早稲田大学 産業経営研究所『産業経営』
第40号　2006年12月　pp. 3-20

中日家庭電器機器企業の R&D と技術的効率の比較研究

何　　楓*
陳　　栄**

要　旨

本稿では，まず競争の激しい家庭用電気機器市場における企業の市場勢力効率と収益性効率を測定するために２つの確率フロンティア分析モデルを構築し，次に2001年から2004年までの中国と日本の上場企業のデータを用いて技術効率性を測定する。そして，企業の R&D 比率，広告宣伝比率およびその他の要因の２種類の技術効率性に対する効果を分析する。本稿の実証結果によれば，この２種類の技術効率性について，中国企業の平均スコアは日本企業の平均スコアの半分程度である。そして，長期的には研究開発が企業の収益性効率を改善するのに対して，短期的には広告が企業の収益性効率に有意味に正の効果を及ぼしているが，日本企業に比べて，中国企業では，広告が研究開発より重視されていることがわかる。

キーワード：家庭用電気機器会社，上場会社，技術的効率，研究開発，確率生産関数

A Comparative Analysis on Home-electrical Appliance Companies' R&D and Technical Efficiency in China and Japan

HE Feng[a]
CHEN Rong[b]

Abstract

This paper begins by proposing two models on how to measure an enterprise's market power efficiency and profitability efficiency in the highly competitive home-electrical appliance industry, and then measures the two technical efficiencies based on two stochastic frontier analysis models from 2001 to 2004. Moreover, the effect of R&D, advertising and other factors' on both efficiencies is analyzed. According to our estimates, The average scores of Chinese companies' on both efficiencies are just half of the Japanese efficiencies scores. These estimates also indicate that R&D helps a company's profitability efficiency in the long-term, and advertising has a significant and positive effect on a company's profitability efficiency in the short-term. In addition, compared with Japanese companies in the home-electrical appliance industry, Chinese companies have focused on advertising much more than R&D in recent years.

Key words: home-electrical appliance company, listed company, technical efficiency, research & development, stochastic frontier analysis

*早稲田大学産業経営研究所，東京
**清華大学経済管理学院，北京

1. Introduction

The development of Chinese home-electrical appliance industry started from introducing assembly line since 1980s, then followed by technology imitation, and now begins to focus on independent R&D and technology innovation. Anyway, Chinese home-electrical appliance industry's international competitive strength increased steadily in recent 20 years. As for Japanese home-electrical appliance industry, its rapid development began from 1960s and made a great achievement. It is well known that Japanese home-electrical productions have a good design, perfect function, reliable quality, advanced technology and so on. One of roots that Japanese home-electrical appliance industry owns powerful international competitiveness is that almost all of Japanese enterprises focus on the sustained and large-scale R&D on new technology and new production (David, 2000). By choosing Chinese and Japanese home-electrical appliance industry as sample, this paper will make a comparative research on the relationship between R&D and enterprise's technical efficiency across the two countries.

The main purpose of this study is to measure Chinese and Japanese companies' technical efficiency basing on stochastic frontier analysis (SFA) in home-electrical appliance industry, and show the association between firm technical efficiency and R&D in recent years. The basic model of stochastic frontier analysis was proposed by Meeusen and Broeck (1977), Aigner, Lovell, and Schmidt (1977), Battese and Corra (1977) independently by the end of 1970s, then followed by Jondrow et al. (1982), Battese and Coelli (1988). They estimated production efficiency by introducing a two-part error term in a regression model. One is an ordinary statistical noise that accounts for measurement error and the other is a disturbance term that captures inefficiency. And there are further series of development on stochastic frontier analysis in the middle of 1990s. Basing on these models, it is possible for researchers to get the quantitative relationship between some factors and firm technical efficiency while computing firm technical efficiency. Among these researches, the model proposed by Battese and Coelli (1992, 1995) is applied widely, especially in the field of finance and business. For example, Hunt- McCool, Koh and Francis (1996) utilized the stochastic frontier model to measure the degree of initial public offering (IPO) under-pricing. Basing on the stochastic frontier analysis, Hay and Liu (1997) found that relationship between relative efficiency and market varies substantially across 19 UK manufacturing sectors, indicating different degree of competition. Long-run efficiency is related to investment by the firm, suggesting that in a more competitive environment the firm has a strong incentive to improve its efficiency performance. Torii (2001) made a deep research on the relationship between technical efficiency and R&D and other factors, and particularly a comparison to US was made at the same time. Toru

(2002) estimated and compared U.S. and Japanese electric utilities' technical efficiency during the period 1982-1997. Back and Pagan (2003) used 1992-1998 data on the S&P 1500 firms to examine the relationship between executive pay and technical productive efficiency. Ferrantiono (1992), Dilling-Hansen et al. (2003), Dutta et al. (2005), Kenller and Stevens (2006) estimated empirically the relationship between company's technical efficiency and R&D, and all of these literatures showed that R&D plays a significantly positive role on firm efficiency. As for Chinese firm technical efficiency, particularly on SOE's efficiency (State owned enterprise), many literatures analyzed empirically firm efficiency from some factors, such as economic reform, government regulation, ownership structure, corporate governance, R&D and so on (Shiu, 2002; Zheng, et al., 2003; Movshuk, 2004). In addition, Gao and He (2005), He and Yuan (2006) measured Chinese home-electrical appliance listed companies and some manufacturing sectors' technical efficiency, and the results showed that the tight linkage does exist between ownership structure and firm efficiency.

The remainder of this paper is organized as follows. Section 2 provides a brief review of stochastic frontier analysis and outlines our two models. Section 3 discusses the data to be used. In section 4 we present results from our estimates, while section 5 concludes.

