Efficiency and Productivity in the Japanese Broadcasting Market

by Sumiko ASAI*

Introduction

Japanese broadcasters expanded successfully until the 1990s. However, investment in digitalization (1), the decrease of advertising expenditures due to the recession and the growth of competition in the media industry (2) are all considered to have had adverse effects on the operation of broadcasters. The purpose of this study is to calculate efficiency and productivity indexes of broadcasters, using Data Envelopment Analysis (DEA) and to analyze their economic characteristics from the following two perspectives.

First, entry into the terrestrial broadcasting market has been regulated due to the scarcity of available radio frequencies. As a result, the market has been an oligopoly and incentive mechanisms may not be expected to work in the market. On the other hand, Japanese commercial broadcasters will invest a total of 808 billion Yen to initiate digital broadcast services (3) and the investment required for digitalization imposes a considerable financial burden on small-scale broadcasters. Therefore, the Ministry of Internal Affairs and Communications (MIC) decided to permit mergers between small-scale broadcasters that faced financial difficulties in March 2004 (4). However, it is not clear whether, in advance of the merger, broadcasters have operated efficiently in the oligopoly market. This paper calculates three kinds of efficiency indexes by the size of broadcasters' revenues and tests whether efficiencies of small-scale broadcasters are inferior to those of large-scale ones.

Second, the Ministry has expected commercial broadcasters to transmit local programs, and has restricted their service areas to accomplish localization (5). In addition, some local governments have recognized local broadcasting as an important local resource and have played a leading role in establishing and operating local stations. They are major stockholders of local stations and provide some staff, including a chief executive officer. On the other hand, most large-scale broadcasters and other local stations are private companies. This study tests whether there are some differences in the efficiencies of broadcasters under different types of ownership.

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Model

Farrell (1957) proposed three kinds of efficiency indexes: technical efficiency, allocative efficiency [(6)] and overall efficiency. First, this study calculates these efficiency indexes.

The revenues of commercial broadcasters are derived principally from advertising. The rate per commercial message depends on the audience ratings of the programs and economic circumstances. If commercial broadcasters produce popular programs, they can increase their revenues against a set level of inputs. Therefore, this paper assumes that broadcasters seek to maximize revenue on the basis of output that utilizes no more than the observed amount of any input, and that adopts an output-oriented model. Since Asai (2004) indicated that economies of scale existed in the Japanese broadcasting market through the estimation of total cost function, this paper does not assume constant returns to scale. The Banker, Charnes and Cooper (BCC) model, which does not assume constant returns to scale, defines the production possibility set as follows:

$$P = \{(\boldsymbol{x}, \boldsymbol{y}) \mid \boldsymbol{x} \geq X\boldsymbol{\lambda}, \boldsymbol{y} \leq Y\boldsymbol{\lambda}, \boldsymbol{e\lambda} = 1, \boldsymbol{\lambda} \geq 0\} \tag{1}$$

P is the production possibility set. **x** is the input vector (m × 1) and X is the matrix, $X = (x_j) \in R^{m \times n}$ and **y** is the output vector (s × 1) . Y is the matrix, $Y = (y_j) \in R^{s \times n}$ where n represents the number of broadcasters. $\boldsymbol{\lambda}$ is the non-negative weights $\boldsymbol{\lambda} \in R^n$. **e** is a row vector with all elements equal to 1.

$$\begin{aligned} &\max \ \theta \\ &\text{subject to} \\ &\quad X\boldsymbol{\lambda} \leq \boldsymbol{x} \\ &\quad \theta\boldsymbol{y} \leq Y\boldsymbol{\lambda} \\ &\quad \boldsymbol{e\lambda} = 1 \\ &\quad \boldsymbol{\lambda} \geq 0 \end{aligned} \tag{2}$$

θ is a scalar and represents technical efficiency. θ takes a value between zero and one. $\theta = 1$, if and only if the firm is fully efficient.

