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Productivity of Taiwan's 1000 largest companies

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This paper investigates the productivity of the 1000 largest companies in Taiwan – 500 manufacturing and 500 service. For the 523 companies with available data, their average productivity is 1.0845, indicating that the total value of the outputs produced by these companies is greater than that of the inputs consumed. However, there are still approximately a quarter of the companies whose productivity is smaller than 1. The service industry is slightly higher than the manufacturing industry. This paper also investigates the relationship between productivity and profitability. Overall, the results show that profitability increases with productivity. A regression analysis indicates that, due to the effect of income tax, the slope of the regression line for companies with positive profitability is less than that for those with negative profitability. Based on the relationship between profitability and productivity, a company is able to predict its net profit from productivity.

Keywords: total factor productivity; profitability; net profit margin

1. Introduction

Productivity, as defined by Kendrick [13], is the relationship between outputs of goods and services and inputs of the resources, human and non-human, used in the production process. It measures the efficiency that a production activity converts inputs into outputs. To be more competitive in world markets, a company must have high productivity such that fewer inputs are used to produce more outputs. For this reason, every company aims to improve productivity by various means, including information technology [5,6,17], mergers and acquisitions [2], international outsourcing [11], and different techniques of management [1,12,27].

Taiwan is a newly industrialized country. Many of its electronic products have the largest share in the world. Its stable economic growth in the last three decades has brought it an international reserve of 347.19 billion US dollars, which is ranked the fourth in the world (next to China, Japan, and Russia). It is worthwhile to investigate the productivity of the companies in Taiwan. The performances of department stores [4], logistic firms [16], airports [26], etc. have been studied. However, the investigation is not complete, especially that several representative industries, such as electronics, semi-conductors, IC designs, and computers, are not included.

Different measurements for productivity at the firm level have been proposed [3,7,9,15,22]. While some require detailed information of the production process, this paper uses a measurement which needs only the information contained in financial statements, so that a reliable and consistent result can be obtained for every company, and the method is applicable to both manufacturing and service industries. To investigate the productivity of the companies in Taiwan, the 1000 largest ones – 500 manufacturing and 500 service – are considered as their data are more reliable.

One of the major goals of a company is to make a profit, and while productivity indicates how efficiently resources are utilized, high productivity does not guarantee a profit. The outputs must be produced at the right time and in the right quantities to have good prices so that a profit can be earned. While productivity is concerned with output production alone, profitability is also concerned with output sales. A company with high productivity but low profitability cannot survive in the competitive environment, and thus, the latter is more important than the former as far as sustainability is concerned.

Under normal conditions, high productivity implies high profitability. However, there are situations where one is high while the other is low, which makes using one to predict the other difficult. In the literature, there is a class of procedures for measuring productivity at the firm level which link productivity changes to the firm's profitability. Miller [18,19] described an approach based on the relationship that profitability = productivity + price recovery, where price recovery represents the net effect on profits of changes in sales prices and input-resource prices

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(due to inflation). Miller and Rao [20] then modified the model to incorporate return on investment rather than gross profit margin. Another type of studies is based on efficiency measures [8,21], and links changes in productivity and profit. Specifically, the profit change is decomposed into a productivity change effect, an activity effect (which includes a product mix effect, a resource mix effect, and a scale effect), and a price effect. From a sample of service companies in Hong Kong, He et al. [10] applied regression analysis and found a positive relationship between productivity and profitability, where the latter is represented by return on equity.

This paper will also investigate the relationship between productivity and profitability. Based on the relationship, one will be able to predict profitability from productivity. Profitability also has different measurements, and the one used in this paper is net profit margin (NPM), which is also calculated from the data contained in financial statements.

This paper is organized as follows. Section 2 describes how to calculate the total factor productivity (TFP) of a company, either manufacturing or service, from the data contained in its financial statements. Section 3 calculates the NPMs, as a measure of profitability, of the sampled companies in Taiwan. The relationship between productivity and profitability is then investigated in Section 4. Finally, some conclusions are drawn in Section 5.

