A Context-dependent Efficiency Evaluation of Japanese Securities Firms

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Abstract

This research adopts context-dependent data envelopment analysis (CD-DEA) proposed by Seiford and Zhu (2003) to compute the efficiencies of Japan's 23 securities companies during 2010-2015 and discusses whether or not online securities firms are relatively more efficient. We use three inputs and one output to compute the efficiency scores and divide a set of DMUs into different levels of efficiency frontiers, constructing several levels of efficiency frontiers in order to provide the inefficient securities firms with achievable targets and to present sub-targets as role models in management practice. Online securities firms concentrating on the brokerage business with lower costs are stable on levels 1 and 2 for six years. However, quasi-major and mid-ranked securities firms operating counter services in local areas show a downward trend in their efficiency over this period. On the other hand, the major securities firms and securities firms affiliated with major banks managing diversified businesses (including retail and wholesale) move up and down in the middle efficiency levels. The empirical results show that online securities firms are more efficient than other types of securities firms in Japan, and that the middle-ranked regional securities firms reside at the lowest efficiency level.

Keywords: Context-dependent data envelopment analysis (DEA); Securities firms; Japan; Online securities firms

JEL Classifications: D24, G23, L81

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1. Introduction

Prime Minister Ryutaro Hashimoto in 1996 published a Japanese version of the Big Bang to reform Japanese financial markets. In order to achieve a free market based on market principle, a series of easing regulations were introduced by the government, including removing the limitations on entry into banking, securities, and insurance business, allowing bank-owned subsidiaries to handle the securities business, and liberalizing various fees and commissions (particularly stock brokerage commissions). The Japan securities market underwent a revolutionary change, as existing securities firms were reorganized and online securities firms were established. Harimaya and Okuyama (2006) noted that the relaxation of regulatory restrictions increases the number of securities market participants. Liu (2010) pointed out that the Japan stock market is more efficient following the brokerage commission deregulation. In addition, lower transaction costs help to increase market informational efficiency (Liu, 2007). Waiving the securities transaction tax not only reduced the trading cost of securities firms, but also encouraged individual investors to participate in the market. Moreover, liberalized brokerage commissions allowed firms to discount fees, price competition spurred new circumstances, and online securities firms entered this competitive market.

The Japan stock market is the world's third largest market by capitalization. Japan Exchange Group, Inc. (JPX) is the world's third largest (behind NYSE Euronext and NASDAQ OMX Group) and Asia's largest bourse. JPX was established via the business combination between Tokyo Stock Exchange (TSE) and Osaka Securities Exchange (OSE) on January 1, 2013. TSE, located in Tokyo, is the largest stock exchange in Asia with market capitalization of 580 trillion Japanese yen at the end of 2016.

After the 2008 bankruptcy of Lehman Brothers, TSE's market capitalization fell to 283 trillion Japanese yen and fell even more to 256 trillion Japanese yen by 2011 (Table 1). Tokyo stock price index (TOPIX), based on all the domestic common stocks listed on the TSE first section, is a measure of the overall trend in the stock market and is used as a benchmark for investment in Japan stocks. When the TOPIX index fell from 859.24 in 2008 to 728.61 in 2011, the new government cabinet targeted an anti-deflationary economic goal and set forth its three-arrow strategy (also known as Abenomics) in late 2012.

One of the arrows is an aggressive monetary policy, whereby the Bank of Japan (BOJ) introduced quantitative and qualitative monetary easing to double the monetary base over two years. This policy lifted the stock market, as TOPIX at the end of 2015 hit 1,547.30, or an increase of up to 2.12 times that at the end of 2011 (728.61). TOPIX by the end of 2015 had exceeded the previous year's ending level for the fourth consecutive year. Table 1 shows that market capitalization and trading value continued to rise from 2012 to 2015, as the trading value at the end of 2015 was 697 trillion Japanese yen compared to the end of 2012 at

307 trillion Japanese yen, or more than double the growth.

Table 1: Market Capitalization, Trading Value, and Stock Price

Year	Number of TSE listed companies	Market Capitalization (Billion yen)	Trading Volume (Billion yen)	Trading Value (Billion yen)	TOPIX Tokyo stock index, average	Nikkei 225 Stock Average
2008	2,373	283,460	555,106	576,319	859.24	8,859.56
2009	2,319	307,779	563,576	373,766	907.59	10,546.44
2010	2,280	310,451	520,052	359,170	898.80	10,228.92
2011	2,279	255,855	536,774	347,112	728.61	8,455.35
2012	2,293	300,797	529,928	310,886	859.80	10,395.18
2013	3,406	477,509	887,952	682,702	1302.29	16,291.31
2014	3,456	524,899	709,104	643,105	1407.51	17,450.77
2015	3,502	589,788	709,718	745,955	1547.30	19,033.71
2016	3,533	579,596	665,769	691,102	1518.61	19,114.37

Notes: 1. End of year data. 2. Index of the total market value of all stocks listed on the first section of the Tokyo Stock Exchange against a base value of 100 as of January 4, 1968.
Sources: Tokyo Stock Exchange, Inc.; Bank of Japan; Nikkei Inc.

According to the Japan Securities Dealers Association (JSDA), there were 256 securities firms as regular members of JSDA in Japan at the end of March 2016. From the revenues and expenses of the total securities industry in fiscal year 2015 (at the end of March 2016), total selling and administrative costs were 2.799 trillion Japanese yen, and total operating revenues were 4.038 trillion Japanese yen. The breakdown of operating revenue was commissions of 2.297 trillion Japanese yen (57%) from retail sales, trading gains of 1.088 trillion Japanese yen (27%) from underwriting, and trading and financial revenue of 605 billion Japanese yen (15%). Overall, the commission revenue of securities firms accounted for 57% of the total operating revenue (JSDA 2016).

From the customer structure of the Japan securities market, there are three types of clients. Among them, overseas investors make up the largest proportion, accounting for 71% of the total securities market, domestic institutions are 9%, and the remaining 20% go to domestic individual investors (data at the end of March 2016). Market participants are mainly foreign investors, followed by domestic individuals.

