X-Inefficiencies in the Residential Real Estate Approach

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Abstract

This article examines the productive efficiency levels present in the market for residential real estate brokerage services by employing the stochastic frontier approach. At the time this study was conducted (Anderson, Zumpano, Elder and Fok, 1998) that examined productive efficiency in this sector employed data envelopment analysis. This current article addresses potential statistical limitations of Data Envelopment Analysis and uses an alternative statistical tool, the stochastic frontier approach, to estimate X-efficiencies.

This technique overcomes many of the statistical limitations of DEA and provides additional productive efficiency estimates. The results suggest that residential real estate brokerage firms are relatively efficient, in contrast to the earlier study that found significant inefficiencies present in this market. Firms could only reduce their average total costs by 12% given firm outputs and input prices. Additionally, the firms were divided into three size categories to examine the impact of firm size on efficiency. The results indicate that small firms are the most efficient group. Hence, there seems to be a tradeoff between scale efficiency and productive efficiency.

Introduction

The ability to accurately characterize and evaluate the efficiency aspects of the residential real estate market, in terms of both housing and brokerage services, has been a major concern of academics, practitioners and policymakers for the past four decades. In the not too distant past, data constraints limited most prior research[1] in this area to anecdotal evidence, or were based on local data that made generalizations about the market and the real estate brokerage industry virtually impossible. Recently, however, the availability of national data on the residential real estate market has allowed for much more rigorous analysis of this market. Starting with traditional cost studies that focused on estimation of economies of scale and scope (Zumpano, Elder and Crellin, 1993; and Zumpano and Elder, 1994) this research has progressed to more inclusive analyses of the other market performance measures, commonly referred to as X-efficiencies (Anderson, Zumpano, Elder and Fok, 1998). These studies suggest that the market for residential brokerage services, characterized by economies of both scope and scale, remains inefficient in terms of resource allocation. Although this research represents an important advance in our understanding of the market for brokerage services, the validity of these findings requires additional corroboration. In particular, statistical problems encountered with the use of Data Envelopment Analysis (DEA), as detailed in the next section, makes it essential that the X-efficiency implications of this earlier work be further substantiated.

This article addresses the statistical concerns regarding DEA and re-estimates X-efficiency levels using a stochastic frontier technique. Analyzing X-efficiency results using the stochastic frontier approach in addition to DEA will allow for a better understanding of the true performance characteristics in the real estate brokerage market. Additionally, the article provides insights on optimal firm size by identifying three firm size categories and measuring productive efficiency levels across size groups.

The next section provides a brief review of earlier research. The following sections discuss the stochastic frontier technique, the sample data and the empirical findings. The final section is the conclusion.

Previous Research

There are currently only three studies that directly address the efficiency of the residential real estate brokerage market from a production perspective. Using data from 1987–88 Zumpano, Elder and Crellin (1993) and Zumpano and Elder (1994) estimated cost functions for real estate brokerage firms seeking to determine whether the production of real estate services were subject to scale and scope economies. These studies found that the existing firms in the industry were too small to take advantage of economies of scale. The recent increase in average firm size along with the increase in merger and acquisition activity among real estate firms lends support to this contention and may be thought of as a movement towards improved efficiency. Zumpano and Elder (1994) also found that significant economies of scope existed and that firms that produce a balanced output of both listings and sales are more cost efficient then firms specializing in only one side of the real estate sales transaction. This may explain the growth in the use of dual agency and non-agency brokerage arrangements.

The above mentioned cost studies assume that all firms are operating on their efficient frontier.[2] Studies of other industries, however, show this assumption does usually not hold. Research shows that firms within a given industry operate, to differing degrees, off their efficient frontier. Deviations from the efficient frontier are termed X-inefficiencies, and have been shown to be more important in determining overall firm efficiency than losses from failure to be efficient in an economies of scale or scope context (Berger, Hunter and Timme, 1993).

Anderson et al. (1998), using the same database as the cost studies, employ data envelopment analysis to measure overall, allocative, technical, pure technical and scale efficiency levels. Their results suggest that relative inefficiencies exist in the market for residential real estate brokerage services. The results indicate that the average firm in this sample could significantly reduce input utilization without decreasing output. The majority of the inefficiencies were scale in nature as most firms were operating in the increasing returns to scale region of their long-run average cost curve. While this study added to the literature by measuring X-efficiency levels in this market, the authors suggest that additional research is necessary because of several statistical concerns about the DEA technique.

X-efficiency studies in other industries have found dramatically different results depending on the estimation technique employed (Berger, et al. 1993). Hence, for the simple purpose of robustness, X-efficiencies should be examined using an alternative statistical tool.

