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# PROFIT INEFFICIENCY OF JAPANESE SECURITIES FIRMS

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We develop a new indicator of profit inefficiency, which is based on decision-makers choosing the amount to spend on each input and the amount to earn on each output, rather than choosing physical quantities of inputs and outputs. The method is suitable for situations when prices and quantities are not directly observable, when markets are non-competitive, or when qualitative differences exist for inputs and outputs between firms. The indicator of profit inefficiency equals normalized lost profits arising from technical inefficiency and allocative inefficiency. We offer an empirical example of our method using firms in the Japanese securities industry during the period 1989-2005. We find profit inefficiency rises from 1989 to 1993, declines during the 1994-2001 period, and then increases during the years 2002-2005. Allocative inefficiency tends to be a greater source of profit inefficiency than technical inefficiency. Lost profits as a percent of assets range from 0% to 15% and are highest in 2002-2005.

*JEL classification codes*: C67, D24, G23
*Key words*: DEA, profit inefficiency indicator, Japanese securities firms

## I. Introduction

A problem in the financial institutions efficiency literature is that price data on outputs and inputs are usually synthetically constructed and represent average, rather than

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marginal prices. For instance, the price of loans is often constructed as the ratio of interest income on loans to the asset value of loans (see for example, Berger and Mester 1997). Similarly, the price of deposits is taken to equal the ratio of interest expense divided by the value of deposits. Since managers make decisions at the margin, analysis of efficiency using average price data can distort measures of allocative efficiency. In this paper we develop a new indicator of profit inefficiency that uses financial data on output earnings and input spending, rather than physical outputs and inputs. Our method builds on the work of Chambers, Chung and Färe (1998), who took the Luenberger (1992, 1995) shortage function of consumer theory and adapted it for use in production theory by proposing a directional technology distance function. We also extend the value added efficiency measurement framework of Tone (2002) and Fukuyama and Weber (2004a). To illustrate our new method, we examine the efficiency of Japanese securities firms during the period 1989-2005.

The present paper makes several contributions to the literature on the efficiency of the Japanese securities industry. First, we extend cost and revenue efficiency to a broader examination of overall profit efficiency. Comparing observed outcomes of profit maximization allows a broader comparison of firm efficiency than that offered by cost or revenue efficiency studies. Second, we construct theoretically consistent measures of profit inefficiency when data on output earnings and input spending are used instead of data on physical quantities of outputs or inputs. Past efficiency studies have used asset or liability values as proxies for outputs or inputs and have taken ratios of expenses to liabilities or revenues to assets as measures of input prices or output prices. See for example, Goldberg et al. (1991), Fukuyama and Weber (1999), and Tsutsui and Kamesaka (2005) for such a use. Third, we show how our indicators of technical inefficiency can be aggregated to an industry indicator of technical inefficiency. Fourth, the period we examine, 1989-2005, encompasses the reforms implemented in the wake of the bursting of the bubble in the Japanese economy and stock market. An analysis of the trend in overall profit inefficiency for securities firms should allow some indication of the success of the post-bubble financial reforms.

In the next section we present our theoretical method. We introduce the directional value added distance function, which is used to represent the technology of production and measure technical inefficiency. We also present our indicator of profit inefficiency and examine its aggregation properties. In Section III, we show how our method can be implemented using DEA (data envelopment analysis). We also review the history of the Japanese securities industry, evaluate the studies that have measured the efficiency of Japanese securities firms, and describe our data. In Section IV of our paper, we present the empirical estimates of technical inefficiency, profit inefficiency, and compare actual spending and earnings with optimal spending and earnings. The final section offers a summary and conclusions.

## II. Theoretical Framework

### A. The directional value added distance function

Our theoretical framework to represent the technology and construct an indicator of profit inefficiency extends the work of Chambers, Chung, and Färe (1998) to what we call the directional value added (input spending-output earnings) distance function. This distance function gauges inefficiency in terms of value added variables consisting of (input) spending and (output) earnings vectors in a general production framework. When all DMUs (decision making units) face the same output prices and input prices, our proposed inefficiency indicators are equivalent to inefficiency indicators based on physical quantities of outputs and inputs.

To begin let $x \in R_+^N$ represent inputs, let $w \in R_{++}^N$ represent input prices, let $y \in R_+^M$ outputs, and let $p \in R_{++}^M$ represent output prices. The output earnings vector is $e = py \in R_+^M$ and the input-spending vector is $s = wx \in R_+^N$. Our first technology assumes that earnings and physical inputs are observed, but not output prices or quantities. We represent this technology as

$$T_{XE} = \{(x, e): \quad x \text{ can produce } e\}. \tag{1}$$

We assume the physical input-output earnings' set (1) is closed and convex and satisfies free disposability of physical inputs and output earnings. Free disposability implies that if $(x, e) \in T_{XE}$ and $(-x', e') \leq (-x, e)$ then $(x', e') \in T_{XE}$. Relative to $T_{XE}$ we define a directional input-earnings distance function as

$$\vec{D}_{XE}(x, e; g, h) = \max_{\beta}\left[\beta : (x - \beta g, e + \beta h) \in T_{XE}\right]. \tag{2}$$

This directional distance function seeks the simultaneous maximum contraction in inputs for the pre-specified N-dimensional vector $g$ and maximum expansion in outputs for the pre-specified M-dimensional vector $h$. The technology (1) and directional input-earnings distance function (2) are related in that

$$(x, e) \in T_{XE} \quad \Leftrightarrow \quad \vec{D}_{XE}(x, e; g, h) \geq 0. \tag{3}$$

In the literature on the efficiency of banks, Shaffer (1994) introduced a revenue restricted cost function that is a variant of Shephard's (1974) indirect cost function. In Shaffer's formulation, banks choose a physical input vector that minimizes the cost of generating a given vector of bank revenues. The directional input-earnings distance function (2) measures inefficiency with $\vec{D}_{XE}(x,e;g,h)=0$ corresponding with efficiency and $\vec{D}_{XE}(x,e;g,h)>0$ implying inefficiency for the directional vectors $(g,h)$.

Suppose the researcher is interested in measuring efficiency but is limited to data on output earnings and input spending, rather than physical quantities of outputs and inputs. Let the financial technology relation between input spending and output earnings be represented by

$$T_{SE}=\left\{(s,e):(s,e) \text{ is feasible}\right\}. \tag{4}$$

We assume the value added technology $T_{SE}$ is convex and closed and satisfies free disposability of spending and earning. Free disposability implies that if $(s,e)\in T_{SE}$, $(-s',e')\leq(-s,e)$ then $(s',e')\in T_{SE}$. The directional value added distance function is defined on (4) as

$$\vec{D}_{SE}(s,e;g,h)=\max_{\beta}\left[\beta:\left(s-\beta g,e+\beta h\right)\in T_{SE}\right]. \tag{5}$$

Note the pre-specified directions $g$ and $h$ may differ depending upon where they are used. If used in (2) the directional vectors scale physical inputs and earnings to the frontier of $T_{XE}$ while in (5) the directional vectors scale input spending and output earnings to the frontier of $T_{SE}$.

