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A metafrontier study of securities broker and dealer efficiency under zero-sum gains

Abstract

This paper studies the broker and dealer (B&D) efficiency across groups of securities firms under zero-sum gains (ZSG) framework from the concept of a metafrontier. Existing studies that estimate the firm-level efficiency using conventional data development analysis (DEA) neglect the 100% market share restriction. The empirical findings suggest that the conventional DEA model underestimates the efficiency of inefficient securities firms in Taiwan, as compared to the ZSG-DEA. The output-oriented technology gap ratio of a metafrontier indicates that the foreign ownership form has a significantly positive impact on efficiency in Taiwan. The financial holding companies (FHC) in Taiwan show insignificantly negative effects on their securities subsidiaries. Specialized securities brokerage firms (SBFs) have significantly higher efficiency than Non-FHC's integrated securities firms (ISFs). These results prove that the financial reform triggered by the government is not able to improve B&D efficiency in the securities industry.

Keywords: metafrontier, zero-sum gains, technology gap ratio, ownership.
JEL Classification: D24, G24, G2, C61, C6.

Introduction

Securities firms serve as brokers intermediating between fund suppliers and business at a low cost and with a maximum degree of efficiency involving the trading of stocks in the secondary market in Taiwan. These firms generally receive the largest percentage of their revenue from brokerage commissions on stocks transactions. Hence, how to maximize market shares of stocks is the major objective of each securities firm in Taiwan. Market share is a frequently identified goal of corporate management (Mueller, 1983). Research addresses on the relationship between market share and efficiency for the Hungarian corporate sector (Halpern and Körösi, 2001).

The application of modern technologies has made it possible to trade securities via telephone or Internet, inducing the securities firms to invest more in electronic trade technologies in order to grab more shares of traded stocks. In Taiwan and in the UK, the stock market value to GDP is approximately 140. There is a higher turnover ratio in terms of trading value for the Taiwan stock market compared to other major stock markets. The total trading amount in Taiwan's securities market in 2006 achieved NT$24,205 billion including 98.7% in stocks (in dealing and brokerage), 0.12% in TDRs, 0.72% in warrants, 0.31% in ETFs, and 0.10% in others, respectively. Hence, the securities firms in Taiwan pursue the maximization of market share in terms of stock dealing and brokerage to reap more revenue and dominate the stock market of the broker and dealer (hereinafter B&D). In June 1989, the Taiwan Stock Exchange Corporation (TWSE) accepted the application of foreign securities firms to set up branches in Taiwan to engage in domestic brokerage business as well as international securities transactions. The securities industry in Taiwan has become increasingly competitive, because of the establishment of financial holding companies (FHCs) in 2003. In other words, this highly competitive environment is close to zero-sum gains (Lins et al., 2003) in which securities firms want to expand their market share within the 100%-sum constraint. Especially in the short term, the market size is fixed such that the sum of stock market share of B&D is 100%. In the securities industry, an individual SF pursues the goal of market share maximization by innovating itself as an e-broker or e-trader. Hence, securities firms try to expand their market shares by their investments. Market share is the trading amount in brokerage and proprietary trading of an individual firm divided by the total trading amount of all securities' brokers and dealers. The efficiency score is measured by the economic performance using the productive efficiency of obtaining maximal output levels. The first main objective of this study is to measure the firm-level B&D efficiencies of securities firms (hereinafter SFs), under a zero-sum gains framework, which measure production efficiency representing maximum B&D market share from a given fixed assets, financial capital, as well as general and administrative expenses. The second objective of this paper is to examine the influence of the ownership structure on efficiency, and find out the determinants of efficiency in the securities industry. Under B&D market share competition, given the fact that a securities firm's market share gain is another's market share loss, the conventional BCC data envelopment analysis (hereinafter BCC-DEA) model (Banker, Charnes and Cooper, 1984) neglects the 100% market share restriction. Lins et al. (2003) introduce a zero-sum gains data envelopment analysis (hereinafter ZSG-

DEA) model, whereby the sum of outputs is constant, in order to assess the ranking of participant countries in the Sidney 2000 Olympic Games based on single aggregated medals. This paper herein utilizes the ZSG-DEA model to measure the B&D efficiency with a consideration of a constant sum of output.

The number of securities firms totals 92 in Taiwan's market including integrated securities firms (hereinafter ISFs), which perform various major services including brokerage activity, underwriting services, and proprietary trading, and securities brokerage firms (hereinafter SBFs). Foreign securities firms were permitted to set up branches in Taiwan in 1989. Advanced technology accompanies foreign direct investment to enter the host country, making foreign firms more efficient than domestic competitors (Dimelis and Louri, 2002). We define the foreign-affiliated SFs for those branches of multinational SFs in Taiwan since 1989, in contrast to the domestic SFs. The financial holding companies (hereinafter FHC) had been established during 2002-2003, but only allowing the ISFs to be the securities subsidiary of an FHC according to *the Financial Holding Company Act* in Taiwan. The number of ISFs increased from 39 in 1990 to 48 in 2006; the number of foreign-owned securities firms increased to 18 in 2006; the number of FHC-affiliated ISFs was 14 in 2006; however, the number of SBFs decreased from 373 in 1990 to 44 in 2006. Hence, a question is raised of whether the policymakers prohibit the SBFs from being a subsidiary of FHC, because they are inefficient or small-sized. Therefore, this paper includes SBFs, whose average asset value is NT$0.5bn in 2006 which is relatively smaller than the average asset value of ISFs (NT$31.2bn), and ISFs as the dataset of this model.