Japanese securities firms can be divided into four types: major securities firms, securities firms affiliated with major banks, quasi-major and mid-ranked securities firms, and online securities firms (Harimaya and Okuyama, 2006; Hu *et al.*, 2018). The major securities firms and securities firms affiliated with major banks are considered as distinctive companies in Japan, engaging in three businesses: securities brokerage from retail and wholesale affairs, investment banking services, and trading in the global market (Harimaya and Okuyama, 2006). Both wholesale brokerage and investment banking revenue are their main profit. Unlike the diversified businesses of these major securities firms and securities firms affiliated with major banks, online securities concentrate on brokerage business with individual investors.

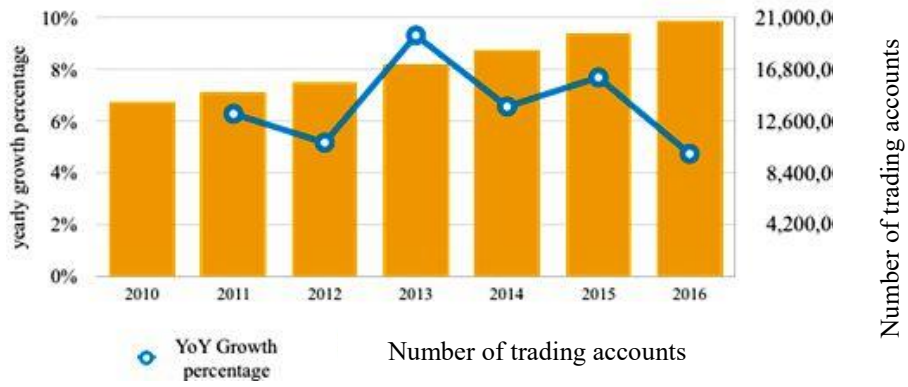

Figure 1: Online Securities Trading Activity

Notes: 1. Data are based on reports by the following 15 members of JSDA, which agreed to disclose their data. Matsui Securities Co. Ltd., Monex Inc., kabu.com Securities Co. Ltd., SBI Securities Co. Ltd., Daiwa Securities Co. Ltd., Securities Japan, Inc., Nomura Securities Co. Ltd., Marusan Securities Co. Ltd., Mito Securities Co. Ltd., Rakuten Securities, Inc., SMBC Nikko Securities, Inc., Naito Securities Co., Ltd., IwaiCosmo Securities Co. Ltd., Mizuho Securities Co. Ltd., and GMO CLICK Securities, Inc. 2. Corporate customer accounts are included in the number of accounts.
Source: Japan Securities Dealers Association (JSDA).

Jin *et al*. (2010) stated that pure online retailers do not have physical branches, but do have less employees and lower-cost operations that offer a more competitive price to individual investors. Figure 1 shows the number of online securities trading accounts collected from 15 members of JSDA. Online securities trader increased from 14.1 million in 2011 to 20.7 million in 2016. The number of accounts rose more than 5% per year during 2010-2016. On the other hand, the quasi-major and mid-ranked securities firms that operated counter services were greatly affected by the reduction of brokerage fees under the more competitive circumstances.

With the popularity of the Internet and the great development of financial technology (fintech), Japan's securities industry has gradually diversified. The major securities firms mainly show dominance in the market. Thus, those local-based small- and medium-sized securities firms are seeking differentiation, while online securities firms tend to focus on retail business.

Are online securities firms more efficient than other securities firms? What are attainable targets for those inefficient securities firms in the competitive brokerage industry? To answer these questions, we employ the context-dependent DEA approach to measure the efficiencies of Japanese securities firms.

Data envelopment analysis (DEA) is a non-parametric linear programming method that provides the relative efficiency of decision making units (DMUs) with multiple inputs and multiple outputs (Charnes *et al.*, 1978). According to Lovell and Schmidt (1993) and Coelli *et al.* (2005), DEA has one main advantage: it provides detailed efficiency information for DMUs to evaluate themselves relative to their competitors without any specific production function form and the weight of different inputs and outputs. DMUs located at the

efficiency frontier represent the most efficient ones that can be set up as targets to other inefficient DMUs. However, when those inefficient DMUs are large in number, it is not easy for each DMU to obtain the targets. Seiford and Zhu (2003) constructed different levels of efficiency frontiers with respect to a given evaluation context, calling them context-dependent DEA methods. It now makes it more realistic for each inefficient DMU to find attainable targets and planning strategies through this approach (Ulucan and Atıcı, 2010).

The rest of the paper runs as follows. Section 2 contains the current state of the securities market in Japan, four participating types of securities firms in the domestic market, and a discussion of efficiency studies on securities firms. Section 3 introduces the methodology and selection of variables. Section 4 summarizes the empirical results of the context-dependent DEA approach. Section 5 offers conclusions and managerial implications.

2. Literature Review

There are many studies that have examined the efficiency of depository financial institutions and insurance firms (Berger and Humphrey 1997), but far fewer have evaluated the efficiency evaluation of the securities industry. Previous literature on securities firms' efficiency uses the data envelopment analysis (DEA) method to investigate the efficiencies. Fukuyama and Weber (1999) analyzed the efficiency of production change of Japanese securities firms with the DEA method during the period 1988-1993, finding that the Big Four firms (Daiwa, Nikko, Nomura, and Yamaichi) were more cost-efficient than smaller securities firms in the late 1980s under BOJ's expansionary monetary policy.

Ever since government deregulation of brokerage commissions, the Japan stock market is now more efficient and online securities firms have been encouraged to enter the competitive securities market (Liu 2007, 2010). Harimaya and Okuyama (2006) found that half of the online securities firms have significant product-specific scale economies for brokerage commissions during the sample period 1998-2002, which supports the existence of small online securities firms engaged in a certain specific business. Toufaily and Pons (2017) focused on a comparison between pure online securities firms and multichannel securities firms (such as store, phone, and Internet) from a survey of Canadian online securities users. They found that customers of pure online securities firms are more loyal than those of multichannel securities firms.

As far as we know, there is no study using context-dependent DEA to examine the efficiencies of Japanese securities firms. However, the context-dependent DEA method has been applied in different industries, including private and public sectors. Seiford and Zhu (2003) first presented the context-dependent DEA concept, extending the original DEA method and providing inefficient DMUs with more appropriate performance benchmarks.