The directional value added distance function measures technical inefficiency relative to the value added technology set (4). Multiplying the directional vectors $(g,h)$ by $\vec{D}_{SE}(s,e;g,h)$ gives the reduction in spending on each input and expansion in earnings on each output if the DMU produced on the frontier of $T_{SE}$. It is easy to show:

$$\vec{D}_{SE}(s,e;g,h)\geq 0 \quad \Leftrightarrow \quad (s,e)\in T_{SE}. \tag{6}$$

An implication of (6) is that $T_{SE}=\left\{(s,e):\vec{D}_{SE}(s,e;g,h)\geq 0\right\}$.

Using the directional value added distance function we define a directional value added inefficiency measure as

$$\mathbf{D}_{SE}(s,e;g,h)=\vec{D}_{SE}(s,e;g,h). \tag{7}$$

The properties of the value added inefficiency measure given by (7) are

$\mathbf{D}_{SE}.1$: $\mathbf{D}_{SE}(s,e;g,h)$ is nondecreasing in $s$.
$\mathbf{D}_{SE}.2$: $\mathbf{D}_{SE}(s,e;g,h)$ is nonincreasing in $e$.
$\mathbf{D}_{SE}.3$: $\mathbf{D}_{SE}(s,e;\delta g,\delta h) = (1/\delta)\times\mathbf{D}_{SE}(s,e;g,h)$ for $\delta > 0$.
$\mathbf{D}_{SE}.4$: $\mathbf{D}_{SE}(s-\eta g, e+\eta h; g,h) = \mathbf{D}_{SE}(s,e:g,h)-\eta,\qquad \eta\in\Re$.

Properties 1 and 2 imply that if the DMU spends more on inputs or earns less on outputs, then inefficiency is no less. Property 3 implies that scaling the directional vectors by some proportion causes inefficiency to be inversely scaled by that same proportion. Property 4 is the translation property, which implies that if inputs are reduced by $\eta$ along the directional vector $g$ and outputs are expanded by $\eta$ along the directional vector $h$, measured inefficiency declines by $\eta$. The translation property is closely related to the homogeneity property of Shephard's (1970) input and output distance functions (Chambers, Chung, and Färe 1998).

**B. Profit inefficiency decomposition**

In this section we examine the relation between maximum profit and the directional distance functions that are defined on each of the sets $T_{XE}$ and $T_{SE}$. We closely follow the work of Chambers, Chung, and Färe (1998), who examined profit inefficiency when firms choose physical inputs and physical outputs given input prices and output prices. Consider the technology represented by $T_{XE}$. Since (1) is convex in physical inputs and output earnings, maximal profit is obtained by the DMU choosing earnings and physical inputs as

$$\pi_{XE}(w) = \sum_m e_m^* - \sum_n w_n x_n^* = \max_{x,e}\left\{\sum_m e_m - \sum_n w_n x_n : \vec{D}_{XE}(x,e;g,h) \geq 0\right\}, \tag{8}$$

where $e_m^*$ and $x_n^*$ are solution values. The associated Lagrangian function ($L$) for (8) is

$$L = \sum_m e_m - \sum_n w_n x_n + \mu \vec{D}_{XE}(x,e;g,h), \tag{9}$$

where $\mu$ is the Lagrangian multiplier. Using the first order conditions and the envelope theorem, the optimal Lagrangian multiplier is $\mu^* = \sum w_n g_n + \sum h_m$. Substituting the optimal multiplier into (9) and rearranging yields the profit inefficiency indicator:

$$P_{XE}(w,x,e;g,h) = \frac{\pi_{XE}(w) - (\sum_m e_m - \sum_n w_n x_n)}{\sum_n w_n g_n + \sum_m h_m}. \tag{10}$$

Profit inefficiency, $P_{XE}(\cdot)$, equals the difference between maximal profit and actual profits normalized by the optimal Lagrangian multiplier. Let technical inefficiency relative to $T_{XE}$ be represented by the directional distance function ($\mathbf{D}_{XE}(x,e;g,h) = \vec{D}_{XE}(x,e;g,h)$). Allocative inefficiency equals the difference between profit inefficiency and technical inefficiency

$$\mathbf{A}_{XE}(w,x,e;g,h) = \frac{\pi_{XE}(w) - \left(\sum_m e_m - \sum_n w_n x_n\right)}{\sum_n w_n g_n + \sum_m h_m} - \vec{D}_{XE}(x,e;g,h). \tag{11}$$

The overall decomposition of profit inefficiency defined on $T_{XE}$ is

$$\mathbf{P}_{XE}(w,x,e;g,h) = \mathbf{A}_{XE}(w,x,e;g,h) + \mathbf{D}_{XE}(x,e;g,h). \tag{12}$$

For the value added technology represented by $T_{SE}$, profit inefficiency can also be decomposed into technical inefficiency and allocative inefficiency. Since (4) is convex in the earnings and spending vectors, maximal profit is obtained by the DMU choosing earnings and spending as

$$\pi_{SE} = \sum_m e_m^* - \sum_n s_n^* = \max_{s,e}\left[\sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n : \vec{D}_{SE}(s,e;g,h) \geq 0\right], \tag{13}$$

where $e_m^*$ and $s_n^*$ are the solutions to (13). This profit function is related to Tone's (2002) cost function and is an extension of Shaffer's (1994) revenue restricted cost function. Given a unique solution to (13), the associated optimal Lagrangian function is

$$L^* = \sum_m e_m^* - \sum_n s_n^* + \mu^* \vec{D}_{SE}(s^*, e^*; g,h). \tag{14}$$

The optimal Lagrangian multiplier is $\mu^* = \sum h_m + \sum g_n$. Substituting $\mu^*$ into (14) yields

$$\pi_{SE} = \sum_{m=1}^{M} e_m^* - \sum_{n=1}^{N} s_n^* + \vec{D}_{SE}(s^*, e^*; g,h)\left(\sum_n g_n + \sum_m h_m\right). \tag{15}$$

The implication of (15) is expressed as the following proposition:

**Proposition 1**

*The maximal profit associated with the DMU choosing spending and earnings is*

$$\pi_{SE} = \max_{s,e}\left[\sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n + \vec{D}_{SE}(s,e;g,h)\left(\sum_n g_n + \sum_m h_m\right)\right].$$

**Proof**: *"≥" Since* $(s,e) \in T_{SE}$, *the directional value added (spending-earnings) distance function projection is* $(s - \vec{D}_{SE}(s,e;g,h)g, e + \vec{D}_{SE}(s,e;g,h)h) \in T_{SE}$, *by the definition of the maximal profit function we can establish the desired inequality.*

*"≤" From (6) and (13) along with* $\vec{D}_{SE}(s,e;g,h) > 0$ *for interior points, we obtain:*

$$\pi_{SE} \le \max_{s,e}\left[\sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n + \vec{D}_{SE}(s,e;g,h)\left(\sum_n g_n + \sum_m h_m\right)\right]. \qquad Q.E.D.$$

For directional model results related to Proposition 1, where physical inputs and physical outputs are chosen instead of output earnings and input spending, see Luenberger (1995) and Chambers, Chung and Färe (1998).