There are also other specific problems with the DEA. First, the methodology is very sensitive to the manner in which the inputs and outputs are specified. The exact model specification may dramatically influence the efficiency results. Moreover, the technique measures relative efficiency levels. Hence, if several firms are either much more efficient or much less efficient than the average firm in the sample, the methodology will show large levels of inefficiencies. Additionally, the DEA is a non-parametric approach that does not allow for random error. Thus, with this technique, deviations from the efficient frontier are deemed inefficient. In short, there exists the possibility of significant measurement error when calculating the inefficiencies using this approach.

Data and Methodology

Alternative X-Efficiency Methodologies

In addition to DEA, there are three other methods that can be used for measuring X-efficiencies. These models are the thick frontier approach, the distribution-free approach and the stochastic or econometric frontier approach.

The thick frontier approach attempts to separate out deviations from the efficient frontier (X-inefficiencies) and random error by dividing the magnitude of the error terms into quartiles. Any difference in efficiency within groups represents random error, but efficiency differences between the highest and lowest quartiles represent inefficiency. An arbitrary assumption must be made to determine where the inefficiencies stop and random error starts.[3]

The distribution-free approach basically replaces distribution assumptions by assuming that X-inefficiencies persist throughout time, but that the random errors will cancel out. A major advantage of this approach is that technical and allocative inefficiencies can be separated.[4] The technique does require multi-period time series or panel data at the firm level, which is not available for the residential real estate brokerage sector.

The stochastic frontier approach uses a statistical procedure that decomposes the error terms into two parts. One part of the disturbance term is assumed to be normally distributed and captures random error. Hence, it can either increase or decrease costs. The other part of the disturbance term reflects inefficiencies and is assumed to be positive for the cost frontier. Thus, the cost inefficiency term can only increase costs.[5]

While there exists no definitive study on which methodology is superior, analyzing efficiency levels with multiple techniques allows for a more robust characterization of the true performance characteristics present in this market. Currently, there has been a movement towards the use of the distribution-free methodology because it requires the least number of restrictive assumptions. However, this method cannot be employed here due to the data limitations already noted.

Determination of Cost X-Inefficiencies: The Stochastic Frontier Approach

Cost X-efficiency requires achieving the lowest possible cost, given current prices and firm output. Bauer (1990) reviews the literature on stochastic frontier models first introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The basic stochastic frontier model is shown below:

$$\ln TC_i = \ln TC\,(Q_i,P_i) + U_{i+} + V_i, \tag{1}$$

where TC_i is the observed cost of the firm, Q_i is a vector of firm output, P_i is a vector of input prices, U_i is a one-sided disturbance term for the cost frontier that captures inefficiency and V_i is a two-sided disturbance term assumed to capture random error or noise. The stochastic cost frontier itself is written as:

$$TC\,(Q_i,P_i)\,EXP\,(V_i). \tag{2}$$

Again following Aigner, Lovell and Schmidt (1977), the likelihood function can be expressed below by defining $V_i \sim IID(0,\sigma_v^2)$ and $U_i \sim (0, \sigma_u^2)$ as:

$$\ln l = N/2(\ln(2/\pi)) - N \ln \sigma + \sum_{i=1}^{N} \ln[1 - \Psi(-(\varepsilon_i\lambda)/\sigma))] - (1/2\sigma^2) \sum_{i=1}^{N} \varepsilon_i^2, \quad (3)$$

where N is the sample size, ϵi, is equal to $V_i + U_{i,}$ $\sigma^2 = (\sigma^2 u + \sigma^2 v)$, λ defines the skewness of the composed error term as $\sigma u/\sigma v$, and $\Psi(\cdot)$ represents the standard normal distribution.

This model can be estimated by corrected least squares or maximum likelihood techniques. In the current study, maximum likelihood is used as (see Olsen, Schmidt and Waldman, 1980).

Jondrow, Lovell, Materov and Schmidt (1982) show how to obtain firm-specific inefficiency measures by examining the conditional distribution of the composed error term as follows (for simplicity and consistency with the literature notation, the subscripts are dropped here):

$$E(U|\varepsilon) = (\sigma_U^2\sigma_V^2)/\sigma^2[(\theta(\varepsilon\lambda/\sigma))/(1 - \Psi(\varepsilon\theta)/\sigma) - ((\varepsilon\lambda)/\sigma)], \quad (4)$$

where θ is the standard normal density function, and the other variables are defined as before.

In this study, a translog cost function[6] with five input prices and one output assumed. Other less commonly used functions such as the transcendental, Zellner-Revankar, Cobb-Douglas, Nerlove-Ringstad and AIM were estimated, but did not prove better than the more common translog, which is expressed below:

$$\ln TC_i(p,Q) = a_0 + \sum_{i=1}^{5} a_i \ln p_i + \frac{1}{2} \sum_{i=1}^{5} \sum_{j=1}^{5} a_{ij} \ln p_i \ln p_j + a_q \ln Q_i + a_{qq} \ln Q_i^2 + \varepsilon_i, \quad (5)$$

where symbols are defined as before.