2. Model

2.1. Stochastic frontier analysis (SFA)

For jointly measuring firm technical efficiency and estimating some factors effect on technical efficiency, we adopt the stochastic frontier production function model of Battese and Coelli (1995). The Battese and Coelli model can be expressed as:

$$y_{it} = x_{it}\beta + (v_{it} - u_{it}), \qquad i = 1, \cdots, N, t = 1, \cdots, T \tag{1}$$

Equation (1) reflects the frontier of production function, where y_{it} is the natural log output of *i-th* firm in *t-th* time period; x_{it} is a k×1 vector of (transformations of the) natural log input of the *i-th* firm in the *t-th* time period; β is a vector of unknown parameters to be estimated. v_{it} are random variables that are assumed to be *iid.* $N(0, \sigma_v^2)$, and independent of the u_{it} which are non-negative random variables that are assumed to account for technical inefficiency in production. u_{it} are also assumed to be independently distributed as truncations at zero of the $N^+(m_{it}, \sigma_v^2)$ distribution where[1]

$$m_{it} = z_{it} \cdot \delta + \eta_{it} \tag{2}$$

Equation (2) means the efficiency function, where z_{it} is a p×1 vector of variables, which may influence the efficiency of a firm; and δ is a 1×p vector of parameters to be estimated, and η_{it} is an error term that follows a normal distribution but has a variable truncation point at $-z_{it}\delta$. z_{it} includes the variables that capture all kinds of efficiency variables of firms as well as other control variables. Battese and Coelli (1995) set up a parameter, $\gamma = \sigma_u^2/(\sigma_v^2+\sigma_u^2)$. Obviously, γ must lie between 0 and 1. One can also test whether any form of stochastic frontier production function is required at all by testing the significance of the γ parameter. If the null hypothesis, that γ equals zero, is accepted, this would indicate that σ_u^2 is zero and hence that the u_{it} term should be removed from the model, leaving a specification with parameters that can be consistently estimated using ordinary least squares(2). The parameters in equation (1) and (2) are estimated jointly by the maximum likelihood method (Battese and Coelli, 1995). And the technical efficiency in the above model is given by:

$$TE_{it} = \exp(m_{it}) = \exp(-z_{it} \cdot \delta) \tag{3}$$

TE_{it} means firm technical efficiency for firm i in time t. Stochastic frontier analysis allows us to ask two related questions: (1) do firms perform efficiency? and (2) if not, does the degree of inefficiency depend on some factors? And stochastic frontier analysis does not suffer from the need to be comprehensive, because it proceeds by first establishing whether a significant fraction of firms are inefficient and then testing how the degree of inefficiency is related to firm-by-firm differences in some variables for which data is available, for example, R&D, the scale economy, technology progress, advertising and promotion, corporate governance and so on. And this allows us to separate the test efficiency from the test of the determinants of inefficiency: if certain firms are below the frontier, they are inefficient for whatever reason(s), some or all of which we may or may not be able to capture with our choice of efficiency variables (Habib and Ljungvist, 2005).

2.2. Which factors affect technical efficiency?

In general, a lot of factors can affect firm technical efficiency. For instance, the ownership structure, financial pressure, R&D activities, even advertising and promotion are important for the firm technical efficiency and below we discuss their effects briefly.

The ownership structure and dispersion in large corporations and the effects to their efficiency have been examined in a lot of studies (Gugler, 2001; Dilling-Hansen, et al., 2003). This discussion is based on the assumption that owners and managers of large corporations have different objectives for the company. The owners want a high long-term return on their investment, whereas the managers want a high growth rate and large fringe benefits to the leaders. In large and widely hold listed companies the individual owner has no incentive to control the managers of the company as only a small fraction of the benefit from his controlling effort will belong to himself. This separation of ownership and control of the firm has a serious effect on firm efficiency as the manager can pursue their own goals without any control from the owners.

The financial situation or capital structure of the company is also important for its efficiency. Firms with high debt ratio, i.e. lower solvency (equity capital in relation to total assets) have a higher risk of bankruptcy. As the manager team often will lose their jobs if the firm goes bankrupt, they will put more effort into the management of the firm and they will have pursue a policy to increase firm's profitability in order to reduce the risk of bankruptcy. In other words, the idea is that higher debts will have a disciplinary effect causing non- or weakly profitability activities to be cut way. Investing in projects that do not contribute immediately to the firm's earnings is left out even though the management might wish to go on with the investment for other reasons (Dilling-Hansen, et al., 2003; Habib and Ljungvist, 2005). Another argument for this relation is the free cash flow theory of Jensen (1986). Normally, the interest to be paid on loan capital is higher than the alternative interest which the firm management will impute on the firm's own available funds. Therefore, projects that are financed exclusively by internal funds from the free cash flow, tend to be not quite as profitable as projects financed by loan capital which has to meet the rate of interest. Because low-solvency companies are compelled to go to the money market, these companies will engage in project that are presumably slightly more profitable on average and hence more productive than projects usually undertaken by solvent companies. Accordingly, the liquidity constraint has an effect on the firm efficiency.

A company's innovative activities and more specifically its investment in R&D can be expected to have a positive effect on their efficiency. According to the product lifecycle theory of Vernon (1966), the whole product lifecycle can be divided into three phases, which are new product, mature product and standardized product respectively. In general, just some large or leading companies can explore and provide new product for a small part of consumers by enough and sustainable R&D input. In this phase, the new product's price is usually expensive, but the firm has to endure the higher operating cost at the same time. During the mature product phase, the product's cost will decrease significantly due to the effect of learning curve, but the product's price still remains a relatively high level. Obviously leading companies begin to get much extra economic profit. However, because of spillover effect and other companies' technology imitation, more and more companies can provide this product for market, then the price will decrease rapidly due to the fierce market competition and the standardized product phase comes. During the standardized product phase, almost all of companies cannot get extra profit in the highly competitive market. In words, R&D will result in new technology or new product, and finally result in much more sales and profit than before. Hence, a company with R&D will produce more output than the one operating without R&D, *ceteris paribus*. In addition, some literatures have emphasized the importance of learning-by-doing in high-technology markets (Irwin and Klenow, 1994; Dutta, et al., 2005). This immediately suggests that a firm's past R&D expenditures are an important resource available to it. Some studies indicated that the significantly positive relation exists between R&D and firm technical efficiency (Ferrantino, 1992; Dutta, et al., 2005; Dilling-Hansen, et al., 2003; Kneller and Stevens, 2006).