Since the profit function (13) is defined as a maximum, the value added version of Mahler's inequality is:[1]

$$\pi_{SE} \ge \sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n + \vec{D}_{SE}(s,e;g,h)\left(\sum_n g_n + \sum_m h_m\right). \tag{16}$$

The inequality in (16) arises from the fact that after actual earnings on outputs and actual spending on inputs are scaled to the value added frontier of $T_{SE}$ and the DMU is technically efficient, some lost profit might still exist if the technically efficient vector of earnings and spending is not equal to the optimal vector of earnings and spending.

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[1] See Färe and Primont (1995) for the Mahler inequalities that are based on Shephard's (1970) distance functions. For the directional technology distance function-based Mahler inequality, see Chambers, Chung and Färe (1998).

Rearranging (16), we can define the value added profit inefficiency indicator as

$$\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) = \frac{\pi_{SE} - \left(\sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n\right)}{\left(\sum_n g_n + \sum_m h_m\right)}. \tag{17}$$

The profit inefficiency indicator, $\mathbf{P}_{SE}(s, e; g, h)$, gives the difference between maximal profit and actual profit normalized by the sum of the directional vectors for spending and earnings. The value added profit inefficiency indicator (17) has monotonicity and homogeneity properties that we summarize as Proposition 2.

**Proposition 2**

*(a) If* $\pi_{SE} \geq \pi'_{SE}$, *then* $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) \geq \mathbf{P}_{SE}(\pi'_{SE}, s, e; g, h)$.
*Furthermore* $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) > \mathbf{P}_{SE}(\pi'_{SE}, s, e; g, h)$ *holds if* $\pi_{SE} > \pi'_{SE}$.

*(b) If* $(-s, e) \geq (-s', e')$, *then* $\mathbf{D}_{SE}(s, e; g, h) \leq \mathbf{D}_{SE}(s', e'; g, h)$
*and* $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) \leq \mathbf{P}_{SE}(\pi_{SE}, s', e'; g, h)$.
*Furthermore,* $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) < \mathbf{P}_{SE}(\pi_{SE}, s', e'; g, h)$ *holds if* $(-s, e) > (-s', e')$.

*(c)* $\mathbf{P}_{SE}(\delta\pi_{SE}, \delta s, \delta e; g, h) = \delta \mathbf{P}_{SE}(\pi_{SE}, s, e; g, h), \quad \delta > 0.$

Part (a) of Proposition 2 means that as maximum profit increases, profit inefficiency is no less. Part (b) says that as spending decreases or earnings increase, value added technical inefficiency does not increase and profit inefficiency does not increase. Part (c) says that the profit inefficiency indicator is homogenous of degree one in maximum profit, spending, and earnings. To see this homogeneity property observe that

$$\mathbf{P}_{SE}(\delta\pi_{SE}, \delta s, \delta e; g, h) = \frac{\delta\pi_{SE} - \left(\sum_{m=1}^{M} \delta e_m - \sum_{n=1}^{N} \delta s_n\right)}{\left(\sum_n g_n + \sum_m h_m\right)} = \delta \mathbf{P}_{SE}(\pi_{SE}, s, e; g, h), \quad \delta > 0.$$

To develop an indicator of allocative inefficiency, note that by the construction of (17) $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) \geq \vec{D}_{SE}(s, e; g, h)$. We follow previous work by Chambers, Chung, and Färe (1998) and define an allocative inefficiency indicator to equal the difference between profit inefficiency and technical inefficiency. That is,

$$\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = \frac{\pi_{SE} - \left( \sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n \right)}{\left( \sum_n g_n + \sum_m h_m \right)} - \vec{D}_{SE}(s, e; g, h). \tag{18}$$

Allocative inefficiency equals the lost profit due to an inappropriate mix of input spending and output earnings. The allocative inefficiency indicator in (18) equals the difference between normalized lost profit and the directional value added distance function.

If a DMU has zero profit inefficiency then resources must be efficiently allocated and $\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = 0$. However, the converse is not necessarily true if a DMU is not also technically efficient. We summarize these possibilities as Proposition 3.

**Proposition 3**

*(a) Profit efficiency implies* $\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = 0$.
*(b)* $\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = 0 \Leftrightarrow \mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) = \mathbf{D}_{SE}(\pi_{SE}, s, e; g, h)$.

**Proof***: "(a)" Since* $(s, e) \in T_{SE}$*, the projected point based on the directional spending-earnings distance function is* $(s - \vec{D}_{SE}(s, e; g, h)g, e + \vec{D}_{SE}(s, e; g, h)h) \in T_{SE}$. *By the profit efficiency assumption, we have*

$$\pi_{SE} = \sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n + \vec{D}_{SE}(s, e; g, h)\left( \sum_n g_n + \sum_m h_m \right),$$

*which yields* $\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = \dfrac{\pi_{SE} - \left( \sum_{m=1}^{M} e_m - \sum_{n=1}^{N} s_n \right)}{\left( \sum_n g_n + \sum_m h_m \right)} - \vec{D}_{SE}(s, e; g, h) = 0.$

*"(b)" "⇒" Assume* $\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = 0$. *Then* $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) = \mathbf{D}_{SE}(s, e; g, h)$ *by the definition of the directional spending-earnings allocative inefficiency measure. "⇐" Assume* $\mathbf{P}_{SE}(\pi_{SE}, s, e; g, h) = \mathbf{D}_{SE}(s, e; g, h)$*, then* $\mathbf{A}_{SE}(\pi_{SE}, s, e; g, h) = 0$*. Q.E.D.*

Thus, value added profit inefficiency can be decomposed into additive indicators of value added technical inefficiency and value added allocative inefficiency:

$$\underbrace{\mathbf{P}_{SE}(\pi_{SE},s,e;g,h)}_{\text{profit inefficiency}} = \underbrace{\mathbf{A}_{SE}(\pi_{SE},s,e;g,h)}_{\substack{\text{directional value added}\\ \text{allocative inefficiency}}} + \underbrace{\mathbf{D}_{SE}(s,e;g,h)}_{\substack{\text{directional value added}\\ \text{technical inefficiency}}}. \tag{19}$$

Allocative inefficiency arises because of an inappropriate choice of mix of spending on inputs and earnings on outputs and technical inefficiency is caused by a lack of managerial oversight. Values of the inefficiency indicators greater than zero imply inefficiency.