Homogeneity and symmetry were imposed using five input prices as follows:

$$a_{ij} = a_{ji} \text{ for all } i, j = 1,2, \ldots, 5, \tag{6}$$

$$\sum_{i=1}^{5} a_i = 1, \tag{7}$$

$$\sum_{j=1}^{5} a_{ij} = 0(i, j = 1,2, \ldots, 5), \tag{8}$$

$$\sum_{i=1}^{5} a_{iq} = 0. \tag{9}$$

The firms in the sample are subsequently divided into size categories and the degree of cost X-inefficiencies is calculated for each group. Small firms, medium firms and large firms are divided up as less than 194 revenue transactions, 196–525 revenue transactions and over 525 revenue transactions, respectively.[7] The data used to estimate Equation (5) is discussed in the next section.

The Data

The data employed to estimate the efficiency scores were obtained from the Economics and Research Division of the National Association of Realtors. They conduct periodic nationwide surveys of the real estate brokerage industry. The current data come from the sixth survey, which encompasses 1990–91. The information was obtained from professionals who are Certified Real Estate Brokerage Manager designees and a random selection of members of the National Association of Realtors.

Only a subset of the data is used. This subset includes real estate brokerage firms who obtained at least 75% of their revenues from residential transactions. With adjustment for incomplete and missing data, the final data set has 276 firms.

As with Zumpano and Elder (1994) and Anderson et al. (1998), two outputs and five input prices are specified in estimating the translog cost function. The output consist of the total number of sales and listings that the firm produced during the period under consideration.[8] In this manner, an "in-house" sale counts as both a listing and a sale. The five input prices include the price for salespersons, non-salespersons, building and occupancy, advertising and promotion, and all other inputs.

The selling expenses include multiple listing service fees that vary directly with sales, bonuses of sales managers based on sales-staff performance, commissions paid to owners and commissions paid directly to the sales staff. The price of a salesperson was computed by dividing total sales-related expenses by the number of full-time equivalent salespersons. The price of non-sales labor was calculated

Exhibit 1 | Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
y	763.5	1,637.9	26	
y1	375.5	817	9	10,642
y2	392.4	833.6	10	10,633
X1	59.5	129.7	1	1,472
X2	16	33.2	1	350
X3	3.5	14.1	1	225
X4	176,124.4	416,441.9	2,490	4,818,769
X5	231,580.1	410,859.5	8,018	3,445,090
p1	25,690.3	13,785.1	2,156	127,100
p2	14,098.8	8,333.3	1,143.08	55,000
p3	42,414.3	35,295.5	1,725	254,000
p4	268.6	284.8	40	3,895.5
p5	413.9	466.9	29.8	4,506.3

y = Total revenue transactions
y1 = Sales transactions
y2 = Listing transactions
X1 = Number of sales personnel
X2 = Number of nonsales employees
X3 = Number of offices
X4 = Advertising and promotion expense
X5 = Other expenses
P1 = Price of sales personnel
P2 = Price of nonsales employees
P3 = Price of an office
P4 = Price of advertising and promotion
P5 = Price of other inputs

Exhibit 2 | Cost Efficiencies for Sample Firms

	Mean	Var.	Min.	Max
All Firms	0.879	0.002	0.637	0.945
Small Firms	0.928	<0.001	0.880	0.961
Medium Firms	0.809	0.011	0.387	0.960
Large Firms	0.848	0.015	0.584	0.992

Exhibit 3 | Cost Efficiency Differences by Category

Group 1	Score 1	Group 2	Score 2	Difference	*t*-Stat
Whole	0.879	Large	0.848	0.032	2.4**
Whole	0.879	Medium	0.809	0.071	6.3**
Whole	0.879	Small	0.928	−0.049	−16.4**
Large	0.848	Medium	0.809	0.039	2.3**
Large	0.848	Small	0.928	−0.081	−6.2**
Medium	0.809	Small	0.928	−0.120	−10.7**

*Significance at the 10% level.
**Significance at the 5% level.

by dividing clerical, secretarial and sales managers' salaries by the number of non-sales employees. The price of the building and occupancy expenses was calculated by dividing total occupancy expense by the number of real estate offices. The last two prices, advertising and promotion and other inputs, are expressed as a percentage of revenue transactions. Summary statistics for the inputs, outputs and input prices are given in Exhibit 1.

Empirical Results

The mean, variance, maximum, and minimum efficiency scores from the stochastic frontier estimation are summarized in Exhibit 2. The results show that the residential real estate firms operate close to their efficient cost frontier. In particular, the average firm in the sample was approximately 88% efficient. Small firms were the most efficient with an efficiency score of 93%, followed by large firms and medium-sized firms with efficiency scores of 85% and 81%, respectively.

