

Different Forms of Efficiency in the Manufacture of Furniture Products in India - An Application of DEA

Manonmani M*

Department of Economics

Avinashilingam Institute For Home Science And Higher Education For Women
Coimbatore – 641 043 India

Abstract

The Indian furniture business has been witnessing a virtually exponential expansion in the recent years. The business demands the utilization of variegated uncooked supplies and that as well in incredibly large proportions. The furniture market as a total needs wood, leather-based, wooden foundation panel, metals, textiles, plastics and several other elements in fantastic source. Wooden furniture is commonly of assorted types, forms, measurements and even coloration combinations. These include things like chairs, wardrobes, kitchen area cabinets, tables and various other Indian Wooden Furniture goods. They serve different uses at homes, colleges, colleges, offices and other corporations. The Indian furniture sector has been production and exporting substantial good quality furniture products to all above the globe. In simple fact, over the many years, Indian wooden furniture has formulated an identity for itself and found spot in the houses of royals and commoners as effectively.

Keywords: DEA model, CCR model, BCC model, scale efficiency, cost efficiency, technical efficiency.

Introduction

The Indian furniture business has been witnessing a virtually exponential expansion in the recent years. The business demands the utilization of variegated uncooked supplies and that as well in incredibly large proportions. The furniture market as a total needs wood, leather-based, wooden foundation panel, metals, textiles, plastics and several other elements in fantastic source. Wooden furniture is commonly of assorted types, forms, measurements and even coloration combinations. These include things like chairs, wardrobes, kitchen area cabinets, tables and various other Indian Wooden Furniture goods. They serve different uses at homes, colleges, colleges, offices and other corporations. The Indian furniture sector has been production and exporting substantial good quality furniture products to all above the globe. In simple fact, over the many years, Indian wooden furniture has formulated an identity for itself and found spot in the houses of royals and commoners as effectively.

The structured market entails institutional production units and exporters that cater to numerous sections of the culture. The Indian wooden furniture marketplace solely contributes more than 60 crore rupees. The latest study of the Indian furniture business has claimed that the market place is slated to grow by above 20 for every cent in the coming a long time. So what are the primary factors that have contributed to the progress of the furniture business in India? The concept of a far better life style and great living is fast catching the center class fancy in the place.

Interior creating is no additional the prerogative of the wealthy and the higher class. The center class, buoyed by an improvement in income, are selecting the providers of inside decorators and obtaining their households upholstered as for every their extravagant. They don't find paying a couple dollars extra on purchasing quality picket furniture. The greater buying strength of the middle course has exceptionally contributed to the progress of the Indian furniture market. Overseas makers are also selling out much more cash in the business top rated to an all-round growth. Nowadays, globalization has impacted each nook and corner of the entire world. A single person do not spend a fortune to purchase a product that is readily available on the other aspect of the world. It has also bolstered the requirement of Indian furniture. Moreover, men and women have learnt about great living and want to have the finest furnishings in their homes. Architects and builders have also contributed to the growth. Indian furniture manufactures are generating their presence through worldwide trade fairs and house and overseas. This has resulted in an elevated publicity of their items in advance of the entire world marketplace.

Efficiency has been the subject of research in a wide range of production activities. It is expressed as a percentage which can calculate as the ratio total output power to total input power under specified conditions. Efficiency analysis has always been linked to the relative difficulty encountered is assessing the performance of decision-making units (DMUs). In the words of Farrell (1953) the measurement of efficiency of an industry is important both the economic theorist and economic policy maker. If economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase

*Corresponding author email: manomyil@yahoo.com

its output by simply increasing its efficiency, without absorbing further resources. Allocative efficiency is a type of economic efficiency in which economy/producers produce only those types of goods and services that are more desirable in the society and also in high demand. According to the formula the point of allocative efficiency is a point where price is equal to marginal cost ($P=MC$) or ($MC=MR$). At this point the social surplus is maximized with no deadweight loss, or the value society puts on that level of output produced minus the value of resources used to achieve that level.

Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs, such as labor, capital and technology. For example a firm would be technically inefficient if a firm employed too many workers than was necessary or used outdated capital. The concept of technical efficiency is related to productive efficiency. Productive efficiency is concerned with producing at the lowest point on the short run average cost curve. Technical efficiency is necessary for allocative efficiency to be achieved. However, allocative efficiency also requires the optimal allocation of resources. Cost Efficiency of a productive enterprise is an important indicator of its performance. The cost efficiency of a firm is defined by the ratio of minimum costs to actual costs for a given output vector is computed by measuring the distance of its observed (cost) point from an idealized cost frontier. Scale efficiency refers to output at a scale that maximizes profits for a firm and where capital and infrastructure can be set to their profit-maximizing levels. On the basis of the above points this analysis had been undertaken with objective measuring different types of efficiencies by applying DEA approach.