## C. Aggregation

Under certain conditions our value added indicators of profit inefficiency and technical inefficiency can be aggregated to industry indicators of inefficiency. Following Koopmans (1957) and Färe and Grosskopf (2004) we define the industry value added set for $k = 1,\ldots,K$, DMUs as $\hat{T}_{SE} = \sum_{k=1}^{K} T_{SE}^{k}$, where

$$\sum_{k=1}^{K} T_{SE}^{k} = \left\{ z : z = \sum_{k=1}^{K} (s^k, e^k),\ (s^k, e^k) \in T_{SE}^{k},\ k = 1,2,\ldots,K \right\}.$$

Koopmans (1957) shows that the industry profit function equals the sum of the $K$ individual DMU profit functions: $\hat{\pi}_{SE} = \sum_{k=1}^{K} \pi_{SE}^{k}$. Färe and Grosskopf (2004) restate and extend Koopmans' work to cost and revenue functions. Adapting Koopmans' result in our value added setting, we obtain the following relation:

$$\widehat{T}_{SE} = \sum_{k=1}^{K} T_{SE}^{k} \quad \Leftrightarrow \quad \widehat{\pi}_{SE} = \sum_{k=1}^{K} \pi_{SE}^{k}. \tag{20}$$

The relation (20) can be proved by adapting the proof of Färe and Grosskopf (2004, p. 147). The Koopmans' result related to (20) requires constant input and output prices across firms. Although our value added model does not require the same prices, the equivalence (20) holds true because we can think that the prices of spending and earnings are unity. We define an industry value added profit inefficiency indicator as

$$\widehat{\mathbf{P}}_{SE}\left( \sum_{k=1}^{K} \pi_{SE}^{k}, \sum_{k=1}^{K} s^k, \sum_{k=1}^{K} e^k; g,h \right) = \frac{\sum_{k=1}^{K} \pi_{SE}^{k} - \left( \sum_{k=1}^{K} \sum_{m=1}^{M} e_m^k - \sum_{k=1}^{K} \sum_{n=1}^{N} s_n^k \right)}{\sum_{n} g_n + \sum_{m} h_m}. \tag{21}$$

The value added industry profit inefficiency indicator is related to Chambers, Chung and Färe's (1998) Nerlovian industry profit indicator. In (17) we defined a value added profit inefficiency indicator for the $k^{\text{th}}$ DMU as the difference between maximum profits and actual profits normalized by the sum of the directional vectors. Following Blackorby and Russell (1999, p.11) and Färe and Grosskopf (2004), we establish an aggregate efficiency indication axiom for value added profit inefficiency.

**Aggregate efficiency indication axiom**:

$$\widehat{\mathbf{P}}_{SE}\left(\sum_{k=1}^{K}\pi_{SE}^{k},\sum_{k=1}^{K}s^{k},\sum_{k=1}^{K}e^{k};g,h\right)=0 \quad \Leftrightarrow \quad \mathbf{P}_{SE}^{k}(\pi_{SE}^{k},s^{k},e^{k};g,h)=0, k=1,\ldots,K.$$

This axiom states that industry value added profit efficiency is consistent with value added profit efficiency of each DMU. Does a similar result hold for the aggregation of firm inefficiency to industry inefficiency? Define the industry directional value added distance function as

$$\widehat{\vec{D}}_{SE}\left(\sum_{k=1}^{K}s^{k},\sum_{k=1}^{K}e^{k};g,h\right)=\max_{\beta}\left[\beta:\left(\sum_{k=1}^{K}s^{k}-\beta g,\sum_{k=1}^{K}e^{k}+\beta h\right)\in\widehat{T}_{SE}\right].$$

The industry directional value added allocative inefficiency indicator is denoted by

$$\widehat{\mathbf{A}}_{SE}\left(\sum_{k=1}^{K}\pi_{SE}^{k},\sum_{k=1}^{K}s^{k},\sum_{k=1}^{K}e^{k};g,h\right)=\widehat{\mathbf{P}}_{SE}\left(\sum_{k=1}^{K}\pi_{SE}^{k},\sum_{k=1}^{K}s^{k},\sum_{k=1}^{K}e^{k};g,h\right)-\widehat{\vec{D}}_{SE}\left(\sum_{k=1}^{K}s^{k},\sum_{k=1}^{K}e^{k};g,h\right).$$

For the $k^{\text{th}}$ DMU value added allocative inefficiency is

$$A_{SE}^{k}\left(\pi_{SE}^{k},s^{k},e^{k};g,h\right)=P_{SE}^{k}\left(\pi_{IE}^{k},s^{k},e^{k};g,h\right)-\vec{D}_{SE}^{k}(s^{k},e^{k};g,h). \tag{22}$$

Utilizing the aggregate efficiency indication axiom and (22) we can establish the following proposition.

**Proposition 4**

*Industry technical inefficiency equals the sum of individual firm's technical inefficiency if and only if industry allocative inefficiency equals the sum of individual firm's allocative efficiency. That is,*

$$\overrightarrow{\overline{D}}_{SE}(\sum_{k=1}^{K} s^k, \sum_{k=1}^{K} e^k; g,h) = \sum_{k=1}^{K} \vec{D}_{SE}^k(s^k, e^k; g,h) \Leftrightarrow \widehat{\mathbf{A}}_{SE}\left(\sum_{k=1}^{K} \pi_{SE}^k, \sum_{k=1}^{K} s^k, \sum_{k=1}^{K} e^k; g,h\right)$$
$$= \sum_{k=1}^{K} \widehat{\mathbf{A}}_{SE}^k\left(\pi_{SE}^k, s^k, e^k; g,h\right).$$

Observing the inequality, $\overrightarrow{\overline{D}}_{SE}(\sum_{k=1}^{K} s^k, \sum_{k=1}^{K} e^k; g,h) \geq \sum_{k=1}^{K} \vec{D}_{SE}^k(s^k, e^k; g,h)$, and its consequence, $\widehat{\mathbf{A}}_{SE}\left(\sum_{k=1}^{K} \pi_{SE}^k, \sum_{k=1}^{K} s^k, \sum_{k=1}^{K} e^k; g,h\right) \leq \sum_{k=1}^{K} \widehat{\mathbf{A}}_{SE}^k\left(\pi_{SE}^k, s^k, e^k; g,h\right)$, we can prove Proposition 4 by following the proof strategy of Färe and Grosskopf (2004, pp. 103-104). Proposition 4 means that if the sum of the allocative inefficiency indicators equals zero, then industry value added technical inefficiency equals the sum of the technical inefficiency indicators for the *K* DMUs.

## III. Empirical strategy and data

### A. DEA Framework

We use data envelopment analysis (DEA) to estimate each of the profit functions and associated directional distance functions. The DEA method was developed by Charnes, Cooper and Rhodes (1978) and Banker, Charnes and Cooper (1984) as a linear programming method for obtaining estimates of efficiency. For the original idea related to efficiency measurement, see Farrell (1957). An advantage of DEA over stochastic methods is that DEA defines the best practice frontier from observed outputs and inputs, rather than a hypothetical average frontier. In addition, DEA does not require the researcher to specify an ad hoc functional form for the distance function, nor does it require specification of an error structure as do stochastic methods. However, a disadvantage of DEA is that all deviation from the frontier is assigned as inefficiency, whereas stochastic methods assign some of the deviation as random error. Kumbhakar and Lovell (2000) are an excellent source for the use of stochastic methods in estimating inefficiency.