2. Productivity measurement

Productivity is a measure of production efficiency. Since all units of production use more than one input to produce more than one output, there will be different combinations of partial productivity measures which are interdependent. For any particular period, some measures may rise while others may fall, which blurs the aggregate performance of a production unit. In order to get a whole picture of the performance, a TFP which includes all types of input and output is needed. The TFP, in general form, is: TFP = g(output 1, output 2,..., output t)/f(input 1, input 2,..., input s), where s and t are the number of inputs and outputs, respectively [22]. Usually f and g are assumed to be linear additive functions. Based on the concept of Bitran and Chang [3], the productivity is:

$$\text{Productivity} = \frac{\sum_{j=1}^{t} (\text{Weight of output } j) \times (\text{Quantity of output } j)}{\sum_{i=1}^{s} (\text{Weight of input } i) \times (\text{Quantity of input } i)} \quad (1)$$

where the weight is a conversion factor used to convert all inputs and outputs into the same denomination for aggregation. Various formulae have been proposed under this framework [22].

Since different industries have different outputs, the same conversion factor must be used so that all industries will have a common basis for comparison. In this regard, all inputs and outputs are expressed in monetary terms via the corresponding unit costs and prices. Many studies [14,23,24] use value added to represent the aggregate output, and the sum of labor inputs and capital inputs to represent the aggregate input, so that the total factor, labor, and capital productivity can be defined. Specifically, the TFP is a ratio of [Sales + ΔInventory − C] to [(Labor inputs) + (Capital inputs)], where C is the costs of purchased materials and labor consumed. However, some data items in the associated formula are not obtainable without the help of the company. To solve this problem, this paper proposes a measurement which uses only the data contained in the balance sheet and income statement as these are open to the public for companies listed on the Taiwan Stock Exchange Corporation (TSEC) [25]. When all factors are expressed in monetary terms, the TFP can be formulated as:

$$\text{Productivity} = \frac{\text{Sales} + \Delta\text{Inventory} + \text{Other Income and Profit}}{\text{Cost of Sales} + \text{Expenses} + \text{Other Expenses and Losses}} \quad (2)$$

where

Sales: total value of sales of goods and services that were made by a company.

ΔInventory: increase in the value of inventory since the last period.

Other Income and Profit: revenues from other than primary business activities, e.g. interest income, rent, and income from patent.

Cost of Sales: amount of direct costs incurred for creating the goods and services.

Expenses: indirect costs, such as R&D, administration, and marketing, in accruing the revenues.

Other Expenses and Losses: expenses not related to primary business operations, e.g. foreign exchange losses.

The difference between costs and expenses, from the accounting point of view, is that the former is the amount of money that has been used up to produce something, and hence is not available for use any more, while the latter refers to the outflow of cash to another person or company.

Of the six components in Equation (2), the inventory is recorded in the balance sheet and all the others can be found in the income statement. Notably, this measurement is applicable to both manufacturing and service industries. Once the relevant data is collected, the productivity indexes of the companies can be calculated.

This study investigates the 500 largest manufacturing and service companies in Taiwan in 2009, and the ranking is based on sales [28]. There are 347

manufacturing companies and 176 service ones which have data available on the website of the TSEC [25] for calculating the productivity via Equation (2). The result is an average productivity of 1.0845, indicating that the total value of the outputs produced by these companies is greater than that of the inputs consumed, since it is greater than one. However, there are still 142 companies (99 manufacturing and 43 service), approximately 27.15% of the total, whose productivity is smaller than one.

For the manufacturing industry, the average is 1.0766 and the variance is 0.0386. A t-test, with the statistic of $t=(1.0766-1)/\sqrt{0.0386/347}=7.2637$, shows that the average productivity is significantly greater than one (as the p-value is smaller than 0.0005). The largest productivity index is 1.8948, occurring at a plastic and rubber company. In contrast, the smallest productivity index, with a value of 0.4533, is for a metal products company. The third column of Table 1 shows the average productivity indexes of different types of the manufacturing industry. The one with the largest average is non-metal mines, followed by plastic and rubber. Taiwan's famous industries, such as IC design, electronics, semi-conductors, and computers, are, as expected, ranked near the top, in third, fourth, seventh, and eighth place, respectively. Surprisingly, another famous industry, photoelectronics, is ranked last, and its average index is less than one, a sign of inefficiency in converting inputs into outputs. Industry types with less than nine companies are grouped into the category of "others."

