Operational Efficiency and the Value-Relevance of Earnings

by

Fatma Cebenoyan*

Assistant Professor

Hunter College/CUNY
Department of Economics
695 Park Avenue
New York, New York 10021

E-mail: Fatma.Cebenoyan@hunter.cuny.edu

Running title: Operational Efficiency & Value-Relevance of Earnings

*I appreciate helpful comments from conference participants at the meetings of AAA Northeast Regional in Boston, and EFMA in Athens, Greece, especially from Patricia Dechow, and three anonymous referees. This project is partially funded by CUNY Research Grant at Hunter College.
Operational Efficiency and the Value-Relevance of Earnings

Abstract: This paper extends prior valuation literature by offering a new dimension to the economic analysis of differential earnings/price behavior. Specifically, a measure of firm performance, estimated using stochastic frontier methodology, is introduced to reexamine this relation. Results provide strong evidence that this efficiency measure explains some of the differences in value-relevance of earnings. The results are robust to functional forms, portfolio choices, timing differences, as well as to the inclusion of other explanatory variables such as risk, profitability, size and R&D. Finally, the possible link between efficiency and persistence is tested by evaluating the firms grouped based on their efficiency scores. The results indicate a significant relationship between the firms’ relative operational efficiency and earnings persistence.
Operational Efficiency and the Value-Relevance of Earnings

1. Introduction

While there appears to be ample anecdotal evidence for the value relevance of accounting earnings, research in accounting has managed to uncover only a weak relation between contemporaneous stock prices and earnings. Initial modifications to the empirical price-earnings model and variable specifications have provided modest improvements (see Lev, 1989). The standard, linear price-earnings model has later been extended to incorporate the effects of firm-specific characteristics (for example, size, risk, etc.), cross-sectional variations in the persistence of earnings innovations, losses, and non-linearities. Yet, much of this literature develops from methodological innovations to the empirical price-earnings models employed, rather than from an economic analysis of the factors governing the price-earnings relation.¹

Fundamental analysis has identified certain additional accounting variables (for example, profitability ratios, liquidity ratios, sales, R&D, order backlog) as being value-relevant. However, statistical search procedures (e.g. Ou and Penman, 1989) or analysts’ preferences (Lev and Thiagarajan, 1993) usually guide the selection of these variables. Although both approaches contribute valuable information about firm-specific characteristics that are value-relevant, the former (intentionally) stays away from suggesting any economical and theoretical reasons as to why they are value-relevant, while the latter compiles them based on the analysts’ judgements. This study contributes to the extant valuation literature by introducing a relative performance measure developed in economics literature based on production theory. The goal is to offer an economically justifiable explanation for this differential price/earnings relation by
examining the choices made by management in revenue-generating process relative to their competitors, and evaluate the value-relevance of their earnings according to their competitive success in this process. In particular, the relative operational efficiency of firms is estimated using observed accounting variables provided in the income statement. These relative efficiencies are, in turn, shown to be a determinant of the differential value-relevance of earnings.

In this study, a stochastic frontier methodology is adopted to develop firm-specific efficiency rankings within selected industries. Borrowing from production theory, an input-output relation for firms is specified using accounting variables from income statement. The best-practice frontier for each industry, which describes the optimal industry-specific relation among these variables, is then estimated. Deviations from these frontiers represent firm-specific inefficiency scores which are subsequently used to proxy for firms’ competitive advantage, a variable that affects the firm’s current profitability and its future potential.

Results support the hypothesis that incorporating firms’ relative operational efficiency can enhance the explanatory power of earnings in firm valuation. Specifically, a stronger relation exists between earnings and prices for firms which are relatively more efficient. These results persist after controlling for other factors in price/earnings relation (e.g. risk, profitability, non-linearity, and the effects of negative earnings). Following the evidence provided by Lev and Sougiannis (1996) regarding the “economically meaningful” association between R&D and earnings, the results are reexamined after controlling for possible R&D effects with no significant changes. Further diagnostic tests indicate that the discriminatory nature of these efficiency scores is robust to alternative
dependent variables, to different portfolio sizes, and to various scaling concepts. Finally, the possible link between efficiency and persistence concepts is tested by evaluating the autocorrelation coefficients of firms grouped based on their efficiency scores. The results provide evidence that efficiency is a factor associated with persistent earnings.

The next section presents a brief review of the literature and hypothesis development. The empirical issues related to both the valuation process and the estimation of efficiency scores are presented in Section 3. Section 4 describes the sample, and presents the empirical findings of general tests. The results of the sensitivity analysis regarding the alternative explanations for efficiency measures, as well as their correlation with other going-concern concepts are presented in Section 5. Section 5 also looks at the efficiency scores as a possible explanation for earnings “persistence”, and provides evidence for their association. Section 6 concludes the study.

2. Review of the literature and hypothesis development

A large body of research examines the price/earnings relation providing evidence about the value-relevance of earnings as a summary measure as well as the value-relevance of components of that measure (e.g. Barth et al, 1992 and 1996). In attempts to explain the differences in this relation, one line of this research provides evidence for a list of firm-specific or industry-specific determinants. Fundamental analysis contributes a list of accounting variables and relations (e.g. profitability ratios, liquidity ratios, sales, R&D, order backlog) which have been found to enhance this price/earnings relation (e.g. Ou and Penman, 1989, Lev and Thiagarajan, 1993). Mostly, the selection of the variables has been governed by either a statistical procedure (Ou and Penman, 1989)² or through
surveys of financial statement users (Lev and Thiagarajan, 1993). Other studies offer abandonment option and financial health as determinants of equity/earnings and book values relation (Hayn, 1995, Burgstahler and Dichev, 1997, Barth, et al, 1998). This study tries to contribute to this debate in two ways. First, instead of focusing on econometric properties of price/earnings relationship, it proposes an economic condition in which value-relevance of earnings is enhanced. It introduces a firm-specific performance concept, efficiency, which evaluates a firm according to its input-output choices and how successfully those are matched to produce results. Second, instead of using earnings as a proxy, this study adopts a stochastic frontier methodology to estimate firm-specific efficiency levels. This methodology provides a richer performance measure since it utilizes components of earnings, and evaluates a firm relative to its competitors in its choice and use of these components.

While discussing the roles of financial statements, Barth et al, (1998), states that income statement is useful for valuing equity due to information provided in it about the “unrecognized net assets” (Barth et al, 1998, pg. 2). Unrecognized assets are defined as research and development, advertising, brand names, technological core competencies, customer loyalty and growth options. In a similar argument, Barth et al, 1995, talks about different values of assets, entry values and values-in-use. They define the assets’ entry values as their acquisition costs (or replacement values) as reported on balance sheet while they present value-in-use as the incremental value of an asset that is firm-specific. They argue that value-in-use provides a measure for intangible assets (similar to unrecognized net assets above) including management skill and growth options. This type of value is realized and reported in the income statement while the acquisition value is
reported on balance sheet. Barth et al, 1998, recognizes income statement’s role as provider of this information which is an indication of future performance, hence its value-relevance. They use net income as a proxy since, they argue, net income reflects all the revenue and expense items related to these unrecognized net assets. But this proxy can be improved upon by incorporating other valuable information. First, there is evidence in accounting literature that using components of earnings, instead of just earnings, provide incremental value-relevant information (e.g. Barth et al, 1992, 1996). Second, firm’s relative success in utilizing these components to meet its objectives has richer information value since relative performance also provides information on the firm’s competitive advantage. Firms which exploit their competitive advantages produce profits sustainable for a longer period of time leading to greater market shares at the expense of other firms (McWilliams and Smart, 1993).

This study proposes an efficiency measure as a discriminatory variable to explain the varying levels of earnings’ value-relevance across firms. Not only efficiency is an economic concept that measures performance (discussed below), but also very suitable proxy extracting richer value-relevant information from income statement. Estimation of efficiency measures in this study uses income statement components (revenue and cost items) since in measuring firm’s efficiency level, the mix of inputs is as important as their total effect on final outcome (Kolari and Zardkoohi, 1987). Further, in this study, stochastic frontier methodology is employed to capture the firm’s relative, rather than absolute, strength. This relativity is not established by comparing firms to their industry averages as usually done (e.g. ratio analysis) but to the “best-practice” frontier that
defines where the firms should be, given the current industry conditions. This measure brings firm level as well as industry level performance factors together.

