs in India can be increased by 14 per cent without increasing the quantum of inputs. There found inter-temporal variation in the technical efficiency of Medium and Small Scale Industries from 1981-82 to 2014-15, which has declined over the years from 97.12 per cent (1981-82) to 93.25 per cent (2014-15). The findings further highlight the problem of overstaffing in the MSME sector thereby indicating negative productivity of employees. The study further reveals that the share of MSME exports in total exports and GDP growth rates are key factors in reducing technical inefficiency of Medium and Small-Scale Industries in India. The study recommends that the fixed investment should be increased not only for sake of enhancing productivity of his sector but also to increase the contribution of human resources.

Keywords: Technical Efficiency, Stochastic Frontier, Medium and Small-Scale Sector.

1. Introduction

Micro, Small and Medium Enterprises (MSME) sector has emerged as a highly vibrant and dynamic sector of the Indian economy over the last five decades. MSMEs not only play crucial role in providing large employment opportunities at comparatively lower capital cost than large industries but also help in industrialization of rural & backward areas, thereby, reducing regional imbalances, assuring more equitable distribution of national income and wealth. MSMEs are complementary to large industries as ancillary units and this sector contributes enormously to the socio-economic development of the country. These industries are widely scattered all over the country and produces a large number of consumer goods, industrial goods and services. Major segment of the SSIs is unregistered and lies in the unorganised sector so that a sizeable portion of its output goes unrecorded in economy like India. Small enterprises play a very significant role in terms

of balanced and sustainable growth of the economy by way of employment generation, development of entrepreneurial skills and contribution to export earnings. These units produce a wide range of items employing traditional to state-of-the-art technology.

In India, the Micro, Small and Medium Enterprises Development (MSMED) Act was enacted in 2006 to address policy issues affecting MSMEs as well as the coverage and investment ceiling of the sector. The Act seeks to facilitate the development of these enterprises as also enhance their competitiveness. It provides the first-ever legal framework for recognition of the concept of "enterprise" which comprises both manufacturing and service entities. It defines medium enterprises for the first time and seeks to integrate the three tiers of these enterprises, namely, micro, small and medium.

Table 1: Classification of MSME Sector in India.

Type of MSME	Investment in Plant and Machinery		
	Micro Enterprises	Small Enterprises	Medium Enterprises
Manufacturing Sector	Up to 2.5 Million	2.5 - 50 million	50 - 100 million
Service Sector	Up to 1.0 Million	1.0- 20 Million	20- 50 Million

Source: MSME, Annual Report (2014-15), Government of India.

This vibrant segment of the Indian economy, has been contributing over 37.52 per cent of the manufacturing sector output and 7.48 per cent of gross domestic product, 37 per cent of the national exports and providing employment to nearly 111.43 million people, next to agriculture sector only through medium and small scale units located in both the rural and urban areas across the country (MSME, 2014-15).

The growth rates of MSME sector for the different years, estimated on the basis of the 2001-02 series of Index of Industrial Production (IIP) with total manufacturing sector and over all industrial sector (Table 2) describe that by and large industrial growth rate of the small scale industrial sector in terms of Index of Industrial Production (Base: 2001-02=100) rose to 12.60 per cent during the year 2005-06 as compared to 8.68 per cent during the year 2002-03. Whereas, the overall growth rate of industrial sector in 2014-15 is 15.47 per cent as compared to 2006-07 (10.8 per cent). The importance and contribution of small sector in accomplishing macroeconomic goals of an economy, especially in developing nations, has engrossed the concentration of scholars in recent years. In a complex global environment in which SMEs survive, grow and thrive is, therefore, considered an important objective of policy makers in both developed and emerging economies around the world [1]. The MSME sector has also consistently registered a higher growth rate as compared to the growth rate of overall manufacturing sector and overall industrial sector during the period mentioned in the Table 2.

Table 2: Annual Growth Rate of SSIs, Manufacturing Sector and Industrial Sector in India

Year	Growth rate of SSIs (With 2001/02 Base IIP)	Manufacturing Sector	Overall Industrial Sector
2002-03	8.68	6	5.75
2003-04	9.64	7.4	7.02
2005-06	12.32	9.1	8.15
2006-07	12.60	12.5	10.8
2012-13	15.02	22.46	15.30
2013-14	15.68	22.56	15.47