At first examination, it appears as if these results are very different from those obtained from using the DEA. However, the majority of the relative inefficiency levels obtained with the DEA were scale in nature. The stochastic frontier technique measures firm deviations from the efficient frontier separate and distinct from scale economies. Hence, the magnitude of the efficiency results is not as different as it first appears. In fact, in Anderson et al. (1998), firms were found to be fairly efficient at utilizing inputs, but inefficient at allocating them.

To determine if the efficiency scores are significantly different, a series of one-sided *t*-tests were performed,[9] with the results summarized in Exhibit 3. The results suggest that the small firm group was significantly more efficient than any other sample group. The set of all firms was more efficient than the large and medium-sized groups due to the inclusion of small firms. Finally, large firms are significantly more efficient than the set of medium-sized firms.

The results from the various size category estimations may help to explain the existence of so many small firms in the industry. While the small firms seem to be scale inefficient, these firms may be able to offset these inefficiencies by operating closer to their efficient frontier. Hence, there may be a tradeoff between scale gains and input allocation and utilization. Therefore, the recent increase in firm size is not necessarily representative of a move towards efficiency.

Conclusion

This article re-estimates X-efficiency levels for a set of residential real estate brokerage firms employing the stochastic frontier technique. The results of the study are significant in that additional information obtained regarding the productive efficiency levels in this market allows for better judgment about the true efficiency of real estate brokerage firms. Overall, firms were shown to operate relatively efficiently. In fact, the mean efficiency score of 88% is higher than those found in most banking and financial institution studies. High efficiency scores and competitive environments are related according to Leibenstein (1966). Hence, the results suggest that the market for residential real estate brokerages is relatively competitive. The results of the stochastic frontier approach are also in line with other studies that indicate that individual real estate firms wield very little market power. These results stand in contrast to the earlier DEA efficiency results, which suggests that the specification and statistical problems encountered with the use of DEA can lead to inappropriate conclusions regarding the operation of this market.

Additionally, this study reveals more information about the relationship between firm size and productive efficiency levels. Prior studies suggested that firms in this industry are too small to take advantage of economies of scale. The results of this study, however, suggest that smaller firms are better able to operate closer to their efficient frontier than their larger firm counterparts. These findings are completely consistent with other studies that indicate that although larger real estate firms tend to be more profitable than smaller firms, they do not employ resources as efficiently. Smaller firms generate more revenue transactions per full-time salesperson than do the larger firms (Elder and Zumpano, 1998). In the residential brokerage industry, the expression 'making it up in volume' may prove true. There seems to be a tradeoff between scale efficiency and productive efficiency. If true, recent consolidation activity and growth in average firm size may not necessarily be indicative of increased market competitiveness and efficiency.

Endnotes

1. For a complete review of these early efficiency studies, see Anderson et al. (1998).
2. Or at least the studies assume that all firms deviate from the efficient frontier by the same magnitude.

[3] For example, see Berger and Humphrey (1991), (1992a) and Bauer, Berger and Humphrey, (1993).

[4] For additional information on this approach, see Bauer et al. (1993) and Berger and Humphrey (1992b).

[5] For example, see Ferrier and Lovell (1990) and Timme and Yang (1992).

[6] As discussed in Zumpano et al. (1993), it is appropriate to specify a cost function to study production in an industry such as real estate where the demand for a broker's services is assumed to be a derived demand, which is based on the supply and demand of homes. Simple regression between the outputs and input vectors bears out this assumption. For a more detailed discussion, refer to Zumpano et al. (1993).

Additionally, the translog function was selected over the Cobb-Douglas and other functional forms because it is relatively flexible and allows for variable returns to scale. In order to gain flexibility, the translog functional form may lead to violations of monotonicity and concavity. Minor violations of concavity are found in the current article. The only restrictions imposed were the standard homogeneity and symmetry restrictions. For a detailed discussion of these issues, see Terrell (1996).

[7] Many different size categories were used in the analysis process. However, the results were virtually the same for every size categorization. The reported categories were obtained by simply dividing the sample into three categories—92 firms each.

[8] It could be argued that the number of listings a firm has should not be considered an output, but rather an intermediate good or an input. However, the survey only included listings that were subsequently sold, thus generating output in the form of revenue to the firm. Hence, it is appropriate to classify a listing as a firm output.

[9] Due to the distributions of the efficiency measures, it is appropriate to test for differences in efficiency using several non-parametric techniques. We used four different approaches and all lead to the same conclusions. Hence, for simplicity, we only report the *t*-test results. The non-parametric results are available from the authors.

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