Overall efficiency (E_c) is defined as the ratio of the minimum cost to the observed cost and is calculated by equation (3) using linear programming.

$$\begin{aligned} &\min C \ \ C = \mathbf{p}'\mathbf{x}^* \\ &\text{subject to} \\ &\quad X\boldsymbol{\lambda} \leq \boldsymbol{x}^* \\ &\quad \boldsymbol{y} \leq Y\boldsymbol{\lambda} \\ &\quad \boldsymbol{e\lambda} = 1 \\ &\quad \boldsymbol{\lambda} \geq 0 \end{aligned} \tag{3}$$

where **p** is the vector of input prices (m×1) and **x*** is the input vector that realizes cost minimization, which is calculated by linear programming.

Allocative efficiency (E_a) is defined by equation (4).

$$E_a = E_c / \theta \tag{4}$$

Both E_a and E_c take values between zero and one. E_a (E_c) = 1, if and only if the firm is fully efficient.

Second, this study calculates the productivity of broadcasters. The output distance function is defined for time period t as

$$D_t (x_t, y_t) = \min\{ \rho \mid (x_t, y_t / \rho)\} \in P_t\} \tag{5}$$

$\rho = 1$ if and only if (x, y) are on the production frontier. This is technical efficiency as defined by Farrell (1957) and calculated by equation (2). Similarly, the distance function evaluating (x_t, y_t), relating to technology in period t+1, is shown as equation (6).

$$D_{t+1} (x_t, y_t) = \min\{ \rho \mid (x_t, y_t / \rho)\} \in P_{t+1}\} \tag{6}$$

Caves, Christensen and Diewert (1982) defined the output-based Malmquist productivity index as equations (7) and (8).

$$M_t = D_t (x_{t+1}, y_{t+1}) / D_t (x_t, y_t) \tag{7}$$

$$M_{t+1} = D_{t+1} (x_{t+1}, y_{t+1}) / D_{t+1}(x_t, y_t) \tag{8}$$

The Malmquist productivity change index is specified as the geometric mean of equations (7) and (8) in order to establish an arbitrary reference technology by equation (9).

$$M (x_{t+1}, y_{t+1}, x_t, y_t) \\ = [\{D_t (x_{t+1}, y_{t+1}) / D_t (x_t, y_t)\}\times\{D_{t+1} (x_{t+1}, y_{t+1}) / D_{t+1} (x_t, y_t)\}]^{1/2} \tag{9}$$

Equation (9) is written as

$$M (x_{t+1}, y_{t+1}\ x_t, y_t) = A\times B \tag{10}$$

where $A = D_{t+1} (x_{t+1}, y_{t+1}) / D_t (x_t, y_t)$

$B = [\{D_t (x_{t+1}, y_{t+1}) / D_{t+1} (x_{t+1}, y_{t+1})\}\times\{D_t (x_t, y_t) / D_{t+1} (x_t, y_t)\}]^{1/2}$

The Malmquist productivity index calculated by equation (10) is the total factor productivity (TFP) index that does not assume cost-minimizing, and is composed of A (efficiency change between t and t+1) and B (technical change between the two periods). When the value of the Malmquist productivity index (efficiency) is greater than one, it denotes improvement. Similarly, when the value of technical change is greater than one, it implies expansion of the production frontier.

Data

The subjects of this study are 30 broadcasters that submitted financial statements to the Ministry of Finance during fiscal years 1997-2002 (7). The inputs are L = labor, K = capital and M = materials. The data on inputs and output have been obtained from financial statements submitted to the Ministry of Finance.

L represents the number of employees at the end of a fiscal year. K is fixed assets, excluding assets in construction and land. Capital is constructed using the perpetual inventory method. $K_t = (1 - \delta) K_{t-1} + I_t$, where δ is the depreciation rate of capital and is calculated as the ratio of depreciation expenses to book-valued fixed assets at the beginning of the period. Investment is calculated by adding the depreciation expenses and changes in assets between the beginning and end of the fiscal year. It is deflated using the price index of investment goods taken from the *Annual Report on Corporate Price Indexes*, issued by the Bank of Japan. Materials (M) as input quantity, is transmitted programs and is calculated as the program cost divided by the program price. Since most program costs of a broadcaster, in particular a small-scale broadcaster, is made up of the expenditure for packaged programs on average, the price index of recorded materials is adopted as the programming price.