The interest in efficiency in this study stems from its direct relationship to profitability, which is, in turn, a success indicator that measures performance. Efficiency, in general, is considered a “survival condition” for firms that function in competitive environments (e.g. Färe, Grosskopf, and Lovell, 1985). Although the concept of efficiency and its linkage to profitability have been explored in both the business (management and finance) and the economics literatures, it has been, for the most part, ignored in accounting. In determining the sources of profitability, the industrial organization (IO) and strategic management (SM) literatures provide theoretical and empirical evidence that firms with certain competitive advantages end up being more “efficient” and subsequently more profitable. Afriat (1988) loosely defines “efficiency” as the relation between ends and means and its measure as “the extent to which they are matched”. Efficiency is viewed in both IO and SM literatures as the product of firm-specific factors such as management skill, innovation, cost control, and market share (very similar concepts to the unrecognized net assets defined in accounting literature) as the determinants of current firm performance and its sustainability (see, e.g., McWilliam and Smart (1993), Jacobsen (1988)). This relationship between firm’s efficiency, its current performance and the sustainability of this performance makes the efficiency measure a viable factor in evaluating firms’ performance (earnings) and the relevance of that performance to the firm’s future (price). Estimation of this measure by using income statement items combines the role of income statement in equity valuation and incremental information value of earnings components. Also, by utilizing frontier
methodology, this measure is further improved to include information on firm’s relative competitive strength in this area.

The primary hypothesis in this study tests the relationship between efficiency and firm value through effects of efficient operations upon firm’s relative current performance and its future potential. More specifically,

**H1**: The value-relevance of earnings increases in firms’ relative efficiency.

In this study, relative efficiency scores of firms are estimated using stochastic frontier methodology. Since its introduction by Farrell (1957) and operationalization by Aigner, Lovell, and Schmidt (1977) and Jondrow, Lovell, Materov, and Schmidt (1982), the estimation of technical efficiency scores with frontier functions has been used extensively in the economics, engineering and operations research literature. This methodology was introduced into business research through finance literature evaluating the efficiencies of financial institutions within various contexts such as deregulation and mergers (e.g. Allen and Rai (1996), Bauer et al (1990, 1993), Berger et al (1993, 1997), Mester (1996) to name a few. See also a very thorough survey by Berger and Humphrey, 1997, on efficiency of financial institutions and estimation techniques and issues). There are very few efficiency studies in accounting literature, using stochastic frontier estimation techniques. Hayes and Millar (1990) employs the translog cost functions and cost shares to measure inefficiency in not-for-profit setting, using OLS technique. As an extension to this study, Mensah and Li (1993) introduce the frontier concept in a deterministic model to measure the inefficiency for possible budgeting and control purposes. They acknowledge, in a footnote, the recent focus on the stochastic models but state that they
choose “a deterministic cost frontier” since it fits the purpose of their study better (footnote 4, pg. 70).

Until very recently, the only efficiency study in accounting literature using stochastic frontiers has been by Dopuch and Gupta (1997) in which this methodology is introduced as the potentially best benchmarking technique to measure performance. Their application follows the traditional efficiency studies in the education area evaluating expenditure-performance relation among school districts analyzing their relative success. Two recent studies by Banker, et al (2003) and by Dopuch, et al (2003) apply this technology to auditing field, former studying the productivity of human resources employed while the latter focusing on the production efficiency in auditing and its effects on audit service pricing. The current study is perhaps the first in business research that employs this methodology as a tool to extract value-relevant performance information using the accounting variables.

3. Methodology

Two research design issues are central to this study. Section 3.1 deals with the first of these issues, estimation of the firm-specific efficiency measures to be used as the discretionary variable to classify firms for the valuation analysis in the second step. Section 3.2 describes the empirical models used to test the earnings/price relationship.

3.1 Stochastic Frontier Methodology

Estimation of the Benchmark The present study employs the basic input-output production function relationship with some modifications to the variables. This study evaluates firms’ relative ability to utilize their resources and links this ability to the value-
relevance of their earnings. The objective function employed to estimate the frontier is a production function and can be written as:

\[ Y = f(X, u, v) \]  

(1)

where \( Y \) is sales revenue, \( X \) is a vector of operational inputs generating this revenue, \( u \) denotes an inefficiency factor that affects the firm’s comparative performance level, and \( v \) is the random error that incorporates a measurement error and/or luck that affects the firm’s performance (see Berger and Mester (1997)). The model chosen for estimating this best-practice frontier, which defines the revenue and expense relationship is the standard translog functional form (see Bairam, 1994), and can be written for one output (\( Y \)) and three inputs (\( X \)'s) as follows:

\[
\ln(Y) = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + 0.5 \beta_{11} (\ln X_1)^2 + 0.5 \beta_{22} (\ln X_2)^2 + 0.5 \beta_{33} (\ln X_3)^2 + \beta_{12} (\ln X_1 \ln X_2) + \beta_{13} (\ln X_1 \ln X_3) + \beta_{23} (\ln X_2 \ln X_3) + \ln \varepsilon
\]

(2)

The firm identification of \( i \) is omitted for notational simplification. Developed by Christensen, Jorgenson, and Lau (1973), this functional form has become very popular in estimation of production (or cost) functions, especially in efficiency literature due to its improvement over other functional forms. It allows estimation of production functions with more than one output and more than two inputs. Further, it is flexible in that it allows for non-uniform scale characteristics, and a degree of substitution among inputs which is not limited to unity.
**Input and Output Variables**  
In the absence of prior studies employing this technology using accounting data from publicly available sources, variables are chosen in this study following considerations in other areas like finance. In banking industry, cost variables are identified as fixed costs (fixed asset and administrative expenses) and variable costs (expenses that can be directly allocable to products produced) (Kolari and Zadkoohi, 1987). Fixed asset costs (also called physical capital) include the depreciation and rent expenses while variable costs include direct labor and acquisition costs (e.g. interest paid on deposited funds). The variable cost component used in this study is direct product costs (cost of goods sold), while selling and administrative costs, and the physical capital cost that consists of rent and depreciation expenses reflect the fixed cost component. Traditional efficiency studies are more exact in terms of product costs (labor and material) and selling and administration costs (managerial labor and other) to determine the effect of exact mix and levels of these inputs. Nevertheless, the use of aggregate expenditure categories satisfies the goal of this study. Since the purpose is not to determine the sources of inefficiencies but relative inefficiencies in general, estimated scores provide an overall (in)efficiency measure resulting in a suitable proxy for a firm’s selection and utilization of its resources (see Dopuch and Gupta, 1997).

Sales are used as a measure of output, the dependent variable in this study (e.g. see van den Broeck, 1988, and Bairam, 1994). This is also analogous to the use of loans and non-loan assets produced in dollar amounts instead in efficiency studies in finance. Using dollar values instead of quantities helps to control for a few possible product-related problems estimation (Berger and Mester, 1997). While efficiency scores are calculated within industries, the possibility exits that there are slight product differences
among the firms, and any cost effects of these differences will not be picked up by the quantity measure of output, but will be reflected in the cost. This may erroneously classify a firm as less efficient when evaluated against a firm with different products. A similar problem exists when there are quality differences among products of different firms. This may result due to use of better inputs and/or better-trained labor force. Either way, the cost of the product will be higher than the lower quality products, and will be reflected in the firm’s total cost, but not in its quantity of output. Using sales revenues instead of quantity output alleviate this problem by introducing (possibly) higher prices charged for these higher quality products into the equation. The higher costs of such firms will be offset by the higher level of output, not necessarily in the quantity, but in revenues. All the variables are specified as ratios to total assets to control for scale biases in estimation (Berger and Mester, 1997). Since costs and revenues of large firms are expected to be larger than for small firms, the random errors of large firms would have larger variances without any normalization. This is an important consideration since the (in)efficiency terms, as explained below, are derived from the combined residuals. Without an appropriate normalization, this may cause the variances in these terms dependent on firm size. Normalization by the total assets also provides an economic meaning to the dependent variable. Sales divided by total assets is basically the total asset turnover which is a standard asset utilization ratio. Such ratios are intended to describe how efficiently a firm uses its assets to generate sales.

The estimation of the frontier through equation (2) is followed by the decomposition of the error term \( \epsilon \) into its two components \( \nu \) and \( u \), as defined in equation (1). The justification for this specification of the error term is that the firms
differ from each other in terms of their objective due to 1) random fluctuations such as luck, climate, machine performance, etc, and 2) their ability to follow the best practice. Thus, $e$ decomposes into two parts:

$$ e = v + u $$

(3)

where $v$ represents the disturbances due to uncontrollable events (#1), and $u$ the deviations caused by the controllable factors (#2). Since the inefficiency component, $u$, cannot be observed directly, it has to be obtained from the estimated $e$ which obviously contains information on $u$. The suggested solution considers the conditional distribution of $u$, given $e$, $(u | v + u)$. The firm-specific inefficiency scores obtained through this methodology are further transformed into the more appealing efficiency scores using Battese and Coelli’s (1988) algorithm. The technical details of the decomposition and the transformation are given in the Appendix. The resulting efficiency scores are employed in the following valuation models as the discriminant variable.