Chen *et al.* (2005) applied context-dependent DEA to examine the efficiency of Tokyo public libraries. Morita *et al.* (2005) considered the inefficiency represented by non-zero slacks in the context-dependent DEA and proposed a slack-based context-dependent DEA. Ulucan and Atıcı (2010) examined the efficiency of DMUs in a social risk mitigation project in Turkey supported by the World Bank via the context-dependent DEA model. Through the application, the cities in the social risk mitigation project were clustered to 10 efficiency levels, and the model provided inefficient cities with more achievable sub-targets.

Seiford and Zhu (2003) applied an output-oriented CD-DEA in computer printers to conduct context-dependent DEA. In our study, according to securities firms' intermediary role, inputs are the cost components that brokers want to minimize, and outputs are the revenue components that brokers want to maximize. We thus apply output-oriented models in order to pursue profit with limited resources.

3. Research Method

This study applies the context-dependent approach to evaluate the relative efficiency of the securities industry in Japan. The main inputs include stakeholder equity (SE), operating expenses (O), and the number of employees (E). The output is operating revenue (Y). In order to pursue profit with limited resources, we apply output-oriented models. This study uses the levels obtained through constant returns to scale analysis in order to take both technical and scale efficiencies into account. The DEA approach evaluates the relative efficiencies of DMUs and divides them into two groups: efficient and inefficient DMUs. We focus on forming different levels of efficient frontiers and allowing inefficient DMUs to find achievable imitated targets by context-dependent DEA.

3.1. Context-dependent DEA

Data envelopment analysis (DEA) is a mathematical procedure using a linear programming technique to build a non-parametric piecewise frontier of DMUs. The DEA approach was first introduced by Charnes *et al.* (1978), who extended Farrell's (1957) efficiency measurement to multiple inputs and multiple outputs so as to evaluate the relative efficiency of DMUs. Charnes *et al.* (1978) assumed constant returns to scale (CRS), called the CCR model. Banker *et al.* (1984) relaxes the assumption and proposed variable returns to scale (VRS), which is called the BCC model. Due to the objective of pursuing maximum earnings under limited expenses, this study employs the output-oriented CCR model.

In the output-orientated CRS DEA model, there are K inputs and M outputs, represented by the column vectors x_i and y_i for each of these N DMUs. For each DMU, there is a $K \times N$ input matrix X and $M \times N$ output matrix Y. For firm *i* in each year, the output-orientated CRS DEA model can be represented by the following linear programming model:

$$\begin{aligned} &\underset{\phi,\lambda}{\text{Max}} \quad \phi \\ &\text{s.t.} -\phi y_i + Y\lambda \geq 0 \\ &x_i - X\lambda \geq 0 \\ &\lambda \geq 0, \end{aligned} \tag{1}$$

where λ is an N×1 vector of constants, consisting of the reference weights of DMU *i* over all DMUs. The value of ϕ is the inverse of the technical efficiency score for the i^{th} firms, with $\phi \geq 1$. A higher ϕ means a lower efficiency score.

Seiford and Zhu (2003) identified several levels of efficient frontiers by the following algorithm steps.

Step 1: Evaluate the datasets of all DMUs by Eq. (1), the original output oriented CCR model, to obtain the first-level efficient frontier.

Step 2: Exclude the efficient DMUs from later DEA runs.

Step 3: Evaluate the new subset of inefficient DMUs by model (1) to obtain a new set of efficient DMUs. The second-level efficient frontier is formed.

Step 4: Re-run step 2 until the algorithm stops.

3.2. Data Collection and Variable Definitions

The data for this study are mainly obtained from Nikkei's financial statements of Japanese securities firms. For some securities firms affiliated with holding companies that are not shown separately on the Tokyo stock exchange, we checked each financial statement from EDINET (Electronic Disclosure for Investors' NETwork), which is an official electronic corporate disclosure system in Japan. Even though there are 256 securities firms as regular members of JSDA, many of them are unlisted. In EDINET, only data of 23 firms are available. These 23 firms are representative of Japanese securities firms for the following reasons. First, they exhaustively contain all major types of securities firms except small ones in recent Japanese securities companies; i.e., traditional major firms, bank-affiliated ones, medium-sized ones, and online ones. Many small securities firms have only one or a few offices and specialize in retail trade with limited areas. Hence, they are not so important for analyzing Japanese securities firms. Second, the number of employees of the 23 firms accounts for approximately 60% of the total securities firms' employees in Japan in each year in the data period. Third, their net assets and operating profit also account for at least 50% of the total of the Japan securities industry.

According to the classification of Nikkei and the companies listed on Tokyo stock exchange, we focus on four types for a total of 23 major Japanese securities firms whose data are complete (Table 2). There are two securities firms affiliated with major banks (Mitsubishi UFJ Securities Holdings Co., Ltd. and SMBC Nikko Securities, Inc.) listed in the Nikkei225 whose financial statements are not shown separately, but we find both financial

statements from EDINET. The other 21 firms are listed in the first section of the Tokyo stock exchange.

In this study the data period spans from 2010 to 2015 for a total of six fiscal years. Fiscal year refers to the 12 months beginning in April 1 of a year. We use the GDP deflator approach to deal with the effect of price changes. All nominal data have been transformed into real data through GDP deflators using 2010 as the base year.

