Using financial factors to investigate productivity: an empirical study in Taiwan

Liang-Hsuan Chen
Department of Industrial Management Science, National Cheng Kung University, Tainan, Taiwan, Republic of China

Shu-Yi Liaw
Department of Industrial Management Science, National Cheng Kung University, Tainan, Taiwan, Republic of China

Yeong Shin Chen
Department of Industrial Management Science, National Cheng Kung University, Tainan, Taiwan, Republic of China

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Abstract
Since a firm’s management performance can be evaluated in terms of financial ratios, efficient management using financial factors is proposed as the key element for upgrading a firm’s productivity. This study investigates productivity in terms of certain financial factors of large-scale manufacturing firms in Taiwan. First, determining several influential financial factors using factor analysis, based on these factors, employs fuzzy c-means clustering approaches to categorize the manufacturing firms into several patterns with distinct characteristics of financial factors. Using the characteristics of productivity and financial factors for each pattern, makes two kinds of analysis, and proposes some suggestions to improve the firms' productivity.

Introduction
The Asian financial crisis has reminded the enterprises and industries of the region to emphasize effective management (Weiss, 1999). Enterprises must efficiently utilize their business resources so as to create more valuable output. To promote national competition and firms’ productivity, efficient and effective management is necessary to sustain the growth of manufacturing industry. In general, the managing performance of a business unit can be evaluated from its published financial statements. Using the financial data from financial statements, a variety of financial ratios are usually used to examine the functionality of a business unit from different perspectives. Meanwhile, productivity is also considered as an aggregate index for measuring a business unit’s efficiency, since a business unit with higher productivity is generally more profitable.

Since various financial ratios are used to measure the performance of particular management functions, the relationship between these ratios and productivity deserves further investigation. Then, based on that understanding, managers can adopt appropriate strategies to improve the associated financial ratios and thereby improve the unit’s total productivity. In order to illustrate this idea, this paper focuses on the investigation of productivity for large-scale manufacturing firms in Taiwan as shown by their financial ratios. For measuring productivity of the firms, an aggregate productivity index, total factor productivity (TFP), is adopted in this study. In addition, 48 general financial ratios listed in the Taiwan Economics Database are used to evaluate the management performance of the sample firms. We first apply correlation analysis to find the financial ratios that more closely correlate with the TFP. Factor analysis is then conducted to determine the more critical financial factors. Based on these financial factors, fuzzy clustering analysis is employed to categorize the sample firms into several groups. Each group of firms is characterized with a set of financial factors and a weighted average TFP. Finally, appropriate strategies can be proposed to promote productivity within each group of firms according to their respective financial characteristics.

In the following section, productivity measurement by TFP is described. In the next section, we find the financial ratios that are more correlated with TFP, and the critical financial factors are then determined. After performing fuzzy clustering analysis, we discuss the productivity characteristics of each group of sample firms based on the financial factors in the following section. Finally, some comments to improve these firms’ productivity are proposed.

Productivity measurement
Productivity is often used to evaluate the aggregate performance of a business unit, generally defined as the ratio of outputs to inputs. However, for different applications and research domains there are different definitions of productivity. Kendrick and Cramer (1985) presented three kinds of productivity indices, i.e., total productivity index, capital-labor productivity index, and partial productivity index. Craig and Harris (1975) first pointed out that the partial productivity index might cause fallacies because of the influence of other input factors, suggesting that the partial productivity index could not be used individually. Mundel (1976) proposed two alternative indices of productivity, but measurement between inputs and outputs was not specified clearly. Taylor and Davis (1977) presented a model of TFP to assess the productivity of an enterprise. In this model,
the concept of value-added is used as the output, and labor and capital inputs are included in the input items for measuring the added value by a production unit per unit of input. Sumanth (1984) set forth a total productivity model, considering inputs and outputs in terms of "tangible (physical)" concept.

Though the above definitions of productivity differ, they all use the ratio of output to input to measure productivity. In this paper, the TFP model (Taylor and Davis, 1977) is adopted, since it is informative to explain a manufacturing firm's performance. Mathematically, the TFP is defined as:

\[
\text{TFP} = \frac{\text{value-added}}{\text{Labor inputs + capital inputs}}
\]

In this formula, the denominator is the firm's inputs, and the numerator is the firm's output. They are further described in the following.