Figure 1(a) is a scatter plot of productivity vs. sales for the sampled manufacturing companies. Due to the scaling difficulty for large companies, only those with sales less than 30 billion New Taiwan dollars (30 NTD $\cong$ 1 USD) are plotted. There are 303 such companies. Visually, there is no specific trend between these two attributes. By using sales as the independent variable and productivity as the dependent one, the following regression line is obtained:

$$\begin{gathered}\text{Productivity} = 1.076 + 8.233 * 10^{-12}(\text{Sales}),\\ (98.651)\ (0.082)\\ \text{d.f.} = 345,\quad p\text{-value} = 0.934\end{gathered}$$

where the numbers in parentheses under the regression coefficients are the t-statistics of the corresponding coefficients. The p-value indicates that, from the statistical point of view, there is no significant relation between productivity and sales. The non-significant t-statistic for the slope (0.082) also confirms this.

For the service industry, the average of the productivity indexes calculated from Equation (2) is 1.1000, with a variance of 0.0856. Similar to the manufacturing industry, the average is also significantly greater than one, with a p-value smaller than 0.0005. The one with the largest productivity index (2.7866) is a land development company. Interestingly, the one with the smallest productivity index (0.5578) is also a land development company. The third column of Table 2 presents the average productivity indexes of different types of service industry firm. Those types less than five companies are grouped into the category of "others." Of the 11 types, securities has the largest average of 1.3986. The next three, computer software, utilities, and land development, have relatively high averages of 1.3614, 1.2730, and 1.2492, respectively. The one with the smallest average is tourism and entertainment. Its value of 0.9505, which is less than one, signifies an inefficiency in converting inputs into outputs.

Table 1. Average productivity indexes and profitability ratios of different types of manufacturing industry.

Industry	Number of sampled companies	Productivity	Profitability (%)
1. Non-metal mines	9	1.2292	23.6489
2. Plastic and rubber	13	1.2256	22.5277
3. IC design	15	1.2006	9.1573
4. Electronics	35	1.1415	12.6689
5. Food and beverages	13	1.1140	10.7062
6. Chemical materials and products	28	1.1043	9.9604
7. Semi-conductors	26	1.0781	0.4015
8. Computers	55	1.0495	4.6604
9. Communications products	20	1.0481	−1.6400
10. Metal products	29	1.0420	4.3141
11. Textiles	15	1.0391	4.6853
12. Machines and tools	13	1.0289	7.3546
13. Metal materials	18	1.0284	2.3139
14. Photoelectronics	37	0.9708	−3.8914
Others	21	1.0934	9.7138
Total/average	347	1.0766	6.1417