It has become commonplace in estimating the efficiency of financial institutions to include a constraint that controls for the risk-return tradeoff that managers face, in their role as the owners' agents. Some owners might prefer lower profits in return for less risk so managers employ resources to better monitor and oversee the brokerage and underwriting process. Other owners might be willing to accept greater risk and prefer that fewer resources, such as financial analysts (labor) be employed so that higher profits can be earned. We follow the work of Färe, Grosskopf, and Weber (2004), Fukuyama and Weber (2004a), and Devaney and Weber (2002) and include in our specification of the technology a constraint that captures the risk-return tradeoff that managers face.

For the $K$ DMUs let **S** represent the $N \times K$ matrix of observed spending, let **E** represent the $M \times K$ matrix of observed earnings from outputs, let **X** represent the $N \times K$ matrix of observed physical inputs, let $eq^o$ represent the amount of equity capital used by DMU $o$ and let $\boldsymbol{EQ}$ represent the 1x$K$ vector of observed equity capital use. The DEA set, $T_{XE}$, given by (1) for DMU $o$ is

$$T_{XE} = \{(x,e) : \boldsymbol{X}\lambda \le x, \quad \boldsymbol{E}\lambda \ge e, \quad \boldsymbol{EQ}\lambda \le eq^o, \quad \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K\}. \tag{23}$$

The non-negative variables $\lambda_k$ serve to form a linear combination of observed inputs and earnings. The constraint $\sum_k \lambda_k = 1$ allows for variable returns to scale. Similarly, the DEA value added set, $T_{SE}$, given by (4) is

$$T_{SE} = \left\{(s,e) : \mathbf{S}\lambda \le s, \mathbf{E}\lambda \ge e, \ \boldsymbol{EQ}\lambda \le eq^o, \quad \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K \right\}, \tag{24}$$

which is an extension of Färe and Grosskopf's (1985) spending-based technology. The constraint $\boldsymbol{EQ}\lambda \le eq^o$ controls for the risk-return tradeoff. Adding this quasi-fixed input constraint means that securities firms that employ similar amounts of equity are compared to each other when estimating inefficiency.

Given the technology sets defined in (23) and (24), the corresponding directional distance functions are estimated for DMU $o$, $k = 1,...,o,...,K$, as

$$\begin{aligned} &\vec{D}_{XE}(x^o, e^o, eq^o; \bar{g}, h) \\ &= \max_{\beta,\lambda} \left[ \beta : \mathbf{X}\lambda \le x^o - \beta\bar{g}, \mathbf{E}\lambda \ge e^o + \beta h, \ \boldsymbol{EQ}\lambda \le eq^o, \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K \right], \end{aligned} \tag{25}$$

and

$$\begin{aligned} &\vec{D}_{SE}(s^o, e^o, eq^o; g, h) \\ &= \max_{\beta,\lambda} \left[ \beta : \mathbf{S}\lambda \le s^o - \beta g, \mathbf{E}\lambda \ge e^o + \beta h, \ \boldsymbol{EQ}\lambda \le eq^o, \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K \right]. \end{aligned} \tag{26}$$

The DEA maximal profit functions take the form:

$$\pi_{XE}(w^o, eq^o) = \max_{x,e,\lambda}\left[\sum_{m=1}^{M} e_m - \sum_{n=1}^{N} w_n^o x_n : \mathbf{X}\lambda \le x, \mathbf{E}\lambda \ge e,\ \boldsymbol{EQ}\lambda \le eq^o, \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K\right], \tag{27}$$

and

$$\pi_{SE}(eq^o) = \max_{s,e,\lambda}\left[\sum_{m} e_m - \sum_{n} s_n : \mathbf{S}\lambda \le s, \mathbf{E}\lambda \ge e,\ \boldsymbol{EQ}\lambda \le eq^o, \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K\right]. \tag{28}$$

The indicators of overall profit inefficiency are decomposed into indicators of technical inefficiency and allocative inefficiency by combining the estimates of the directional distance functions with the estimates of maximal profits and the actual profits of each DMU.

We note that the directional vector scaling physical inputs in (25) is represented by $\bar{g}$ while the directional vector scaling input spending in (26) is represented by $g$. The directional vector scaling output earnings in (25) and (26) is represented by $h$. The directional vectors scaling physical inputs and input spending need not be the same. However, if input prices are the same across DMUs and the directional vectors are chosen as

$$g = w \cdot \bar{g} = (w_1\bar{g}_1, \ldots, w_N\bar{g}_N)\,, \tag{29}$$

then

$$\vec{D}_{SE}(s^o, e^o, eq^o; w\cdot\bar{g}, h) = \vec{D}_{XE}(x^o, e^o, eq^o; \bar{g}, h) \tag{30}$$

for any DMU $o$, $k = 1,\ldots,o,\ldots,K$ and $e^o = p\cdot y^o$ and $s^o = w\cdot x^o$. Note that if firms face the same input and output prices, the directional distance functions given in (25) and (26) don't necessarily coincide unless the directional vectors are adjusted as in (29).

**B. Background and data**

Japanese securities firms are closely identified with the economic boom and inflation of the bubble in Japan in the 1980s. The 1986 Maekawa Report suggested a reduction in the barriers between banking and securities firms, but those reforms were successfully resisted by the securities industry which had been a major beneficiary of regulated financial markets (Amyx 2004). However, the bursting of the Japanese stock market bubble in 1989 ushered in a decade of financial reforms. In 1992, the

Financial System Reform Act allowed banks to form subsidiaries to enter the securities business. Also in 1992, the Ministry of Finance established a Securities and Exchange Surveillance Commission to oversee the securities industry. In November of 1996, Prime Minister Hashimoto called for a "Big Bang" in financial market deregulation. The Big Bang reforms included the application of capital adequacy requirements to securities firms and allowed banks to engage in the lending, trading, and underwriting of securities, thereby promoting competition between banks and securities firms (Hoshi and Kashyap 2001). Despite increased oversight, the first post-war failure of a brokerage company occurred on November 3, 1997 with the failure of Sanyo Securities. On November 24, 1997 Yamaichi Securities collapsed representing the biggest bankruptcy ever in Japan (Amyx 2004).

The reforms and deregulation of financial markets in the 1990s will likely impact the competitive structure and efficiency of financial services in Japan. In 1998, U.S. citizens held 43% of personal financial assets as securities (Board of Governors 2004) while the Japanese held only 14% of personal financial assets as securities. Given the relative importance of securities as a financial asset in the U.S. and a prediction by Hoshi and Kashyap (2001) that Japanese banks will decline relative to the securities industry, a study of the efficiency of Japanese securities firms is important.