3.2 Price-Earnings Relation

The standard price-earnings models used in the literature are price (levels) and return models (Kothari and Zimmerman, 1995). In its most general form, the relation between market value and earnings is expressed as:

$$ MV_i = \alpha + \beta E_i + \varepsilon $$

(4)

where $MV$ is the market value of equity and $E$ is earnings for period $t$. The estimation of equation (4) serves the purpose of establishing benchmark results with which augmented models can be compared. All variables are deflated by the number of shares outstanding at the end of the year to reduce heteroscedasticity in the residuals (Barth, Beaver and Landsman, 1992).
To investigate the primary hypothesis, I use portfolio approach. The portfolio approach provides an incremental analysis to investigate the earnings coefficient as efficiency varies, and offers some controls for potential confounding factors. First, the portfolio-based tests are not as sensitive to outliers in the efficiency measure estimated. Second, the portfolio approach provides control for potential non-linearities in the relation between market value and efficiency scores (Wilson, 1987). For the portfolio analysis, three different portfolios, grouping firms based upon their efficiency measures, are created to test the differential relation between earnings and market values for these three sub-samples. Firms are initially partitioned into three portfolios (high (H), medium (M), and low (L)) depending on their efficiency scores, and incorporated into equation (4) through differential dummy variables. The extended version of the equation is as follows:

\[
MV = \alpha_0 + \sum_{i=1}^{3} \alpha_i D_{e_i} + \beta_0 E + \sum_{i=1}^{3} \beta_i D_{e_i} * E + \epsilon
\]

(5)

where \( D_{e_i} \) is an efficiency dummy, which takes the value of 1 when \( i = H \) or \( L \) with portfolio M selected as the base portfolio. \( \alpha_0 \) and \( \beta_0 \) represent the intercept and slope coefficients for portfolio M, while \( \alpha_{1,2} \) and \( \beta_{1,2} \) capture the incremental coefficients for firms with high and low efficiency scores, respectively. In sum, estimation of equation (5) accounts for the potential impact of efficiency scores on the explanatory power of earnings. The incremental coefficients of firms from portfolio H(L) are expected to be significantly higher (lower) than the firms from the base portfolio M with signs positive (negative) respectively.
4. Data and the empirical results

4.1 Sample Selection

Variables

The Active and Research files from the 1999 edition of the Compustat database are used to identify firms with available variables to estimate the frontier in addition to the variables necessary to test the relation between market values and earnings. Net sales, selling, general, and administrative expenses and depreciation expense are employed directly, while the cost of goods sold is adjusted for the rent expense, which is originally included in this item. Rental expense is reported net of rental income when available. All the variables in the frontier estimation are scaled by total assets to avoid heteroskedasticity and scale bias (Berger and Mester, 1997). Market price and earnings are scaled by the number of shares outstanding to ameliorate the heteroskedasticity problem in the valuation regression models (Barth, Beaver, and Landsman, 1992). The dependent variable in the valuation regression models is the price reported at the end of the third month following the firms’ fiscal year-end to allow time for financial reports to be made public.

Industries

Although there are no criteria for industry selection process, certain industries are intentionally avoided. They include financial services and other regulated industries, such as transportation and utilities. The main reason for this exclusion is to avoid pooling firms with vastly different operational environments (e.g. regulated vs. competitive), which may affect their behavioral goals (e.g. cost-minimization vs. profit-maximization). The objective function employed here (Equation 1) focuses on generating maximum possible revenue (output) given the cost components of that process. That specification may not be suitable for firms within regulated industries
where output is generally assumed to be exogenous. Additionally, following prior research, these industries are also avoided as the standard earnings/price relationship doesn’t hold for them (e.g. Fama and French, 1992, Burgstahler and Dichev, 1997). The selection process for the rest of the industries is only restricted by the availability of the relevant data to estimate the production frontier and valuation regression models.

The sample selection process and industries which pass these criteria are summarized in Table 1.

[Insert Table 1 about here]

After the elimination of firms due to missing information, 21,034 firm-years were available for the testing period, 1993-1997. At both frontier estimation and valuation stages the data is tested for possible outliers using the standardized residuals method suggested by Belsley, Kuh, and Welsch (1980). These additional procedures caused a loss of 1,399 firm years (about 6.6 % of the total sample). Panel B of Table 1 shows the industry composition of the final sample. These firms are spread over thirty different industries, which include mining, construction, manufacturing, wholesale, retail and service.

4.2 Empirical Results

(In)efficiency Scores

The first set of results pertains to the estimation of firm-specific inefficiencies and their translation into efficiency scores. To estimate the efficiency scores, a separate frontier is estimated using the translog equation (2) in section 3.1 for each industry in every year. Residuals are decomposed into their two
components, random and firm specific, and are, subsequently, transformed to efficiency terms using the Battese and Coelli (1988) algorithm (see Greene, 1993) (see equation (A6) in Appendix). This procedure is repeated for each of the selected industries separately in each year. All frontier estimation equations show a good statistical fit, with $R^2$s ranging from 71% to 98% (not reported due to space considerations). Summary of the estimated efficiency scores by industry is given on Table 2. Majority of the industry groups’ scores (85 %) falls within the range of 85-95 % of efficiency consistently over the testing period. Only four industries show performance within 70-79 % range during the same period.

[Insert Table 2 about here]

In this section, I investigate the primary hypothesis that the explanatory power of firms’ earnings increases with the level of efficiency, using a portfolio approach. Firms are sorted according to their efficiency levels, and then grouped into three groups, each with equal number of firms. Dummy variables D1 and D2 indicate the high (H) and the low (L) ranges, respectively. Table 3 presents the results of the regression estimates of equations (4), which are estimated for benchmarking,\textsuperscript{11} and (5). The intercept differential coefficients on both high (H) and low (L) relative to medium (M) efficient firms are statistically significant (except for H in 1995) implying that the price/earnings relation among these three groups is completely different. Additionally, all differential slope coefficients (with the exception of H in 1993) are statistically significant with coefficients on H(L) group positive (negative). $R^2$s (all reported in this study are adjusted) have improved substantially with the inclusion of
the efficiency metric: improvement in the model’s fit ranges from 37% in 1993 to more than 600% in 1994 with portfolio approach over general price/earnings model. The evidence in Table 3 provides strong support for the primary hypothesis, that earnings’ explanatory power is enhanced when firm’s comparative operational efficiency is incorporated into the analysis. Since the descriptive results on Table 2 suggest a relation between efficiency scores and industry membership, these tests are repeated after controlling for industry membership. Results (not reported) are qualitatively the same to ones reported here with R²’s improving in two years (25 and 27% in years 1994 and 1997 respectively).

[Insert Table 3 about here]

Figure 1 depicts the relationship between price and efficiency scores discussed above, graphically. For this presentation, the five-year pooled data has been ranked according to the efficiency scores, and then grouped into 100 portfolios with equal number of firms (approximately 167) in each portfolio. Then price/earnings model is estimated for each portfolio separately, and earnings coefficients of each portfolio have been plotted against average efficiency scores of each portfolio. As can be seen from Figure 1, mean efficiency scores and response coefficients display a positive association between them.

[Insert Figure 1 about here]
5. Efficiency and Alternative Explanations of Price/Earnings Relation

Empirical regularities are routinely examined in the efficiency literature as well as valuation literature regarding the correlation between the efficiency scores and certain firm characteristics such as size, profitability, risk and market share (see, e.g., Subramanyam and Wild (1992), Berger, et al , 1993, and Allen and Rai, 1996). These characteristics are also investigated here to establish initial relation with the efficiency scores estimated. For measures of performance (profitability), I use return on equity (ROE). For risk, the chosen variables follow the valuation literature: Debt-To-Total assets ratio (DAT) for financial risk, and Operating Leverage (OL) for operating risk (Subramanyam and Wild (1992) and Biddle and Seow (1991)). OL is calculated by dividing the fixed operating expenses by variable operating expenses. Fixed expenses are the sum of depreciation expense, interest expenses, and selling and administrative expenses. Variable operating expenses are measured as cost-of- goods-sold (Biddle and Seow (1991)). Finally, as a size variable, market share is used as a proxy for market power, and is calculated by dividing firm’s sales revenue by total industry revenue. All variables are adjusted by the industry averages to capture the relativity of efficiency score estimations.

[Insert Table 4 about here]

Table 4 shows the rank-order correlations between efficiency, and performance and risk variables replicating the results in the literature investigating the correlates of the efficiency scores (Berger, et al. (1992), Allen and Rai (1996)). As expected, the efficiency scores are highly correlated with the profitability measure of ROE, implying
that it is an alternative performance measure. Efficiency scores are also highly correlated with size, measured as the market share. Although the causality is not clear, the notion that large firms are more efficient (hence profitable) in the IO literature is confirmed here. Finally, the risk variables show a significant association with the efficiency scores in the expected direction.