This paper utilizes the metafrontier to DEA approach developed by Rao et al. (2003) in order to study the impact of foreign ownership, the membership in an FHC, and the variety of services on efficiency. All securities firms are arranged into four groups in this paper. Foreign-owned securities firms including foreign-owned ISFs and SBFs are the first group, the subsidiaries in a financial holding company are the second group, the non-FHC ISFs are the third group, and the domestic SBFs are the fourth group.

Avkiran (1999) employs two DEA models to measure the efficiency and indicates that DEA analysis is sensitive to the choice of variables. However, this is also a kind of strength in providing management-specific information as the method for improving firm-level efficiency. Efficiency measurement using DEA models from different perspectives can depend on the decision-making requirements.

This is the little research, where there are various groups and securities firms in each group operating under an ownership-specific technology, to measure efficiency with respect to group frontiers and metafrontier. The majority of Taiwan's market players pursue the maximization of a stock's market share in order to be the leading securities firms and attract the attention of institutional investors.

This paper is organized as follows: The literature review is presented in section 1. Section 2 introduces zero-sum gains DEA and metafrontier frameworks. Section 3 describes data resources and variables. Section 4 presents empirical results. The last section concludes this paper.

1. Literature review

Blundell et al. (1999) investigate the relationship between market share and innovation. Halpern and Körösi (2001) take a look at the link between market share and efficiency for the Hungarian corporate sector and indicate a gradual improvement in efficiency due to the growing share of small firms. Avkiran (1999) assumes a positive correlation between change in market share and change in efficiency after a merger and acquisition.

Al-Obaidan (2008) analyzes the efficiency by measuring a production function representing maximum output levels from a given inputs, and measures economic performance using the productive efficiency of obtaining maximal output levels.

The lack of firm-level data has made research on securities firms very difficult and rare to see (Goldberg et al.., 1991), not to mention any study on small-sized and specialized SBFs. Goldberg et al. (1991) adopt survey data in a translog multi-product cost function to examine the economies of scale and suggest that if the Glass-Steagall restrictions are relaxed, then banks are able to enter the securities industry with a brokerage division and see about US$30 million in revenue. In Taiwan the group of SBFs has not received adequate attention in existing studies even though the number of SBF is similar with the number of ISFs. Wang et al. (2003) study the efficiency of ISFs in Taiwan during 1991-1993 using a DEA model as well as a Tobit censored regression and conclude that the impact of a firm's service concentration on its technical efficiency is positive, which means that the diverse services of a firm decrease its technical efficiency. When the stock market is declining, having more branches instead becomes a burden for management and the diversified complexities on operations make it difficult for managers to make decisions. However, Wang et al. (2003) exclude the dataset of SBFs.

Elyasiani and Mehdian (1995) show that small banks were more efficient than large banks in the U.S. during 1979, however, this finding became statistically insignificant in 1986 and suggests that mergers produce little gain in efficiency to make equal efficiency between small and large banks. Rhoades and Savage (1981) suggest that small banks can achieve profitability levels compared to their larger counterparts, because small banks cater to a different group of customers about whom they have informational advantages and offer a set of products differentiated from those of large banks. On the contrary, Mukherjee et al. (2001), Baldwin (1996) and Miller and Noulas (1996) support that larger financial institutions associate with the higher efficiency. This article attempts to measure the efficiency score under the 100% market share constraint and investigate the impact of ownership toward efficiency.

2. Zero-sum gains DEA and metafrontier methodology

2.1. BCC and ZSG DEA models. DEA is a linear programming model that identifies an efficient frontier, which consists of the efficient decision making units (DMUs). Efficient DMUs are those for which no other DMUs are able to generate at least the same amount of each output under given inputs (Charnes et al., 1978). Efficiency scores reflect the ability of firms to generate the maximum outputs under a given level of inputs. This paper is to measure the firm-level B&D efficiencies of SFs, under a zero-sum gains framework, which measure production efficiency representing maximum B&D market share from a given fixed assets, financial capital, as well as general and administrative expenses.

2.2. Traditional BCC-DEA model. DMU_i is the object unit that is attempting to maximize its output. All DMUs in the same year constitute the reference set to construct the efficiency frontier for each DMU_i. The aim of the traditional DEA model is to make the less efficient object unit at least as efficient as the others by increasing its output. Banker et al. (1984) extend the constant returns to scale (CRS) DEA model to a variable returns to scale (VRS) situation.