- **Inputs.** In this study, labor inputs are defined as all the related human resource costs, including salary, after-hour allowance, pension, and bonus for direct labor, indirect labor, salesmen, supervisors, and managers. The measurement of capital inputs in this study will refer to the concept of "service volume" presented by Craig and Harris (1973) to take into account both the fixed capital and operating capital.

- **Output.** We use value added as the output determinant of productivity. In business accounting, value added is the capital profit generated by a business unit through production and operation activities within a certain period of time.

For determining a firm's TFP, certain financial data have to be gathered to calculate labor input, capital input, and value added. We acquired most this financial data from relevant financial statements in the published financial database, the Taiwan Economics Database. In addition, some data were provided by the sample firms through questionnaires for information, such as personnel expenses, parts and material costs and so on, if it could not be found from the database. The sample of Taiwanese firms consists of large-scale manufacturing enterprises in Taiwan, since these firms have economic scale of production so that the investigation of productivity in terms of financial factors is logical. The large-scale manufacturing firms in this study are located in the list of Taiwan's top 1,060 manufacturing firms and are first-category companies in the stock market. A total of 117 firms satisfy this condition, and 63 firms answered the questionnaires. After calculations based on the equation, the average TFP of the sample is 2.8666, with a maximum value of 7.6526 and minimum value of -0.0454. Via normal Q-Q plot, the productivity distribution of the sample firms is determined to be normal. This indicates that the information from the sample firms is representative for large-scale manufacturing firms in Taiwan.

### Critical financial factors

In order to investigate productivity in terms of the performance of the sample firms' management functions, certain critical financial factors are determined. First, 48 kinds of financial ratios for the sample firms were solicited from the Taiwan Economics Database and adopted in this study. The sample firms consisted of large-scale Taiwanese manufacturing firms, defined as in the previous section. In accordance with the productivity data, the financial ratios from 63 firms that returned the productivity questionnaires are used. We then perform correlation analysis to find the financial ratios more correlated with productivity, with an absolute value of correlation coefficient larger than 0.2. A total of 15 financial ratios are found and used in the subsequent analysis. An F-test is performed to further examine the relationship of these ratios with productivity of the sample firms. A significant conclusion is made (p-value = 0.008351) for this test, indicating that these ratios are effective to describe productivity. The 15 financial ratios are defined and listed below:

1. After-tax return on net worth =
   (income after tax/average net works) × 100 per cent.
2. Before-tax return on net worth =
   (income before tax/average net worth) × 100 per cent.
3. Return on total assets =
   (income after tax - interest expense × (1 - 25 per cent)/average total assets) × 100 per cent.
4. Total assets turnover =
   net sales/total assets.
5. Inventory turnover =
   cost of sales/average inventories.
6. Days-inventory turn =
   (average inventories/cost of sales) × days.
7. Fixed assets turnover =
   net sales/average fixed assets.
8. Net worth turnover =
   net sales/average net worth.
9. Net operating cycle =
   days-A/R turnover + days-inventory turn - days-A/P turnover (A/R = Accounts Receivable, A/P = Accounts Payable)
10. Fixed assets growth ratio =
    ((depreciable fixed assets this year/ depreciable fixed assets last year) - 1) × 100 per cent.
11 Operating income per share =
   (operating income/common stocks +
    preferred stocks + reserved-capital
    increase) × 10.
12 Sales per share =
   (net sales/common stocks + preferred
    stocks + reserved-capital increase) × 10.
13 Pre-tax income per share =
   (pre-tax income – preferred stock
    dividend/weighted average stocks) × 10.
14 Earnings per share =
   (ordinary income/common stocks +
    preferred stocks) × 10.
15 Effective tax ratio =
   (income tax expense/pre-tax income) ×
   100 per cent.

To simplify the subsequent analysis, factor analysis is applied to find critical financial factors to describe the above ratios. After performing certain approaches of factor analysis, such as principal component method and orthogonal rotation, four critical financial factors are determined. The accumulated ratio of variation explained by the four factors is more than 80 per cent. The financial ratios with absolute value of factor loading larger than 0.7 are selected as indicating financial factor. Two of these 15 financial ratios, earnings per share and fixed assets growth ratio, have absolute values of factor loading too small to be grouped into any factor. Consistency test is also conducted to check the similarity of financial ratios in each factor to determine whether the factor analysis is appropriate. The four financial factors and their tests are described as follows.