With regard to company's advertising and promotion, obviously it is a useful tool for keeping or strengthening company's market power particularly in highly competitive industry, *ceteris paribus*. In other words, advertising, more or less, can improve the transformation ability between inputs and output. Some early literatures showed that the tight and positive advertising-sales relationship does indeed exist in most of time (Kudisch, 1965; Rao, 1972; Assmus, et al., 1984). Nelson (1974) has suggested that products be categorized as "experience goods" and "search goods" in term of patterns of consumer information search. For experience goods, which are predominantly frequently purchased and frequently used products, experience is the major source of information and hence advertising elasticity may be relatively low, other things being equal. For durable and new products, a search for sources of information (including advertising) is more likely to accompany purchase. Herein, it is clear that most of household appliance products belong to typical durable goods. In addition, combining to product lifecycle theory, elasticity should be higher during the early growth phase, when a significant number of new customers are brought in as triers, than during the maturity phase of the product of lifecycle, when most customers have substantial experience. Because sales during the early phases of the product lifecycle are relatively small, sales increases due to advertising should represent a large percentage gain in contrast to the gain in later periods when more sales are repeat purchases (Parsons, 1975; Assmus, et al., 1984). As the discussion hereinabove, we further enrich our empirical result by taking into account the relationship between advertising and company's efficiency hereafter.

2.3. Our two empirical SFA models

On the basis of Battese and Coelli (1995), this paper proposes two models in order to analyze empirically enterprise's efficiency on market power and profitability respectively. These two SFA models can be expressed as:

$$\ln(Sale_{it}) = \beta_0 + \beta_1 \ln(K_{it}) + \beta_2 \ln(L_{it}) + \beta_3 \ln(K_{it})^2 + \beta_4 \ln(K_{it}) \ln(L_{it}) + \beta_5 \ln(L_{it})^2 + (v_{it} - u_{it}) \quad (4)$$

$$\ln(profit_{it}) = \beta_0 + \beta_1 \ln(K_{it}) + \beta_2 \ln(L_{it}) + \beta_3 \ln(K_{it})^2 + \beta_4 \ln(K_{it}) \ln(L_{it}) + \beta_5 \ln(L_{it})^2 + (v_{it} - u_{it}) \quad (5)$$

where:

$i = 1, \cdots, N, t = 1, T$;

$\ln(Sale_{it})$ = The log of the Chinese dollar(RMB) value of sales for firm i in year t;

$\ln(profit_{it})$ = The log of the Chinese dollar value of gross profit for firm i in year t;

$\ln(K_{it})$ = The log of the Chinese dollar value of total asset for firm i in year t;

$\ln(L_{it})$ = The log of total number of employees;

$\beta_0 \sim \beta_5$ are unknown parameters which need to be estimated;

v_{it} is normally distributed error term with a zero mean and variance σ_v^2; and

u_{it} is a random variable that has a truncated distribution with mean m_{it} and variance σ_u^2.

Equation (4) and equation (5) are the frontier function in the framework of stochastic frontier analysis. To analyze possible sources of technical inefficiency, the inefficiency effect, m_{it}, in the stochastic frontier function can be specified as below:

$$m_{it} = \delta_0 + \delta_1 Teck_{it} + \delta_2 D_{it} + \delta_3 (CUM\_R\&D)_{it} + \delta_4 \left(\frac{AD}{Sale}\right)_{it} + \delta_5 Scale_{it} + \delta_6 \left(\frac{L}{E}\right)_{it} + \eta_{it} \qquad (6)$$

where:

$Tech_{it}$ captures natural technological progress for firm i in year t, which is equal to 1, 2, 3 and 4 from 2001 to 2004 respectively. We use it as control variable herein.

D_{it} means Dummy variable for firm i in year t, which captures some important differences between China and Japan, for example, the different macro-economic environment, institution, corporate governance and so on. In the following empirical analysis, we let D be equal to 1 when enterprise is Japanese company, and let D be equal to 0 when enterprise is Chinese company. We use it as control variable herein.

$(AD/Sale)_{it}$ is the ratio of advertising and promotion expenditures to sales for firm i in year t, which reflects the firm's attitude to sustaining market share in a relative short-term period. Strictly speaking, it is no doubt that advertising effects on firm efficiency can be divided into two types. One is short-term effect, and another is long-term effect. However, the adverting effect is obviously shorter than R&D effect. Therefore, for simplicity, we focus on the advertising short-term effect hereafter.

$(CUM\_R\&D)_{it}$ is the cumulative ratio of R&D expenditures to sales for firm i in year t, which reflects the firm's attitude to technology innovation and profitability in a relative long-term period. For all of Japanese listed companies, we cumulate the ratio of R&D expenditures to sales since 1996(3). However, the trouble comes when we collect Chinese listed companies' R&D expenditures. On one hand, in fact, almost of Chinese listed companies in home-electrical appliance industry have no R&D expenditures before 1999. Hence, we decide to cumulate the ratio of company's R&D

expenditures to sales from 1999 for Chinese listed companies. On the other hand, most of Chinese listed companies did not disclosure explicitly R&D expenditures from 1999 to 2000. Therefore, we have no choice but estimating the relative ratio basing on the average ratio of R&D expenditures to sales through 2001 to 2004.