The price of labor (P_L) is calculated as the compensation of employees divided by the number of employees. According to Christensen and Jorgenson (1969), the price of capital service (P_K) is calculated by $p (r + \delta) / (1 - \tau)$. The price index of capital goods is p, and r is the long-term prime lending rate from the *Bank of Japan's Monthly Report*. δ is the depreciation rate for capital as mentioned above. τ is the corporate tax rate and is computed as the corporate tax divided by income taken from the financial statements.

The output quantity is measured as the sum of television and radio revenues divided by the price index of broadcasting advertising service. This price index is adopted because the revenue source of commercial terrestrial broadcasters is advertising expenditure. The price indexes of recorded materials (P_M), capital goods (p) and broadcasting advertising service are taken from the *Bank of Japan's Monthly Report on Price Indexes*.

Table 1 presents some summary statistics on inputs and output. The maximum output is ninety times larger than the minimum one, and the difference in the scale of broadcasters can be clearly seen from this data. Table 2 indicates the correlation coefficients between variables. The correlation coefficient between output and program is quite high at 0.996.

Table 1 Sample Summary Statistics

	Employ	Capital	Program	Revenue
Average	283.1	5633.2	9558.3	25606.1
Standard error	287.0	6185.9	22661.3	52379.3
Maximum	1323	27561	108751	257872
Minimum	51	693	576	2783

Table 2 Correlation Coefficients

	Employ	Capital	Program	Output
Employ	1.000			
Capital	0.907	1.000		
Program	0.935	0.868	1.000	
Output	0.930	0.876	0.996	1.000

Partial productivities of labor, capital and materials in Table 3 are calculated using the variables mentioned above. Broadcasters with annual revenues of more than 20 billion Yen are classified as large-scale companies and others are defined as small-scale ones in this study. Five of the 30 broadcasters are large-scale broadcasters and have operated across several prefectures, owing to the economic connection between these areas. The other 25 stations are small-scale broadcasters that have provided services within single prefectures, in accordance with the license issued by the MIC.

While on average the labor and capital productivity of large-scale broadcasters is high, their materials productivity is low in comparison with that of small-scale broadcasters. This implies that small-scale broadcasters have depended on the networks for programs through their network affiliate contracts (8). The 25 small-scale broadcasters are divided into two sub-groups: local government-owned and private companies (9). Only the small-scale broadcasters are divided by type of ownership in order to exclude the effect of the size of revenues. It is indicated that on average the labor productivity of small-scale private companies exceeds that of small-scale local government-owned companies.

Table 3 Partial Productivity (average)

	Y/L	Y/K	Y/M
Average (30)	90.44	4.54	2.67
By Revenue			
More than 20 billion Yen (5)	137.21	6.61	2.39
Less than 20 billion Yen (25)	45.11	2.37	4.08
Revenue less than 20 billion Yen			
Local Government-owned Companies (11)	37.74	2.38	4.69
Private Companies (14)	50.62	2.35	3.80

Note: The number of broadcasters is in parentheses.

Calculation Results

Tables 4, 5 and 6 show the three efficiency indexes calculated by equations (2), (3) and (4) respectively [10]. In Table 4, technical efficiency is 0.940 on average and the values of the coefficient of variation during the period 1997–2002 remain almost constant. In the right-hand columns of Tables 4–6, it can be seen that the average values of the three efficiency indexes of large-scale broadcasters are greater than those of small-scale broadcasters. While the average value of the overall efficiency of large-scale broadcasters is 0.825 in Table 5, that of small-scale ones is 0.757, making a noticeable difference. Similarly, the difference in the allocative efficiency between large-scale and small-scale broadcasters is seen to be considerable in Table 6. However, the null hypothesis that the distributions of three indexes are the same between large-scale and small-scale broadcasters is not rejected respectively using the non-parametric Wilcoxon test.