Methodology

Data Base of the Study

The basic data source of the study on fixed capital (cost input), wages (cost- input) and net value added (output) was Annual Survey of Industries (ASI) published by Central Statistical Organization (CSO), Government of India. All the referred variables were normalized by applying Gross Domestic Product (GDP) deflator. The GDP at current and constant prices were obtained by referring to Economic Survey, published by Government of India, Ministry of Finance and Economic Division, New Delhi. The reference period chosen for the study covers between 2001-02 and 2011-12.

Tools of Analysis:

DEA Model

There are basically two approaches for estimation of efficiency, viz., the Stochastic Frontier Approach (SFA) and Data Envelopment Approach (DEA). While the stochastic frontier approach (econometric approach) estimates the efficiency of the firms by estimating the production function, the DEA technique involves the use of mathematical programming to estimate the efficiency of the firms/industry. DEA is a non-parametric, deterministic methodology for determining relatively efficient production frontier, based on the empirical data on chosen inputs and outputs of a number of entities called Decision Making Units (DMUs). From the set of available data, DEA identify reference points (relatively efficient DMUs) that define efficient frontier (as the best

practice production technology) and evaluate the inefficiency of other interior points (relatively inefficient DMUs) that are below the frontier (Ray, 2004).

The DEA provides a measure of efficiency that allows intra-firm comparison, as the efficiency measure is a pure number. The main advantage of DEA is that unlike SFA, it does not require a priori assumption about the analytical form of the production function. Instead, it constructs the best practice production solely on the basis of observed data and therefore the possibility of misspecification of the production technology is minimized. In the case of SFA, the parameter estimates are sensitive to the choice of the probability distribution specified for the disturbance term. There are two approaches to estimating the efficiency of the firm in the DEA approach viz., the output-oriented efficiency and the input-oriented efficiency. In the output oriented approach, efficiency is determined by maximum output that can be produced from an input bundle. In the input-based measure, the technical efficiency of the firm is evaluated by the extent to which all inputs could be proportionally reduced without a reduction in the output. Among number of DEA models, the two most frequently used ones (input oriented) are, CCR model (Charnes et al. 1978) and BCC model (Banker et al. 1984), both of which are used in the study. The DEA model is used to estimate the technical, scale, cost and allocative efficiency of the industries under study.

Technical Efficiency:

CCR Model (based on constant returns to scale)

Charnes et al. (1978) introduced a measure of efficiency for each DMU that is obtained as a maximum of ratio of weighted outputs to weighted inputs. The weights for the ratio are determined by a restriction that the similar ratios for every DMU have to be less than or equal to unity, thus reducing multiple inputs and outputs to single "virtual" output without requiring pre-assigned weights. The efficiency measure is then a function of weights of the "virtual" input-output combination. Formally, the efficiency measure for the DMU can be calculated by solving the following mathematical programming problem:

$$\max h_0(u, v) = \frac{\sum_{r=1}^s u_r Y_{r0}}{\sum_{i=1}^m v_i X_{i0}} \quad (1)$$

Subject to

$$\frac{\sum_{r=1}^s u_r Y_{rj}}{\sum_{i=1}^m v_i X_{ij}} \leq 1, j = 1, 2, \dots, j_0, \dots, n \quad (2)$$

$$u_r \leq 0, r = 1, 2, \dots, s \quad (3)$$

$$v_i \geq 0, j = 1, 2, \dots, m \quad (4)$$

where x_{ij} is the observed amount of input of the i^{th} type of the DMU ($x_{ij} > 0, i = 1, 2, \dots, n, j = 1, 2, \dots, n$) and y_{rj} = the observed amount of output of the r^{th} type for the j^{th} DMU ($Y_{rj} > 0, r = 1, 2, \dots, s, j = 1, 2, \dots, n$).