Table 2: List of the 23 Securities Firms in This Study

Type	Firm	DMU
Major securities firms (M)	Daiwa Securities Co. Ltd.	1
	Nomura Securities Co., Ltd.	2
Securities firms affiliated with major banks (B)	Mitsubishi UFJ Securities Holdings Co., Ltd.	3
	SMBC Nikko Securities, Inc.	4
Quasi-major and mid-ranked securities firms (Q)	Aizawa Securities Co., Ltd.	5
	Ichiyoshi Securities Co., Ltd.	6
	Invast Securities Co., Ltd.	7
	Iwaicosmo Holdings, Inc.	8
	Kosei Securities Co., Ltd.	9
	Kyokuto Securities Co., Ltd.	10
	Maruhachi Securities Co., Ltd.	11
	Marusan Securities Co., Ltd.	12
	Mito Securities Co., Ltd.	13
	Okasan Securities Group Inc.	14
	Sawada Holdings Co., Ltd.	15
	Takagi Securities Co., Ltd.	16
	Tokai Tokyo Financial Holdings, Inc.	17
	Toyo Securities Co., Ltd.	18
Online securities firms (L)	kabu.com Securities Co., Ltd.	19
	Matsui Securities Co., Ltd.	20
	Monex Group, Inc.	21
	SBI Holdings, Inc.	22
	Traders Holdings Co., Ltd.	23

Many studies have examined bank efficiency. Berger and Humphrey (1987) and Farrier and Lovell (1990) analyzed bank production efficiency. The production approach is to treat the bank as a factory that produces all revenues by using inputs such as capital and labor. Similarly, according to securities firms' intermediary role, their output should include underwriting revenue, trading revenue, and securities brokerage, while their inputs should include employees, capital, and operating costs.

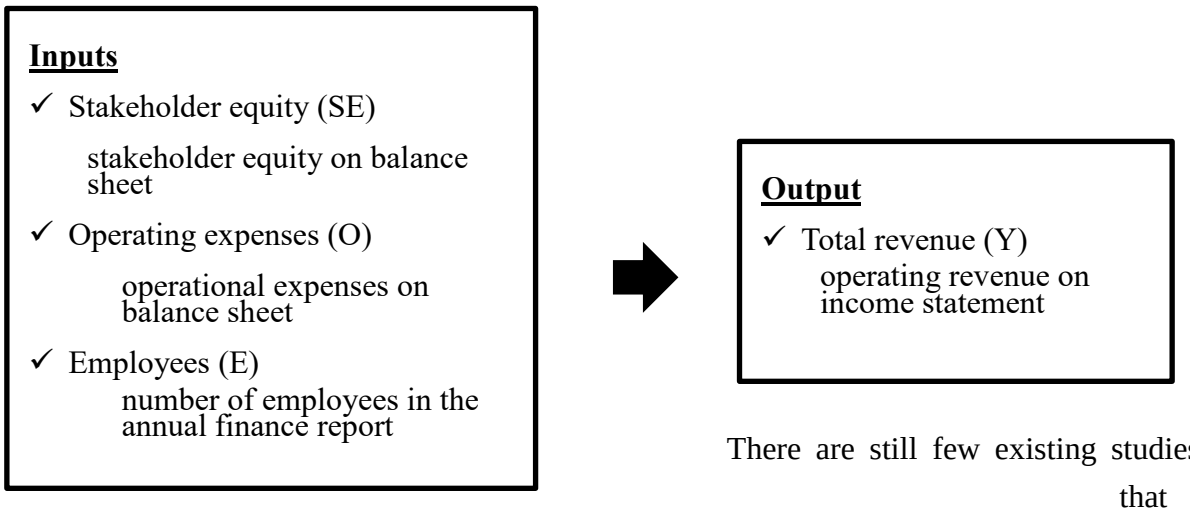

Figure 3: Input and Output Variables and Definition

Notes:
1. The units of stakeholder equity, operating expenses and total revenue, are billions of yen.
2. The unit of employees is number of people.
3. The period of an annual finance report is 12 months beginning in April 1 of a year.

There are still few existing studies that have examined the efficiencies of Japanese securities firms. Fukuyama and Webber (1999) measured the cost efficiency of Japanese securities firms by using equity and employees as two inputs and revenue from brokerage and underwriting as two outputs. Zhu (2000) evaluated Fortune 500 companies' profitability via stockholder equity, employees, and assets as three inputs and revenues and profits as two outputs. Drake and Hall (2003) adopted general and administrative expenses and fixed assets as the inputs in their efficiency analysis of Japanese banks. Fang and Hu (2009) utilized operating expense as one of the inputs to measure the efficiency of securities firms in Taiwan.

This study accordingly adopts stakeholder equity (SE), operating expense (O), and the number of employees (E) as the three inputs of the context-dependent model. Considering that online securities firms neither have an investment banking section nor a trading position, we use total revenue as output in this study. Table 3 shows the definitions of input and output variables. The year 2010 is the base period, and all the nominal variables are converted into real variables through the GDP deflator.

This study employs the output-oriented CRS CCR-DEA (Charnes *et al.*, 1978) and context-dependent DEA models (Seiford and Zhu 2003) to assess the efficiency of securities firms. As mentioned above, the data composed of three inputs (stakeholder equity, operating expense, and number of employees) and one output (total revenue) of 23 DMUs spans the years 2010 to 2015. Table 3 lists the descriptive statistics of variables. The mean of the output variable (total revenue) is 92.28 billion yen, the minimum is 0.70 billion yen, and the maximum is 839.70 billion yen. The mean of stakeholder equity is 173.13

billion yen, the minimum is 0.40 billion yen, and the maximum is 1.099 trillion yen. The mean of the input of operating expenses is 64.02 billion yen, the minimum is 1.00 billion yen, and the maximum is 511.30 billion yen. The mean of employees is 2,312 people, the minimum is 28 people, and the maximum is 12,997 people.

Table 3: Descriptive Statistics for All Variables

Variable	Units	N	Std.	Min	Mean	Max
Output						
Total revenue (Y)	Billions of yen	138	173.25	0.70	92.28	839.70
Input						
Stakeholder equity (SE)	Billions of yen	138	285.99	0.40	173.13	1,098.90
Operating expenses (O)	Billions of yen	138	117.72	1.00	64.02	511.30
Employees (E)	Number of people	138	3,437	28	2,312	12,997

Notes: The period is from years 2010 to 2015. We use the gross domestic product deflator approach to transform all nominal variables into real variables by using 2010 as the base year.

4. Empirical Results

Table 4 shows the positive correlation coefficients between multiple inputs and one single output. There is a 0.946 correlation between total revenue and stakeholder equity; 0.989 between total revenue and operating expenses; 0.930 between total revenue and employees; 0.961 between stakeholder equity and operating expenses; 0.899 between stakeholder equity and employees; and 0.942 between operating expenses and employees. We can see there are positive correlation coefficients between a single output and multiple inputs. The correlation coefficients are between 0.899 to 0.989, thus supporting isotonicity between inputs and output and allowing us to measure efficiency by using the DEA model.