While bank efficiency studies are widespread (see Berger and Humphrey 1997 for a review), only a few researchers have examined the efficiency of securities firms. Goldberg et al. (1991) estimate a translog cost function for 68 U.S. securities firms to estimate scope and scale economies in the securities industry. They find that if Glass-Steagall restrictions are relaxed, banks could enter and compete effectively with securities firms if they realized about $30 million in brokerage revenues. Fukuyama and Weber (1999) use DEA to analyze the technical, allocative, and cost efficiency of firms in the Japanese securities industry during 1988-1993. They find that the Big Four securities firms (Nomura, Daiwa, Nikko and Yamaichi) are more cost efficient than smaller securities firms. They also find that non-Big Four securities firms with keiretsu links to banks are more cost efficient than non-Big Four securities firms with keiretsu links to Big Four securities firms. Tsutsui and Kamesaka (2005) estimate a translog revenue function to estimate the degree of competition in the Japanese securities industry. Using the Panzar-Rosse (1987) H-statistic they conclude that the industry is characterized by monopolistic competition for the period 1997-2002.

The data for our empirical illustration are obtained from *Financial Quest* for the fiscal years 1989 to 2005. We assume that securities firms produce two outputs associated with their brokerage business and other business associated with underwriting securities offerings and handling subscriptions. Thus, the earnings vector is $e = (e_1, e_2)$ where $e_1$ = brokerage commissions and $e_2$ = total commissions earned less brokerage commissions = underwriting and distribution commissions + commissions for handling subscriptions and offerings + other commissions earned. The earnings vector is generated through the employment of labor ($x_1$) and capital ($x_2$). Labor is measured as the number of employees at year-end and capital equals the sum of tangible and intangible fixed assets. The input-spending vector is composed of personnel expenses ($s_1$) and real estate related expenses and other expenses related to fixed capital assets ($s_2$). Input prices ($w_n$) are constructed as the ratio of spending on each input ($s_n$) to the amount of each input employed ($x_n$).

Descriptive statistics on each of the variables for the pooled sample are provided in Table 1. To allow comparison across the years, we deflate all financial amounts by the Japanese GDP deflator. The pooled sample includes 825 firm observations, ranging from 48 firms in 1989, to a high of 52 firms in 2000, to a low of 41 firms in 2005. The wide range of equity capital underscores the importance of controlling for equity as a quasi-fixed input. On average, labor costs represent about 51% of the total costs ($s_1$+$s_2$) and revenues earned from underwriting ($e_1$) represent 75% of total revenues ($e_1$+$e_2$). Average profits are positive in 1989, 1990, and 2000 and are negative in the other years. We note that our theoretically constructed profit inefficiency indicators are well-defined when actual profits are negative, unlike profit efficiency indexes that take the ratio of actual profits to maximum profits. Throughout the

**Table 1.** Descriptive statistics (1989-2005, n = 825)

| Variable | Mean | Std. deviation | Minimum | Maximum |
|---|---|---|---|---|
| $x_1$=# of workers | 1,442 | 2,238 | 5 | 11,399 |
| $x_2$ = value of tangible and intangible assets (millions of yen) | 6,908 | 15,445 | 5 | 122,816 |
| $w_1$= wage rate (millions of yen) | 31 | 528 | 3 | 14,984 |
| $w_2$ = ratio of other expenses to $x_2$ in percent | 5 | 9 | 0 | 125 |
| $s_1$= personnel expenses (millions of yen) | 14,196 | 24,816 | 70 | 156,839 |
| $s_2$ = sum of other expenses (millions of yen) | 18,063 | 37,552 | 85 | 305,172 |
| $e_1$= brokerage revenues (millions of yen) | 18,222 | 36,917 | 5 | 399,346 |
| $e_2$ = non-brokerage revenues (millions of yen) | 12,020 | 31,504 | 4 | 320,920 |
| Actual profits = $e_1$+$e_2$-$s_1$-$s_2$ (millions of yen) | -2,018 | 23,521 | -120,645 | 284,656 |
| equity (millions of yen) | 100,102 | 248,083 | 130 | 1,644,238 |

Notes: Financial and employment data taken from Nikkei Economic Electronic Database System (NEEDS) via Financial Quest. All financial data are deflated by the Japanese GDP deflator taken from Annual Report on National Accounts provided by Economic and Social Research Institute (ESRI).

period, the ratio of equity to assets increases from 12.5% in 1989 to 43% in 2002, before falling to 29% in 2005.

## IV. Empirical results

To estimate the directional value added distance function we choose an earnings directional vector equal to $h$ = (1,1) and a spending directional vector equal to $g$ = (1,1). To estimate $\vec{D}_{XE}(x,e,eq;\overline{g},h)$ we choose $\overline{g} = (\frac{1}{w_1}, \frac{1}{w_2})$ so that we can compare the inefficiency estimates for the $T_{XE}$ and $T_{SE}$ technologies. If securities

**Table 2.** Decomposition of profit inefficiency into technical inefficiency and allocative inefficiency

| Year | # of firms | $g$ = (1,1) and $h$ = (1,1) | | $\overline{g} = (\frac{1}{w_1}, \frac{1}{w_2})$ and $h$ = (1,1) | |
|---|---|---|---|---|---|
| | | $\mathbf{D}_{SE}(\cdot)$ | $\mathbf{P}_{SE}(.)$ | $\mathbf{D}_{XE}(\cdot)$ | $\mathbf{P}_{XE}(.)$ |
| 1989 | 48 | 367 | 893 | 401 | 2,400 |
| 1990 | 50 | 545 | 1,553 | 995 | 4,017 |
| 1991 | 50 | 303 | 1,572 | 589 | 3,043 |
| 1992 | 50 | 257 | 3,213 | 553 | 3,801 |
| 1993 | 50 | 216 | 3,765 | 551 | 4,126 |
| 1994 | 51 | 246 | 1,339 | 719 | 3,946 |
| 1995 | 51 | 334 | 2,193 | 669 | 3,707 |
| 1996 | 51 | 412 | 1,499 | 671 | 3,614 |
| 1997 | 51 | 220 | 1,208 | 580 | 3,434 |
| 1998 | 49 | 164 | 1,625 | 484 | 3,238 |
| 1999 | 49 | 130 | 1,464 | 464 | 2,896 |
| 2000 | 52 | 323 | 1,355 | 852 | 2,706 |
| 2001 | 46 | 258 | 1,043 | 733 | 1,463 |
| 2002 | 46 | 316 | 2,469 | 777 | 2,492 |
| 2003 | 45 | 406 | 2,676 | 1,638 | 4,472 |
| 2004 | 45 | 646 | 2,397 | 1,657 | 4,197 |
| 2005 | 41 | 589 | 2,939 | 2,061 | 5,008 |

Notes: Profit inefficiency is $\mathbf{P}_{SE}(\cdot) = \frac{\pi_{SE}(\cdot) - (actual\ profit)}{4}$ and $\mathbf{P}_{XE}(\cdot) = \frac{\pi_{XE}(\cdot) - (actual\ profit)}{4}$, where $\pi_{SE}(\cdot)$ and $\pi_{XE}(\cdot)$ are maximal profit functions. $\mathbf{D}_{SE}(\cdot)$ and $\mathbf{D}_{XE}(\cdot)$ represent technical inefficiency which equals the unit expansion in earnings and unit contraction in either spending or inputs. Allocative inefficiency is $\mathbf{A}_{SE}(\cdot) = \mathbf{P}_{SE}(\cdot) - \mathbf{D}_{SE}(\cdot)$ and $\mathbf{A}_{XE}(\cdot) = \mathbf{P}_{XE}(\cdot) - \mathbf{D}_{XE}(\cdot)$.

firms face the same input prices, then using equation (30) the implied directional vector is $g = (w \cdot \overline{g}) = (1,1)$. Given $\overline{g} = (1/w_1, 1/w_2)$, the estimate of $\vec{D}_{XE}(x,e,eq;\overline{g},h)$ gives the simultaneous expansion in earnings on the two outputs and spending on the two inputs. Thus, the frontier estimate of spending and earnings is $\left\{w \cdot (x - \beta\overline{g}), e + \beta\overline{h}\right\} = \left\{w \cdot x - \beta, e + \beta)\right\}$.