1 Profitability factor (F₁). In this financial factor, there are five financial ratios with absolute values of factor loading larger than 0.7. These are: after-tax return on net worth, return on total assets, before-tax return on net worth, pre-tax income per share, and operating income per share. The values of factor loading for the five financial ratios are all positive, and they are all profitability-related indices, therefore this factor is referred to as the profitability factor. In this factor, reliability of these five financial ratios is 0.9796, implying that they are of high similarity in the profitability characteristic. Considering business performance, this factor reveals a firm’s capability for investment profit and the profitability of fund management. A firm with higher value of this factor is a better firm.

2 Assets turnover factor (F₂). Four financial ratios, namely total assets turnover, fixed assets turnover, net worth turnover and sales per share, satisfy the requirement for the absolute values of factor loading in this factor. These ratios are all related to assets turnover or business income, therefore we refer to it as the assets turnover factor. This factor can be used to measure a firm’s financial efficiency and the robustness of its total assets investment. When this factor is higher, the firm’s ability to raising funds and appropriate investments is better. Reliability of the four financial ratios in this factor is 0.9613, which shows they are of high similarity in the characteristic of assets turnover.

3 Inventory turnover factor (F₃). Based on the absolute values of factor loading, three financial ratios with absolute values of factor loading in descending order, inventory turnover, net operating cycle, and days-inventory turn, are incorporated in this factor. The latter two ratios have negative values of factor loading, indicating that the higher these two indices, the worse this factor. However, the factor loading of inventory turnover is positive, which shows that the higher the index, the better this factor. Reliability of the three financial ratios in this factor is 0.9267. Although it is lower than those of the previous two factors, the similarity in this financial factor is also sufficient. Therefore, this financial factor is referred to as the inventory turnover factor, which can indicate the capability of a firm’s interior financial management, as well as the integration of manufacturing and marketing.

4 Effective tax ratio factor (F₄). Only one financial ratio, the effective tax ratio, whose absolute value of factor loading (0.8209) is larger than 0.7 in this factor. Therefore it is referred to as the effective tax ratio factor. Consistency test is not conducted, since only one variable is included into this factor. Based on the definition of effective tax ratio, the lower the ratio is the better, which makes a firm’s profit strength advantageous due to reduced income taxes, such as official tax incentives for the strategic industries of a country.

Using the factor scores of the four financial factors, clustering algorithms are applied to categorize the sample firms into several distinct patterns for investigating productivity in terms of financial factors.

Analysis

For the investigation of productivity in terms of financial factors, we employ clustering to find the characteristics of the sample firms’ productivity. Instead of traditional statistical clustering approaches, fuzzy clustering algorithms are adopted to conduct data
clustering in this study, since traditional clustering approaches assign a sample firm to a single class, assuming that the boundaries between classes are well defined. This may not reflect actual situations, where the boundaries are ambiguous. However, fuzzy approaches can assign a membership degree \( \mu : [0,1] \) to a sample firm to indicate the strength of membership belonging to some class based on the similarity. Among several fuzzy clustering algorithms, the fuzzy C-means (FCM) clustering algorithm, presented by Bezdek (1981), is the most frequently used. Many studies have employed this technique successfully to resolve practical problems (Gath and Geva, 1989; Gu and Duboisson, 1990; Xie and Beni, 1991; Chen et al., 1996).

Before using FCM, some features should be determined in order to make up a feature space. We consider our four financial factors to be the features, since these factors are used to find the characteristics of the productivity in this study. The associated factor scores are employed to calculate the similarity in the clustering. After performing FCM and certain relevant approaches, such as unsupervised fuzzy clustering analysis (Gath and Geva, 1989) and the validity function (Xie and Beni, 1991), the 63 sample firms are satisfactorily grouped into four classes. In addition, the centroid of each class and the membership degree \( \mu : [0,1] \) of each firm belonging to each class are also determined by the algorithms. Here, we define a threshold value \( \theta = 1/4 \) to determine whether a sample firm has a strong evidence of belonging to a particular class. A class consists of the sample firms with the membership degree greater than 1/4 belonging to this class. Finally, classes 1, 2, 3 and 4 contain 23, 22, 15 and 11 firms respectively. Note that the total of firms contained in the four classes exceed the number of sample firms, because eight firms have stronger evidence of belonging to more than one pattern, relative to the threshold value.