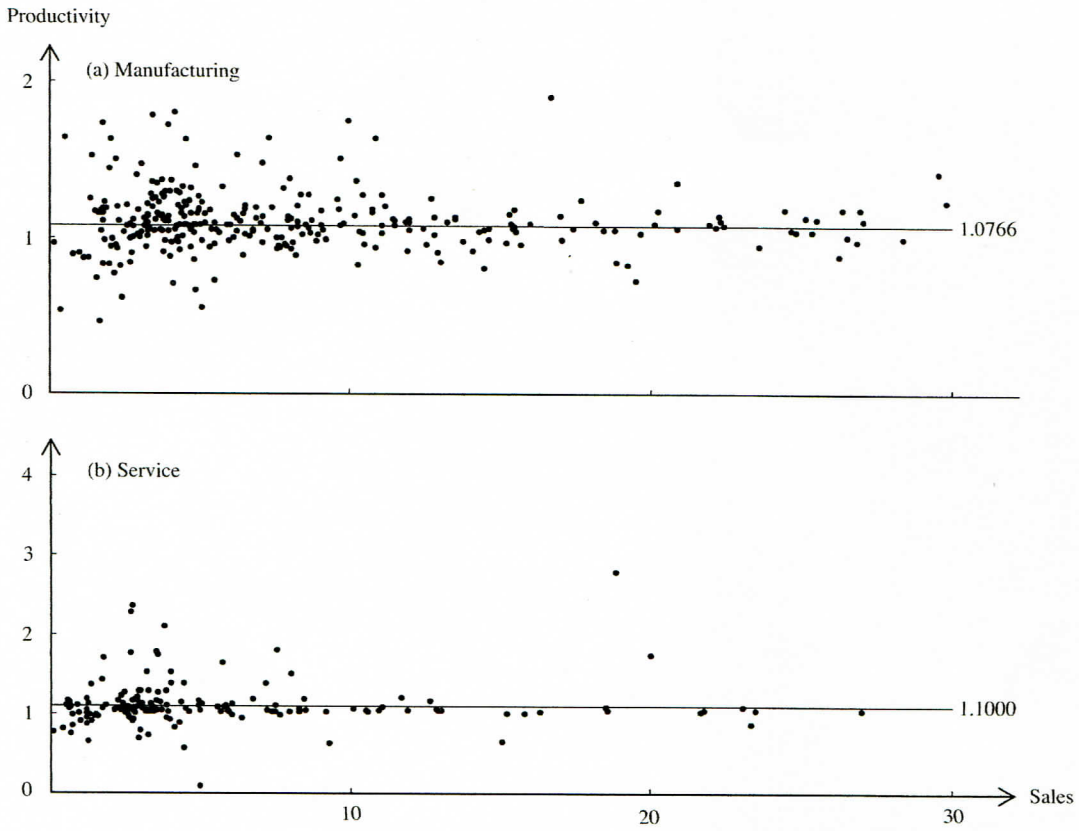

Figure 1. Scatter plots of productivity vs. sales for the sampled companies.

Table 2. Average productivity indexes and profitability ratios of different types of service industry.

Industry	Number of sampled companies	Productivity	Profitability (%)
1. Securities	6	1.3986	22.9433
2. Computer software	10	1.3614	21.7270
3. Utilities	5	1.2730	17.5140
4. Land development	17	1.2492	21.5324
5. Construction and development	18	1.0902	4.6711
6. Transportation	13	1.0772	3.4377
7. Information services	19	1.0403	4.7505
8. Wholesale and retailer	13	1.0368	3.3492
9. International trade	11	1.0160	3.0282
10. Information components distribution	47	1.0141	2.7479
11. Tourism and entertainment	8	0.9515	−6.3575
Others	9	1.1862	11.6244
Total/average	176	1.1000	7.3144

Figure 1(b) plots productivity vs. sales for those companies with sales less than 30 billion New Taiwan dollars. There are 160 such companies. Similar to the manufacturing industry, no clear trend exists between productivity and sales. To formally test whether there is significant relationship between these two variables, a regression line is fitted. The results are:

$$\begin{aligned} \text{Productivity} &= 1.102 - 1.182 * 10^{-10}(\text{Sales}), \\ &\quad (47.127) \quad (-0.251) \\ \text{d.f.} &= 174, \quad p = 0.802 \end{aligned}$$

The p-value of the model and the t-statistic of the slope indicate that there is no significant relationship between productivity and sales.

Comparing these two industries, it is found that the average productivity of the service industry is greater than that of the manufacturing industry by 2.17%, 1.1000 vs. 1.0766. The variance of the former is approximately 2.2 times greater than that of the latter, 0.0856 vs. 0.0386. Reasonably, higher productivity is accompanied with higher uncertainty (variance). Since the sample sizes are large, with 347 manufacturing companies and 176 service companies,

their difference approaches a normal distribution. The statistic $z=(1.1000-1.0766)/(0.0856/176+0.0386/347)^{1/2}=0.9577<1.65=z_{0.95}$ shows that, although the average productivity of the service industry is greater than that of the manufacturing industry, the difference is not significant.

3. Profitability measurement

Profitability measures a company's financial performance, that is, the ability to increase its stakeholder's value and to generate profit. There are several widely-used measures of profitability, for example, NPM, return on assets, and return on invested capital. These measures provide insights into the profits made by the company in relation to its sales, assets, and size. One objective of this study is to find the relationship between productivity and profitability. Since productivity is measured from the data of a period of time, it is better to use an index of profitability which is measured from the data of the same period of time to be consistent. Of the several popular profitability indices, only NPM is measured from the data of a period of time. So in this study, we use NPM to measure the profitability of a company.

NPM is defined as the ratio of net income to sales:

$$\text{NPM} = \frac{\text{Net Income}}{\text{Sales}}$$

where *Sales* is the same as that used for calculating productivity in Equation (2). *Net Income* is the net profit (after tax) earned, which, like *Sales*, also appears in the income statement. Hence, similar to the TFP, NPM can also be calculated from information accessible by the public, without needing the assistance of the company. This ratio shows how much profit is generated per dollar of sales.