Source: Extracted and projected from MSME, Annual Reports, 2014-15

Inefficiency is the inability of the firm to produce maximum possible output with a given bundle of inputs. Recent researches in Indian Small-Scale Industries have shown that there is high degree of inefficiency in this sector**.** Page [14] deterministic frontier approach on small scale units in shoes, printing, soap and machine tool found that printing and the machine tools unite are more technically efficient as compared to others, whereas Little et al. [11]. using the same technique on the same group of industries found that additional experience of employees increased productivity of soap units and additional stock of capital decreases the efficiency in all units except printing. Goldar [8] using index number approach on 37 three digit industries and found that SSIs are less productive that the larger ones. Bhavani [4] by using deterministic stochastic approach on four metal industries at 4 digit level, found 70 per cent technical efficiency. Ramaswamy [15] on four groups of industries at three digit level data, using stochastic production function approach and found that their role of random factors in affecting technical efficiency and further profitability is positively related to the technical efficiency. Nikado [13] examined technical efficiency on two digit SSIs group and found that most SSIs operated at 80 percent efficiency level. The study further depicts that agglomeration has positive effect on the measures technical efficiency, while the size of the firm has a negative effect on it. Shallu et al. [17] analyzed the sources and level of technical efficiency of Indian small scale sector and found the mean technical efficiency of Small-Scale Industries in India turns out to be 84.12 per cent

Evidentially, the role of MSME sector in employment generation and growth is acknowledged worldwide. MSMEs form the precursor of the modern enterprise sector and present the propelling force of economic modernization and growth in developing economies. Hence it is the need of the hour to examine their efficiency levels in order to formulate appropriate policies for the development of SMEs [1]. The absence of quantitative as well as qualitative research on technical efficiency is surprising. Resultantly, there is a great scope for manufacturing sector to improve its technical efficiency. In the recent periods, very little literary contribution in the field of estimating stochastic frontier production and consequently dealing with technical inefficiency of small scale industries production have been made in India. In this backdrop, the present

paper investigates the technical efficiency of small scale industries (SSI) manufacturing segment of MSME in India.

The remainder of this paper as follows. Section 2 highlights the methodology employed in the study while Section 3 devoted to the results and discussion. Conclusions and suggestions are made in Section 4.

2. METHODOLOGY

The notion of technical efficiency was propounded by Farrell [7]. The technical inefficiency of industrial sector was estimated by fitting deterministic frontier production function proposed by Little et al. (1984) whereas the stochastic production frontier approach was used by Ramaswamy [15], Nikado[13] and Shallu et al. [17] for small scale sector of India. In such a specification, output of each firm is bounded above by a frontier, which varies across observations. The stochastic frontier technique measures efficiency of firms relative to their own frontier. In stochastic frontier production the disturbance term is composed of two parts; one symmetric, which captures the random effects outside the control of firms including droughts, floods etc. and the statistical noise contained in every empirical relationship and the other one-sided, which captures deviations from the frontier due to technical inefficiency. Formally,

$$Y = f(x)\, eEi \tag{1}$$

Where

$Ei = Vi - Ui \qquad i = (1, 2 \ldots n)$

vi = the symmetric component

$ui \geq 0$ = the one-sided component

Since the frontier is stochastic in nature, permitting random variations of the production frontier across observations, the technical inefficiency, which is captured by the one-sided error component, i.e., $ui \geq 0$, is relative to the stochastic frontier.

2.1 Model Specification

Technical inefficiency of a modern firm is estimated through the stochastic frontier production function, which is defined as:

$$\ln Yi = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + Vi - Ui \tag{2}$$

Where

Yi = Output (million)

X_1 = Employees

X_2 = Investment (million)

b's = Parameters to be estimated

Vi = Symmetric error term which is assumed to be independently and identically distributed having N (0, σ_v^2) distribution; and Ui = One sided error term, reflecting technical inefficiency, which is assumed to be independent of Vi, is such that Ui is the non-negative truncation (at zero) of the normal distribution with mean μ and variance σ^2, which is defined as

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 \quad (3)$$

Where

Z_1 = Share of MSME in total exports

Z_2 = Growth Rate of GDP

The variables Z_1 and Z_2 are included in the model for technical inefficiency effects to indicate probable effects of the variables on the technical efficiency of MSME in the country. It is expected that share of SSIs exports in total exports will cast a positive effect on the level of efficiency. Similarly, the growth rate of GDP is expected to cast a positive impact on the performance of SSIs. The b's and δ's are unknown parameters to be estimated together with the various parameter, which are expressed in terms of

$$\sigma_s^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \sigma_u^2 / \sigma_s^2 \quad (4)$$

Where, the γ parameter lies between zero and one.

The inefficiency model can be estimated only if the inefficiency effects are stochastic and follow a particular distribution specification. Hence, it is interesting to test the following hypotheses:

a) H_0: $\gamma = a_0 = \ldots = a_2 = 0$, i.e., inefficiency is absent

b) H_0: $\gamma = 0$, i.e., inefficiency effects are not stochastic

c) H_0: $a_0 = \ldots = a_2 = 0$, i.e., the coefficients of explanatory variables in the model are simultaneously zero

d) H_0: $a_1 = \ldots = a_2 = 0$, i.e., the coefficients of the variables in the model for inefficiency effects are zero.