Table 4: Correlation Coefficients among the Output and Input Variables

Variable	Total revenue (Y)	Stakeholder equity (SE)	Operating expenses (O)	Employees (E)
Total revenue (Y)	1.000			
Stakeholder equity (SE)	0.946	1.000		
Operating expenses (O)	0.989	0.961	1.000	
Employees (E)	0.930	0.899	0.942	1.000

Efficiency scores obtained through the original CRS-DEA model are given in a 0-1 scale in Table 5, among which the average efficiency score is 0.782, and only 5 securities firms are efficient in 2010. These five efficient DMUs stand as role models for the other inefficient DMUs. However, some of the inefficient DMUs are far from the efficient DMUs, and it may be quite difficult for them to take efficient DMUs as their role model.

Table 5: Year 2010 Level 1 Efficiency Scores

Type	Firm	DMU	Efficiency score
Major securities firms (M)	Daiwa Securities Co. Ltd.	1	0.989
	Nomura Securities Co., Ltd.	2	1.000
Securities firms affiliated with major banks (B)	Mitsubishi UFJ Securities Holdings Co., Ltd.	3	0.504
	SMBC Nikko Securities, Inc.	4	0.886
Quasi-major and mid-ranked securities firms (Q)	Aizawa Securities Co., Ltd.	5	0.514
	Ichiyoshi Securities Co., Ltd.	6	0.692
	Invast Securities Co., Ltd.	7	0.664
	Iwaicosmo Holdings, Inc.	8	0.773
	Kosei Securities Co., Ltd.	9	0.355
	Kyokuto Securities Co., Ltd.	10	0.904
	Maruhachi Securities Co., Ltd.	11	0.842
	Marusan Securities Co., Ltd.	12	0.641
	Mito Securities Co., Ltd.	13	0.640
	Okasan Securities Group Inc.	14	0.866
	Sawada Holdings Co., Ltd.	15	1.000
	Takagi Securities Co., Ltd.	16	0.448
	Tokai Tokyo Financial Holdings, Inc.	17	0.769
	Toyo Securities Co., Ltd.	18	0.679
Online securities firms (L)	kabu.com Securities Co., Ltd.	19	1.000
	Matsui Securities Co., Ltd.	20	1.000
	Monex Group, Inc.	21	0.977
	SBI Holdings, Inc.	22	0.840
	Traders Holdings Co., Ltd.	23	1.000
	Average		0.782

Table 6. Levels of Efficiency Frontiers of Japanese Securities Firms during 2010-2015

Year	Frontier	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
2010	Securities firms	2(M), 15(Q), 19(L), 20(L), 23(L)	1(M), 7(Q), 10(Q), 21(L), 22(L)	4(B), 14(Q)	3(B), 8(Q), 11(Q), 17(Q)	5(Q), 6(Q), 18(Q)	12(Q), 13(Q)	9(Q), 16(Q)	
	CRS efficiency range	1	0.664-0.989	0.866-0.886	0.504-0.842	0.514-0.692	0.640-0.641	0.355-0.448	
2011	Securities firms	1(M), 10(Q), 15(Q), 19(L), 20(L), 21(L), 23(L)	2(M), 7(Q), 14(Q), 22(L)	3(B), 4(B), 8(Q), 11(Q)	6(Q), 17(Q)	5(Q),18(Q)	12(Q), 13(Q)	16(Q)	9(Q)
	CRS efficiency range	1	0.732-0.997	0.657-0.896	0.730-0.782	0.537-0.708	0.627-0.668	0.608	0.296
2012	Securities firms	2(M), 9(Q), 10(Q), 15(Q), 19(L), 20(L), 21(L), 22(L), 23(L)	1(M), 3(B), 4(B), 7(Q), 14(Q),	6(Q), 11(Q), 17(Q)	5(Q), 8(Q), 13(Q), 16(Q)	12(Q)	18(Q)		
	CRS efficiency range	1	0.789-0.971	0.844-0.952	0.636-0.777	0.697	0.621		
2013	Securities firms	2(M), 15(Q), 19(L), 20(L), 21(L), 23 (L)	6(Q), 10(Q), 14(Q), 22(L)	1(M), 3(B), 11(Q), 17(Q)	4(B), 7(Q), 8(Q), 9(Q)	5(Q), 12(Q)	13(Q), 16(Q)	18(Q)	
	CRS efficiency range	1	0.658-0.905	0.733-0.857	0.387-0.807	0.541-0.669	0.528-0.616	0.582	
2014	Securities firms	2(M), 15(Q), 19(L), 20(L),21(L), 23(L)	14(Q), 22(L)	1(M), 3(B), 6(Q), 10(Q)	4(B), 7(Q), 9(Q), 11(Q), 17(Q)	5(Q), 8(Q), 12(Q)	13(Q), 18(Q)	16(Q)	
	CRS efficiency range	1	0.795-0.956	0.692-0.862	0.457-0.769	0.518-0.691	0.576-0.604	0.450	
2015	Securities firms	2(M), 15(Q), 19(L), 20(L), 21(L)	22(L), 23(L)	1(M), 3(B), 6(Q)	4(B), 7(Q), 10(Q), 14(Q)	8(Q), 17(Q)	5(Q), 11(Q), 12(Q), 13(Q)	9(Q), 18(Q)	16(Q)
	CRS efficiency range	1	0.842-0.918	0.693-0.742	0.546-0.671	0.612-0.624	0.433-0.535	0.276-0.492	0.302

Notes:

1. CRS efficient scores are obtained from the original DEA model.
2. Types of abbreviation: Major securities firms (M); Securities firms affiliated with major banks (B); Quasi-major and mid-ranked securities firms (Q); and Online securities firms (O).

Efficient DMUs for each level are respectively shown in Table 6 during 2010-2015. Results show a total of eight efficiency levels in this dataset during the six years. In 2015, online securities firms are stably efficient in levels 1 and 2, while most quasi-major and mid-ranked securities firms range in levels 3 to 8. Those major securities firms and securities firms affiliated with major banks span from levels 1 to 4. During 2010-2015, online securities show stable efficiency in levels 1 and 2 each year, while quasi-major and mid-ranked securities firms are in the middle and lower levels of the efficiency frontiers.