For the 523 companies whose balance sheets and income statements are available, their profitability, in terms of NPM, can be calculated via Equation (3). The average is 6.5363%. The positive value indicates that these companies were earning a profit in 2009, and every dollar of sales could bring in 0.065363 dollars of net profit. However, there are still 88 companies (16.83%), 61 manufacturing and 27 service, whose NPM is negative.

For the manufacturing industry, the largest profitability ratio is 80.30%, occurring at the plastic and rubber company which also has the largest productivity index. The firm with the smallest profitability ratio (−159.23%) is a communication products company, which has the second smallest productivity index. The average of the 347 companies is 6.1417% and the variance is 400.5862. A *t*-test shows that this value is significantly different from 0 (with a *p*-value of smaller than 0.0005).

The last column of Table 1 shows the average profitability ratios of different types of manufacturing industry. The one with the largest ratio is non-metal mines, with a value of 23.6489%, which also has the largest average productivity index. Similarly, the industry with the smallest ratio (−3.8914%), photoelectronics, also has the smallest productivity index (0.9708). The negative profitability ratio of this industry is consistent with its productivity index of less than one. In addition to photoelectronics, there is another industry, communications products, whose profitability ratio is also negative. In general, profitability ratios have the same trend as productivity indexes.

Bigger companies are expected to make more profit because their sales are larger. However, when the profit is expressed in per-dollar-sales, this trend may not exist. Figure 2(a) is a scatter plot showing the relation between NPM and sales of the 303 companies whose sales are less than 30 billion New Taiwan dollars. There seems to be no clear trend. A regression analysis obtains the following relationship between NPM and sales:

$$\begin{gathered}\text{NPM} = 6.180 - 1.389 * 10^{-9}(\text{Sales}),\\ (5.560)\quad(-0.137)\\ \text{d.f.} = 345,\quad p\text{-value} = 0.891\end{gathered}$$

The *p*-value of the regression model and the *t*-statistic of the slope confirm that there is no statistically significant relationship between NPM and sales.

Similarly, the NPM of the 176 service companies can also be calculated by using Equation (3). The largest profitability ratio obtained is 80.93% and the smallest is −65.43%, both occurring at transportation companies. The former has the second largest productivity index and the latter has the third smallest. The average NPM of the 176 companies is 7.3144% and the variance is 227.8375. The *t*-statistic of 6.4287 $(=7.3144/\sqrt{227.8375/176})$ shows that the average is significantly different from 0 (with a *p*-value of less than 0.0005). The last column of Table 2 shows the average profitability ratios of different types of service industry. The one with the largest average ratio (22.9433%) is securities, which also has the largest productivity index (1.3986). The one with the smallest average ratio (−6.3575%) is tourism and entertainment, which, at the same time, has the smallest productivity index (0.9515). The negative profitability ratio is consistent with the productivity index of less than one. Figure 2(b) plots NPM vs. sales for those 160 companies whose sales are less than 30 billion New Taiwan dollars. Similar to the manufacturing companies, no specific trend between