The dual solution of the traditional output-oriented BCC-DEA using duality expressed by Coelli (1996) to measure the efficiency score θ_i for DMU_i is shown as:

$$
\begin{aligned}
&1/\theta_i = \underset{\phi_i, \lambda_1, \ldots, \lambda_N}{Max}\ \phi_i \\
&s.t. \quad \phi_i y_i^m \le \sum_{j=1}^{N} \lambda_j y_j^m,\ m = 1,\ldots,M, \\
&\qquad x_i^k \ge \sum_{j=1}^{N} \lambda_j x_j^k, k = 1,\ldots,K, \\
&\qquad \sum_{j=1}^{N} \lambda_j = 1, \\
&\qquad \lambda_1,\ldots,\lambda_N \ge 0,
\end{aligned}
\tag{1}
$$

where ϕ_i shows the inverse of efficiency score of DMU_i; the efficiency score θ_i of DMU_i is $1/\phi_i$; N is the number of DMUs; K and M are respectively the number of inputs and outputs; x_j^k is the amount of the k-th input consumed by the j-th DMU; y_j^m is the amount of the m-th output produced by the j-th DMU; λ_j is each efficient DMU's individual share in the definition of the target for DMU_i.

The BCC-DEA model here measures the firm-level efficiency score (θ_i) in the securities industry. An SF (as a DMU in the DEA model) pursuing more market share naturally means that other SFs lose some market share, because the total market share is 100%. Accordingly, this constant sum of output is unable to use the traditional BCC-DEA model, in which the output of any given DMU is not influenced by the output of the others, to assess the efficiency score. This is our motivation to adopt the ZSG-DEA model to measure the efficiency score of SFs.

2.3. Zero-sum gains DEA model. The ZSG-DEA model assesses the efficiency score provided that the sum of outputs is constant. Lins et al. (2003) indicate that this is similar to a zero-sum game whereby how much is won by a player is lost by one or more of the other players. The equal output reduction strategy is generated to measure the efficiency score ($\theta_{iR} = 1/\phi_{iR}$) for DMU_i in equation (2) shown below and graphically represented using a simple case involving one input, x, and one output, y, in Figure 1:

$$
\begin{aligned}
&1/\theta_{iR} = \underset{\phi_{iR}, \lambda_1, \ldots, \lambda_N}{Max}\ \phi_{iR} \\
&s.t. \quad \phi_{iR} y_i^m \le \sum_{j=1}^{N} \lambda_j y_j^m [1 - \frac{y_i^m(\phi_{iR} - 1)}{N-1}],\ m = 1,\ldots,M, \\
&\qquad x_i^k \ge \sum_{j=1}^{N} \lambda_j x_j^k, k = 1,\ldots,K, \\
&\qquad \sum_{j=1}^{N} \lambda_j = 1, \\
&\qquad \lambda_1,\ldots,\lambda_N \ge 0,
\end{aligned}
\tag{2}
$$

where term ϕ_{iR} is the inverse of efficiency score of the ZSG-DEA model with $\phi_{iR} \ge 1$; and the efficiency score θ_{iR} of DMU_i is the inverse of ϕ_{iR} ($\theta_{iR} = 1/\phi_{iR}$) in the ZSG-DEA model. The term $y_i^m(\phi_{iR} - 1)$, representing losses of the other DMU j ($j \neq i$), must have one DMU i to win $y_i^m(\phi_{iR} - 1)$ output units.

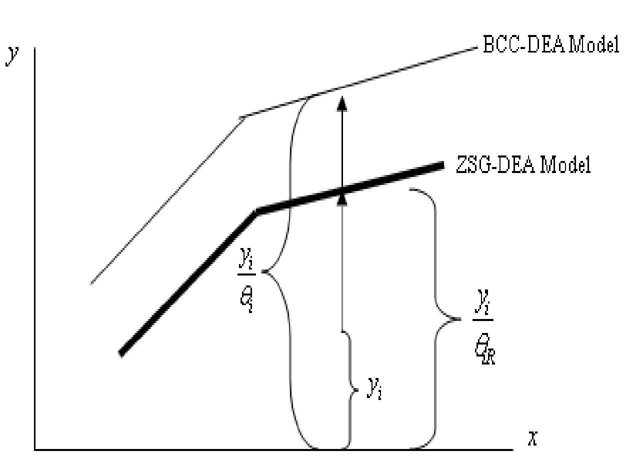

Fig. 1. Graphical representation of the equal output reduction method

This model here causes some DMUs to have a negative output after replacing the output as the reduction coefficient. A simple example in Appendix A illustrates an unreasonable case in which an equal output reduction under zero-sum gains set-up generates a negative output. Hence, provided that $y_i^m(\phi_{iR}-1) \le \min(y_j^m),\ m=1,...,M$, this equal output reduction strategy can apply. To avoid this major weakness, Lins et al. (2003) further develop the proportional output reduction strategy for any given DMU i, by the ratio $\frac{y_i^m(\phi_{iR}-1)}{Y^m-y_i^m}$, where Y^m is the constant sum of the m-th output. Thus, DMU i needs to win $y_i^m(\phi_{iR}-1)$ output units, and the losses of the other DMUs are proportional to their levels of output. The condition that the sum of losses is equal to the gains of DMU i still holds.