On the other hand, since five large-scale broadcasters have operated across several prefectures including the metropolitan areas, a possibility of the impact of economic circumstances on these indexes is considered. Therefore, this study tests whether efficiency indexes depend on the demand density calculated as the number of households per the dimension of service area. As a result, Table 7 shows that the density of demand is not significant.

Table 4 Technical Efficiency (average)

	1997	1998	1999	2000	2001	2002	Average
Average	0.939	0.944	0.928	0.938	0.952	0.939	0.940
Coefficient of Variation	0.083	0.071	0.091	0.076	0.065	0.077	0.071
By Revenue							
More than 20 billion Yen	0.968	0.948	0.938	0.920	0.966	0.960	0.950
Less than 20 billion Yen	0.933	0.943	0.926	0.942	0.949	0.934	0.938
Revenue less than 20 billion Yen							
Local Government-owned Companies	0.907	0.922	0.910	0.928	0.941	0.919	0.921
Private Companies	0.952	0.959	0.938	0.953	0.956	0.946	0.951

Table 5 Overall Efficiency (average)

	1997	1998	1999	2000	2001	2002	Average
Average	0.782	0.771	0.763	0.751	0.759	0.787	0.769
Coefficient of Variation	0.151	0.179	0.183	0.181	0.177	0.154	0.162
By Revenue							
More than 20 billion Yen	0.836	0.807	0.823	0.808	0.834	0.843	0.825
Less than 20 billion Yen	0.771	0.763	0.751	0.739	0.744	0.775	0.757
Revenue less than 20 billion Yen							
Local Government-owned Companies	0.696	0.702	0.676	0.677	0.696	0.727	0.695**
Private Companies	0.830	0.812	0.809	0.789	0.782	0.816	0.806**

Note: **5 percent level

Table 6 Allocative Efficiency (average)

	1997	1998	1999	2000	2001	2002	Average
Average	0.835	0.817	0.822	0.799	0.796	0.837	0.817
Coefficient of Variation	0.135	0.161	0.155	0.154	0.155	0.115	0.137
By Revenue							
More than 20 billion Yen	0.863	0.850	0.877	0.878	0.865	0.878	0.869
Less than 20 billion Yen	0.829	0.810	0.811	0.784	0.783	0.828	0.807
Revenue less than 20 billion Yen							
Local Government-owned Companies	0.771	0.762	0.743	0.728	0.738	0.787	0.755**
Private Companies	0.874	0.847	0.864	0.827	0.817	0.861	0.849**

Note: **5 percent level

Table 7 Efficiency and Density of Demand

	Technical efficiency	Overall efficiency	Allocative efficiency
Constant	0.9375(0.016)*	0.7672(0.026)*	0.8171(0.020)*
Density of Demand	0.000004(0.000003)	0.00008(0.000006)	0.00008(0.00004)
adj.R^2	0.0005	0.0269	0.0635

Notes: The standard errors are in parentheses. This table is estimated by ordinary least squares (OLS). * 1 percent level

Tables 4–6 show that the three efficiency indexes of private companies are greater than those of local government-owned companies. As a result of the non-parametric test, the differences in the distributions of overall efficiency and allocative efficiency between private companies and local government-owned companies are significant at the five percent level.

Table 8 shows the annual change rates of technical efficiency, technical progress and the Malmquist productivity. Judging from Tables 3–6, although differences in the partial productivities and efficiency indexes calculated using DEA between subgroups are observed, no differences in the change rates of efficiency and productivity by group are apparent (11). Therefore, only the values of the Malmquist indexes by group are presented in Table 8. If yardstick competition works, inefficient broadcasters exert more effort to improve their efficiencies. The result of this study indicates that the efficiency gap between broadcasters continues and yardstick competition does not obtain good results in the broadcasting market.