The variables u_r and v_i are the weights to be determined by the above programming problem. However, this problem has infinite number of solutions since if (u^*, v^*) is optimal then for each positive scalar α ($\alpha u^*, \alpha v^*$) is also optimal. Following the Charnes and Cooper (1962) transformation, one can select a representative solution (u, v) for which

$$\sum_{i=1}^m v_i x_{io} = 1 \quad (5)$$

To obtain a linear programming problem that is equivalent to the linear fractional programming problem (1) - (4). Thus, denominator in the above efficiency measure h_0 is set to equal one and the transformed linear problem for DMU can be written.

$$\max z_0 = \sum_{r=1}^s u_r Y_{ro} \quad (6)$$

Subject to

$$\sum_{r=1}^s u_r Y_{rj} - \sum_{i=1}^m v_i x_{ij} \leq 0, j = 1, 2, \dots, n \quad (7)$$

$$\sum_{r=1}^m v_i x_{io} = 1 \quad (8)$$

$$u_r \geq 0, r = 1, 2, \dots, s \quad (9)$$

$$v_i \geq 0, i = 1, 2, \dots, m \quad (10)$$

For the above linear programming problem, the dual can be written (for the given DMU) as:

$$\min z_0 = \Theta_0 \quad (11)$$

Subject to

$$\sum_{j=1}^n \lambda_j Y_{rj} \geq y_{ro}, r = 1, 2, \dots, s \quad (12)$$

$$\lambda_j \geq 0, j = 1, 2, \dots, n \quad (13)$$

Both of the above linear problems yield the optimal solution Θ^* , which is the efficiency score (so-called technical efficiency or CCR efficiency) for the particular DMU and repeating them for each DMU, $j = 1, 2, \dots, n$ efficiency scores for all of them are obtained. The value of Θ is always less than or equal unity (since when tested, each particular DMU is constrained by its own virtual input-output combination too). DMUs for which $\Theta^* < 1$ are relatively inefficient and those for which $\Theta^* = 1$ are relatively efficient, having their virtual input-output combination points laying on the frontier. The frontier itself consists of linear facets spanned by efficient units of the data and the resulting frontier production function (obtained with the implicit constant returns to scale assumption) has no unknown parameters.

BCC model (based on Constant Returns to Scale)

Since there are no constraints for the weights λ_j , other than the positivity conditions in the problem (11) - (14), it implies constant returns to scale. For allowing variable returns to scale, it is necessary to add the convexity condition for the weights, λ_j , i.e. to include in the model (11) - (14) the constraint:

$$\sum_{j=1}^n \lambda_j = 1 \quad (14)$$

The resulting DEA model that exhibits variable returns to scale is called BCC model (Banker et al., 1984). The input-oriented BCC model for the DMU0 can be written formally as:

$$\min z_0 = \Theta_0 \quad (15)$$

Subject to

$$\sum_{j=1}^n \lambda_j Y_{rj} \geq Y_{ro}, r = 1, 2, \dots, s \quad (16)$$

$$\Theta_0 x_{io} - \sum_{j=1}^n \lambda_j x_{ij} \geq 0, i = 1, 2, \dots, m \quad (17)$$

$$\sum_{j=1}^n \lambda_j = 1 \quad (18)$$

$$\lambda_j \geq 0, j = 1, 2, \dots, n \quad (19)$$

Running the above model for each DMU, the BCC efficiency scores are obtained (with similar interpretation of its values as in the CCR model). These scores are also called "pure technical efficiency scores", since they are obtained from the model that allows variable returns to scale and hence eliminate the "scale part" of the efficiency from the analysis. Generally, for each DMU the CCR efficiency score will not exceed the BCC efficiency score, what is intuitively clear since in the BCC model each DMU is analyzed "locally" (i.e. compared to the subset of DMUs that operate in the same region of returns to scale) rather than "globally".

Scale Efficiency

Following the scale properties of the above two models, (Cooper et al. 2000) the scale efficiency is defined as follows. For a particular DMU, the scale efficiency is defined as a ratio of its overall technical efficiency score (measured by the CCR model) and pure technical efficiency score (measured by the BCC model).

Cost Efficiency

The standard measure of cost efficiency is obtained via a two stage process. i) Estimate the minimum price-adjusted resource usage given technological constraints, and (ii) compare this minimum to actual, observed costs. Cost efficiency can be measured if input prices are available in addition to output and input data.

Let $x = (x_1, \dots, x_k) \in R^+ + k$ denotes a vector of inputs and $y = (y_1, \dots, y_m) \in R^+ + m$ denote vector of outputs. Formally, the cost efficiency model can be specified as :

$$\text{Min}_{z,x} \sum_{j=1}^m w_{jo} x_j \quad (20)$$

$$\text{s.t. } \begin{aligned} z \cdot Y &\leq y_0 \\ z \cdot x &\leq x_0 \\ z_i &\geq 0 \end{aligned}$$

$$\sum_{i=1}^n z_i = 1 \quad (21)$$

where Y is an $n \times m$ matrix of observed outputs for n industries and x is an $n \times k$ matrix of inputs for each industry. z is a $1 \times n$ vector of intensity variables and $w = (w_1, \dots, w_k) \in R^+ + k$ denoted input prices. The constraints of the model (21) define the input requirement set given by:

$$L(y) = \{x, z, y \geq y_0, z \cdot x \leq x, z_i \geq 0, \sum_{i=1}^n z_i = 1\} \quad (22)$$

The input requirement set specifies a convex technology with Variable Returns to Scale (VRS), which is imposed by the constraint $\sum_{i=1}^n z_i = 1$.