According to results of the CRS DEA model in Table 6, the first-level efficient DMUs are the same as the original DEA efficient units. As Table 5 shows, the most inefficient securities firm in 2010 was DMU 9 Kosei Securities Co. Ltd., whose efficiency score is 0.355 and forms the last-level efficiency frontier (see year 2010 in Table 6). Interestingly, DMU 7 Invast Securities Co. Ltd., which has an efficiency score of 0.664, is less efficient than DMU 14 Okasan Securities Group Inc., which has an efficiency score of 0.866 in the original DEA model of 2010. However, as Table 6 shows, Invast Securities Co. Ltd. is on level 2, and Okasan Securities Group Inc. is on level 3. This indicates that the rankings made by levels obtained by CD-DEA do not need to follow the efficiency rankings in the first-level DEA efficiency scores. This is because starting from level 2, the DMUs constructing the efficiency frontier are different, hence producing varying peer weights, efficiency scores, and efficiency rankings.

In summary, relative to major securities firms, securities firms affiliated with major banks and quasi-major and mid-ranked securities firms, online securities firms are on higher efficiency frontier levels during 2010-2015. We also identify several levels of the efficiency frontier for inefficient DMUs to obtain targets and sub-targets as role models separately.

Online securities firms provide online trading and brokerage services and can be divided into two types: pure online securities firms and multichannel securities firms. In this study, Kabu.com securities Co. Ltd., Monex Group, Inc., and Traders Holding co., Ltd. are pure online securities firms. In order to enhance customer experience and strengthen customer loyalty, they focus on website user convenience and pay attention to customer evaluation by providing customized investment advisory services. Some securities firms have expanded their business by consolidation. For instance, Monex Group, Inc. merged with a pure online securities firm, Nikko Beans, in 2005 and in 2010 acquired another pure securities firm, ORIX Securities. Similarly, Kabu.com securities became a subsidiary of Mitsubishi UFJ Securities Holdings in 2015. Traders Holding Co. Ltd. Subsidiary Traders Financial Technology and Nextop.asia merged and changed the resultant firm's name to Nextop.asia Inc.

While pure online securities firms through an expansion strategy continue to focus on service quality improvement, multichannel securities firms diversified their business by strategic alliances. These multichannel securities firms include Matsui Securities Co. Ltd.

and SBI Holdings, Inc. Matsui Securities was established as a small-scale conventional securities firm in 1918 and undertook structural reforms to turn its business into innovative services following the economic bubble that burst in 1990. Since the 1999 deregulation of retail brokerage commissions in Japan, the company has concentrated its resources on online-base businesses to become one of the leading online securities firms in Japan. SBI Holdings began in 1999 as SoftBank Investment and undertook venture capital and private equity asset management. In 2003 the company merged with E*TRADE Japan and converted E*TRADE Securities to a subsidiary. SBI Holdings has since established a global network financial service system and integrated the three core businesses of securities, banking, and insurance through its online service.

Due to financial deregulations, securities firms facing the liberalization of the competitive market have to respond rather quickly. Pure online securities firms are increasing market share and aiming to reduce operating costs in order to concentrate on online services. However, those multichannel securities firms have diversified their business and entered the online market via strategic alliances such as merger or have acquired other firms.

In this study we find that online securities firms are more efficient during 2010 to 2015, and that quasi-major and mid-ranked securities firms show a downward trend in their efficiency. We also construct several levels of efficient frontiers for inefficient securities firms to obtain efficient targets and sub-targets as role models. Each securities firm may find attainable targets, learn the strategy of these role models (also competitors), and based on each firm's own resources and core strengths then plan a strategy to develop a more efficient business model.

5. Conclusion

5.1. Conclusions and Managerial Implications

This study applies context-dependent DEA analysis from Seiford and Zhu (2003) to evaluate the efficiencies of securities firms in Japan. The panel datasets contain 23 securities firms in Japan during 2010-2015. We use three inputs and one output to compute the total efficiency scores and divide the set of DMUs into different levels of efficiency frontiers.

From the efficiency scores of these four types of securities firms during 2010-2015, we see that online securities firms concentrating on the brokerage business with lower costs are stable at efficiency levels 1 and 2 for these six years. However, quasi-major and mid-ranked securities firms operating counter services in local areas show a downward trend in their efficiency during the six-year period. On the other hand, the major securities firms and securities firms affiliated with major banks managing diversified businesses (including retail and wholesale) move up and down in middle efficiency levels.

The findings of this study have several managerial implications. First, Japanese online securities firms are more efficient than other types of securities firms during the period of

2010 to 2015. Second, by using context-dependent DEA approach, the inefficient securities firms in the original DEA model can be considered as role models for the securities firms located in lower levels. Moreover, the context-dependent efficiency frontiers provide inefficient DMUs, such as quasi-major and mid-ranked securities firms, with attainable targets for management execution. The inefficient units can learn from the attainable targets' development strategy and according to their firm's own resources then develop more efficient business models.

5.2. Research Limitations and Recommendations for Future Research

There are many factors that could influence a securities firm's performance, such as economic environment, government policies, development direction of the company, etc. We try to control uncertain factors, but still encounter the limitation of collecting data. In this study, we only apply four variables to describe them. Future studies could target to include more influence factors to measure securities firms' performances more completely.

This study's data period is 2010-2015. If the future studies could extend the research period, by including the period of the 2008 financial crisis, then the results might be more objective and reflect long-term business performance.

The financial sector is now seeing how fintech development can help clients find effortless ways to save on trading costs and improve securities firms' trading procedures more efficiently. A few fintech startup securities firms are even allowing their customers to trade stock with no fees. Without brokerage income, these online securities increase their profit through customer margin accounts and non-invested customer cash balances. Future studies could focus on the relationship between fintech development and online securities firms' performance efficiency.