Figure 2 represents the ZSG-DEA frontier created by this proportional reduction strategy and the BCC-DEA frontier using a simple case involving one input and one output. DMU i wins $y_i^m(\phi_{iR}-1)$ output units, and losses of other DMUs are proportional to their levels of output, which is $y_j^m(\frac{y_i^m(\phi_{iR}-1)}{Y^m-y_i^m})$. If the output y_j of DMU j is larger than those of other DMUs, then the output reduction $y_j^m(\frac{y_i^m(\phi_{iR}-1)}{Y^m-y_i^m})$ is also larger than others, vice versa. Model (3) substitutes model (2) for the proportional output reduction strategy to measure the efficiency score ($\theta_{iR} = 1/\phi_{iR}$) of DMU_i as:

$$1/\theta_{iR} = \underset{\phi_{iR},\lambda_1,...,\lambda_N}{Max}\ \phi_{iR}$$

$$\begin{aligned} s.t.\quad & \phi_{iR}y_i^m \le \sum_{j=1}^{N}\lambda_j y_j^m[1-\frac{y_i^m(\phi_{iR}-1)}{Y^m-y_i^m}], m=1,...,M, \\ & x_i^k \ge \sum_{j=1}^{N}\lambda_j x_j^k, k=1,...,K, \\ & \sum_{j=1}^{N}\lambda_j = 1, \\ & \lambda_1,...,\lambda_N \ge 0, \end{aligned} \quad (3)$$

However, Lins et al. (2003) report that it is very labor-consuming to obtain results in this non-linear programming problem as well as for a large number of variables. The model is simplified when there is only a single output (m =1). Appendix A provides an example to explain the computational steps of the proportional output reduction strategy.

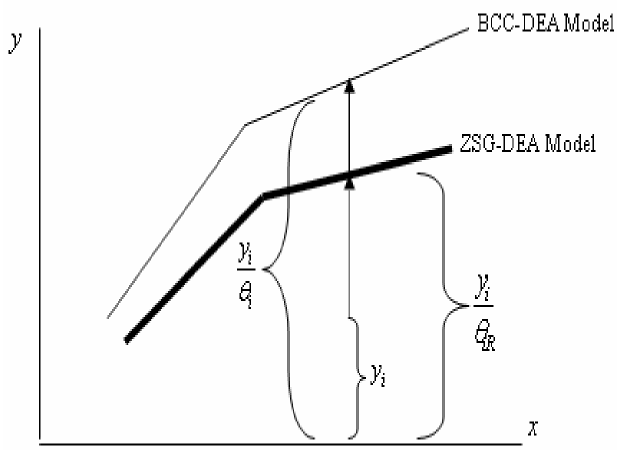

Fig. 2. Graphical representation of the proportional output reduction method

The following theorem holds under a single output ZSG-DEA proportional reduction strategy.

Lins Theorem (Lins et al., 2003). The target for a DMU to reach the efficiency frontier in a ZSG-DEA proportional output reduction strategy model equals the same target in the traditional BCC-DEA model multiplied by the reduction coefficient ($1-\frac{y_i(\phi_{iR}-1)}{Y-y_i}$).

Owing to this theorem, equation (4) below holds.

$$\begin{aligned} \phi_{iR}y_i &= \sum_{j=1}^{N}\lambda_j y_j[1-\frac{y_i(\phi_{iR}-1)}{Y-y_i}] \\ &= \phi_i y_i[1-\frac{y_i(\phi_{iR}-1)}{Y-y_i}] \end{aligned} . \quad (4)$$

The efficiency score of the ZSG-DEA model is obtained from equation (5), due to the fact that the sum of total market share (%) is 100:

$$\theta_{iR} = \frac{\theta_i y_i(100 - y_i) + y_i^2}{y_i(100 - y_i + 1)}. \quad (5)$$

Lins et al. (2003) also infer that the value of the weight of DMU i's peers (λ_i) equals its value in the traditional BCC-DEA model. This ZSG-DEA model with the proportional reduction is only applied on the single output for Olympic rankings. This ZSG-DEA model is then applied to measure efficiency score of SFs when the market share in percentage always sums up to 100 in terms of B&D business.

2.4. Construction of the DEA approach to a metafrontier and the technology gap ratio. Rao et al. (2003) use the DEA approach to construct a metafrontier obtained by pooling all observations from all the regions and build various regional frontiers so as to analyze the efficiencies and technology gap ratio. Figure 3 shows the graph of the metafrontier function from Battese et al. (2004) using a simple example involving one input, x, and one output, y.