The tests of these hypotheses for the parameters of the frontier are conducted using the generalized likelihood ratio statistics [5]. λ is defined as:

$$\lambda = -2 [L (H_R) - L (H_G)] \quad (5)$$

Where, L (H_R) is the value of likelihood function for the frontier model, in which parameter restrictions specified by null hypothesis, H_0, are imposed, and L (H_G) is the value of the likelihood function for the general linear frontier model. If the null hypothesis is true, then λ has approximately a chi-square (or mixed square) distribution with degrees of freedom equal to the difference between the parameter estimated under H_G and H_R respectively [6] The technical efficiency of the MSME sector, given the specification of the model, is defined by TEi = E (–Ui). Thus, the technical efficiency of the MSME sector lies between zero and one and is contrariwise related to the inefficiency model. Furthermore, the parameters of the stochastic frontier production function model are estimated by the method of maximum likelihood using the Econometric Computer Program FRONTIER Version 4.1xp [5].

2.2 The Database

The study uses time series data pertaining to the period 1981-82 to 2014-15 for the indicators like production, fixed investment and employment generated by the SSI sector. The date pertaining to the period 1981-82 to 2006-07 was collected from the Development Commissioner MSME and for the period 2007-08 to 2014-15 from the annual reports of MSME. Whereas, in case of the exports of SSIs and growth of GDP the Hand book of Statistics of Indian Economy published by RBI, Mumbai has been referred. In the present study Gross Value added method is used for measuring output in the MSME sector while the number of employees for a measure of labour input to estimate the technical efficiency. Further, investment in the fixed assets employed in the MSME sector is taken as additional independent variable in the model for measuring technical efficiency. The method of perpetual inventory accumulation method (PIAM) has been employed fir measuring the fixed Investment in which capital stock for a given period is traced by adding the previous investments starting from a benchmark year, converting to constant value by a price index of capital assets. The base year for the present study is year 1981-82 as the study covers the period from 1981-82 to 2014-15. The book value of fixed capital is taken as a measure of capital stock for year 1981-82 ([2],[8] and [3]).

3. Results and Discussion

The maximum likelihood estimates for the parameters in stochastic frontier as well as inefficiency model are presented in section 3.1 to 3.3.

3.1 Estimation of Stochastic Frontier model and Inefficiency Model

The parameters estimates for the number of employees are found statistically significant at 5 per cent level of significance but with a negative sign indicating excessive or more use of labor input thereby signifying the diminishing marginal productivity of labour input in the MSME sector. On the other hand, the parameter estimate for investment turns out to be positive and significant at 5 per cent level of significance indicative the positive contribution in the efficiency or productivity.

The coefficients of technical inefficiency effects, in the inefficiency model, are of interest and have important implications. Its results are presented in Table 3. The coefficient of share of MSME sector in total exports is negative and statistically significant at 5 per cent level of significant, which indicates that the growing share of SSI in export have a progressive effect on the performance and productivity of the small scale sector. Similarly, the coefficient growth of GDP is also found statistically significant attached with a negative sign, which indicates that inefficiency in SSIs tends to decrease with the level of growth of GDP. The parameter γ also reflects that the inefficiency effects are highly significant in the analysis of efficiency of MSME sector. Thus, given the specification of frontier production function, the tests of hypotheses indicate that the two variables in the efficiency model make a significant contribution in explaining the inefficiency associated with MSME production.

Table 3: Maximum-Likelihood Estimates for Parameters of the Stochastic Frontier and Inefficiency Model for MSME sector in India

Variable	Parameter	Coefficients
Constant	β_0	-0.1304 (0.16812)
Employees	β_1	-0.3910* (0.0531)
Fixed Investment	β_2	0.1665 (0.1845)
Inefficiency Model		
Constant	δ_0	-0.29 459 (0.2101)
Share of SSIs in Total Exports	δ_1	-0.0318* (0.0124)
Growth rate of GDP	δ_2	-0.0152* (0.0146)
Variance Parameters	σ^2	0.0141* (0.0064)
	γ	0.745* (0.0641)
Log likelihood function		-25.18

