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Ranking the Indian real estate firms in pre & post demonetization periods using hybridized data envelopment analysis

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Abstract

Purpose – the purpose of the study is to analyze administrative personal expenses (APE), manufacturing-selling expenses (MSE), earnings before depreciation interest taxes amortization (EBDITA), and sales turnover (ST) to identify the most efficient real estate company.

Research methodology – the study has been conducted on the available secondary data with a sample of eight Indian real estate companies as decision-making units (DMUs). The study is carried out using data envelopment analysis (DEA) clubbed with Shannon's entropy and is termed a hybridized DEA method.

Findings – the study reveals that the sequential ranking of DMUs is obtained using hybridized DEA method. Using hybridized DEA method, it is found that after the demonetization the DMUs performance is aligned in an organized pattern and almost similar in pre-and-post demonetization under hybridized input-oriented variable return to scale method.

Research limitations – the study is based on available secondary data considering eight DMUs. It may be overcome through thorough on-sight qualitative and quantitative study to include more datasets.

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Originality/Value – efficiency of real estate companies is analyzed using DEA clubbed with Shannon's entropy and it is further utilized to rank all DMUs.

Subject Classification: *90B50, 90C32, 90C90.*

Keywords: *Data envelopment analysis, Shannon's entropy, Ranking of DMUs, Real estate firms, Efficiency.*

Introduction

India's real estate sector, which is the country's second-largest after agriculture, must grow more quickly to keep up with the nation's expanding demands from both business and consumers. The profitability and long-term development of the Indian real estate market have both seen challenges in recent years. The real estate sector was pushed in the direction of recovery due to the proactive steps undertaken by the Government (*Indian Brand Equity Foundation*, n.d.). Many sectors such as real estate, aviation, automobile, agriculture, and banking, etc. in India have witnessed the effect of demonetization in several ways (Raja Prasad, 2019).

Raja Prasad (Raja Prasad, 2019) discussed the impact of demonetization on Indian real estate companies. He adopted the data envelopment analysis (DEA) of variable returns to scale (VRS) under input orientation (IPO). Efficiency scores of all DMUs, using DEA-VRS-IPO, for both pre- and post-demonetization periods are obtained and studied. Further, the study, using Spearman's rank correlation coefficient measured the efficiency scores of selected real estate players and concluded that the Indian real estate sector is adversely impacted by demonetization (Garg et al., 2020; Singh et al., 2016).

The environmental performance of the cement industry, which is active in 21 different countries around the world, has been examined by Oggioni et al (Oggioni et al., 2011). They employed data envelopment analysis and took into account both desirable and undesirable variables for their research.

It is evident from the literature that the DEA method was applied to obtain the performance of real estate companies (Zheng et al., 2011), mutual funds of real estate trusts (Anderson et al., 2004), and construction segments safety (El-Mashaleh et al., 2010; Rajaprasad et al., 2013).

The present study has extended the studies of Raja Prasad (2019) by implementing the DEA and DEA clubbed with an entropy method. The DEA has two direct methods, namely constant return to scale (CRS) and

VRS. Each method can be applied in two orientations input and output (OPO). Cook, et al (Cook et al., 2014) have discussed the applicability, implication, and situations to choose an appropriate method among the four standard methods. Xie, et al (Xie et al., 2014) have identified that the standard DEA methods cannot discriminate the DMUs effectively and hence introduced a new DEA method clubbed with Shannon's entropy. Now for the present study two methods such as VRS-DEA-IPO & VRS-DEA-OPO, named as direct methods, and two entropy methods such as VRS-DEA-IPO & VRS-DEA-OPO clubbed with Shannon's entropy, named as hybridized DEA methods have been considered (Aujla et al., 2019; Sharma & Kumar, 2016; Verma et al., 2019).

It can be found that many DMUs in the case of Raja Prasad (2019) have obtained the same rank and could not distinguish them further. The present study focused on this key issue to rank the DMUs using the hybridized DEA methods and the rest of the paper is organized as follows. A brief description of the direct and hybridized DEA methods and, data and variables have been discussed in section 1 and section 2 respectively. Section 3 illustrates the results and discussion using the proposed methods applied to the eight data sets from Raja Prasad (2019). In section 4, conclusions and future scope have mentioned.

1. Direct and Hybridized Data Envelopment Analysis Methods

1.1 *Direct DEA methods*

DEA is a non-parametric approach invented by Charnes, et al (Charnes, A., Cooper, W. W. and Rhodes, E., 1978) to obtain the efficiency score for the firms known as DMUs which depends on multi-input and multi-output variables. Obtaining the efficiency score is a multi-stage approach like forming the fractional linear programming problem, converting it to a linear programming problem, and solving the linear programming problem. Anto et al., (2021) determined the efficiency of 58 banks selected from ASEAN-5 countries using a two-stage data envelopment analysis method (Anto et al., 2021). The study identified and classified the chosen variables which cause the negative and positive effects on bank efficiency. In the literature, it can be found a review article published by Rostamzadeh et al., (2020) on the application of DEA using selected 51 journal articles between 2003 to February 2020 (Rostamzadeh et al., 2021). The study focused on eight major application areas and out of them, 31% of articles are found to be transportation areas. For the present

study, variable returns to scale input and output oriented DEA methods are adopted and it can be found in Cook and Seiford (Cook & Seiford, 2009).