5.1 Controls for Alternative Explanations

Given the (mostly) strong correlation found in the previous section, these characteristics are added as control variables to the basic interactive model to check whether the estimated efficiencies only reflect these well-known value-relevant firm characteristics rather than relative competitive strength of the firm. The high correlation between the efficiency and profitability brings in the possibility of the effects of losses\(^{13}\) (Hayn, 1995) on this price/earning relation, as well as the effects of extreme observations (Freeman and Tse, 1992) which might be captured by these scores. To test for the additional informativeness of these scores over the aforementioned variables, the interactive model of (5) in Section 3.2 has been expanded to include all these variables as controls. The model then becomes:

\[
MV = \alpha_0 + \alpha_1 EPS + \alpha_2 EPSEFF + \alpha_3 EPSAROE + \alpha_4 EPSAOL + \alpha_5 EPSADAT + \alpha_6 EPSAMSHI + \alpha_7 EPS2 + \alpha_8 D_{nc} \ast EPS + \epsilon
\]

where

- EPS = earnings per share (before discontinued and extraordinary);
- EPSEFF = EPS \ast Efficiency;

(6)
EPSAROE = EPS * industry adjusted ROE;
EPSAOL = EPS * industry adjusted operating leverage;
EPSADAT = EPS * industry adjusted debt-to-total assets;
EPSAMSHI = EPS* industry adjusted market share;
EPS2 = earnings * |earnings| (Lipe, et al. 1998) and
D_ne is a dummy variable that takes the value of 1 when earnings are negative.

The other variables for profitability (price-cost margin) and size (log of total assets) are also used as robustness checks. The results (not reported here) are qualitatively the same to those reported on Table 5. EPSEFF variable is positive as expected in 4 out of 5 years, three being significant at less than 0.01 level. Hence, inferences regarding the efficiency scores seem to hold after consideration of additional variables.¹⁴

Recently, the nature of R&D expenditures has become an area of interest as a possible determinant of price/earnings relation. Specifically, Lev and Sougiannis (1996) provide evidence which indicates a “statistically significant and economically meaningful” association between R&D expenditures and subsequent earnings. Under current US GAAP, current earnings feel the direct impact of R&D expenses fully in the year they are incurred, however, the indirect effect of current R&D expenses on the future earnings aren’t in any way reported on the financial statements. The average useful life of R&D benefits is found to be between five and nine years (Lev and Sougiannis (1996)). As a result, the traditional price/earning relation is improved when adjustments are made to the R&D expenses in the form of partial expensing, partial capitalization and amortization over its life since they enhance the matching of revenues with expenses.
Given the above results, it becomes important to investigate the R&D effect on earnings in this study. In the estimation process of efficiency scores, the dependent variable used is sales revenue, which reflects the indirect benefits of prior R&D expenditures that are already expensed in prior years. Current R&D expenditure, on the other hand, is fully recognized on the financial statements as part of the general and administrative expenses, which is one of the independent variables of the frontier estimation. Consequently, these two R&D effects on costs and revenues have the potential of driving the prior efficiency score results. As a result, the sample is divided into two distinct groups based on their R&D intensity: manufacturing (with SIC codes of 28, 35, 36, 37 and 38 (see Lev and Sougiannis (1996)) vs. service (with SIC codes of 53, 54, 56, 70, 72, 78, 80, 82, and 87). Each group is tested separately by using the main model, and the results are examined for any R&D related effects.

The results of these tests (not reported) on both manufacturing and service groups show similar patterns of price/earnings relation when examined within an efficiency concept. Specifically, earnings of highly efficient firms in both groups display higher relation to price than the firms in low efficiency group, after controlling for non-linearity and negative earnings, at (four out of five years) .01 significance level with R^2's ranging from .16 to .37. This evidence implies that the R&D explanation for differential value-relevance of earnings can not be the sole driving force of efficiency effect.

5.2 Additional Sensitivity Tests

Dependent Variable The dependent variable used in the estimation of price/earnings is the market value of equity measured at the third month following the fiscal year-end of
the company. This timing choice assures that all the earnings related information for the current period is reflected in the price. However, all other variables that are used to estimate the efficiency scores and the price/earnings models are measured at the firms’ fiscal year-end. Matching the year-end earnings information with the three-month-later prices can induce specification error as these prices reflect the effect of the events, which occur during that time interval, but have no bearing on the prior period earnings (Barth, Beaver, and Landsman, 1992). Hence all valuation models are re-estimated using fiscal year-end price information. The results (not reported) are very similar to those reported here.

Scaling Concerns All price/earnings models are estimated after deflating all variables by the number of shares outstanding at the fiscal year-end. The use of per-share values of prices and earnings has been recommended by Barth, Beaver and Landsman (1992) to reduce heteroscedastic disturbances in undeflated forms of these variables. In the process of evaluating various valuation models, Kothari and Zimmerman (1995) provide evidence that the price models using per share values still suffer from heteroscedasticity-related problems. They offer the book value of assets at the beginning of year as an alternative deflator to the price model. They argue that the book value of assets is preferable to earnings as a scaling variable since book values are (almost) always positive and less likely to generate outliers (Kothari and Zimmerman (1995)). Market value of equity at the beginning of year is also a very common deflator used in the literature (especially in return studies; see Christie, 1987) to reduce heteroscedasticity. Hence, I reestimate all the valuation models using book value of assets and market value of equity.
at the beginning of year to assure that the results are not driven by the scale differences which have not been properly controlled for.

The results (not reported) using total assets and market value of equity at the beginning of the period reveal no significant changes in statistical inferences. Finally, I reestimate the models above with corrected White’s estimator (not reported). The corrected standard errors are somewhat higher than the original estimations, but the level of statistical significance is unaffected.

*Portfolio Formation* The price/earnings model in (5) is estimated by grouping firms into three portfolios based on the firms’ efficiency rankings. However, it should be noted that the choice of three portfolios is arbitrary. Hence, these models are reestimated using five portfolios with equal number of firms in each group. This exercise is also repeated using two groups, divided by the median value of efficiency scores with similar conclusions.

5.3 Linking Efficiency to Persistence

The final section of this analysis focuses on the extent to which efficiency scores are able to capture information about the future performances of the company from current earnings, by ranking firms based on their relative strengths in generating revenues. As mentioned above, the more important aspect of this measure is its informativeness about the future of the firm’s current performance: How persistent is it? Cross sectional evidence on the relative ability of a firm in generating a large market share indicates current profitability, although it may not represent sustained competitive advantage. The main argument here is not just the relation between the efficiency measures and the firm-
specific profitability, but it is their connection to the firm’s market shares along with risk information. Sometimes, a firm can catch a temporary competitive advantage based on a resource that is easily attainable or a strategy that is easily imitable by other firms (McWilliams and Smart, 1993). This temporary advantage can result in current profitability but may not be sustainable in the future. It becomes important, then, to look at the time series relation of firms’ earnings with an efficiency context to see if associations and conjectures developed in the IO and finance literatures regarding efficiency-profitability and sustainability of this profitability hold true.

Earnings persistence, as mentioned above, has received a great deal of attention in the valuation literature (e.g. see Kormendi and Lipe (1987), Collins and Kothari (1989), and Lipe (1990)). In attempts to improve the price/earnings relation and investigate the reasons behind differential market reactions to earnings announcements, the time-series behavior of earnings is analyzed. Estimates of earnings persistence, which is defined as the continuation of earnings at the current level, are found to be positively correlated with earnings response coefficient (Lipe (1990)). These studies derive these estimates from the statistical properties of the time series of earnings (Lipe (1990), and Lev and Thiagarajan (1993)). This study offers efficiency as an economic explanation behind these statistical properties. The following test is intended to investigate that conjecture and link efficiency scores to earnings persistence.

In this study, all valuation relations are evaluated at levels, using the price model (Kothari and Zimmerman (1995)). Accordingly, I define persistence as the time series relation between current and future earnings, rather than current earnings shocks to future earnings (Lipe (1990)). I divide the sample firms for each year into three groups, based
on their efficiency scores, high, medium and low, and estimate the following one-lagged autoregressive model (AR (1)):

\[ E_{t+1} = \alpha_0 + \alpha_1 E_t + \sum_{i=1}^{2} \delta_i D_i * E_t + \epsilon \]  \hspace{1cm} (7)

where \( E \) is earnings before extraordinary items and discontinued operations, \( D_i \) dummy variables that take 1 when efficiency score is above (below) the cutoffs, 0 otherwise, and \((\alpha_1 + \delta)\) are coefficients that define the time series relation. If efficiency scores reflect earnings persistence, one should observe higher autocorrelation coefficients for firms with high efficiency scores than the ones with low scores, and the difference is expected to be statistically significant.

