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Efficiency Measurement of Housing Sector; Using DEA Model

Hamid Sepehrdoust
Assistant Professor, Faculty of Economics & Social Science, Bu-Ali-Sina University ,Hamedan , Iran,
hamidbasu1340@gmail.com

*ABSTRACT—***Production economics is a fundamental concept in economic theory and housing production is no exception. The present research provides a critical review of the housing industry efficiency in Iran. Data Envelopment Analysis (DEA) is used to evaluate housing industry performance in different states based on the relevant data collected from Statistical Centres of Iran during 2006-2009. The research found that only 37 percent of the states operate technically efficient and the average efficiency score obtained by all the states is 0.94. Most of the technically efficient states had the opportunity to employ illegally migrated workers of neighbouring countries in building construction activities using the advantages of lower level of payments and less commitment to the worker's insurance regulations in the country. Providing subsidy assistance to the disadvantaged states and stimulating legal employment of building workers will supplement government to improve efficiencies in the sector and finding a solution to the current housing problem.**

Keywords: Housing, performance, Data Envelopment Analysis, Efficiency, Iran

I. INTRODUCTION

The bilateral relationship between housing investment and economic growth has long been a popular issue of debate in the literature of economic development and planners almost believe that encouraging housing improvement should not only be considered as a part of economic development strategy but also massive-scale housing improvement is just a necessary outcome of economic growth. Studies on the role of housing in economic development include Burns and Grebler (1977), Wells (1985), Phang (2001), Leung (2004) and Harris and Arku (2006). These studies examined topics like employment and income effects, household savings effect, labor productivity effect, health influence and growth effects of housing investment. In short, most of the studies suggest that, housing investment may affect economic development through its impact on employment, savings, total investment, and labor productivity (Chen and Aiyong, 2008).It has been well demonstrated by the known hypothesis of Turin (1973) that because of the relationship between construction activity and economic development, housing and related infrastructure can revitalize and sustain economic growth and development, employment creation and poverty reduction. After analyzing data on all significant countries for period 1955-1965, Turin concluded that developed countries, typically have stronger construction industries which contributed 5-8% to GDP, while in less developed countries, the proportion is around 3-5% of GDP. On the basis of cross sectional data for 87 countries in his further study, Turin (1978) found that construction industry can play a central role in development strategy of many less-industrialized countries by creating durable and productive employment at relatively low level of capital intensity.

II. THE CONTEXT OF IRAN

Iran's Economy is a transition economy with a large public sector. It is the sixteenth largest economy in the world by parity and an estimated 50% of the economy is centrally planned. Exports are dominated by oil and gas (80%) and constituted 60% of the government revenue in 2010.Economic activities are dominated by industrial sector, which represents about 45% of the country’s GDP and includes oil and gas, petrochemicals, steel, textile, and automotive manufacturing. The services sector accounts for another 43% .Agriculture continues to be one of the economy’s largest employers (11%), representing one-fifth of all jobs (Ilias, 2008).Iran is one of the few major economies that did not suffer directly from the current downturn crisis. High oil prices in recent years have enabled Iran to amass US$ 97 billion in foreign exchange reserves. Although this increased revenue has aided self-sufficiency and domestic investments, but double-digit unemployment and inflation remain while economy has seen only moderate growth (World Bank, 2009).At present Iran’s territory consists of 30 provinces, which are governed by a local center, mostly the largest local city.

Normally construction of housing and commercial buildings is carried out in collaboration and with participation of the owners, people’s assistance, support of banks and the free technical and engineering services from the government. The role of the Ministry of Housing and Urban Development and its affiliated Housing Foundation is very important as these are the two major organizations for the approval and implementation of special plans, housing projects and building codes including earthquake mandatory codes. According to the global estimates, Iran is placed in the list of the top ten countries facing disasters among the developing countries and as a disaster-prone country preparation of housing models suitable to various climates, expansion of insurance schemes regarding natural resources and strengthening of buildings are very important for risk reduction and natural disasters.