The component estimates of profit inefficiency are reported in Table 2. For the directional vectors $g$ and $h$, the estimate of $\mathbf{D}_{SE}(\cdot)$, gives the simultaneous expansion in output earnings and contraction in input spending. To illustrate, consider the estimate of the directional distance function in 1989 for a hypothetical firm. Given $\mathbf{D}_{SE}(\cdot) = 367$, earnings on each of the two outputs could increase by 367 and spending on each of the two inputs could decrease by 367 indicating that profits could increase by 367 × 4 = 1468 if the average firm produced on the frontier of $T_{SE}$. The estimates for the remaining years indicate a mostly downward trend in technical inefficiency until 1999 and then an upward trend until 2004. The estimates of $\mathbf{D}_{XE}(\cdot)$ are greater than the estimates of $\mathbf{D}_{SE}(\cdot)$ and indicate greater inefficiency for the average firm. However, technical inefficiency for the two technologies follows a similar pattern, trending downward from 1990 until 1999 and then trending upward until 2004 or 2005.

Allocative inefficiency equals the residual between lost normalized profits and technical inefficiency. This kind of inefficiency arises from the firm choosing a non-optimal mix of spending on inputs and earnings on outputs. Allocative inefficiency dominates technical inefficiency except in 2001 for the $T_{XE}$ technology, when the estimates of technical inefficiency and allocative inefficiency are about the same. Adding the estimates of allocative inefficiency to the estimates of technical inefficiency gives the estimate of overall profit inefficiency. Given our choice of directional vectors $g$=(1,1) and $h$=(1,1) for the value added technology ($T_{SE}$) the estimates of profit inefficiency can be aggregated to an industry measure of inefficiency. Industry profit inefficiency increases from 1989 until 1993, declines from 1994 to 2001, and then increases during 2002 to 2005. The large increase in industry profit inefficiency in the 2002 to 2005 period was preceded by regulations establishing capital adequacy requirements for security firms that were imposed in December 1998 as part of the Big Bang. At the same time, new regulations "imposed a strict separation of client assets from those of the securities houses." (Hoshi and Kashyap 2001, p. 295).

In Table 3 we report the mean values of optimal earnings and spending found as the solution to the two profit functions $\pi_{SE}(\cdot)$ and $\pi_{XE}(\cdot)$, and actual earnings and spending. We use a $t$-test to test for differences between the optimal and actual

[2] Details of these tests are available upon request.

values. Our findings indicate that optimal earnings tend to differ from actual earnings in fewer years than optimal spending differs from actual spending. For $\pi_{SE}(\cdot)$, actual earnings differ significantly from optimal earnings in eleven out of seventeen years and actual spending differs significantly from optimal spending in fifteen out of seventeen years. On average, securities firms should expand earnings and contract spending to increase profits, except in 2000 and 2004. When earnings and physical inputs are optimally chosen in $\pi_{XE}(\cdot)$, actual earnings and optimal earnings are significantly different only in 2000, while actual spending differs from optimal spending in fourteen out of seventeen years.

The data in Table 3 can also be used to reconstruct the profit inefficiency measures in Table 2. For example, value added profit inefficiency in 1989 is

**Table 3.** Optimal earnings and spending vs. actual earnings and spending

| Year | Optimal earnings and spending from $\pi_{SE}(\cdot)$ | | Optimal earnings and spending from $\pi_{XE}(\cdot)$ | | Actual earnings and spending | |
|---|---|---|---|---|---|---|
| | $\sum_m e_m$ | $\sum_n s_n^*$ | $\sum_m e_m$ | $\sum_n w_n x_n^*$ | $\sum_m e_m$ | $\sum_n s_n = \sum_n w_n x_n$ |
| 1989 | 40,728 | 22,761** | 43,457 | 19,462** | 42,323 | 27,927 |
| 1990 | 79,044* | 45,931** | 84,190 | 41,224** | 82,940 | 56,040 |
| 1991 | 42,013** | 36,110** | 47,577 | 35,791** | 46,748 | 47,134 |
| 1992 | 4,377** | 4,484** | 20,740 | 18,497** | 29,385 | 42,345 |
| 1993 | 1,136** | 1,601** | 15,094 | 14,111** | 21,693 | 37,215 |
| 1994 | 9,937* | 9,893** | 30,503 | 20,029** | 30,836 | 36,148 |
| 1995 | 1,255** | 1,592** | 23,221 | 17,502** | 24,938 | 34,048 |
| 1996 | 25,581 | 25,204** | 27,137 | 18,300* | 28,153 | 33,770 |
| 1997 | 23,281** | 23,333** | 30,197 | 21,345* | 27,632 | 32,516 |
| 1998 | 1,136** | 1,402** | 21,481 | 15,295* | 20,575 | 27,340 |
| 1999 | 3,876** | 3,629** | 22,302 | 16,328 | 20,323 | 25,933 |
| 2000 | 44,227** | 28,879** | 43,089** | 22,340 | 31,364 | 21,437 |
| 2001 | 21,490 | 18,530** | 21,806 | 17,168* | 22,230 | 23,444 |
| 2002 | 6,922* | 4,122** | 12,431 | 9,538** | 14,335 | 21,409 |
| 2003 | 7,609 | 4,810* | 15,833 | 5,851* | 15,113 | 23,019 |
| 2004 | 26,940 | 19,159 | 23,653 | 8,674* | 23,033 | 24,841 |
| 2005 | 17,239 | 7,419 | 29,363 | 11,268 | 30,881 | 32,818 |

Notes: * denotes optimal earnings or optimal costs are significantly different from actual earnings or actual costs using a *t*-test at $\alpha$ = 5%. ** denotes optimal earnings $(e_1^* + e_2^*)$ or optimal costs $(s_1^* + s_2^*)$ are significantly different from actual earnings $(e_1 + e_2)$ or actual costs $(s_1 + s_2)$ using a t-test at $\alpha$ = 1%.

[3] Test statistics available from the authors upon request.