Actually, we consider each class as a particular pattern in this study, since each class has its own nature, and therefore a class is referred to as a pattern hereinafter. To further examine the characteristics of the resulting patterns, we make two kinds of analyses, regression analysis and pattern analysis. Regression analysis is applied to find the relationship between productivity and the financial factors for each pattern. To perform regression analysis, we first determine the weighted TFP and weighted financial factors for each firm in the same pattern by considering the membership degree corresponding to the weight, since the membership degree deals with the evidence associated with the pattern in this study. In addition, we also conduct pattern analysis to determine the firms’ financial characteristics of productivity through the centers of the four patterns in terms of the four financial factors and weighted averaged TFPs of each pattern. They are described as follows.

**Regression analysis**

We perform regression analysis for each pattern by considering the weighted TFP as response, and the weighted factor scores of the four financial factors as decisive variables. Table I lists the statistical model of each pattern, and the associated \( p \)-value and coefficient of determinant. In the table, \( F_r \) and \( Z_r \), with \( i = 1, \ldots, 4 \), denote the four weighted financial factors and the weighted TFPs of the four patterns respectively. Particularly, the statistical model before fuzzy clustering is also determined by using the original data for purposes of comparison. The notations of \( Z_r \) and \( F_r = 1, \ldots, 4 \), are used in this model. As seen from Table I, all of the five statistical models are significant with a significance level of 0.05. Almost all the coefficients in each model are also significant based on the \( t \)-test with a significance level of 0.05. However, the coefficients of determinant \( (R^2) \) of the models for the four patterns are greater than that of \( Z_r \). This indicates that the relationship between financial factors and productivity from distinct patterns can be further investigated. Using the four models, we can know the financial factors that are connected to the productivity of the firms of each pattern due to their pattern’s characteristic, and we can understand their competitive status in comparison with the other patterns.

**Pattern analysis**

Using the centers of the four patterns and weighted averaged TFPs of each pattern, the financial characteristics of productivity for each pattern can be examined. Table II lists the coordinates of the four patterns in terms of the four financial factors and the weighted averaged TFP of each pattern. Based on the consequences of the clustering, some characteristics of each pattern are discussed as follows:

- **Pattern 1.** There are 23 firms in this pattern, whose weighted averaged TFP is the best and whose performance in terms of profitability, assets turnover and inventory turnover is better than those of other patterns, as shown in Table II. In the \( t \)-test of regression coefficients in Table I, these three financial factors also show dominance. Therefore, Pattern 1 is referred to as the “high profitability and high turnover” pattern. Most of the firms in this pattern are high tech related.
companies, such as electronics, semiconductors, computers and components manufacturing companies, and on average have higher capital, sales, profit margin and return on total assets, as shown in Table III. These firms conform to the official high-tech strategic industries of Taiwan in the past decade, so that a large amount of assets from the stocks markets have flowed into these companies. Based on financial factors, these firms surely have better conditions of internal and external financial management, thus distinguishing profitability and productivity. This indicates that there is a correlation between the characteristics of financial factors and productivity. Currently, Taiwan is prepared to shrink the scope of tax incentives for its massive semiconductor industry, and it encourages firms to make investments in other leading global technologies instead of the chip industry. According to the characteristics of productivity and the associated financial factors, the firms of Pattern 1 should promote research and development abilities to upgrade product quality and processing skills so as to maintain global competitiveness, thereby expanding capital profitability and TFP.

- **Pattern 2.** This pattern contains 22 firms. It has a weighted averaged TFP of 1.96, and its factor scores for profitability, assets turnover and inventory turnover are -0.57, -0.15 and -0.48 respectively. The productivity and performance of these three financial factors are the worst among the four patterns. We refer to this pattern as “low profitability and low turnover” pattern, since profitability and assets turnover factors are significant based on significant level of 0.05. The firms in this pattern include traditional metal, cement, machinery and paper companies, and on average individual lower return on total assets of 1.31 per cent and profit margin of 2.32 per cent, as listed in Table III. Although the firms of this pattern do not have many benefits from...
effective tax ratio, such as official tax breaks or incentives, they could enhance their assets turnover and inventory turnover to improve profitability. By building up a sound financial management system, especially for the mechanism of capital turnover, the firms of Pattern 2 could successfully upgrade their productivity.