This paper utilizes the output-orientated DEA model which consists of k regions, and observations of L_k units in the k-th region, to construct the regional frontiers as below:

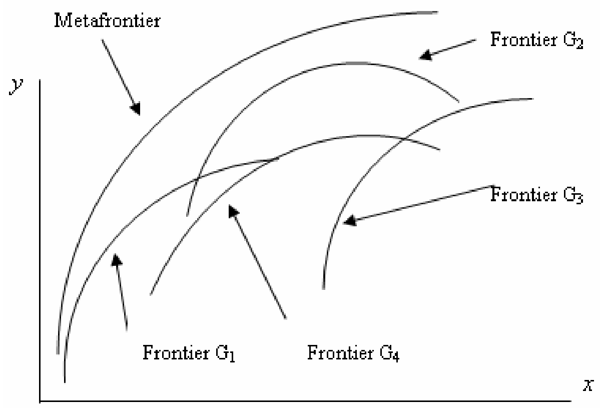

Fig. 3. Metafrontier function model

$$1/\theta_{iL_k} = Max\ \phi_{iL_k}$$

$$\phi_{iL_k}, \lambda_1, ..., \lambda_{L_k}$$

$$s.t. \quad \phi_{iL_k} y_i^m \le \sum_{j=1}^{N} \lambda_j y_j^m, m = 1,...,M,$$

$$x_i^k \ge \sum_{j=1}^{L_k} \lambda_j x_j^k, k = 1,...,K, \quad (6)$$

$$\sum_{j=1}^{L_k} \lambda_j = 1,$$

$$\lambda_1, ..., \lambda_{L_k} \ge 0,$$

where $N = \sum_k L_k$ and ϕ_{iL_k} is the reciprocal of efficiency θ_{iL_k} with respect to the G_k-th regional frontier. Using the definition of output-orientated efficiency, equation (7) expresses the technology gap ratio of the i-th DMU as follows:

$$TGR_{ik} = \frac{\phi_{iL_k}}{\phi_i}. \quad (7)$$

This paper assesses the efficiency under the ZSG framework in all observations and constructs the technology gap ratio of the i-th DMU under the ZSG model from equations (5) and (7) as below:

$$TGR_{ik-ZSG} = \frac{\phi_{iL_k}}{\phi_{iR}}. \quad (8)$$

Thus, the efficiency under ZSG relative to the metafrontier function is the product of the efficiency relative to the regional frontier and the TGR_{ik-ZSG} as follows:

$$\theta_{iR} = \theta_{iL_k} \times TGR_{ik-ZSG}. \quad (9)$$

2.5. The two-stage approach and environmental variables. The two-stage approach (McCarty and Yaisawarng, 1993; Wang et al., 2003) involves solving a DEA problem in the first stage and then the efficiency obtained in the first stage being regressed upon the environmental variables in the second stage. Some factors, which are environmental variables, may affect the efficiency of DMUs. The sign of the coefficients of the environmental variables indicates the direction of the influence, and the standard hypothesis tests can be used to measure the strength of the relationship. Researchers adopt the Tobit regression model instead of the OLS model to measure the significance of the relationship. Esho (2001) adopts the second-stage regression to investigate the relationship between the capital to asset ratio, size, age, and efficiency. Mukherjee et al. (2001) investigate the relationships between the asset value, the square of asset value, and productivity growth and find out that the bigger-sized American banks have significantly positive influences on productivity growth, but insignificant coefficients on the square of asset value. Dimelis and Louri (2002) analyze the efficiency gains caused by the diverse degree of foreign ownership in Greece in 1997 which indicate a positive effect on labor productivity of foreign ownership. Deyoung and Nolle (1996) find out that foreign-owned banks are less profit-efficient than U.S.-owned banks. Elyasiani and Mehdian (1997) report that foreign-owned banks are less cost efficient than U.S. banks and even statistically insignificant. Wheelock and Wilson (2000) include a dummy variable to test whether membership in a multi-bank holding company affects the probability of failure. These authors indicate that if a parent company injects cash into a weak subsidiary, than a holding company membership might lessen the chance of failure. On the other hand, the failure of a primary bank in a holding company has sometimes led regulators to close all holding company members. It is an interesting issue of this paper to investigate whether the efficiency of foreign-owned securities firms or the securities subsidiaries of FHCs is better than that of the domestic specialized securities firms or not.

This study examines the determinants of efficiency by regressing on the measured efficiency using the Tobit censored regression model.

3. Data and variables

3.1. Variables. The paper herein follows the model developed by Lins et al. (2003) to choose single output and multiple inputs to measure efficiency. Drake, Hall and Simper (2006) introduce a profit-oriented model with revenue components as outputs and cost components as inputs in a banking efficiency study. Banks capture their profit maximization goal by increasing revenue and reducing cost. In the securities industry, an individual securities firm pursues the goal of market share maximization by innovating itself as an e-broker or e-trader. Thus, this output-oriented ZSG-DEA model chooses market share as the single output. Drake and Hall (2003) adopt general and administrative expenses and fixed assets as the two inputs of the DEA model. Berger and Mester (1997) indicate that another important aspect of efficiency measurement is the treatment of financial capital. A bank's available financial capital to absorb possible losses helps reduce its insolvency risk. Accordingly, this study adopts fixed assets, in which the securities firms increase their fixed assets by investing in computer hardware, financial capital, as well as general and administrative expenses as the three inputs of the ZSG-DEA model.

To examine the isotonicity between a single output and multiple inputs, one can use the key elements of production functions, and subsequently assess the efficiency using DEA. This study has calculated the positive correlation coefficients (0.9, 0.9, and 0.75, respectively) between a single output and multiple inputs and it allows us to measure efficiency using DEA model.