The results for this simple autoregressive model (Table 6) provide support for persistence argument: The autocorrelation parameter for highly efficient firms is found to be higher than the one for low efficient firms, suggesting that these efficiency scores capture (at least part of) the firms’ future performance information. For example, in 1997, the high efficient firms’ coefficient is 0.82 (0.67+0.15) as opposed to 0.75 (0.67+0.08) of low efficient firms, both at a significance of .01 level (\( R^2 = .77 \)). The F-statistic for testing the hypothesis that there is no difference between the coefficients of these groups is constructed. The null hypothesis of \((\delta_1 - \delta_2) = 0\) is rejected at .01 level. Similar results have been observed through five years studied here. Clearly, a direct association exists between these efficiency scores and autocorrelation coefficient supporting the original evidence that the high efficient firms’ earnings carry more information regarding future performances than the low efficient firms', hence they are more value-relevant.15
6. Concluding Remarks

The main motivation for this study is to develop an empirical construct that evaluates the relation between earnings and market value within an economical context and helps us understand further the factors affecting the value-relevance of contemporaneous earnings. Firms’ relative level of operational/production efficiency are measured with the efficiency scores estimated from accounting variables. These scores are subsequently used to test the differential effects of earnings of different firm groups on their market values. The results provide strong evidence that the efficiency measure explains, at least partly, the differential value-relevance of earnings, and are found to be robust with respect to various variable and model specifications.

This study contributes to the existing literature in two ways. First of all, it introduces the concept of efficiency as a partitioning variable to gauge earnings’ value-relevance. More efficiently run firms are considered to have competitive advantage in making better input-choice- and-use decisions, and produce better results. These firms are expected to survive the competition, and sustain the level of their performances in the future (Jacobsen (1988)). Recently, McGahan and Porter (1999) find that firm-specific effects like efficiency have a more persistent effect on profitability for highly profitable firms. There is also evidence in the finance literature that banks with high variability in their returns (ROAs) tend to have low efficiencies (Berger and Mester (1997)).

Second, this study introduces an improved proxy, which extracts richer value-relevance information from income statement using frontier methodology. Although estimated here with some modification, this measure has been defined thoroughly, and
utilized extensively in other areas investigating firm performance. Conceptually and methodologically, it is an alternative measure to other traditional (such as ratios) or non-traditional measures (such as Ou and Penman’s Pr (1989) or Lev and Thiagarajan’s aggregate fundamental score (1993)), and has great potential to be developed and used in other ways.
Appendix

The Econometric Efficiency Model  Developed by Aigner, Lovell and Schmidt (1977) and improved by Jondrow, Lovell, Materov and Schmidt (1982), the stochastic frontier methodology takes any objective function, estimates a best practice frontier based on the chosen variables, and then provides the firm-specific inefficiencies from a decomposed residual term. The objective function can be rewritten, in short form, as:

\[ Y = f(X; \beta) + e \]  \hspace{1cm} (A1)

where \( Y \) is the maximum attainable output from the input vector of \( X \)’s, \( \beta \) is the vector of parameters estimated, and \( e \) a composite error term made up of two components. The justification for this specification of the error term is that firms differ from each other in terms of their objective due to 1) random fluctuations such as luck, climate, machine performance, etc, and 2) their ability to follow the best practice. Hence \( e \) decomposes as follows:

\[ e = v + u \]  \hspace{1cm} (A2)

where \( v \) represents the disturbances due to uncontrollable events (#1 above), and \( u \) the deviations caused by the controllable factors (#2 above). Let \( Y^* \) be the maximum output (sales in this study) that can be produced given the inputs of \( X_1, X_2, \) and \( X_3 \) (cost of goods sold, general and administrative expenses, and physical capital, respectively). \( Y^* \) is the frontier objective function of which its parameters, vector \( \beta \), are estimated from the given observations of \( Y \), and \( X \)’s. Since the frontier function is assumed to be stochastic, rather than deterministic, equation (A1) becomes:

\[ Y = Y^* + u \]  \hspace{1cm} (A3)

where

\[ Y^* = f(X; \beta) + v \]  \hspace{1cm} (A4)
in which $v$ assumes random fluctuations (both negative and positive) and $u$ assumes only negative values. Since the external events can be both favorable and unfavorable, they can increase or decrease the output and are consequently assumed to be drawn from a two-sided distribution (usually normal). On the other hand, inefficiencies only decrease the output or increase the costs and are assumed to drawn from a one-sided distribution (usually half-normal). Since the inefficiency component, $u$, cannot be observed directly, it has to be obtained from the estimated $e$ which obviously contains information on $u$.

The suggested solution considers the conditional distribution of $u$, given $e$, $(u|v+u)$. To do this, first, the joint density of $u$ and $v$ is written (as the product of their individual densities). Since $e$ is defined as the sum of these two error terms, this joint density is transformed into the joint density of $e$ and $u$ (D1). The density of $e$ is obtained by integrating $u$ (D2). The conditional distribution of $u$, then, is given as the ratio of D1 to D2 (Maddala, 1977. See also Appendix of Jondrow, et al, 1982, for detailed calculations). The mean or the mode of this distribution is used as a point estimate of firm-specific $u$s. Jondrow, et al. (1982) gives expressions for these point estimates assuming half-normal for $u_i$ as follows:

$$E(u|e) = \mu_e + \sigma_e \frac{f(-\mu_e / \sigma_e)}{1 - F(-\mu_e / \sigma_e)}$$

(A5)

where $\mu_e = -\sigma_u^2/\sigma^2$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\sigma_e^2 = \sigma_u^2 \sigma_v^2 / \sigma^2$ and $f$ and $F$ represent the standard normal density and cdf respectively.

Finally, due to its intuitive and economic appeal, the efficiency, rather than inefficiency, concept has been employed in the study. That has been accomplished using Battese and Coelli’s (1988) algorithm for the logarithmic cases to translate
inefficiency scores (u’s above), into technical efficiencies (Green 1993). Since the frontier production function is defined for the logarithm of production, Battese and Coelli don’t recommend to use simply 1-u to arrive at firm specific efficiency, but rather to use \( \exp(-u_i) \) which is equivalent to the following general ratio:

\[
Efficiency_i = \frac{\exp(x_i \beta + v_i - u_i)}{\exp(x_i \beta + v_i)}
\]

where the firm’s estimated production function at its own inefficiency is compared to the firm’s estimated production function if the firm effect \( u_i \) is zero. This measure by design has values between zero and one. If a firm’s efficiency measure is 0.70, then it implies that the firm realizes 70 percent of the production possible for a fully efficient firm operating under the same conditions (Battese and Coelli (1988)).
References


### Table 1

**Sample Selection**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of usable firms</td>
<td>3,891</td>
<td>5,166</td>
<td>4,834</td>
<td>3,827</td>
<td>3,316</td>
<td>21,034</td>
</tr>
<tr>
<td>Outliers</td>
<td>175</td>
<td>255</td>
<td>240</td>
<td>201</td>
<td>178</td>
<td>1,049</td>
</tr>
<tr>
<td><strong>Observations Used for Frontier Estimation</strong></td>
<td>3,716</td>
<td>4,911</td>
<td>4,594</td>
<td>3,626</td>
<td>3,138</td>
<td>19,985</td>
</tr>
<tr>
<td>Observations Lost due to Missing Price Information</td>
<td>327</td>
<td>586</td>
<td>765</td>
<td>694</td>
<td>545</td>
<td>2,917</td>
</tr>
<tr>
<td>Observations from Frontier Estimation</td>
<td>3,716</td>
<td>4,911</td>
<td>4,594</td>
<td>3,626</td>
<td>3,138</td>
<td>19,985</td>
</tr>
<tr>
<td>Observations Lost due to Missing Variables</td>
<td>660</td>
<td>825</td>
<td>891</td>
<td>679</td>
<td>440</td>
<td>3,495</td>
</tr>
<tr>
<td>Observations from Frontier Estimation</td>
<td>2,954</td>
<td>3,812</td>
<td>3,455</td>
<td>2,678</td>
<td>2,412</td>
<td>15,311</td>
</tr>
<tr>
<td>Observations Lost due to Missing Variables</td>
<td>240</td>
<td>328</td>
<td>252</td>
<td>13</td>
<td>8</td>
<td>841</td>
</tr>
<tr>
<td>Observations from Frontier Estimation</td>
<td>3,410</td>
<td>4,483</td>
<td>4,259</td>
<td>3,560</td>
<td>3,086</td>
<td>18,798</td>
</tr>
<tr>
<td>Observations Lost due to Missing Variables</td>
<td>66</td>
<td>100</td>
<td>83</td>
<td>53</td>
<td>44</td>
<td>346</td>
</tr>
<tr>
<td><strong>Notes:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Outlier detection technique, standardized residuals, suggested by Belsley, Kuh, and Welsch, 1980, is applied to the used in both the frontier estimation and the valuation regressions. The observations with standardized residuals in excess of 2 (Belsley, Kuh, and Welsch, 1980) are deleted. This number reflects the observations deleted after the first procedure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) This is the result of the second standardized residual process applied to price/earnings model.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) All the variables adopted for control purposes (profitability and market share ratios, operating leverage, etc.) are checked for outliers. All the observations with values three standard deviation more than the industry average are dropped from the data set.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) This is the result of the second standardized residual process applied to earnings t/earnings t-1 model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1 (Cont.)