$(Scale)_{it}$ means the relative firm size for firm i in year t, which captures the effect of firm scale economy. And we let it be equal to the ratio of the enterprise's total asset to the average total asset of the whole sample. We use it as control variable herein.

$(L/E)_{it}$ is the ratio of liability to common equity for firm i in year t, which reflects the company's capital structure. We use it as control variable herein.

$\delta_0 \sim \delta_6$ are unknown parameters which need to be estimated; and

η_{it} is defined earlier.

Equations (4) (6) construct the so-called market power efficiency model (in short, model 1), and equations (5) (6) construct the profitability efficiency model (in short, model 2). When testing the firm's inefficiency, in general, most of researchers will choose the company sales as the output variable, and use the total asset (or fixed asset) and the number of employee as typical input variables (Hay and Liu, 1997; Back and Pagan, 2003; Habib and Ljungqvist, 2005). According to the marketing theory, the company's sales and market share are usually used to capture the company's market power. Therefore, choosing the sales as the output variable just can reflects the company's efficiency on market power. However, the market power is not the only target that company pursues. Actually, most of companies will stress on the improvement of their own profitability at the same time of pursuing market power. Then it is necessary to add another output variable for capturing the firm efficiency on profitability. However, according to financial management theory, in general, there are several indicators which can be used to reflect the firm's profitability, such as gross profit, operating profit, profit before taxation and interest, net profit and so on. But the positive number is necessary for making the natural logarithm if we want to use the stochastic frontier analysis. In fact, for many companies these indicators of profitability always become negative except the gross profit. Hence, the gross profit is utilized as another output variable. Therefore, by combining model 1 with model 2, we can understand the real situation on company's technical efficiency comprehensively.

3. Data

3.1. Data and sources

This paper intends to use balance panel data of home-electrical appliance company for empirical analysis(4). Obviously, it is easy to get long-term continuous Japanese companies' data because

Japanese stock market is relatively mature and most of Japanese home-electrical companies went public many years ago. On the contrary, some problems come in Chinese stock market. Because the Chinese stock market just started from 1990 and most of home-electrical appliance companies went public sooner or later, it is difficult to get a relative long-term balance panel data. Finally, we choose 45 Chinese and Japanese listed companies in the period of 2001 to 2004 as our sample(5). It is worth mentioning that Chinese home-electrical appliance industry's organization structure changed dramatically since 2000, and its competitive strength increased rapidly at the same period. In our sample, there are 24 Chinese listed companies, including QingDao Hai'er, GeLiDianQi, ChunLanKongTiao, XiaoTian'E, MeiDiDianQi and HaiXinDianQi and others. On the other hand, there are 21 Japanese listed companies, including Hitachi, Toshiba, NEC, Fujitsu, Matsushita, Sony, Casio and others. The data of Chinese listed companies comes from their annual financial reports in the period 2001 to 2004, and the data of Japanese listed companies comes from the NEEDS-Financial QUEST purchased by the Graduate School of Commerce, Waseda University. And the combined financial report standardize is used. In addition, for facilitating comparison between the two countries, the authors convert the Japanese currency Yen to Chinese currency RMB by using Chinese official intermediate exchange rate(6).

3.2. Descriptive sample statistics

Table 1 includes some basic descriptive statistics on sales, gross profit, total asset, *R&D/Sale*, *CUM_R&D*, and *AD/Sale*. According to Table 1, it is obvious that the average scale of Japanese companies far exceeds Chinese companies from any angle.

The following conclusions can be drawn from Table 1. First, both sides' listed companies attach importance to advertising. And it is worth mentioning that the average and maximum *AD/Sale* of Chinese industry exceed the Japanese industry at the same period. Second, there is a significant difference on R&D between Chinese and Japanese companies. Concretely speaking, the Chinese companies' *R&D/Sale* averages only 0.2%, but Japanese companies 5%. In addition, the maximum *R&D/Sale* of Chinese companies is no more than 2%, and obviously below to Japanese average; on the contrary, the maximum of *R&D/Sale* of Japanese companies reaches the staggering 10%.

4. Empirical Results

Basing on the above-mentioned sample and the two models on market power efficiency and profitability efficiency, the authors will measure the Chinese and Japanese companies' technical efficiency from 2001 to 2004. And the impact of R&D and other factors on technical efficiency will

Table 1 Description of key indicators (Currency unit: RMB Yuan)