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SBI Holdings, http://www.sbigroup.co.jp/

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Appendix

Appendix Table 1: Efficiency Scores in 2010

Firms	DMU	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Major securities firms (M)								
Daiwa Securities Co. Ltd.	1	0.989	1.000					
Nomura Securities Co., Ltd.	2	1.000						
Securities firms affiliated with major banks (B)								
Mitsubishi UFJ Securities Holdings	3	0.504	0.634	0.817	1.000			
SMBC Nikko Securities, Inc.	4	0.886	0.981	1.000				
Quasi-major and mid-ranked securities firms (Q)								
Aizawa Securities Co., Ltd.	5	0.514	0.615	0.691	0.861	1.000		
Ichiyoshi Securities Co., Ltd.	6	0.692	0.749	0.808	0.827	1.000		
Invast Securities Co., Ltd.	7	0.664	1.000					
Iwaicosmo Holdings, Inc.	8	0.773	0.900	0.943	1.000			
Kosei Securities Co., Ltd.	9	0.355	0.387	0.497	0.619	0.723	0.920	1.000
Kyokuto Securities Co., Ltd.	10	0.904	1.000					
Maruhachi Securities Co., Ltd.	11	0.842	0.905	0.982	1.000			
Marusan Securities Co., Ltd.	12	0.641	0.726	0.757	0.904	0.993	1.000	
Mito Securities Co., Ltd.	13	0.640	0.694	0.737	0.847	0.945	1.000	
Okasan Securities Group Inc.	14	0.866	0.955	1.000				
Sawada Holdings Co., Ltd.	15	1.000						
Takagi Securities Co., Ltd.	16	0.448	0.523	0.556	0.665	0.774	0.872	1.000
Tokai Tokyo Financial Holdings	17	0.769	0.825	0.876	1.000			
Toyo Securities Co., Ltd.	18	0.679	0.742	0.776	0.910	1.000		
Online securities firms (L)								
kabu.com Securities Co., Ltd.	19	1.000						
Matsui Securities Co., Ltd.	20	1.000						
Monex Group, Inc.	21	0.977	1.000					
SBI Holdings, Inc.	22	0.840	1.000					
Traders Holdings Co., Ltd.	23	1.000						

Appendix Table 2. Efficiency Scores in 2011

Firms	DMU	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Major securities firms (M)									
Daiwa Securities Co. Ltd.	1	1.000							
Nomura Securities Co., Ltd.	2	0.997	1.000						
Securities firms affiliated with major banks (B)									
Mitsubishi UFJ Securities Holdings	3	0.839	0.972	1.000					
SMBC Nikko Securities, Inc.	4	0.896	0.995	1.000					
Quasi-major and mid-ranked securities firms (Q)									
Aizawa Securities Co., Ltd.	5	0.537	0.662	0.681	0.816	1.000			
Ichiyoshi Securities Co., Ltd.	6	0.730	0.932	0.987	1.000				
Invast Securities Co., Ltd.	7	0.732	1.000						
Iwaicosmo Holdings, Inc.	8	0.657	0.967	1.000					
Kosei Securities Co., Ltd.	9	0.296	0.461	0.494	0.573	0.683	0.835	0.837	1.000
Kyokuto Securities Co., Ltd.	10	1.000							
Maruhachi Securities Co., Ltd.	11	0.833	0.949	1.000					
Marusan Securities Co., Ltd.	12	0.627	0.734	0.741	0.860	0.898	1.000		
Mito Securities Co., Ltd.	13	0.668	0.779	0.783	0.909	0.976	1.000		
Okasan Securities Group Inc.	14	0.810	1.000						
Sawada Holdings Co., Ltd.	15	1.000							
Takagi Securities Co., Ltd.	16	0.608	0.720	0.728	0.845	0.883	0.997	1.000	
Tokai Tokyo Financial Holdings	17	0.782	0.860	0.899	1.000				
Toyo Securities Co., Ltd.	18	0.708	0.819	0.825	0.957	1.000			
Online securities firms (L)									
kabu.com Securities Co., Ltd.	19	1.000							
Matsui Securities Co., Ltd.	20	1.000							
Monex Group, Inc.	21	1.000							
SBI Holdings, Inc.	22	0.767	1.000						
Traders Holdings Co., Ltd.	23	1.000							

Appendix Table 3: Efficiency Scores in 2012

Firms	DMU	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Major securities firms (M)							
Daiwa Securities Co. Ltd.	1	0.949	1.000				
Nomura Securities Co., Ltd.	2	1.000					
Securities firms affiliated with major banks (B)							
Mitsubishi UFJ Securities Holdings	3	0.936	1.000				
SMBC Nikko Securities, Inc.	4	0.946	1.000				
Quasi-major and mid-ranked securities firms (Q)							
Aizawa Securities Co., Ltd.	5	0.636	0.840	0.901	1.000		
Ichiyoshi Securities Co., Ltd.	6	0.844	0.954	1.000			
Invast Securities Co., Ltd.	7	0.789	1.000				
Iwaicosmo Holdings, Inc.	8	0.777	0.869	0.943	1.000		
Kosei Securities Co., Ltd.	9	1.000					
Kyokuto Securities Co., Ltd.	10	1.000					
Maruhachi Securities Co., Ltd.	11	0.952	0.954	1.000			
Marusan Securities Co., Ltd.	12	0.697	0.840	0.902	0.971	1.000	
Mito Securities Co., Ltd.	13	0.728	0.850	0.912	1.000		
Okasan Securities Group Inc.	14	0.971	1.000				
Sawada Holdings Co., Ltd.	15	1.000					
Takagi Securities Co., Ltd.	16	0.726	0.903	0.969	1.000		
Tokai Tokyo Financial Holdings	17	0.860	0.955	1.000			
Toyo Securities Co., Ltd.	18	0.621	0.735	0.789	0.856	0.956	1.000
Online securities firms (L)							
kabu.com Securities Co., Ltd.	19	1.000					
Matsui Securities Co., Ltd.	20	1.000					
Monex Group, Inc.	21	1.000					
SBI Holdings, Inc.	22	1.000					
Traders Holdings Co., Ltd.	23	1.000					