Since the total average values of the three indexes in Table 8 are less than 1, technical efficiency, technical progress and productivity can be judged to have deteriorated during the calculation period. Terrestrial television service has used analog technologies since the start of terrestrial analog television broadcasting in 1953. Although analog television technology has advanced, it is considered to be mature at present. Therefore, it is unlikely that expansion of the production frontier will result from innovation in the market.

Table 8 Change of Efficiency and Productivity (average)

	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002	Average[1]
Technical Efficiency	0.988	0.982	1.008	1.006	0.993	0.995
Technical Change	0.987	1.036	0.951	0.963	1.026	0.992
Malmquist Productivity	0.977	1.016	0.957	0.968	1.018	0.987
Productivity by Revenue						
More than 20 billion Yen	0.983	1.018	0.967	0.987	1.042	0.998
Less than 20 billion Yen	0.964	1.016	0.955	0.965	1.014	0.981
Productivity by Ownership						
Local Government-owned	0.971	0.997	0.959	0.964	1.005	0.978
Private Companies	0.958	1.031	0.951	0.965	1.021	0.983

Note 1: geometric mean

Conclusions

The calculations show that on average the small-scale broadcasters about whose management the Ministry has been concerned have not operated efficiently. In addition, decomposition of the Malmquist productivity indexes indicates that technical efficiency has not improved, and on average the production frontier has deteriorated. This implies that a review of the management of broadcasters is needed, in advance of any mergers between them.

Finally, certain problems need to be considered. First, since all commercial broadcasters are not obliged to publish their financial statements, the number of the observations in this study is limited. Therefore, drawing definite conclusions about the implications of these findings is not appropriate. It would be highly desirable to be able to re-calculate efficiency indexes using the data from all broadcasters and confirm the results of the present calculation.

Second, reducing the budget for programs contributes to the enhancement of productivity and efficiency. This paper deals with economic efficiency and does not consider the quality of broadcast services. Although the level of expenditures on programs does not necessarily indicate the quality and quantity of programs transmitted, certain expenditures are required to produce high quality programs. While discussing the appropriate structure of the broadcasting industry, the quality of programs should be considered.

NOTES

1. In Japan, digital broadcasting started in three major metropolitan areas in December 2003, and is to replace analog broadcasting in 2011.
2. Terrestrial television service is the most familiar medium in Japan. However, broadcasting via communications satellite (CS), CATV and the distribution of contents through the Internet have been developing since the 1990s.
3. This figure was calculated by the National Association of Commercial Broadcasters in Japan. See the press release from the National Association of Commercial Broadcasters in Japan, dated September 18, 2003: http://www.nab.or.jp/
4. See the press release from the MIC, dated March 17, 2004.
5. For Japanese broadcasting policy, see Sugaya (1997).
6. Farrell (1957) used the term "price efficiency", instead of "allocative efficiency". However, the term "allocative efficiency" has generally been used in recent papers, so we use the term in this study.
7. Firms that meet certain requirements such as the size of capital and the number of stockholders are obliged to submit their financial statements to the Ministry of Finance, in accordance with the Securities and Exchange Law. However, because some broadcasters are small-scale firms, they are not obliged to submit such statements.
8. Networks enter into affiliation contracts with local stations and provide their affiliates with programs and commercial messages at no charge. Since the programs produced by networks are distributed nationally through the contract, networks can gain significant revenues from national advertisers.
9. A local government-owned broadcaster is defined in this study as a company that has a local government as the main stockholder.
10. Aly, Grabowski, Pasurka and Rangan (1990) split pooled data into two groups in the U.S. banking industry and calculated efficiency indexes for each sub-sample, in addition to calculation using the pooled sample. Since the number of the sample in this study is limited, calculation using the pooled sample has been conducted and the efficiency indexes have been averaged by size of revenues.
11. Hjalmarsson and Veiderpass (1992) calculated the Malmquist productivity in the electricity retail distribution and also indicated that there were no significant differences in productivity growth between different types of ownership.

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