Item/Year	Year 2001		Year 2002		Year 2003		Year 2004	
	China	Japan	China	Japan	China	Japan	China	Japan
Sales								
Mean (100 mils)	29.46	1,561.88	33.85	1,526.97	37.39	1,676.32	49.82	1,935.15
Max (100 mils)	114.42	5,441.77	125.85	5,425.97	141.33	6,169.27	192.01	7,194.64
Min (100 mils)	0.42	12.21	0.41	12.15	0.35	13.26	0.49	14.00
Stdev/Mean	118.9%	123.7%	115.4%	123.6%	119.9%	124.0%	114.4%	125.6%
Gross profit								
Mean (100 mils)	4.98	387.12	5.86	411.53	7.05	445.42	7.85	500.82
Max (100 mils)	25.02	1,592.05	27.58	1,652.09	30.30	1,742.47	35.65	2,022.48
Min (100 mils)	0.12	2.76	(0.08)	2.96	(0.24)	3.23	(0.20)	3.37
Stdev/Mean	128.6%	129.2%	120.5%	129.1%	118.6%	128.7%	119.2%	131.1%
Total Asset (100 mil)								
Mean (100 mils)	38.54	1,657.42	39.97	1,565.95	45.19	1,629.52	47.45	1,850.99
Max (100 mils)	176.38	6,750.08	186.70	6,742.52	214.00	6,853.82	156.49	7,759.89
Min (100 mils)	2.12	9.71	1.93	10.15	1.75	10.34	2.01	11.47
Stdev/Mean	99.5%	130.6%	101.0%	134.4%	104.5%	135.5%	93.3%	137.7%
Employee								
Mean (Person)	5,100	81,265	5,554	78,822	6,802	77,922	8,582	79,391
Max (Person)	29,215	315,449	33,466	313,764	34,981	313,702	43,028	314,970
Min (Person)	659	456	868	427	862	418	708	409
Stdev/Mean	129.8%	119.9%	136.7%	120.7%	139.2%	120.8%	134.1%	121.3%
R&D/Sales								
Mean (%)	0.20	5.14	0.11	5.03	0.24	4.95	0.22	5.00
Max (%)	1.84	12.45	1.62	12.95	1.10	8.65	1.42	7.62
Min (%)	0.00	0.37	0.00	0.41	0.00	0.82	0.00	0.73
Stdev/Mean	229.3%	51.4%	297.1%	53.7%	160.9%	43.5%	153.7%	40.1%
CUM_(R&D)								
Mean (%)	0.35	15.84	0.55	20.98	0.66	26.02	0.90	30.97
Max (%)	2.77	30.30	4.61	38.13	4.82	51.08	5.74	50.73
Min (%)	0.00	1.53	0.00	1.90	0.00	2.31	0.00	3.13
Stdev/Mean	216.0%	55.3%	220.1%	52.1%	210.1%	50.7%	181.1%	48.2%
AD/Sales								
Mean (%)	1.12	0.96	0.99	0.96	1.03	1.00	1.16	0.95
Max (%)	8.95	5.30	5.24	5.92	6.99	5.62	7.17	5.02
Min (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stdev/Mean	181.6%	129.3%	146.4%	138.2%	157.7%	134.0%	140.7%	129.8%

be estimated jointly. The authors will firstly make a descriptive comparison between the two countries' home-electrical appliance industry, then further discuss the role of R&D and other factors on enterprise's technical efficiency.

4.1. Testing for efficiency

Two SFA models are estimated by FRONTIER version 4.1. The descriptive statistic and comparison between the two countries' home-electrical appliance companies' technical efficiency is showed in Table 2, which includes the two models on enterprise's market power efficiency and profitability efficiency.

Some conclusions can be drawn as below from Table 2:

(1) In the period of 2001 to 2004, on one hand, both countries' technical efficiencies show a slow upward trend on market power. The average overall market power efficiency scores were 0.575, 0.604, 0.624 and 0.671 from 2001 to 2004 respectively. On the other hand, the average overall profitability efficiency scores were 0.434, 0.469, 0.480 and 0.490 respectively from 2001 to 2004. Obviously, there was just a bit of improvement in contrast to market power efficiency scores.

(2) The divergence in Chinese industry is more serious than Japanese industry on both efficiencies. In this respect, the comparison on indicator *Stdev/Mean* of both countries reflects this phenomenon. According to the model 1, the ratios of *Stdev/Mean* in Chinese industry were 0.516,

Table 2 Descriptive comparisons on Chinese and Japanese Companies' efficiency

Country		Market power efficiency model				Profitability efficiency model			
		2001	2002	2003	2004	2001	2002	2003	2004
Overall	Mean	0.575	0.604	0.624	0.671	0.434	0.469	0.480	0.494
Japan	Mean	0.778	0.810	0.817	0.837	0.603	0.665	0.671	0.667
	Stdev	0.150	0.136	0.141	0.130	0.178	0.181	0.185	0.182
	Min	0.460	0.462	0.455	0.540	0.301	0.321	0.239	0.270
	Max	0.954	0.959	0.959	0.966	0.895	0.921	0.913	0.913
	Stdev/ Mean	0.193	0.168	0.173	0.155	0.295	0.273	0.276	0.273
China	Mean	0.397	0.424	0.455	0.525	0.286	0.297	0.313	0.343
	Stdev	0.205	0.226	0.204	0.239	0.204	0.213	0.190	0.204
	Min	0.057	0.158	0.103	0.141	0.062	0.000	0.000	0.000
	Max	0.919	0.915	0.865	0.968	0.782	0.842	0.837	0.797
	Stdev/ Mean	0.516	0.533	0.449	0.456	0.715	0.719	0.606	0.596
Ratio of (China/Japan)	Mean (%)	51.05	52.42	55.63	62.70	47.46	44.60	46.73	51.37

0.533, 0.449 and 0.456 respectively from 2001 to 2004; but Japanese figures were 0.193, 0.168, 0.173 and 0.155 respectively at the same period. In addition, Japanese *Stdev/Mean* of profitability scores were 0.295, 0.273, 0.276 and 0.273 respectively from 2001 to 2004; and Chinese scores were 0.715, 0.719, 0.606 and 0.596 respectively at the same period. Obviously, in both efficiency scores, Chinese industry's *Stdev/Mean* values was about 2～4 times of Japanese industry. The significant gaps show that more competitive and perfect environment exists in Japanese home-electrical appliance industry than China.

(3) The leading company in Chinese home-electrical industry, on both efficiencies, can basically make competition with the Japanese companies. For instance, in Chinese industry, the maximum of market power efficiency scores were 0.919, 0.915, 0.865 and 0.968 respectively from 2001 to 2004. And in Japanese industry, the maximum of market power efficiency scores were 0.954, 0.959, 0.959 and 0.966 respectively. In the respect of profitability efficiency, Chinese maximum of profitability efficiency scores were 0.782, 0.842, 0.837 and 0.797 respectively from 2001 to 2004; and Japanese maximum of scores were 0.895, 0.921, 0.913 and 0.913 respectively at the same period(7).