$P_{SE}(.) = 893$. Substituting the optimal and actual values for earnings and spending for 1989 into (17) and noting that $g$ = (1,1) and $h$ = (1,1) we have $\boldsymbol{P}_{SE}(.) = \dfrac{(40,728-22,761)-(42,323-27,927)}{(1+1+1+1)} = 893$. Profit inefficiency for the $T_{XE}$ technology can be similarly constructed.

Our two representations of the technology, $T_{SE}$ and $T_{XE}$, provide alternative ways of evaluating DMU performance when data on prices and quantities are missing, but data on input spending or output earnings are available. How different are the estimates of profit inefficiency and technical inefficiency derived from the two technologies? If DMUs sell outputs and buy inputs in competitive markets where all DMUs face the same prices, then the indicators of profit inefficiency and technical inefficiency give the same results. To test the null hypothesis $\mathbf{P}_{SE}\left(\pi_{SE}, s, e, eq; g, h\right)$ $= \mathbf{P}_{XE}(\pi_{XE}, w, e, eq; \overline{g}, h)$, we used an ANOVA F-test and a battery of nonparametric tests for each of the years.[2] We cannot reject the null hypothesis in 1992 and 1993, and during the final five years of our period, 2001 to 2005. The failure to reject the null hypothesis in 2001 to 2005 provides some evidence that the financial reforms begun in 1992 have been successful at fostering competition.

As an alternative method of measuring profit efficiency, Maudos and Pastor (2003) use DEA to estimate an alternative profit function. Their alternative profit function is similar to our equation (27), but includes a physical output constraint. The choice variables for the alternative profit function are physical input quantities and the sum of earnings. The alternative profit function is

$$\pi_{ALT}(y^o, w^o, eq^o) = \max_{x,e,\lambda}\left[\sum_{m=1}^{M} e_m - \sum_{n=1}^{N} w_n^o x_n : \mathbf{X}\lambda \le x, \mathbf{Y}\lambda \ge y^o, \mathbf{E}\lambda \ge e, \boldsymbol{EQ}\lambda \le eq^o, \sum_k \lambda_k = 1, \lambda \ge \mathbf{0}^K\right]. \quad 31)$$

To estimate (31) we take the yen value of stock, margin, and bond transactions as a proxy for brokerage output and take the sum of the yen value of underwritings of stocks, bonds, and certificates plus the yen value of subscriptions of stocks, bonds, and certificates as a proxy for the other output. In Table 4 we report lost profits as a percent of assets for our two profit functions and for the alternative profit function of Maudos and Pastor. Maudos and Pastor report 3.5% lost profits as a percent of assets for Spanish banks in 1996. Our estimates of lost profits range from 0% to 15% of total assets. The addition of the extra set of constraints for the alternative profit function $\pi_{ALT}(\cdot)$ relative to $\pi_{XE}(\cdot)$ restricts the technology and results in lower lost profits as a percent of assets.

Finally, we test whether resources are allocated efficiently at the firm level for the value added technology, $T_{SE}$. If resources are efficiently allocated at the firm level, then the sum of the directional value added distance functions can serve as an indicator of industry inefficiency. Zero allocative inefficiency exists if the indicator of value added technical inefficiency equals the indicator of profit inefficiency. Therefore, the null hypothesis we test is $\mathbf{P}_{SE}\left(\pi_{SE}, s, e, eq; g, h\right) = \mathbf{D}_{SE}(s, e, eq; g, h)$. The test statistics reject the null hypothesis for each test in every year and indicate that security firm profits could be increased by an optimal reallocation of spending on inputs and earning on outputs.[3]

**Table 4.** Lost profits as a percentage of assets (standard deviation)

| Year | $\frac{\pi_{SE}(\cdot) - (\sum e_m - \sum s_n)}{Assets}$ | $\frac{\pi_{XE}(\cdot) - (\sum e_m - \sum w_n x_n)}{Assets}$ | $\frac{\pi_{ALT}(\cdot) - (\sum p_m y_m - \sum w_n x_n)}{Assets}$ |
|---|---|---|---|
| 1989 | 0.011 (.009) | 0.028 (.021) | 0.001 (.003) |
| 1990 | 0.015 (.011) | 0.037 (.026) | 0.000 (.002) |
| 1991 | 0.015 (.009) | 0.031 (.022) | 0.011 (.009) |
| 1992 | 0.031 (.016) | 0.036 (.020) | 0.039 (.016) |
| 1993 | 0.045 (.023) | 0.053 (.025) | 0.060 (.023) |
| 1994 | 0.023 (.014) | 0.068 (.046) | 0.035 (.018) |
| 1995 | 0.035 (.020) | 0.067 (.046) | 0.054 (.024) |
| 1996 | 0.022 (.015) | 0.056 (.037) | 0.035 (.018) |
| 1997 | 0.024 (.015) | 0.064 (.043) | 0.041 (.020) |
| 1998 | 0.029 (.019) | 0.072 (.051) | 0.052 (.028) |
| 1999 | 0.020 (.013) | 0.074 (.061) | 0.039 (.022) |
| 2000 | 0.060 (.088) | 0.114 (.158) | 0.021 (.050) |
| 2001 | 0.054 (.061) | 0.053 (.059) | 0.028 (.031) |
| 2002 | 0.096 (.053) | 0.109 (.070) | 0.072 (.042) |
| 2003 | 0.097 (.054) | 0.152 (.078) | 0.102 (.062) |
| 2004 | 0.096 (.087) | 0.129 (.117) | 0.039 (.053) |
| 2005 | 0.083 (.067) | 0.112 (.097) | 0.029 (.038) |

Notes: The maximal profit functions are $\pi_{SE}(\cdot), \pi_{XE}(\cdot)$, and $\pi_{ALT}(\cdot)$. Actual profits $= (\sum e_m - \sum s_n) = (\sum e_m - \sum w_n x_n) = (\sum p_m y_m - \sum w_n x_n)$, where $e_m$, $p_m$, and $y_m$ are output earnings, output price, and output quantity, and $s_n$, $w_n$, and $x_n$ are input spending, input price, and input quantity.

## V. Summary and conclusions

In much of the literature on the efficiency of financial institutions, output prices and input prices are synthetically constructed as ratios of interest income to a corresponding asset or as interest expense to a corresponding liability. In this paper we develop theoretical indicators of profit inefficiency that are based on value added variables of the amount spent on each input and the amount earned on each output. Our method yields useful indicators of performance when data on prices and quantities are unavailable, or when prices are synthetically constructed.

We estimate the two indicators of profit inefficiency for firms in the Japanese securities industry during the period 1989-2005. Several statistical results emerge from our analysis. First, we find that lost profits range from 0% to 15% of firm assets. Second, we find that allocative inefficiency tends to dominate technical inefficiency during the period, so that most firms could achieve greater profits via an optimal reallocation of input spending and output earnings. Third, although an industry indicator of aggregate profit inefficiency can be constructed, our finding of allocative inefficiency among firms means that an aggregate industry indicator of technical inefficiency cannot be obtained.

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