3.2. Environmental variables. Following the work by Mukherjee et al. (2001) and Esho (2001), this study chooses 5 factors to perform a second-stage econometric analysis. The explanatory variables are discussed next. *SIZE* defines the scale of operation as the total assets. Baldwin (1996) suggests that size, as defined by total assets, is expected to increase productivity, because larger-sized firms may be more efficient. Miller and Noulas (1996) report a significantly positive correlation between bank size (total assets) and pure technical efficiency, but Avkiran (1999) provides evidence that there is no significant correlation between bank size and overall operating efficiency during 1986-1995.

Including the total assets as one of determinants of efficiency is the key issue in this paper. Regulators consider capital adequacy as an important indicator when evaluating the performance of a financial institution. Esho (2001) adopts the second stage regressions to investigate the relationship between the capital to asset ratio, size, age, and efficiency. Accordingly, this paper also selects *Capital-Asset Ratio (CAR)* and age (herein *the year of services; YS*) as two explanatory variables in the analysis. Moreover, the more branches a securities firm has, the more convenient it is for customers even though more branches also involve higher expenses for a securities firm. This model includes the number of branches (*Branch*) as one of the factors toward B&D efficiency.

This study considers four groups of securities firms: Foreign-owned securities firms including foreign-owned ISFs and SBFs are the first group, the subsidiaries in a financial holding company are the second group, the non-FHC ISFs are the third group, and the domestic SBFs are the fourth group. Taking the domestic SBFs as the benchmark, this regression equation includes three dummy variables for each of the other three groups.

3.3. Data. This study collects a cross-sectional dataset during 2006 including 92 securities firms in Taiwan. Market share is measured by the ratio of firm-specific trading amount in brokerage and dealing divided by total trading amount of securities brokers and dealers for 2006. The firm-level data for the variables in this model are fixed asset value, general expenses, financial capital, total assets, year of services, trading volume, the number of branches, and ownership structure. All variable data are from the reports of the Taiwan Stock Exchange Corporation. Output orientation is a better choice here, because the obvious aim for an individual securities firm is to try to dominate the market through maximizing market share in Taiwan. Table 1 provides the statistics of the dataset.

Table 1. Descriptive statistics of variables[a]

Variable	Mean	S.D.	Min	Max
G_1 – Foreign-owned securities group				
MS	0.96	0.67	0.05	1.82
FA	0.24	0.10	0.09	0.50
CA	0.77	0.56	0.15	2.00
EXP	0.83	0.84	0.03	3.40
SIZE	2.29	1.26	0.62	4.85
CAR	0.39	0.27	0.06	0.95
YS	6.44	4.46	1.00	17.00
VOL	466.16	321.83	24.75	878.72
Branch	1.00	0.00	1.00	1.00
G_2 – FHC ISFs				
MS	2.61	1.89	0.37	6.20
FA	3.02	1.82	0.43	5.46
CA	8.93	4.14	3.06	15.50
EXP	5.26	3.57	0.36	10.17
SIZE	36.59	27.60	4.32	85.45
CAR	0.34	0.18	0.14	0.86
YS	17.36	9.91	3.00	46.00
VOL	1265.49	913.89	179.03	2998.91
Branch	35.79	22.30	4.00	67.00
G_3 – Domestic non-FHC ISFs				
MS	1.69	2.13	0.01	8.14
FA	2.73	2.74	0.15	9.89
CA	7.63	8.57	0.66	31.89
EXP	4.79	7.18	0.06	31.41
SIZE	31.15	37.70	0.50	142.85
CAR	0.44	0.33	0.17	1.31
YS	22.05	9.80	9.00	45.00
VOL	821.94	1034.12	5.63	3941.40
Branch	21.18	24.37	1.00	100.00
G_4 – Domestic SBFs				
MS	0.14	0.13	0.02	0.51
FA	0.21	0.14	0.08	0.63
CA	0.30	0.11	0.20	0.70
EXP	0.10	0.07	0.02	0.33
SIZE	0.54	0.37	0.12	2.12
CAR	0.68	0.29	0.33	1.63
YS	16.42	3.36	6.00	19.00
VOL	65.33	60.78	10.15	248.95
Branch	2.18	1.41	1.00	6.00

Notes: 1. [a] All variables are in billions of NT$ dollars except market share. Market share is in %. 2. Mean is the average; S.D. is the standard deviation; Minimum is the minimum value over the observations; Maximum is the maximum value across the selected observations. 3. The variables are defined as follows: market share (*MS*) is measured in an individual firm's trading amount in brokerage and dealing divided by total trading amount in broker and dealer, fixed asset (*FA*), capital (*CA*), general expenses (*EXP*), total asset (*SIZE*), ratio of capital to asset (*CAR*), year of services (*YS*), trading amount (*VOL*), number of branches (*Branch*).

4. Results and discussion

4.1. Results of ZSG-DEA and BCC-DEA models. This research adopts the output-oriented BCC-DEA (Banker et al., 1984) and ZSG-DEA models (Lins et al., 2003) to assess the B&D efficiency of securities firms.