Note: Figures in parentheses represent standard errors

* Statistically significant at 5 per cent level of significance

3.2 Tests of Hypothesis for Inefficiency Model

Tests of various null hypothesis associated with the models were carried out using the likelihood ratio (LR) statistics and the results are presented in Table 4. The first null hypothesis, H_0: $\gamma = a_0 = \ldots = a_2 = 0$, i.e., that inefficiency is absent from

the model, is strongly rejected 5 per cent level of significance. It also indicates that the traditional production function is not an adequate representation of the data for SSIs in India. The second null hypothesis, H_0: $\gamma = 0$, which specifies that the inefficiency effects are not stochastic, is again rejected for the sampled 5 per cent level of significance. So, we do not accept the null hypothesis that there was no technical inefficiency. The parameter γ is estimated to be 0.75, which suggests that 75 per cent inefficiency is due to the factors under firms' control and the remaining 25 per cent are due to the factors outside the control of the decision making units. The third null hypothesis considered in the model, H_0: $a_0 = \ldots = a_2 = 0$, i.e., that the coefficients of the explanatory variables in the inefficiency models are simultaneously zero, is also rejected. It indicates that the two explanatory variables taken in the model make a significant contribution in the explanation of the inefficiency effects associated with SSIs sector in India. The last null hypothesis considered, H_0: $a_1 = \ldots = a_2 = 0$, i.e., that the coefficients of the variables in the model for inefficiency effects are zero, is also rejected for the SSIs units in India. It reflects that all the coefficients of the explanatory model are significantly influenced by the share of SSIs export in total exports and growth rate of GDP on the efficiency of SSIs units in India

Table 4: Likelihood-ratio tests of hypotheses for parameters of the stochastic frontier production function for SSIs in India

Null Hypothesis	Log likelihood	λ	Critical value	Decision
1. H_0: $\gamma = a_0 = \ldots = a_2 = 0$	19.72	14.26	10.37	Reject H_0
2. H_0: $\gamma = 0$	21.18	8.00	2.70	Reject H_0
3. H_0: $a_0 = \ldots = a_2 = 0$	21.07	8.22	7.04	Reject H_0
4. H_0: $a_1 = \ldots = a_2 = 0$	22.54	5.28	5.13	Reject H_0

Note:
1. The critical values for the hypotheses are obtained from Table 1 of Kodde and Palm (1986, p. 1246) at q + 1 degrees of freedom, where q is the number of parameters to be estimated.
2. The Log-Likelihood values in Column No. 3 are compared with the base values of the model in Table 2.
3. All values are significant at 5 per cent level of significance.

3.3 Estimation of Inter-temporal Technical Efficiency

The technical efficiency of each of MSME has been estimated using Equation (1) and the results are reported in Table 5, it pinpoints the inter-temporal variation of the technical efficiency of MSME from 1981-82 to 2014-15. The table reveals that the technical efficiency has declined over the years from 97.12 per cent (1981-82) to 93.25 per cent (2014-15). The table also reflects that the mean technical efficiency declined continuously till the year 1992-93 and after that it shows an upward trend till the year 1996-97 when it was maximum. Technical efficiency of MSME is almost constant at a level of around 90 per cent since 2003-04 to 2006-07. The mean technical efficiency for the period from 1981-82 to 2006-07 turned out to be 86.22 percent which ranges from 99.99 per cent (highest) to 67.55 (lowest).

Table 5: Inter-Temporal Variations in Technical Efficiency of MSME in India

Years	Technical Efficiency (Per cent)	Years	Technical Efficiency (Per cent)
1981-82	97.12	1998-99	73.56
1982-83	86.52	1999-2000	73.93
1983-84	80.25	2000-01	72.49
1984-85	87.51	2001-02	87.20
1985-86	83.01	2002-03	88.85
1986-87	77.59	2003-04	90.04
1987-88	75.43	2004-05	90.17
1988-89	75.43	2005-06	89.64
1989-90	80.21	2006-07	90.01
1990-91	75.93	2007-08	92.31
1991-92	67.56	2008-09	96.21
1992-93	75.26	2009-10	94.52
1993-94	85.97	2010-11	95.38
1994-95	95.24	2011-12	93.97
1995-96	93.10	2012-13	93.15
1996-97	99.99	2013-14	93.02
1997-98	89.70	2014-15	91.25

4. Conclusions and Suggestions

A Cobb-Douglas stochastic production function was estimated for the MSME in India using time series data. The study, through a series of hypothesis, establishes that the traditional response functions inadequate for representation of the data and technical inefficiency effects are significant. The findings reveal that technical efficiency of MSME has declined over the reference period. The mean technical efficiency for the period from 1981-82 to 2014-15 turned out to be 86 per cent, which reflects that the MSME can increase their production by 14 percent without increasing the quantum of inputs. It indicates the potential of small-scale industries to increase output and profitability with the same level of inputs and technology by simply improving industry's level of efficiency. The results indicate that the technical inefficiencies of production of MSME sector are significantly influenced by the share of MSME exports in total exports and Growth rate of GDP. The share of MSME exports in total exports and GDP growth rates are key factors in reducing technical inefficiency of MSME in India. Therefore, a sort of double pronged strategy is the need of the hour with the one prong aim to enhance the investment in MSME sector and the other to increase the labour productivity to the MSME sector.

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