Panel B: Breakdown by Industry:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Extraction</td>
<td>178</td>
<td>209</td>
<td>205</td>
<td>174</td>
<td>160</td>
<td>926</td>
</tr>
<tr>
<td>15</td>
<td>Construction</td>
<td>---f</td>
<td>84</td>
<td>69</td>
<td>60</td>
<td>48</td>
<td>261</td>
</tr>
<tr>
<td>20</td>
<td>Food and Tobacco</td>
<td>149</td>
<td>170</td>
<td>155</td>
<td>135</td>
<td>---</td>
<td>609</td>
</tr>
<tr>
<td>22</td>
<td>Textile</td>
<td>108</td>
<td>111</td>
<td>106</td>
<td>96</td>
<td>90</td>
<td>511</td>
</tr>
<tr>
<td>24</td>
<td>Wood Products</td>
<td>---</td>
<td>72</td>
<td>---</td>
<td>---</td>
<td>61</td>
<td>133</td>
</tr>
<tr>
<td>26</td>
<td>Paper and Allied Products</td>
<td>54</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Printing and Publishing</td>
<td>86</td>
<td>---</td>
<td>93</td>
<td>84</td>
<td>---</td>
<td>263</td>
</tr>
<tr>
<td>28</td>
<td>Chemicals</td>
<td>132</td>
<td>137</td>
<td>138</td>
<td>128</td>
<td>125</td>
<td>660</td>
</tr>
<tr>
<td>283</td>
<td>Drugs</td>
<td>137</td>
<td>147</td>
<td>123</td>
<td>109</td>
<td>114</td>
<td>630</td>
</tr>
<tr>
<td>30</td>
<td>Rubber, Leather and Glass</td>
<td>---</td>
<td>155</td>
<td>158</td>
<td>140</td>
<td>125</td>
<td>578</td>
</tr>
<tr>
<td>33</td>
<td>Metal and Metal Products</td>
<td>171</td>
<td>189</td>
<td>185</td>
<td>---</td>
<td>157</td>
<td>702</td>
</tr>
<tr>
<td>35</td>
<td>Industrial Machinery</td>
<td>206</td>
<td>243</td>
<td>233</td>
<td>206</td>
<td>183</td>
<td>1,071</td>
</tr>
<tr>
<td>357</td>
<td>Computer Equipment</td>
<td>158</td>
<td>241</td>
<td>241</td>
<td>204</td>
<td>171</td>
<td>1,015</td>
</tr>
<tr>
<td>36</td>
<td>Electronic Equipment</td>
<td>125</td>
<td>143</td>
<td>142</td>
<td>---</td>
<td>117</td>
<td>527</td>
</tr>
<tr>
<td>366</td>
<td>Communication Equipment</td>
<td>170</td>
<td>204</td>
<td>216</td>
<td>188</td>
<td>166</td>
<td>944</td>
</tr>
<tr>
<td>367</td>
<td>Electronic Components</td>
<td>176</td>
<td>189</td>
<td>192</td>
<td>172</td>
<td>139</td>
<td>868</td>
</tr>
<tr>
<td>37</td>
<td>Motor Vehicles</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>60</td>
<td>55</td>
<td>115</td>
</tr>
<tr>
<td>38</td>
<td>Instruments</td>
<td>338</td>
<td>369</td>
<td>371</td>
<td>318</td>
<td>292</td>
<td>1,688</td>
</tr>
<tr>
<td>48</td>
<td>Communications</td>
<td>---</td>
<td>199</td>
<td>195</td>
<td>143</td>
<td>119</td>
<td>656</td>
</tr>
<tr>
<td>50</td>
<td>Wholesale-Durable Goods</td>
<td>---</td>
<td>208</td>
<td>208</td>
<td>177</td>
<td>159</td>
<td>752</td>
</tr>
<tr>
<td>51</td>
<td>Wholesale-Non-durable Goods</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>87</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>General Merchandise</td>
<td>---</td>
<td>110</td>
<td>113</td>
<td>---</td>
<td>---</td>
<td>223</td>
</tr>
<tr>
<td>56</td>
<td>Miscellaneous Retail</td>
<td>371</td>
<td>411</td>
<td>406</td>
<td>344</td>
<td>301</td>
<td>1,833</td>
</tr>
<tr>
<td>70</td>
<td>Hotels</td>
<td>---</td>
<td>23</td>
<td>---</td>
<td>---</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Miscellaneous Services</td>
<td>217</td>
<td>237</td>
<td>227</td>
<td>169</td>
<td>---</td>
<td>850</td>
</tr>
<tr>
<td>737</td>
<td>Computer Services</td>
<td>596</td>
<td>624</td>
<td>563</td>
<td>365</td>
<td>285</td>
<td>2,433</td>
</tr>
<tr>
<td>78</td>
<td>Entertainment Services</td>
<td>111</td>
<td>132</td>
<td>123</td>
<td>113</td>
<td>96</td>
<td>575</td>
</tr>
<tr>
<td>80</td>
<td>Health Services</td>
<td>103</td>
<td>128</td>
<td>132</td>
<td>120</td>
<td>---</td>
<td>48</td>
</tr>
<tr>
<td>82</td>
<td>Educational Services</td>
<td>---</td>
<td>38</td>
<td>---</td>
<td>26</td>
<td>---</td>
<td>64</td>
</tr>
<tr>
<td>87</td>
<td>Engineering and Management Services</td>
<td>130</td>
<td>138</td>
<td>----</td>
<td>95</td>
<td>88</td>
<td>451</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,716</td>
<td>4,911</td>
<td>4,594</td>
<td>3,626</td>
<td>3,138</td>
<td>19,985</td>
</tr>
</tbody>
</table>

* Due to undesirable effects of regulation on efficiency as well as valuation, regulated industries such as banking, transportation, and utilities are left out from the final data set.

f Some industry groups in certain years could not be represented due to model’s converging difficulties. Instead of overriding the stringent converging rules, all this data is left out to avoid any possible model specification problems.
Table 2

Descriptive Statistics of Estimated Variable by Industry

<table>
<thead>
<tr>
<th>SIC</th>
<th>EFFIC</th>
<th>SIC</th>
<th>EFFIC</th>
<th>SIC</th>
<th>EFFIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>0.85</td>
<td>33</td>
<td>0.95</td>
<td>51</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td></td>
<td>(0.03)</td>
<td></td>
<td>(0.05)</td>
</tr>
<tr>
<td>15</td>
<td>0.94</td>
<td>35</td>
<td>0.90</td>
<td>53</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td></td>
<td>(0.07)</td>
<td></td>
<td>(0.01)</td>
</tr>
<tr>
<td>20</td>
<td>0.92</td>
<td>357</td>
<td>0.85</td>
<td>56</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td></td>
<td>(0.10)</td>
<td></td>
<td>(0.07)</td>
</tr>
<tr>
<td>22</td>
<td>0.94</td>
<td>36</td>
<td>0.91</td>
<td>70</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td></td>
<td>(0.05)</td>
<td></td>
<td>(0.03)</td>
</tr>
<tr>
<td>24</td>
<td>0.95</td>
<td>366</td>
<td>0.87</td>
<td>72</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td></td>
<td>(0.08)</td>
<td></td>
<td>(0.10)</td>
</tr>
<tr>
<td>26</td>
<td>0.94</td>
<td>367</td>
<td>0.90</td>
<td>737</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td></td>
<td>(0.06)</td>
<td></td>
<td>(0.16)</td>
</tr>
<tr>
<td>27</td>
<td>0.91</td>
<td>37</td>
<td>0.95</td>
<td>78</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td></td>
<td>(0.04)</td>
<td></td>
<td>(0.12)</td>
</tr>
<tr>
<td>28</td>
<td>0.90</td>
<td>38</td>
<td>0.79</td>
<td>80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td></td>
<td>(0.13)</td>
<td></td>
<td>(0.10)</td>
</tr>
<tr>
<td>283</td>
<td>0.71</td>
<td>48</td>
<td>0.73</td>
<td>82</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td></td>
<td>(0.18)</td>
<td></td>
<td>(0.06)</td>
</tr>
<tr>
<td>30</td>
<td>0.94</td>
<td>50</td>
<td>0.93</td>
<td>87</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td></td>
<td>(0.05)</td>
<td></td>
<td>(0.11)</td>
</tr>
</tbody>
</table>

Where SIC= Industry codes as explained in Table 1, EFFIC= Efficiency Scores.