Equations (1) and (5) respectively calculate the B&D efficiency of the BCC-DEA and ZSG-DEA models and are presented in Table 2. With the fact that a securities firm's market share gain is another's market share loss, the conventional DEA model underestimates the efficiency of inefficient securities firms in Taiwan, as compared to the ZSG-DEA. This study calculates a paired-difference *t* test and non-parametric Wilcoxon test to determine whether the efficiencies of these two models are significantly different and Table 2 presents the results of these two tests. The average efficiency in the ZSG-DEA model is statistically, significantly higher than that in the BCC-DEA model. The gap in efficiency between efficient and inefficient securities firms under a ZSG framework is significantly less than that under the conventional models. Hence, with the objective of maximizing B&D market share, the efficient securities firms need to develop more marketing strategies and introduce more techniques to maintain their leading role in the market. Because a securities firm's market share gain is another's market share loss, once one securities firm reaps more market share, the B&D efficiency of this securities firm would make much progress and the other securities firms would relatively decrease their efficiency. The efficiency gap between efficient SFs and inefficient SFs in the ZSG-DEA model is relatively less than the one in the conventional BCC-DEA model.

Table 2. Comparisons of efficiencies between BCC-DEA and ZSG-DEA

Group	L_k	BCC	ZSG	BCC-ZSG	Paired *t*	Wilcoxon
		Mean	Mean	Difference	t ratio	z value
G_1 – Foreign-owned securities	18	0.71	0.71	0.00	-1.82**	-1.54
G_2 – FHC ISFs	14	0.59	0.61	0.02	-4.30***	-3.27***

Table 2 (cont.). Comparisons of efficiencies between BCC-DEA and ZSG-DEA

Group	L_k	BCC	ZSG	BCC-ZSG	Paired *t*	Wilcoxon
G_3 – Domestic non-FHC ISFs	22	0.35	0.36	0.01	-3.46***	-3.96***
G_4 – Domestic SBFs	38	0.42	0.42	0.00	3.24	2.29***
Overall	92	0.46	0.47	0.01	-3.92***	-3.51***

Notes: H1: mean (BCC-DEA – ZSG-DEA) < 0; *** and ** indicate significance at the 5% and 10% levels, respectively.

4.2. Efficiencies and technology gap ratio. Table 3 provides average DEA efficiencies from the group frontier and metafrontiers. The technology gap ratio of the foreign-owned securities group is 0.97, which is the highest ratio across these 4 groups. This means that, given inputs, the potential outputs for the foreign-owned securities group's technology is 97 percent of that represented by the metatechnology. The technology gap ratio of the domestic specialized securities brokerage group is 0.53, which is higher than the ratio of the non-FHC integrated securities group. This means that the technology in the SBFs is higher than that in the non-FHC ISFs. This empirical result is consistent with Wang et al. (2003) and Rhoades and Savage (1981). The efficient specialized SBFs in Taiwan have made efforts in the services of their top-tier VIP customers in order to achieve a higher efficiency even without diverse services, such as underwriting and proprietary trading. FHC-owned ISFs are the second highest group in terms of the technology ratio. However, unlike bank holding companies in U.S., the financial holding company in Taiwan is a financial institution only allowing the investment and management in their different type of subsidiaries without business operations according to *the Financial Holding Company Act.* Whether a parent company like Taiwan's FHC has a positive effect on its securities subsidiaries in terms of efficiency is an interesting issue. Therefore, this paper further investigates the influence of ownership on efficiency.

Table 3. Estimates of efficiencies and technology gap ratios by group

	Group	L_k	Mean	S.D.	Minimum	Maximum
Efficiency with respect to the group frontier (G_k)	G_1 – Foreign-owned securities	18	0.73	0.36	0.04	1.00
	G_2 – FHC ISFs	14	0.83	0.25	0.34	1.00
	G_3 – Domestic non-FHC ISFs	22	0.83	0.22	0.39	1.00
	G_4 – Domestic SBFs	38	0.63	0.27	0.14	1.00
Technology gap ratio (TGR)	G_1 – Foreign-owned securities	18	0.97	0.10	0.65	1.00
	G_2 – FHC ISFs	14	0.73	0.28	0.23	1.00
	G_3 – Domestic non-FHC ISFs	22	0.43	0.31	0.01	1.00
	G_4 – Domestic SBFs	38	0.53	0.28	0.22	1.00
Efficiency under ZSG with respect to the metafrotier	G_1 – Foreign-owned securities	18	0.71	0.36	0.04	1.00
	G_2 – FHC ISFs	14	0.61	0.30	0.15	1.00
	G_3 – Domestic non-FHC ISFs	22	0.36	0.29	0.01	1.00
	G_4 – Domestic SBFs	38	0.42	0.31	0.05	1.00
	All securities firms	92	0.47	0.34	0.01	1.00

4.3. Determinants of efficiency. The research now employs the two-stage approach to examine the influence of environmental variables on the efficiency as follows:

$$Efficiency = f\,(SIZE, CAR, YS, VOL, Branch, D_{foreign}, D_{FHC}, D_{Local\ IS}), \quad (9)$$

where *SIZE* is the asset value of the securities firm, *CAR* is the ratio of capital to assets, *YS* is the years of services existing in the securities market, *VOL* is the total trading amounts, and *Branch* is the number of branches. Taking the domestic SBFs as the benchmark, this regression equation includes three dummy variables for each of the other three groups. ($D_{foreign}$, D_{FHC}, $D_{Local\ IS}$) = (1, 0, 0) represents the foreign-owned securities group, ($D_{foreign}$, D_{FHC}, $D_{Local\ IS}$) = (0, 1, 0) is the group of subsidiaries in an FHC, and ($D_{foreign}$, D_{FHC}, $D_{Local\ IS}$) = (0, 0, 1) means the third group of non-FHC ISFs.