(4) In a whole, according to the *China/Japan mean* of market power efficiency scores, Chinese home-electrical appliance industry's market power efficiency increased significantly since 2001. With specific figures, the relative numbers were 51.05%, 52.42%, 55.63% and 62.70% from 2001 to 2004 respectively. However, in the respect of profitability efficiency, the *China/Japan mean* of profitability efficiency scores were 47.46%, 44.60%, 46.73% and 51.37% respectively from 2001 to 2004. Compared to Japanese industry, it is clear that there was just a bit of improvement on profitability efficiency in contrast to market power efficiency in recent years.

4.2. Comparing market power efficiency and profitability efficiency

Table 3 reports the Spearman's rank correlation of two efficiencies calculated by two SFA models from 2001 to 2004. In each year, obviously, the rank of market power efficiency is highly correlated with the rank of profitability efficiency. And furthermore, all of Spearman's rank order correlation coefficients are significant at level of 1%. The results indicate that tight linkage does

Table 3 Spearman rank correlation coefficient between two models (2001-2004)

Year 2001			Year 2002			Year 2003			Year 2004		
	M (1)	M (2)		M (1)	M (2)		M (1)	M (2)		M (1)	M (2)
M (1)	1.000		M (1)	1.000		M (1)	1.000		M (1)	1.000	
M (2)	0.8186***	1.000	M (2)	0.7978***	1.000	M (2)	0.7835***	1.000	M (2)	0.7532***	1.000

Note: M (1) means market power efficiency model, and M (2) means profitability efficiency model. Three asterisks indicate significance at 1%.

exist between two technical efficiencies.

4.3. Identifying the causes of inefficiency

The estimates by stochastic frontier analysis are shown in Table 4. Herein, two stochastic frontier analysis models are analyzed, one is about market power efficiency, and the other is about profitability efficiency. It is clear from the last row in Table 4 that the two parameters γ and *LR* are significant at level of 1% in two SFA models(8). That indicates that SFA approach is necessary.

According to stochastic frontier analysis theory, efficiency variable's sign is reverse relative to technical efficiency. From Table 4, as indicated by the negative coefficient of variable *Dummy*, we find that, on average, compared with Chinese companies, Japanese home-electrical appliance companies are more efficient in the sample. This is consistent with our findings before, and it holds no matter how we account for environmental variables. Certainly, we have to be careful in interpreting this result, in that the coefficient of the *Dummy* variable captures all the effect of systematic difference between China and Japan. Next, we begin to discuss other factors' impact to

Table 4 Estimation results of R&D and inefficiency basing on SFA (2001-2004)

	Market power efficiency model		Profitability efficiency model	
Variable	Coefficient	t-value	Coefficient	t-value
Frontier Variables:				
β_0: *Constant*	–34.545	–34.57***	–36.380	–4.10***
β_1: $\ln(K)$	4.427	19.84***	5.329	4.25***
β_2: $\ln(L)$	–0.985	–2.24***	–3.288	–2.34***
β_3: $\ln(K)^2$	–0.083	–6.77***	–0.119	–2.64***
β_4: $\ln(K)\ \ln(L)$	0.041	1.03	0.139	1.32
β_5: $\ln(L)^2$	0.005	0.17	–0.001	–0.02
Efficiency Variables:				
δ_0: *Constant*	1.257	6.81***	–15.182	–21.75***
δ_1: *Tech*	–0.165	–2.80***	0.774	2.99***
δ_2: *DUMMY*	–1.898	–6.51***	–30.782	–21.40***
δ_3: *AD/Sale*	–0.068	–1.25	–2.186	–4.80***
δ_4: *CUM_R&D*	0.032	2.89***	–0.111	–3.76***
δ_5: *Scale*	–0.469	–2.76***	1.216	4.72***
δ_6: *L/E*	0.001	0.95	0.009	3.25***
	γ = 0.9738***	*LR* = 131.14***	γ = 0.9986***	*LR* = 305.77***

Note: One, two and three asterisks indicate significance at $p < 10\%$, $p < 5\%$ and $p < 1\%$, respectively.

company's efficiency one by one.

(1) From Table 4, the variable *Scale* coefficient is –0.469 and significant at the level of 1% in market power model. That means the growth of scale will raise company's market power efficiency. This conclusion is also consistent with other studies (Torri, 2001; Habib & Ljungvist, 2005). However, most of existing studies just focused on the relationship between economy scale and market power efficiency, and seldom discuss economy scale impact to profitability efficiency. From our estimates shown in Table 4, we find that the variable *Scale* coefficient is positive and statistically significant at level of 1%. Combining the two estimates about company's *Scale* in home-electrical appliance industry, we think that the scale cannot raise effectively company's profitability efficiency, but can play a positive and significant role in improving company's market power efficiency.

(2) We now focus on R&D's impact to company's efficiency. In market power model, the variable *CUM_R&D* coefficient is estimated to be positive and statistically significant at level of 1%. Therefore R&D's role looks negative in explaining market power inefficiency in our sample. On the other hand, just like our expectation before, its coefficient is estimated to be –0.111 and statistically significant at level of 1% in profitability efficiency model. Combining the two estimates, we can draw a conclusion that R&D expenditures cannot improve enterprise's market power efficiency, but can raise enterprise's profitability efficiency significantly. Basing on the theoretical analysis about product lifecycle and learning curve hereinabove, in highly competitively home-electrical appliance industry, the sustained and stable R&D helps company to keep technological competitive advantage and to provide high-tech products continually for customer. Obviously, high-tech products are company's major source of profit at least before the standardized product phase. Therefore, it is not difficult to understand R&D's important impact to company's profitability efficiency.