Leaving the constraint out of the model changes the technology to Constant Returns to Scale (CRS).

Allocative Efficiency

Allocative efficiency is defined as a ratio of cost efficiency score to technical efficiency score. Both under CRS production technology and VRS production technology, this efficiency score was estimated for the present study.

Results and Discussion

Technical Efficiency

The results regarding technical efficiency scores of the selected industry are presented in Table 1.

Table 1. Technical Efficiency (TE) estimates^a

Sl. No	DMUs	^b CRS	^c VRS
1	2001-02	0.995	1.000
2	2002-03	0.756	1.000
3	2003-04	0.798	0.979
4	2004-05	0.903	1.000
5	2005-06	0.856	0.904
6	2006-07	0.942	0.961
7	2007-08	1.000	1.000
8	2008-09	0.923	0.933
9	2009-10	0.942	0.947
10	2010-11	1.000	1.000
11	2011-12	1.000	1.000
^d Average Technical Efficiency		0.919	0.975
Average Technical Inefficiency		0.088	0.026
No. of Technically efficient DMUs		3	6

^a Calculations are based on ASI data.

^b CRS-Constant Returns to scale

^c VRS-Variable Returns to scale

^d Average technical inefficiency = $1 - \bar{x} / \bar{\bar{x}}$

Under Constant Returns to Scale (CRS) production technology, technical efficiency between 2001-02 and 2011-12 was 0.919. This implied that the industry would have needed only 91.9% of the inputs currently being used. In terms of average inefficiency it would have needed 22.5% more inputs to produce the same output, which meant waste of resources to the extent mentioned above.

Under VRS production technology, the number of efficient DMUs exceeded the number of efficiency DMUs under CRS production technology. Always under VRS production technology, higher average efficiency was recorded. It may be due to the reason that DMUs that were efficient under Constant Returns of Scale (CRS) were accompanied by new efficient DMUs that might operate under increasing or decreasing return to scale. Higher degree of average technology inefficiency particularly under constant return to scale production technology can be attributable to the fact that the industry may not be using the most efficient technology available to transform the input into outputs due to differences in products produced, the industry was likely to have different best practice frontiers; relatively small regional spheres of operation

of the industry may have resulted in inefficiencies; and structured problems regarding staff efficiency and operating efficiency may have prevented the firm from improving its efficiency level. It can be concluded that though the efficiency of the firm varied considerably on account of the various reasons mentioned, the firm was estimated to be on the frontiers at least once. In other words, both under CRS and VRS technology, the number of efficiency scores or levels during the entire period, was indicative of the fact that the efficiency of firm was not strongly influenced by the size of production.

Scale Efficiency

The scale efficiency scores are presented in Table 2.

Table 2. Scale Efficiency (SE) estimates^a

Sl. No	DMUs	Scale Efficiency	VRS
1	2001-02	0.995	^b IRS
2	2002-03	0.756	IRS
3	2003-04	0.816	IRS
4	2004-05	0.903	IRS
5	2005-06	0.947	IRS
6	2006-07	0.979	IRS
7	2007-08	1.000	^c CRS
8	2008-09	0.989	IRS
9	2009-10	0.995	IRS
10	2010-11	1.000	CRS
11	2011-12	1.000	CRS
^d Average Scale Efficiency		0.944	-
Average Scale Inefficiency		0.059	-
No. of Scale efficient DMUs		3.0	-

^a Calculations are based on ASI data.

^b IRS-Increasing Returns to scale

^c CRS-Constant Returns to scale

^d Average scale inefficiency = $1 - \bar{x} / \bar{\bar{x}}$

DEA results applied to know the scale efficiency of industries for the entire period revealed that the industries were not operating at an optimum scale. The average scale efficiency was 94.4%. In terms of average inefficiency, it could increase additional production to the extent of 5.6%, by taking advantage of their scale characteristics. DEA allows to assess whether a firm lies in the range of increasing, constant and decreasing returns to scale. In other words, it revealed the scale characteristics of DMUs. If market contains firms scale, market efficiency can be increased if more DMUs attain constant returns to scale, because fewer resources are wasted. The measurement of economies of scale, therefore, helps assess at the same time whether higher market concentration should be encouraged to improve efficiency. A DMU may be scale inefficient, if it experiences decreasing returns to scale or if it has not taken full advantages of increasing returns to scale. Indeed most of the inefficient DMUs presented increasing returns to scale characteristics which indicated that industries can increase the scale to effectively improve that efficiency.