EFFIC are efficiency scores that are converted from inefficiency scores originally estimated using Model (2). Intuitively, inefficiency scores measure the controllable variables unnecessarily incurred by a firm in producing its outputs, relative to an efficient frontier based on the best-practice firms in the industry.

The values reflect the variables’ means over the testing period. Standard deviations are given in the parentheses below.
Table 3

Regression Results of the Tests for the Explanatory Powers of Earnings within the Efficiency Concept

\[ MV_t = \alpha + \beta E_t + \varepsilon_t \]  \hspace{1cm} (4)

\[ MV_t = \alpha_0 + \sum_{i=1}^{2} \alpha_i D_{i} + \beta_0 E_t + \sum_{i=1}^{2} \beta_i D_{i} * E_t + \varepsilon_t \]  \hspace{1cm} (5)

where

- \( MV \) = The stock price at the end of third month following the year-end;
- \( Earnings \) = Earnings per share before extraordinary items and discontinued operations; and
- \( D_1 \) (\( D_2 \)) takes 1 when “Efficiency” score is above (below) the cutoff point, 0 otherwise. The cutoff values are chosen to divide the firms into three groups with equal number of firms in each.

<table>
<thead>
<tr>
<th>Year</th>
<th>( \beta )</th>
<th>( R^2 ) #</th>
<th>( \alpha_1 )</th>
<th>( \alpha_2 )</th>
<th>( \beta_0 )</th>
<th>( \beta_1 (H) )</th>
<th>( \beta_2 (L) )</th>
<th>( R^2 )</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>1.46</td>
<td>.07</td>
<td>1.60</td>
<td>-5.29</td>
<td>1.45</td>
<td>1.17</td>
<td>-1.12</td>
<td>.16</td>
<td>3,308</td>
</tr>
<tr>
<td></td>
<td>(16.64)***</td>
<td></td>
<td>(3.12)***</td>
<td>(-10.49)***</td>
<td>(8.58)***</td>
<td>(4.71)***</td>
<td>(-5.37)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>1.57</td>
<td>.09</td>
<td>0.58</td>
<td>-3.14</td>
<td>2.14</td>
<td>1.18</td>
<td>-2.07</td>
<td>.17</td>
<td>4,154</td>
</tr>
<tr>
<td></td>
<td>(19.8)***</td>
<td></td>
<td>(1.73)*</td>
<td>(-9.88)***</td>
<td>(13.9)***</td>
<td>(4.94)***</td>
<td>(-11.03)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>0.78</td>
<td>.04</td>
<td>0.69</td>
<td>-2.21</td>
<td>0.74</td>
<td>1.93</td>
<td>-0.66</td>
<td>.09</td>
<td>3,788</td>
</tr>
<tr>
<td></td>
<td>(11.38)***</td>
<td></td>
<td>(1.51)</td>
<td>(-5.01)***</td>
<td>(6.99)***</td>
<td>(8.45)***</td>
<td>(-4.54)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>-0.26</td>
<td>.03</td>
<td>-2.44</td>
<td>-2.69</td>
<td>2.04</td>
<td>3.75</td>
<td>-2.44</td>
<td>.22</td>
<td>2,882</td>
</tr>
<tr>
<td></td>
<td>(-9.42)***</td>
<td></td>
<td>(-5.43)***</td>
<td>(-6.81)***</td>
<td>(11.78)***</td>
<td>(10.5)***</td>
<td>(-13.92)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>-3.17</td>
<td>.30</td>
<td>2.10</td>
<td>-2.90</td>
<td>0.81</td>
<td>0.63</td>
<td>-4.75</td>
<td>.41</td>
<td>2,586</td>
</tr>
<tr>
<td></td>
<td>(-33.54)***</td>
<td></td>
<td>(2.38)***</td>
<td>(-3.30)***</td>
<td>(2.19)***</td>
<td>(1.25)</td>
<td>(-12.40)***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

t-statistics are given in parentheses below the coefficients.

***, ***, * statistical significance at the .01, .05 and .10 levels, respectively.

# All \( R^2 \)'s reported in this study are adjusted.
Table 4

Rank Correlations between Efficiency and, Performance and Risk Variables

<table>
<thead>
<tr>
<th></th>
<th>EFF</th>
<th>ROE</th>
<th>OL</th>
<th>DAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROE</td>
<td>0.091*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OL</td>
<td>-0.061***</td>
<td>-0.038***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAT</td>
<td>-0.052***</td>
<td>0.017**</td>
<td>-0.045***</td>
<td></td>
</tr>
<tr>
<td>MSHI</td>
<td>0.079***</td>
<td>0.013*</td>
<td>-0.037***</td>
<td>0.007</td>
</tr>
</tbody>
</table>

where

EFF = firm’s efficiency, 
ROE = firm’s return-on-equity, 
OL = firm’s operating leverage, and 
MSHI = firm’s market share.

* All the variables are adjusted for industry means.
***, ***, * statistical significance at 1%, 5% and 10% levels.
Table 5

Regression Results of the Earnings-Efficiency Interaction, and Earnings Interactions with Additional Variables after Controlling for Non-linearity and Losses

\[ MV = \alpha_0 + \alpha_1 EPS + \alpha_2 EPSEFF + \alpha_3 EPSAROE + \alpha_4 EPSAOL + \alpha_5 EPSADAT + \alpha_6 EPSMSHI + \alpha_7 EPS2 + \alpha_8 D_{\text{ne}}^* EPS + \epsilon \]

<table>
<thead>
<tr>
<th>Year</th>
<th>(\alpha_1)</th>
<th>(\alpha_2)</th>
<th>(\alpha_3)</th>
<th>(\alpha_4)</th>
<th>(\alpha_5)</th>
<th>(\alpha_6)</th>
<th>(\alpha_7)</th>
<th>(\alpha_8)</th>
<th>(R^2)</th>
<th>(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>14.28</td>
<td>3.49</td>
<td>0.005</td>
<td>0.006</td>
<td>-0.03</td>
<td>33.42</td>
<td>-0.08</td>
<td>-11.96</td>
<td>.49</td>
<td>2,954</td>
</tr>
<tr>
<td></td>
<td>(14.08)***</td>
<td>(3.31)***</td>
<td>(10.90)***</td>
<td>(0.167)</td>
<td>(-4.03)***</td>
<td>(6.57)***</td>
<td>(-34.89)***</td>
<td>(-29.83)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>10.49</td>
<td>0.69</td>
<td>0.0008</td>
<td>-0.17</td>
<td>-0.02</td>
<td>32.42</td>
<td>-0.002</td>
<td>-10.08</td>
<td>.65</td>
<td>3,812</td>
</tr>
<tr>
<td></td>
<td>(21.32)***</td>
<td>(1.41)</td>
<td>(2.44)**</td>
<td>(-4.54)***</td>
<td>(-10.98)***</td>
<td>(10.06)***</td>
<td>(-4.49)***</td>
<td>(-41.77)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>15.38</td>
<td>4.40</td>
<td>0.007</td>
<td>0.49</td>
<td>0.02</td>
<td>29.26</td>
<td>-0.0003</td>
<td>-14.87</td>
<td>.83</td>
<td>3,455</td>
</tr>
<tr>
<td></td>
<td>(31.42)***</td>
<td>(9.51)***</td>
<td>(17.66)***</td>
<td>(13.59)***</td>
<td>(9.76)***</td>
<td>(5.51)***</td>
<td>(-3.41)***</td>
<td>(-49.45)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>13.22</td>
<td>-0.55</td>
<td>-0.001</td>
<td>0.38</td>
<td>-0.02</td>
<td>7.79</td>
<td>-0.0007</td>
<td>-13.92</td>
<td>.84</td>
<td>2,678</td>
</tr>
<tr>
<td></td>
<td>(21.94)***</td>
<td>(-0.94)</td>
<td>(-1.72)*</td>
<td>(5.50)***</td>
<td>(-2.74)***</td>
<td>(2.13)**</td>
<td>(-4.28)***</td>
<td>(-38.80)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>26.08</td>
<td>4.06</td>
<td>0.002</td>
<td>0.39</td>
<td>0.07</td>
<td>-60.11</td>
<td>0.002</td>
<td>-33.29</td>
<td>.77</td>
<td>2,412</td>
</tr>
<tr>
<td></td>
<td>(17.76)***</td>
<td>(2.76)***</td>
<td>(2.35)**</td>
<td>(4.17)***</td>
<td>(11.55)***</td>
<td>(-7.34)***</td>
<td>(6.60)***</td>
<td>(-56.32)***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

where EPS = earnings per share (before discontinued and extraordinary); EPSEFF = EPS * Efficiency; EPSAROE = EPS * Industry adjusted ROE; EPSAOL = EPS * industry adjusted operating leverage; EPSADAT = EPS * industry adjusted debt-to-total assets; EPSMSHI = EPS * firm’s market share; and EPS2 = EPS * |EPS| and D_{\text{ne}} takes 1 when EPS < 0.