(3) Advertising impact to China-Japan home-electrical companies' technical efficiency. From Table 4, the *AD/Sale* coefficient is estimated to –0.068, but it is nearly significant at the level of 10% in market power model. Moreover, the *AD/Sale* coefficient is estimated to be –2.186 and significant at the level of 1%. These estimates indicate that we cannot omit advertising's short-term and positive effects on company's efficiencies in home-electrical appliance industry which providing durable goods for consumer. It is clear that our findings are basically consistent with past literatures hereinabove. By combining the two coefficients of *CUM_R&D* and *AD/Sales* in the two models, we can easily find that both R&D and advertising affect company's efficiencies positively and significantly. However, advertising' role to profitability efficiency is usually regarded as short-term effect in, but R&D's role to profitability efficiency does exist in long time particularly in

highly competitive home-electrical appliance industry. In addition, for many companies that focusing on short-term effect, the advertising strategy is not bad choice especially in highly competitive home-electrical appliance industry, in which technical progress develops quickly so that just some large-scale companies can continuously pay a lot of R&D expenditures for new products and undertake the relative risky. In Chinese home-electrical appliance industry, most of listed companies are typical SOEs (State Owned Enterprise), and it is a common phenomenon that these companies' management team would like to pursue short-term return and seldom consider the long-term development (Shiu, 2002; Zheng et al., 2003). Therefore, it is not difficult to understand Table 1, in which the average *AD/Sales* ratio of Chinese industry was almost equal to Japanese industry, but the average *R&D/Sales* ratio was far lower than Japanese industry.

(4) The variable *L/E* coefficient is 0.001 and insignificant at the level of 10% in market power model. On the other hand, the coefficient is estimated to be 0.009 and significant at level of 1% in profitability efficiency model. The results indicate that a bit of decreasing financial leverage should be helpful to improving company's efficiencies in home-electrical appliance industry.

5. Conclusions

This paper proposes two models for analyzing the company's market power and profitability efficiency. Firstly, the authors utilize SFA approach to measure the Chinese and Japanese home-electrical listed companies' technical efficiencies scores from 2001 to 2004, and further discusses how company's R&D, advertising, scale, financial leverage and other factors' effect on firm's market power efficiency and profitability efficiency. By the above analysis, some conclusions can be drawn as follows.

First, the overall average market power efficiency increases steadily and significantly from 2001 to 2004 in China-Japan home-electrical appliance industry. But there has a bit of growth on overall average profitability efficiency at the same period. Additionally, big gaps on two technical efficiencies between China and Japan still exist without significant change in recent years.

Second, most of Chinese electrical appliance companies hold a different attitude on R&D and advertising with Japanese company. Chinese industry shows more interests in advertising than Japan; their average ratio of *AD/Sale* is even higher than Japanese industry. But consciously and unconsciously, Chinese companies always omit the more important R&D input.

Third, companies must be aware that sustained and stable R&D is the foundation to establish and maintain the long-term competitive advantage in highly competitive home-electrical appliance industry. The *CUM_R&D* plays a positive, significant and long-term role to profitability efficiency. But Chinese companies would prefer choosing advertising strategy to pursuing short-term return rather than utilizing stable R&D strategy for improving the long-term profitability efficiency. On the contrary, Japanese companies can keep a balance between R&D strategy and advertising strategy for improving market power efficiency and profitability.

Acknowledgments

The authors thank the anonymous referee for his valuable comments on this paper. We are also grateful for helpful suggestions for improvements from Professor Shimamura Hiroki at the Graduate School of Commerce, Waseda University, Tokyo Japan. Of course, all errors and omissions are our own.

Note

(a) The Institute for Research in Business Administration, Waseda University, Tokyo Japan
Corresponding author, Tel: (+81) 090-9395-6606; Email: hefeng@fuji.waseda.jp

(b) School of Economics and Management, Tsinghua University, Beijing China

(1) The distribution form of the inefficiency term is usually assumed to be half-normal, $N^{+}(0, \sigma_u^2)$, or the truncated normal, $N^{+}(m_{it}, \sigma_u^2)$, where the superscript '+' means that it takes only a non-negative value. Under these assumptions, the log-likelihood function can be defined and the parameters of the technology and variance of inefficiency can be estimated by the method of maximum likelihood. And one of the disadvantages of the stochastic frontier is that we must assume a particular distribution form for the technical inefficiency, u_{it}.

(2) Note that the parameter γ indicates how much of the variance of the composed error term (v_{it}-u_{it}) is attributed to the technical inefficiency.

(3) With regard to the weights of annual ratio of R&D expenditures to sales, Dutta et al. (2005) indicated that the results were robust to different weights. For simplicity, we use the weight of 1 herein. In addition, we omit the ratio of R&D expenditures to sales before 1996 for Japanese companies, because ten years is really too long for highly competitive home-electrical appliance industry.

(4) Why the authors will choose home-electrical appliance companies as the sample. That is because of the suitable market competition in home-electrical appliance company. In fact, some regulations exist in most of Chinese industries. And the efficiency of market competition in home-electrical appliance industry is better than other industries.

(5) Why the period of the sample is just from 2001? The author will give two explanations for it. The first is the short history of stock market in China. The development of Chinese stock market began from the Shanghai Stock Exchange in 1990, and Shenzhen Stock Exchange was set later. The point is that there are only eight listed companies in 1990. And with more and more companies going public, the number of listed company increased quickly. By the end of 2004, there are almost 1,300 listed companies in Shanghai and Shenzhen Stock Exchange. And actually we can collect enough listed companies for our sample in home-electrical appliance industry until 2001. The second explanation is the significant change of organization in home-electrical appliance industry since 2001. Compared to the situation before 2000, the industry organization became more realizable.

(6) According to Chinese official exchange rate, one US dollar is equal to 8.03～8.28 Chinese dollar (RMB) from 2001 to 2004.

(7) Actually, most of listed companies are SOE in China. According to the policy on SOE, almost all of SOE, which will want to go public in Shanghai or Shenzhen Stock Exchange, basically took so-called "a part of SOE goes public" strategy. The strategy means the original SOE will be divided two parts or companies firstly. In general, one company will own most of good assets of original SOE, and certainly the new company can easily meet the quali-

fication of IPO. In a word, the Chinese listed companies absolutely represent the best part of whole industry.