Annual reports of Iran central bank on housing economy shows that at current prices, investment in housing sector increased more than 75 times during the period 1975-99 and the average share of housing investment in the GDP has been 5.7 percent within the same period. In the thirty-year period 1971-2000, on average 33 percent of the total investment in the country was in housing. The average share of the private sector in investment on housing has been 92.5 percent, thus accounting for the bulk of investment in this sector. According to Zanjani (2006), between 1966 and 1996 there was an annual increase of 3.44 percent in housing units, whereas the annual increase in the number of households was 3.02 percent. That means in all three decades the growth rate of housing exceeded the growth rate of households and population.

III. MATERIALS AND METHODS

Data envelopment analysis (DEA) developed by Charnes et al., (1978), is a non-parametric approach. It is a Linear Programming methodology to measure the efficiency of multiple Decision Making Units (DMUs) when the production process presents a structure of multiple inputs and outputs. DEA is used to measure the relative productivity of a DMU by comparing it with other homogeneous units transforming the same group of measurable positive inputs into the same types of measurable positive outputs.The input and output data can be expressed by matrices X and Y where x_{ij} refers to the i^{th} input data of DMU_j and y_{ij} is the i^{th} output of DMU_j .In this methodology, efficiency is defined as a weighted sum of outputs to a weighted sum of inputs (eq.1), where the weights structure is calculated by means of mathematical programming and constant returns to scale (CRS) are assumed (Charnes et. al, 1978). The CCR model can be expressed by (eq.1)-(eq.4):

$$(FP_o)Max \quad \theta = \frac{u_1 y_{1o} + u_2 y_{2o} + \cdots + u_n y_{no}}{v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo}} \tag{1}$$

Subject to

$$\frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_n y_{nj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_m x_{mj}} \le 1 \quad (j = 1, \cdots, s) \tag{2}$$

$$v_1, v_2, \cdots, v_m \ge 0 \tag{3}$$

$$u_1, u_2, \cdots, u_n \ge 0 \tag{4}$$

The CCR model, measures the maximum efficiency of each DMU by solving the fractional programming (FP) problem in (eq.1) where the input weights $v_1, v_2, \ldots v_m$ and output weights $u_1, u_2, \ldots u_n$ are variables to be obtained. Symbol o in (eq.1) varies from 1 to s which means s optimisations for all s DMUs. Constraint 2 reveals that the ratio of 'virtual output' ($u_1 y_{1o} + u_2 y_{2o} + \cdots + u_n y_{no}$) to 'virtual input' ($v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo}$) cannot exceed than 1 for each DMU, which conforms to the economic assumption that the output cannot be more than the input in production.

The above FP (eq.1)-(eq.4) is equivalent to the following linear programming (LP) formulation given in equations (eq.5 - eq.9).That is necessary to note that transforming the FP model into the LP model has been of great significance for the rapid computation and wide application of DEA.

$$(LP_o)Max \quad \theta = u_1 y_{1o} + u_2 y_{2o} + \cdots + u_n y_{no} \tag{5}$$

Subject to

$$v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo} = 1 \tag{6}$$

$$u_1 y_{1j} + u_2 y_{2j} + \cdots + u_n y_{nj} - v_1 x_{1j} - v_2 x_{2j} - \cdots - v_m x_{mj} \le 0 \quad (j = 1, \cdots, s) \tag{7}$$

$$v_1, v_2, \cdots, v_m \ge 0 \tag{8}$$

$$u_1, u_2, \cdots, u_n \ge 0 \tag{9}$$

The research applied data envelopment analysis (DEA) to evaluate the overall efficiency of housing sector production in 30 states of Iran during 2006-2009, taking each state as a DMU in the model. In addition further in-depth analysis of DEA is made to find out important factors responsible for inefficient states in achieving maximum output with possible combination of inputs and thereby identifying the areas of weak performance. Relevant data for the study were obtained from the six month national reports, published by the ministry of housing and urban planning, Iran statistical center and Central Bank of Iran for the period 2006-2009. Since input factors should be mutually exclusive such as Labor, Land, Material, Capital and man-made aids to further production, three important inputs are selected for present study as follows:

Input 1-Total Area of Lands under building construction (scale: 1000 square meters)

Input 2- Total Private Investment on building construction (scale: 1000000 Rials)

Input 3- Total expenditures of building construction (scale: 1000000 Rials)

On the other hand, since outputs can be categorized into tangible products including goods and intangible products including services, therefore three important outputs are selected as follows:

Output 1-Total Number of Buildings Constructed (units)

Output 2- Total Area of Flats Constructed (scale: 1000 square meter)

Output 3- Total Land Value of Buildings after Construction (scale: 1000000 Rials)

IV. RESULTS

Following Golany and Roll (1989), regression analysis on the selected input and output factors has been used to examine the isotonicity relationships between the input and output factors. The test of reliability and regression analyses is shown in table 1. The significant p-values less than α=0.05 strongly proves that an increase in any input definitely results in an increase in any output.

In order to measure the overall efficiency of the state housing construction undertakings in Iran, the CCR model with constant returns to scale has been applied to evaluate the overall efficiency in each state and also BCC model is used to decompose the total efficiency into the technical and scale efficiency. In their study, (Banker et.al, 1984) developed the model BCC assuming variable returns to scale (VRS). Indeed the scale efficiency score of a DMU is the ratio of the overall efficiency to the technical efficiency.

The overall efficiencies of 30 states are presented in Table 2. The average efficiency score obtained by all states is 0.900 and only ten states including East Azarbaijan, West Azarbaijan, Tehran, Razavi Khorasan, Zanjan, Semnan, Sistan & Baluchistan, Qazvin, Lorestan and Markazi are overall efficient among the other states, i.e. only 37 percent of the states operate technically efficient. The interesting point is that among the overall efficient states there are developed states like Tehran, Semnan, Razavi Khorasan ,Zanjan, Qazvin and also economically deprived areas such as West Azarbaijan, Sistan& Baluchistan, Lorestan and Hormozgan .On the other hand it is found that about 63 percent of states are relatively inefficient out of which the states, Mazandaran, Hamadan, Kerman and Ilam obtain the lowest efficiency scores (i.e.,0.762 0.751, 0.709, 0.646) and states Yazd,Bushehr,Esfahan and North Khorasan achieve the highest efficiency scores (i.e., 0.982, 0.942, 0.942, 0.941).

On the basis of microeconomic production theory, if the scale efficiency is less than 1, the DMU will be operating either at decreasing returns to scale (DRTS) or increasing return to scale (IRTS). This implies that resources may be transferred from DMUs operating at decreasing returns to scale to those operating at increasing returns to scale in order to increase the overall average productivity at both sets of DMUs. To discriminate efficient States for Housing Construction Undertakings in more depth, some studies have suggested that it is worth identifying the number of times that an efficient States acts as a peer (Hlingsworth and Parkin, 1995). Peer states are those active states with higher referenced frequencies which can be regarded as better performing units due to their outstanding operating environment.

V. CONCLUSION

In this study Data Envelopment Analysis (DEA) proved to be a powerful non-parametric technique for comparison of different States (DMUs) and provide a summary measure of relative performance for each Unit. Two DEA models (CCR model and BCC model) were used to evaluate the overall efficiency and further decomposed into technical and scale efficiency of each state.

Based on the results, the research found that only 37 percent of the states operate technically efficient and the average efficiency score obtained by all states is 0.94.Some of the technically efficient states have the opportunity to deploy migrated building workers in construction activities with lower level of wages and less commitments to the law and regulations in the country. Rapid urbanization and migration of refugees into the country have made housing one of the country's most acute social problems. It is worth mentioning that due to the political, social and economic Stability, Iran has been the largest refugee host Country in the region for more than a decade and thus regularly deals with complex human emergencies. In the field of housing and commercial buildings, the bill of compulsory insurance for the housing sector workers has induced many building constructors to prefer illegal cheap workers mostly migrated from Afghanistan rather than employing home workers, resulting in a wide spread of unemployment in the country .