Cost Efficiency

Table 3 gives details regarding cost efficiency scores of the selected industry for the reference period under study.

Table 3. Cost Efficiency (CE) estimates^a

Sl. No	DMUs	^a CRS	^c VRS
1	2001-02	0.777	1.000
2	2002-03	0.735	0.999
3	2003-04	0.784	0.888
4	2004-05	0.900	0.950
5	2005-06	0.841	0.887
6	2006-07	0.940	0.951
7	2007-08	1.000	1.000
8	2008-09	0.789	0.890
9	2009-10	0.808	0.882
10	2010-11	0.865	0.910
11	2011-12	0.855	0.892
Average cost Efficiency		0.845	0.932
^d Average cost Inefficiency		0.183	0.073
No. of cost efficient DMUs		1	2

^a Calculations are based on ASI data.

^b CRS-Constant Returns to scale

^c VRS-Variable Returns to scale

^d Average cost inefficiency = $1 - \bar{x} / \bar{\bar{x}}$

Under Constant Returns to Scale (CRS) technology, the industry was efficient to the extent of 84.5%. Under Variable Returns to Scale (VRS) production technology the industry was more efficient to the extent of 89.2%. Considering the cost efficient DMUs, it was found to be more under VRS production technology. The average cost inefficiency was more under CRS production technology than under VRS production technology.

Allocative Efficiency

Allocative efficiency scores of the industry under the reference period are presented in Table 4. Estimates revealed that over the study period, the industries under CRS production technology had on an average allocative efficiency level of 92.2% implying that the industries were 7.8% inefficient respectively. In the case of VRS production technology, an average allocative efficiency of 95.6%, implying that the industries were on an average 4.4% inefficient. More efficiency DMUs were observed in VRS production technology compared to CRS production technology.

Conclusions

For the entire period, technical, scale, cost and allocative efficient DMUs were more under Variable Returns to Scale (VRS) production technology than under Constant Returns to Scale (CRS) production technology. Also it is very clear that inefficiency could be due to the existence of either increasing or decreasing returns to scale.

Table 4. Allocative Efficiency (AE) estimates^a

Sl. No	DMUs	^b CRS	^c VRS
1	2001-02	0.781	1.000
2	2002-03	0.973	0.999
3	2003-04	0.982	0.908
4	2004-05	0.996	0.950
5	2005-06	0.982	0.980
6	2006-07	0.998	0.989
7	2007-08	1.000	1.000
8	2008-09	0.855	0.954
9	2009-10	0.857	0.932
10	2010-11	0.865	0.910
11	2011-12	0.855	0.892
Average Allocative Efficiency		0.845	0.932
^d Average Allocative Inefficiency		0.183	0.073
No. of Allocative efficient DMUs		1	2

^a Calculations are based on ASI data.

^b CRS-Constant Returns to scale

^c VRS-Variable Returns to scale

^d Average allocative inefficiency = $1 - \bar{x} / \bar{\bar{x}}$

References

- Farrell (1957), The measurement of Productive Efficiency, *Journal of Royal Statistical Society, series A (General)*, Vol. 120, No.3, pp.253-290.
- Annual Survey of Industries Reports (2001-2012)
- Economic Survey of India Reports (2001-2012).
- Ray S (2004), MNEs, Strategic Alliances and Efficiency of Firms: Emerging Trends, *Economic and Political Weekly*, 39 (5), pp.434-440.
- Charnes A, Cooper WW and Rhodes E (1978), Measuring The Efficiency Of Decision Making Units, *European Journal Of Operation Research*, Vol. 2, pp.429-444.
- Charnes, A and Cooper WW (1962), Programming with linear fractional functionals, *Naval Research Logistics Quarterly*, 3-4:pp.181-186.
- Banker RD Charnes A and Cooper WW (1984), Some Models For Estimating Technical And Scale Inefficiencies In Data Envelopment Analysis, *Management Science*, Vol. 30, pp.1078-2092.
- Cooper WW, Lawrence MS, and Joe Zhu (2000), A unified additive model approach for evaluating inefficiency and congestion with associated measures in DEA, *Socio-Economic Planning Sciences*, 34 (1):1-25.

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