t-statistics are given in parentheses below the coefficients. ***,**, * statistical significance at .01, .05, and .10 levels respectively.
Table 6

Efficiency and Earnings Coefficients

\[ \text{Earnings}_{t+1} = \alpha_0 + \alpha_1 \text{Earnings}_t + \delta_1 D_1 \times \text{Earnings}_t + \varepsilon \]

where \( \text{Earnings} = \text{Earnings before extraordinary items and discontinued operations at time } t \) and \( t+1; \) and \( D_1 (D_2) \) takes 1 when “Efficiency” score is above (below) the cutoff point, 0 otherwise. The cutoff values are chosen to divide the firms into three groups with equal number of firms in each.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_1 )</td>
<td>0.67</td>
<td>1.03</td>
<td>1.08</td>
<td>1.03</td>
<td>0.86</td>
</tr>
<tr>
<td>(62.97)***</td>
<td>(108.05)***</td>
<td>(153.8)***</td>
<td>(148.76)***</td>
<td>(67.67)***</td>
<td></td>
</tr>
<tr>
<td>( \delta_1 )</td>
<td>0.15</td>
<td>-0.02</td>
<td>0.015</td>
<td>0.003</td>
<td>0.19</td>
</tr>
<tr>
<td>(9.96)*</td>
<td>(3.30)***</td>
<td>(2.12)**</td>
<td>(0.31)</td>
<td>(9.90)***</td>
<td></td>
</tr>
<tr>
<td>( \delta_2 )</td>
<td>0.08</td>
<td>-0.09</td>
<td>-0.097</td>
<td>-0.004</td>
<td>-0.35</td>
</tr>
<tr>
<td>(3.83)***</td>
<td>(-6.80)***</td>
<td>(-5.46)***</td>
<td>(-0.19)</td>
<td>(-10.48)***</td>
<td></td>
</tr>
<tr>
<td>F-statistic (of ( \delta_1 - \delta_2 = 0 ))</td>
<td>7.05***</td>
<td>26.28***</td>
<td>38.05***</td>
<td>0.11</td>
<td>250.62***</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.77</td>
<td>0.95</td>
<td>0.96</td>
<td>0.93</td>
<td>0.77</td>
</tr>
<tr>
<td>( N )</td>
<td>3,410</td>
<td>4,483</td>
<td>4,259</td>
<td>3,560</td>
<td>3,086</td>
</tr>
</tbody>
</table>

***, **statistical significance at .01 and .05 levels, respectively.
Figure 1
Value-Relevance of Earnings within Efficiency Concept
Lev (1989) complains: “The important questions of why some earnings innovations are more persistent then others….are still largely unanswered.” (pg.172). Lipe (1990) also mentions in a footnote (#2, pg. 52) that in the light of the new developments, the time has come to deal with the economic determinants of earnings behavior (persistence, predictability, etc).

Ou and Penman (1989) study actually mentions that they kept their distance from data and depended on the statistical procedure to come up with the final variable set. They invite the readers to “compare these estimates” with their own “future earnings-generating attributes of firms” (pg.303).

In spite of its restrictive form in these areas, the Cobb-Douglas production function has one major advantage over the translog function in that it is very simple to estimate. But there is evidence in economics literature that assuming a Cobb-Douglas production functional form is not always appropriate in American manufacturing industry (Bairam, 1994).

For example, constant elasticity of substitution (CES) production functions are very restrictive when firm produces more than one product or uses more than two inputs.

However, recent evidence in the finance literature shows that the efficiency scores are robust to the different methodologies used in that area. Berger and Mester (1997) use two different functional forms (translog vs. Fourier-flexible forms) and two different approaches (stochastic frontier vs. distribution-free), and found that choices between these make economically insignificant differences in terms of average industry efficiencies, and the ranking of the firms.

This is the biggest advantage of stochastic frontier approach. None of the other technologies make any accommodations for (random) non-controllable factors. Furthermore, this approach is stochastic which allows the researcher to make statistical inference based on the results.

In this study price model is used in place of return model. First, this study focuses on the relationship between price and earnings rather than the earnings’ information value which requires measurement of price reactions to earnings. Second, prior research shows that the value-relevance of earnings decreased over time (e.g. Collins, et al., 1997, Francis and Schipper, 1999, Ryan and Zarowin, 2003). In explaining the reasons, Ryan and Zarowin theorize and find strong support for earnings becoming increasingly untimely, especially in recent years. Since sample period in their study includes the sample period in this, the price model is chosen over return model to avoid the problems associated with untimeliness of earnings. Still, Kothari and Zimmerman state that “...using both functional forms will help ensure that a study’s inferences are not sensitive to functional form” (Kothari and Zimmerman, 1995, pg.157). Both models 4 and 5 are reestimated using Kothari and Zimmerman’s return model. Although the coefficients and R²’s are smaller as expected, the results of return/earnings relation mimic what’s reported here.

The Feltham-Ohlson (1995) model implies that market value is a function of both earnings and book value. Excluding book value completely may raise question of correlated omitted variables problem because the efficiency scores estimated here might be proxying price-to-book ratio (more efficient firms likely to have larger future growth opportunities). To control for this effect, I reran all the models for all years including book value as a control variable. As expected, R²’s improved dramatically (up to .70 in some) as a result of this inclusion. Additionally, efficiency scores’ statistically significant contribution to the earnings’ explanatory power stayed the same (improved in most cases).
Kothari and Zimmerman (1995) provide evidence that price/earnings level models frequently reject tests of heteroscedasticity. To check for this, the models presented here are reestimated using White’s revised estimator. The results are unchanged.

The other approach considered was the interactive model: \( MV_t = \alpha_0 + \alpha_1 E_t + \alpha_2 E_t \times \text{Effic} + \epsilon_t \) where \( E \) is earnings at time \( t \) and \( \text{Effic} \) is the efficiency score. In all five years of sample period, \( \alpha_2 \) was positive and significant at <.01 implying that the marginal effect of earnings on market value is increased when the firm is highly efficient. Due to the model’s possible sensitivity to outliers, the model’s discussion and results are not reported separately.

The results of Model 4 are not similar to what is usually reported in the literature using price models in terms of the magnitude of coefficients and level of \( R^2 \)’s. It seems like this is due to two factors. First, this sample period includes only five years, 1993-97 which includes one of the most volatile economical periods. Most of the price/earnings include 30-40 years of data starting from 1950s. This sample not only includes a lot of firms with negative earnings, but also the scale of negative earnings are much larger compared to other periods. Second, most of the studies in the literature use several outlier procedures together (e.g. in Collins, et al, 1997, observations in: 1) top or bottom one-half percent ranked on earnings-to-price or book value-to-market; 2) observations in the top one-half percent of the absolute value of one-time items value as a percent of net income before one-time items, and 3) observations with studentized residuals greater than four standard deviation from zero in any yearly regression of price on earnings, price on book values, or price on earnings and book values are eliminated). When this study followed stricter outlier procedure as well, although 507 more firms are lost, the results were very similar to what is reported in the literature: pooled regression of price on earnings produced a coefficient of 2.9 with a statistical significance <.01, and \( R^2 \) of .15 over 16,211 firms.

The analysis is repeated with a different OL measure with omitting the selling and administrative variable from the numerator (Lev (1983)). The results are qualitatively similar to those reported here.

Since efficiency scores are estimated using all firms within each industry to reflect the firm’s relative performance, I kept all firms years, with positive and negative earnings, in the analysis.

Significant correlations are likely to exist among these interaction variables. But the effect of multicollinearity is to inflate the standard errors, which in turn effects the \( t \)-statistic negatively. Since the estimates are statistically significant, the multicollinearity is not that severe to affect these results.

As a robustness check, the same model is estimated using per share information with similar results.

These distributional assumptions can be relaxed if one can use panel data to estimate the inefficiency measures for each producer. See Greene, W.H., “The Econometric Approach to Efficiency Analysis”, in The Measurement of Productive Efficiency, eds. Fried, Lovell, and Schmidt, Oxford University Press, 1993.