Appendix Table 4: Efficiency Scores in 2013

Firms	DMU	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Major securities firms (M)								
Daiwa Securities Co. Ltd.	1	0.857	0.987	1.000				
Nomura Securities Co., Ltd.	2	1.000						
Securities firms affiliated with major banks (B)								
Mitsubishi UFJ Securities Holdings	3	0.733	0.855	1.000				
SMBC Nikko Securities, Inc.	4	0.801	0.906	0.941	1.000			
Quasi-major and mid-ranked securities firms (Q)								
Aizawa Securities Co., Ltd.	5	0.541	0.688	0.784	0.909	1.000		
Ichiyoshi Securities Co., Ltd.	6	0.891	1.000					
Invast Securities Co., Ltd.	7	0.502	0.600	0.831	1.000			
Iwaicosmo Holdings, Inc.	8	0.808	0.912	0.997	1.000			
Kosei Securities Co., Ltd.	9	0.387	0.797	0.962	1.000			
Kyokuto Securities Co., Ltd.	10	0.658	1.000					
Maruhachi Securities Co., Ltd.	11	0.794	0.898	1.000				
Marusan Securities Co., Ltd.	12	0.669	0.816	0.836	0.979	1.000		
Mito Securities Co., Ltd.	13	0.616	0.737	0.751	0.866	0.953	1.000	
Okasan Securities Group Inc.	14	0.905	1.000					
Sawada Holdings Co., Ltd.	15	1.000						
Takagi Securities Co., Ltd.	16	0.528	0.651	0.715	0.833	0.887	1.000	
Tokai Tokyo Financial Holdings	17	0.851	0.963	1.000				
Toyo Securities Co., Ltd.	18	0.582	0.704	0.718	0.841	0.900	0.972	1.000
Online securities firms (L)								
kabu.com Securities Co., Ltd.	19	1.000						
Matsui Securities Co., Ltd.	20	1.000						
Monex Group, Inc.	21	1.000						
SBI Holdings, Inc.	22	0.855	1.000					
Traders Holdings Co., Ltd.	23	1.000						

Appendix Table 5: Efficiency Scores in 2014

Firms	DMU	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Major securities firms (M)								
Daiwa Securities Co. Ltd.	1	0.862	0.994	1.000				
Nomura Securities Co., Ltd.	2	1.000						
Securities firms affiliated with major banks (B)								
Mitsubishi UFJ Securities Holdings	3	0.745	0.901	1.000				
SMBC Nikko Securities, Inc.	4	0.761	0.894	0.920	1.000			
Quasi-major and mid-ranked securities firms (Q)								
Aizawa Securities Co., Ltd.	5	0.518	0.610	0.687	0.842	1.000		
Ichiyoshi Securities Co., Ltd.	6	0.692	0.920	1.000				
Invast Securities Co., Ltd.	7	0.499	0.578	0.840	1.000			
Iwaicosmo Holdings, Inc.	8	0.691	0.843	0.880	0.934	1.000		
Kosei Securities Co., Ltd.	9	0.457	0.822	0.856	1.000			
Kyokuto Securities Co., Ltd.	10	0.700	0.960	1.000				
Maruhachi Securities Co., Ltd.	11	0.715	0.898	0.950	1.000			
Marusan Securities Co., Ltd.	12	0.604	0.712	0.770	0.899	1.000		
Mito Securities Co., Ltd.	13	0.604	0.717	0.738	0.849	0.945	1.000	
Okasan Securities Group Inc.	14	0.795	1.000					
Sawada Holdings Co., Ltd.	15	1.000						
Takagi Securities Co., Ltd.	16	0.450	0.510	0.588	0.707	0.799	0.921	1.000
Tokai Tokyo Financial Holdings	17	0.769	0.910	0.936	1.000			
Toyo Securities Co., Ltd.	18	0.576	0.674	0.726	0.847	0.945	1.000	
Online securities firms (L)								
kabu.com Securities Co., Ltd.	19	1.000						
Matsui Securities Co., Ltd.	20	1.000						
Monex Group, Inc.	21	1.000						
SBI Holdings, Inc.	22	0.956	1.000					
Traders Holdings Co., Ltd.	23	1.000						

Appendix Table 6: Efficiency Scores in 2015

Firms	DMU	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Major securities firms (M)									
Daiwa Securities Co. Ltd.	1	0.742	0.888	1.000					
Nomura Securities Co., Ltd.	2	1.000							
Securities firms affiliated with major banks (B)									
Mitsubishi UFJ Securities Holdings	3	0.693	0.887	1.000					
SMBC Nikko Securities, Inc.	4	0.640	0.783	0.888	1.000				
Quasi-major and mid-ranked securities firms (Q)									
Aizawa Securities Co., Ltd.	5	0.433	0.521	0.683	0.763	0.856	1.000		
Ichiyoshi Securities Co., Ltd.	6	0.714	0.960	1.000					
Invast Securities Co., Ltd.	7	0.554	0.697	0.888	1.000				
Iwaicosmo Holdings, Inc.	8	0.612	0.776	0.851	0.985	1.000			
Kosei Securities Co., Ltd.	9	0.276	0.483	0.633	0.653	0.794	0.924	1.000	
Kyokuto Securities Co., Ltd.	10	0.546	0.739	0.969	1.000				
Maruhachi Securities Co., Ltd.	11	0.535	0.711	0.765	0.860	0.973	1.000		
Marusan Securities Co., Ltd.	12	0.524	0.670	0.755	0.909	0.946	1.000		
Mito Securities Co., Ltd.	13	0.503	0.639	0.712	0.843	0.866	1.000		
Okasan Securities Group Inc.	14	0.671	0.870	0.956	1.000				
Sawada Holdings Co., Ltd.	15	1.000							
Takagi Securities Co., Ltd.	16	0.302	0.356	0.459	0.529	0.575	0.650	0.727	1.000
Tokai Tokyo Financial Holdings	17	0.624	0.774	0.852	0.989	1.000			
Toyo Securities Co., Ltd.	18	0.492	0.620	0.701	0.843	0.879	0.989	1.000	
Online securities firms (L)									
kabu.com Securities Co., Ltd.	19	1.000							
Matsui Securities Co., Ltd.	20	1.000							
Monex Group, Inc.	21	1.000							
SBI Holdings, Inc.	22	0.918	1.000						
Traders Holdings Co., Ltd.	23	0.842	1.000						