Table 4. Tobit regression results

	Dependent variable: Efficiency under ZSG-DEA	
Independent variable	Model 1	Model 2
SIZE	-0.005* (0.003)	-0.006** (0.003)

Table 4 (cont.). Tobit regression results

	Dependent variable: Efficiency under ZSG-DEA	
Independent variable	Model 1	Independent variable
CAR	0.130 (0.109)	-
YS	0.004 (0.005)	-
VOL	0.001*** (0.000)	0.001*** (0.000)
Branch	-0.009 (0.006)	-
$Dummy_{Foreign}$	0.191* (0.112)	0.238*** (0.081)
$Dummy_{FHC}$	-0.080 (0.112)	-
$Dummy_{Local\ IS}$	-0.211** (0.082)	-0.162** (0.073)
σ	0.255 (0.021)	0.264 (0.021)
Log likelihood function	-15.148	-18.584
Pseudo R-square	0.704	0.636

Note: 1. Numbers in the parentheses are standard deviations. 2. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 4 presents the result of the second-stage Tobit regression model. The total amount of assets (*SIZE*) has a significantly negative effect on ZSG-efficiency. This result is consistent with Elyasiani and Mehdian (1995) and Rhoades and Savage (1981). The large-sized securities firms, on the contrary, do not necessarily have higher efficiency. According to Table 1, the respective average asset value of foreign-owned securities firms and domestic SBFs is NT$2.29bn and NT$0.54bn, relatively smaller than the other groups. However, the result of the second-stage regression shows that these two groups of securities firms have significantly higher efficiency than the other groups. The small-sized securities firms do have a positive impact on efficiency. Total trading amount (*VOL*) has a significantly positive impact on ZSG-efficiency. This empirical finding suggests that securities firms are able to achieve higher efficiency when the stock market is booming, or when an individual securities firm surpasses competitors in its dealing or trading volume.

The result also shows a significantly positive effect of foreign ownership on efficiency, which is consistent with Dimelis and Louri (2002). They indicate that the higher the degree of foreign ownership is, the more advanced the technology is that will be transferred and the more efficient the production will be. A fully foreign-owned affiliate is the most efficient, since the parent firm has no inhibition to transfer its top technology to it. This result further confirms the trend that there was a continuous stream of prestigious foreign-affiliated securities firms that established branches in Taiwan during the early 2000s, including Deutsche Securities Asia, Lehman Brothers, HSBC Securities Asia, and Macquarie Securities (acquiring ING Securities in Taiwan). $D_{Local\ IS}$ has a significantly negative relationship with efficiency compared with the group of SBFs. This result suggests that the policymakers may re-consider not prohibiting SBFs from being the subsidiaries of FHCs. The other two variables, the capital to asset ratio and years of services, are insignificantly positive to efficiency. Both the number of branches and the members of FHCs have an insignificant negative effect on efficiency. We omit the insignificant variables from model 1 and present the results of model 2 in Table 4. The above-mentioned findings show further significance at the 1% and 5% levels, respectively. This empirical result shows that the strict entry regulation and FHC ownership of securities firms are adversely affecting Taiwan's securities market development and efficiency of securities firms.

Conclusion

This paper utilizes the DEA approach of metafrontier to investigate the B&D efficiencies of securities firms under the ZSG framework, examine the effect of the ownership form on ZSG-efficiency, and find out the determinants of efficiency in the securities industry. We collect the cross-sectional population of 92 securities firms in Taiwan in 2006, including the small-sized SBFs which current researches studies have ignored.

In order to accelerate the internationalization and liberalization of the domestic capital market, the Ministry of Finance in Taiwan launched integrated securities firms in May 1988. Foreign securities firms were permitted to set up branches in Taiwan in 1989. The launch of FHCs began in 2003. The empirical findings from the technology gap ratio of the metafrontier and the second-stage regression are that both the group of foreign-owned securities firms and the group of SBFs have significantly positive impact on B&D efficiency. Even though the current regulation in Taiwan prohibits specialized securities firms from being the subsidiaries of an FHC, the SBFs show a higher efficiency. The efficient specialized SBFs in Taiwan have made efforts in the services of their top-tier VIP customers even without diverse services, such as underwriting and proprietary trading. The foreign-owned securities firms have taken advantage of their international reputation and investment knowledge from global research teams to attract more customers and maximize market share using less expenditure. This result further confirms the trend that there was a continuous stream of prestigious foreign-owned securities firms that established branches in Taiwan during the 2000s. Future research could utilize the panel dataset to further confirm this finding and suggest to policymakers to include small and specialized securities firms as members of FHCs.

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