(8) *LR* is the likelihood ratio. It should be noted that any likelihood ratio test statistic involving a null hypothesis that includes the restriction that γ is zero does not have a chi-square distribution because the restriction defines a point on the boundary of the parameter space. In this case the *LR* (likelihood ratio) statistic has been shown to have a mixed chi-square distribution. For more on this point see Lee (1993) and Coelli (1995).

References

Aigner, D., C. A. K. Lovell and P. Schmidt. (1977). Formulation and Estimation of Stochastic Frontier Production Functions Models. *Journal of Econometrics*. 6 (1): 21-37.

Assmus, G., Farley, J. U. and Lehmann, D. R. (1984). How advertising affects sales: meta-analysis of econometric results. *Journal of Marketing Research*. 21: 65-74.

Back, Y. and Pagan J. (2003). Executive compensation and corporate production efficiency: A stochastic frontier approach. *Quarterly Journal of Business and Economics*. 41 (1/2): 27-41.

Battese, G. E., and G. S. Corra. (1977). Estimation of a Production Frontier Model: With application to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics*. 21 (3): 169-179.

Battese, G. E. and T. J. Coelli. (1988). Prediction of farm-level technical efficiencies with a generalized frontier producition function and panel data. *Journal of Econometrics*. 38: 387-399.

Battese, G. E. and T. J. Coelli. (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of Productivity Analysis*. 3 (1/2): 153-169.

Battese, G. E. and T. J. Coelli. (1995). A model for technical inefficiency effects in a stochastic production frontier for panel data. *Empirical Economic*. 20 (1): 325-332.

Coelli, T. J. (1995). Estimators and Hypothesis Tests for a Stochastic: A Monte Carlo Analysis. *Journal of Productivity Analysis*. 6: 247-268.

Dilling-Hansen, M., Madsen, E. S. and Smith, V. (2003). Efficiency, R&D and ownership—some empirical evidence. *International Journal of Production Economics*. 83: 85-94.

Dutta, S., Marasimhan, O. and Rajiv, S. (2005). Conceptualizing and measuring capabilities: Methodology and empirical application. *Strategic Management Journal*. 26: 277-285.

Ferrantino, M. J. (1992). Technology expenditures, factor intensity, and efficiency in Indian manufacturing. *The Review of Economics and Statistics*. 74 (4): 689-700.

Flath, D. (2000). The Japanese Economy. Oxford: Oxford University Press.

GAO Wei and HE Feng. (2005). The analysis on technique efficiency of appliance listed companies in China. *Industry Economic Research*. 3: 48-53. (In Chinese)

Gugler, K. (2001). Corporate Governance and Economic Performance. Oxford: Oxford University Press.

Hunt-McCool, J., Koh, S. C. and Francis, B. B. (1996). Testing for deliberate under-pricing in the IPO premarket: a stochastic frontier approach. *Review of Financial Studies*. 9 (4): 1251-1269.

Habib, M. and Ljungvist. (2005). A Firm Value and Managerial Incentives: A Stochastic Frontier Approach. *Journal of Business*. 78: 2053-2093.

Hay, D. A. and Liu, G. S. (1997). The efficiency of firms: what difference does competition make?. *Economical Journal*. 107 (May): 597-617.

HE Feng and YUAN Pengfei. (2006). The Comparative Study on Manufacture's Productivity Efficiency in China. *Productivity Research*. 1: 163-165. (In Chinese)

Irwin, D. A. and Klenow, P. J. (1994). Learning-by-doing spillovers in the semiconductor industry. *Journal of Political Economy*. 102 (6): 1200-1227.

Jensen, M. (1986). Agency costs of free cash flow, corporate finance and takeovers. *American Economic Review*. 76: 323-329.

Jondrow, J., C. A. K. Lovell, I. S. Materov and P. Schmidt. (1982). On the estimation of the technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*. 19: 233-238.

Kneller, R. and Stevens, P. A. (2006). Frontier technology and absorptive capacity: Evidence from OECD manufacturing industries. *Oxford Bulletin of Economics And Statistics*. 68 (1): 1-21.

Kudish, L. (1965). Applying an advertising - sales relationship model to product fields. *Journal of Marketing*. 29 (Oct.): 16-18.

Lee, L. F. (1993). Asymptotic Distribution for the Maximum Likelihood Estimator for a Stochastic Frontier Function Model with a Singular Information Matrix. *Econometric Theory*. 9: 413-430.

Meeusen, W. and Van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*. 18 (2): 435-444.

Movshuk, O. (2004). Restructuring, productivity and technical efficiency in China's iron and steel industry 1988-2000. *Journal of Asian Economics*. 15: 135-151.

Nelson, P. (1974). Information and consumer behavior. *Journal of Political Economy*. 78: 311-329.

Parsons, L. (1975). The product life cycle and time varying advertising elasticities. *Journal of Marketing Research*. 12: 476-480.

Rao, V. R. (1972). Alternative econometric models of sales—advertising relationships. *Journal of Marketing Research*. 9: 177-181.

Shiu, A. (2002). Efficiency of Chinese enterprise. *Journal of Productivity Analysis*. 18: 255-267.

TORII Akio. (2001). *Efficiency in Japanese industries*. NTT Press. (In Japanese)

TORU Hattori. (2002). Relative performance of U. S. and Japanese electricity distribution: an application of stochastic frontier analysis. *Journal of Productivity Analysis*. 18: 269-284.

Vernon, R. (1966). International investment and international trade in the product cycle. *The Quarterly Journal of Economics*. 80 (2): 190-207.

Zheng Jinhai, Liu Xiaoxuan and Bigstern, A. (2003). Efficiency, technical progress and best practice in Chinese state enterperise 1980-1994. *Journal of Comparative Economics*. 31 (1): 134-152.