Model-1: Input oriented variable returns to scale

$$Min.\theta_s$$
$$\theta,\lambda$$

Subjected to

$$Y\lambda \geq Y_s$$

$$X\lambda \leq \theta_s X_s$$

$$\Sigma\lambda = 1$$

$$\lambda \geq 0,\ \theta_s \text{ free}$$

Model-2: Output oriented variable returns to scale

$$\max_{\theta,\lambda} \phi_t$$

Subjected to

$$Y_\lambda \geq \phi_t Y_t$$

$$X_l \leq X_t$$

$$\Sigma\lambda = 1$$

$$\lambda \geq 0;\ \phi_t \text{ free}$$

1.2 *Hybridized DEA method*

The direct DEA methods illustrated in section 1.1 are clubbed with Shannon's entropy and obtained two hybridized methods, namely Entropy-DEA-IPO-VRS (EIV) and Entropy-DEA-OPO-VRS (EOV). The result obtained using hybridized DEA methods is termed a comprehensive efficiency score (CES) (Xie et al., 2014). Recursive evaluation of standard DEA efficiency values using standard DEA methods is a mandate to obtain the CES. The step-wise procedure to obtain CES adopted by Xie, et al (Xie et al., 2014) is described as follows.

Step 1: Find an efficiency score matrix $[D_{ks}]_{d\times S}$ using each of the direct DEA methods as described in section 1.1, where d number of DMUs, $S = (2^i - 1) \times (2^j - 1)$, i and j represent the total number of input and output variables respectively.

Step 2: Compute a matrix $[N_{ks}]_{d\times S}$ obtained by normalizing the matrix D as

$$n_{ks} = D_{ks} / \textstyle\sum_{k=1}^{d} D_{ks},\ s = 1,2,3,\ldots,S.$$

Step 3: Compute an entropy array e_s as

$$e_s = -(\ln d)^{-1} \sum_{k=1}^{d} n_{ks} \ln(n_{ks}),\ s = 1,2,3,\ldots,S.$$

Step 4: Compute a diversification degree array m_{sz} as $m_s = 1 - e_s$, $s = 1,2,3,\ldots,S$.

Step 5: Compute a normalized value of m_s as $M_s = m_s / \sum_{s=1}^{S} m_s$ such that $\sum_{s=1}^{S} M_s = 1$.

Step 6: Finally evaluate the CES as $r_k = \sum_{s=1}^{S} M_s D_{ks}$, $k = 1,2,3,\ldots,d$.

2. Data and Variables

For the present study, we considered the data sets and the variables given by Raja Prasad (Raja Prasad, 2019). His study was carried out using administrative personal expenses (APE) and manufacturing-selling expenses (MSE) as two inputs; and earnings-before-depreciation-interest-taxes-amortization (EBDITA) and sales turnover (ST) as the output variables. The study considered eight Indian real estate companies, that are taken as independent decision-making units (DMUs). The descriptive statistics of all variables are listed in Table 1 and Table 2 for pre-and-post-demonetization periods respectively.

Table 1

Descriptive statistics of the variables for the pre-demonetization datasets

Statistics	ST	EBDITA	MSE	APE
Mean	1292	685	658	189
SD	1114.278	780.311	616.869	129.847
Maximum	3319	2689	1690	445
Minimum	128	117	5	82

Table 2

Descriptive statistics of the variables for the post-demonetization datasets

Statistics	ST	EBDITA	MSE	APE
Mean	1382	592	839	182
SD	1144.684	571.812	726.590	124.516
Maximum	3379	2040	1892	437
Minimum	187	113	15	18

3. Results and discussion

A total of 8 data sets given by Raja Prasad (Raja Prasad, 2019) have been considered and executed the two methods such as direct and hybridized DEA methods as described in section 1. The results of each method have down listed in Table 3 and Table 4 for pre-demonetization and post demonization periods respectively. The correlation between efficiencies using all the adopted methods for both periods is shown in Figure 1.

Table 3

Results using VRS-IPO, VRS-OPO, EIV, and EOV methods for pre-demonetization datasets.