On the other hand 63 percent of the states are found to be relatively inefficient which mostly present decreasing returns to scale. Therefore it is recommended that states like Ilam, Kerman, Hamadan and Mazandaran which posses the lowest level of efficiency scores need to reorganize their structure of inputs in order to get optimum level of outputs. Overall, our results strongly suggest that housing sector in Iran needs to enable communities to improve their housing circumstances, mobilizing private savings and housing credit at scale with adequate protection for consumers, providing subsidy assistance to disadvantaged individuals to assist household's affordability and finally coordinating and integrating public and private sector investment on a multi-functional basis.

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TABLE 1- REGRESSION ANALYSIS OF THE VARIABLES

Variable	Output 1	Output 2	Output 3
Input 1	0.992 (0.000)	0.993 (0.000)	0.795 (0.000)
Input 2	0.846 (0.000)	0.738 (0.000)	0.923 (0.000)
Input 3	0.788 (0.000)	0.993 (0.000)	0.788 (0.000)

(O_1)= 245 +0.000319(I_1)+0.453 (I_2)+0.000056(I_3)	F	P
S = 509.965 R-Sq = 99.5% R-Sq(adj) = 99.5%	1786.30	0.000
(O_2) =-2772952 +1.41(I_1) +1568 (I_2) + 0.837(I_3)	F	P
S = 3511969 R-Sq = 99.2% R-Sq(adj) = 99.1%	1058.74	0.000
(O_3) = 2708 +0.00376(I_1)+3.25 (I_2)- 0.00227(I_3)	F	P
S = 3767.34 R-Sq = 89.5% R-Sq(adj) = 88.3%	73.89	0.000

TABLE 2- OPERATING EFFICIENCY OF STATE HOUSING CONSTRUCTION

States (DMUs)	Overall Efficiency	Technical Efficiency	Scale Efficiency	Returns To Scale	Peer Group Frequen
1-East Azarbaijan	1.000	0.981	1	IRTS	10
2-West Azarbaijan	1.000	1.000	1	CRTS	14
3-Ardabil	0.995	0.997	0.998	DRTS	0
4-Esfahan	0.959	0.985	0.974	DRTS	0
5-Ilam	0.773	0.773	1	DRTS	0
6-Bushehr	0.965	0.965	1	DRTS	0
7-Tehran	1.000	1.000	1	CRTS	9
8-Charmahal& Bakhtry	0.943	0.951	0.992	DRTS	0
9-South Khorasan	0.920	0.927	0.992	DRTS	0
10-Razavi Khorasan	1.000	1.000	1	CRTS	6
11-North Khorasan	0.971	0.971	1	DRTS	0
12-Khuzestan	0.895	0.994	0.900	DRTS	0
13-Zanjan	0.999	1.000	0.999	CRTS	0
14-Semnan	1.000	0.999	1.000	CRTS	15
15-Sistan & Baluchistan	1.000	1.000	1	CRTS	4
16-Fars	0.859	0.895	0.960	IRTS	0
17-Qazvin	1.000	1.000	1	CRTS	10
18-Qom	0.839	0.973	0.862	DRTS	0
19-Kurdistan	0.987	1.000	0.987	DRTS	0
20-Kerman	0.751	0.910	0.825	DRTS	0
21-Kermanshah	1.000	0.960	1.000	DRTS	3
22-Kokiluye & Bu.Ahmad	0.983	1.000	0.983	DRTS	0

23-Golestan	0.927	0.991	0.935	DRTS	0
24-Gilan	0.942	0.956	0.985	DRTS	0
25-Lorestan	1.000	1.000	1	CRTS	6
26-Mazandaran	0.881	0.961	0.917	DRTS	0
27-Markazi	0.859	0.966	0.889	DRTS	0
28-Hormozgan	1.000	1.000	1	CRTS	1
29-Hamedan	0.875	0.974	0.898	DRTS	0
30-Yazd	1.000	1.000	1	IRTS	4
Average	0.944	0.971	0.969		