- **Pattern 3.** This pattern consists of 15 firms, with a weighted averaged TFP of 3.05 and moderate performance of financial turnover, but with a high effective tax ratio. The productivity achieved by this pattern is high. Although the high effective tax ratio indicates that official tax incentives and tax breaks are less, the profitability of firms in this pattern is sufficient, so that this pattern is referred to as “high profitability and high effective tax” pattern. The firms in this pattern are traditional manufacturing industries, such as plastics, steel, automobile and textile companies; however, good profitability and productivity are achieved. On the average, firms in this pattern have $92 million of profit after tax, 5.10 per cent return on total assets and 6.57 per cent profit margin, as listed in Table III. From Table I, the four financial factors are all significant to explain the relationship with productivity. To increase productivity further, the firms of this pattern can strengthen their capabilities of financial turnover, especially in the aspect of inventory turnover related ratios. Meanwhile, multi-investments in leading technologies and strategic alliances with high-tech global enterprises would be helpful to upgrade the firms’ future competitiveness.

- **Pattern 4.** This pattern consists of 11 firms, including network software, medicine, chemical, food and feed companies, providing moderate return on total assets and profit margin compared to other patterns in Table III. Most of firms in this pattern are now prepared to shift from traditional manufacturing industries to being official strategic industries of Taiwan, such as network, wireless communication, and biotechnology industries. The firms of this pattern have lower profitability and weighted averaged TFP; however, the lower effective tax ratio benefits to the firms’ profit after tax of 0.39. This directs the firms of this pattern towards accelerating their strategic transition to upgrade firms’ productivity and leave aside official tax allowances to pursue profitability.

Based on the above descriptions, the relationship between financial factors and productivity has a high degree of correlation. Referring to the magnitudes of profitability and the weighted averaged TFP of each pattern in Table II, as well as those of return on total assets and profit margin of each pattern in Table III, these factors appear in the same order among the four patterns, i.e., Pattern 1 > 3 > 4 > 2. This indicates that a firm’s financial profitabllity can appropriately reflect the accomplishment of a firm’s TFP in the distinct patterns. However, the order of magnitudes cannot be found in the relationship between the firms’ average capital (or sales) and weighted averaged TFP. This indicates that the key feature affecting the achievement of TFP is the financial profitability related ratios instead of the quantity of capital.

**Conclusions**

Faced with global competition, increases of labor cost, and deficiencies of resources, manufacturing firms have to reduce production costs and improve efficiency so as to maintain the business competition. The purpose of this study is to investigate productivity in terms of financial factors from distinct financial patterns. First, by surveying 62 large-scale manufacturing firms in Taiwan, this study has extracted four financial factors, namely profitability factor, assets turnover factor, inventory turnover factor, and effective tax ratio factor. Based on these four financial factors, the sample firms are then grouped into four financial patterns using fuzzy clustering approaches. By building up the statistical models of the four patterns, the firms of each pattern can recognize the financial factors that are critical to productivity due to their pattern’s characteristics, and understand their competitive status in comparison with the other patterns. Furthermore, through pattern analysis, the characteristics of productivity in terms of financial factors can be further examined. The productivity is highly correlated with the financial factors. Thus, the firms with high performance in the four aspects of critical financial factors usually have high productivity.

Through the use of factor analysis, this study investigates the productivity of large-scale manufacturing firms in Taiwan using a few critical financial factors. The employment of fuzzy clustering can identify the degree to which a firm belongs to a specific pattern, and the membership degree is considered as the weight in determining the characteristics of pattern. The advantage of the approaches in this study is that the firms’ financial characteristics of productivity in each pattern can be examined simply and objectively according to their attributes of financial factors. Although the
discussion of this study is confined to manufacturing firms in Taiwan, the methodology developed is applicable to the other countries.

References and further reading