DMU	VRS-IPO	VRS-OPO	EIV	EOV	Ranks EIV	Ranks EOV
1	1.000	1.000	1.000	1.000	1	1
2	1.000	1.000	0.240	0.535	8	5
3	0.949	0.656	0.269	0.474	6	6
4	1.000	1.000	0.586	0.894	4	2
5	1.000	1.000	0.972	0.699	2	3
6	1.000	1.000	0.329	0.683	5	4
7	0.725	0.755	0.254	0.467	7	7
8	0.947	0.378	0.830	0.256	3	8

Table 4

Results using VRS-IPO, VRS-OPO, EIV, and EOV methods for post-demonetization datasets.

DMU	VRS-IPO	VRS-OPO	EIV	EOV	Ranks EIV	Ranks EOV
1	1.000	1.000	1.000	1.000	1	1
2	0.675	0.692	0.432	0.558	5	5
3	0.661	0.691	0.208	0.300	8	8
4	1.000	1.000	0.792	0.877	3	2
5	1.000	1.000	0.821	0.792	2	3
6	1.000	1.000	0.400	0.529	6	6
7	1.000	1.000	0.381	0.493	7	7
8	1.000	1.000	0.746	0.791	4	4

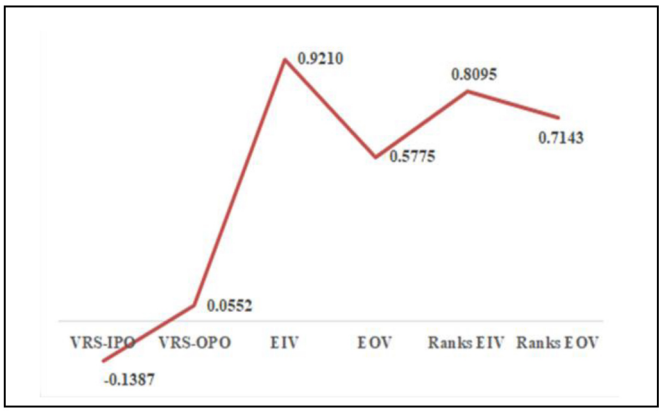

Figure 1

Correlation between efficiencies and ranks

Using direct DEA methods under VRS-IPO and VRS-OPO three DMUs such as DMU3, DMU7 and DMU8 were not efficient before demonetization. However, only two DMUs namely DMU2 and DMU3 were not efficient after demonetization. It was stated in the literature that some of the DMUs have obtained the same rank using the VRS-IPO method.

The results incorporated in Table 3 and Table 4 reveal that DMUs can be ranked using hybridized DEA methods effectively. It can be recognized from Table 3 and Table 4 that the first and second ranks were obtained for the DMU1 and DMU5 respectively, under the EIV method. While applying the EOV method the first rank is obtained to the same DMU1, but the second rank is obtained to DMU4 instead of DMU5. It can be confirmed from the seventh column of Table 3 and Table 4.

It can be noticed from the sixth and seventh columns of Table 3 and Table 4 that the ranks obtained by hybridized DEA methods are sporadic before the demonetization period. However, all the DMUs except two have obtained the same ranks after demonetization. It shows that irrespective of the methods the DMUs have performed without many deviations after demonetization. Irrespective of the methods and the periods, it can be stated that DMU1 is the most efficient among all DMUs.

Correlation values between efficiencies and ranks obtained using adopted methods for pre-and-post demonetization periods are shown in Figure 1. It is noticed from Figure 1 that EIV and ranks-EIV have a strong correlation of 0.9210 and 0.8095 respectively.

4. Conclusion and Future Scope

Direct DEA methods such as VRS-IPO and VRS-OPO may bifurcate the set of DMUs into an efficient and inefficient DMUs subset. Ranking of DMUs using these direct methods cannot give complete information in respect of the most efficient DMU among the others.

However, using the hybridized DEA methods we obtained the ranking of all the DMUs which helps us to arrange the DMUs in sequential order. It can be stated that the two DMUs namely DMU1 and DMU4 are the first and the second most efficient DMUs among the others chosen.

Except for two DMUs remaining all have obtained the same ranks in both the hybridization methods in the post-demonetization period. It may be concluded that after the demonetization the DMUs' performance is aligned in an organized pattern. Moreover, a strong correlation between pre-and-post demonization period efficiencies obtained by the hybridized method using VRS-IPO, and suggests that DMUs performance is almost similar in pre-and-post demonetization.

The study has been conducted on the available secondary data with eight DMUs which consists of two inputs and two outputs. The study may be conducted on more datasets by selecting the appropriate input and output variables that satisfy the desired conditions to implement DEA to know the most efficient real estate firms in India.

Tsai et. al., (Tsai et al., 2012) have analyzed real estate price differences based on a fixed distance from the Taichung city and Kaohsiung city locations. They considered the 256 datasets based on 500 mitres to 1500 mitres distance from shopping district. In the similar lines the present study may be extended by considering the real estate firms datasets based on significant distance.

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