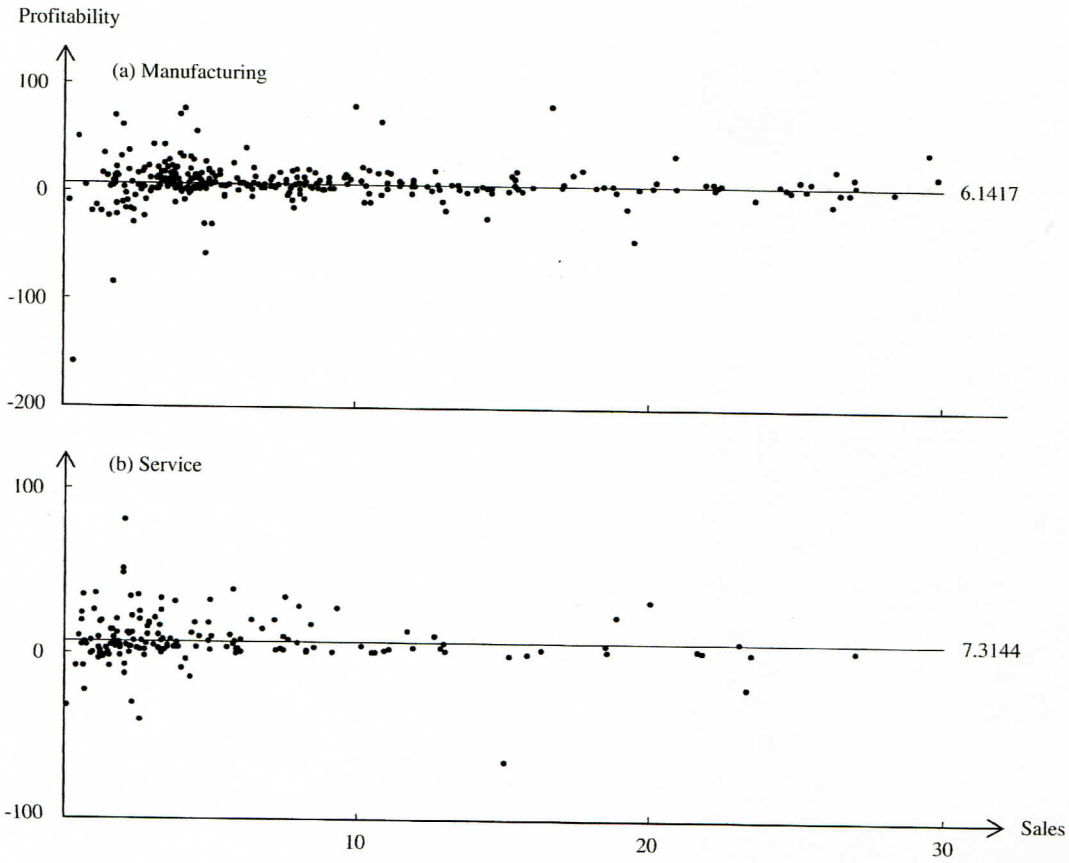

Figure 2. Scatter plots of profitability vs. sales for the sampled companies.

NPM and sales is exhibited in the plot. A formal regression analysis shows that the relationship between NPM and sales is not significant:

$$\begin{gathered}\text{NPM} = 7.596 - 1.747 * 10^{-8}(\text{Sales}),\\ (6.305) \quad (-0.720)\\ \text{d.f.} = 174, \quad p\text{-value} = 0.473\end{gathered}$$

as revealed by the p-value of the model and t-statistic of the slope. Compared with the manufacturing industry, it is found that the service industry has a larger average profitability ratio and a smaller variance, 7.3144 vs. 6.1417 for the average and 227.8375 vs. 400.5862 for the variance. This means that the service industry is more likely to have higher profitability than the manufacturing industry. In the case of productivity, the service industry has a higher average productivity accompanied with a larger variance. Here, the average profitability of the service industry is still larger than that of the manufacturing industry, yet the variance is smaller. Assuming the sample sizes of 347 and 176 are large enough for the difference of the two averages to approach a normal distribution, then the statistic of $z = (7.3144 - 6.1417)/\sqrt{227.8375/176 + 400.5862/347} = 0.7494 < 1.645 = z_{0.95}$ shows that the superiority of the average NPM of service companies over that of manufacturing companies is not significant.

4. Profitability on productivity

Productivity concerns producing same amounts of outputs using fewer inputs or producing more using the same inputs, and its improvement enhances profitability. In this section, the company data is used to empirically find the relationship between profitability and productivity.

Based on Equation (2), a company will be earning a profit if its productivity is greater than one. In other words, the total value of the outputs produced must be greater than that of the inputs consumed to be profitable, unless price changes, inflation, or other economic factors have occurred. Profitability, as expressed in NPM, is the net profit generated from selling goods and services, and it must be positive for a company to be profitable. Theoretically, the situation of "a productivity index of greater than one" is equivalent to that of "a positive profitability ratio," and the situation of "a productivity index of less than one" is equivalent to that of "a negative profitability ratio." However, of the 99 manufacturing companies with a productivity index less than one, 42 have a positive profitability ratio. Similarly, for the 44 service companies with a productivity index less than one, 19 have a positive profitability ratio. On the

contrary, there are four manufacturing and one service companies whose productivity indexes are greater than one, yet their profitability ratios are negative. In total, 46 manufacturing (13.26%) and 20 service (11.36%) companies have inconsistent results. A close examination of Equation (2) reveals that the problem is due to inventory changes, ΔInventory. If a company has relatively high inventory at the end of the preceding year and a low one in this year, resulting in a negative ΔInventory, then more output is sold than is produced in this year. In this case, the calculated profitability ratio will be higher than the real value. For the 42 manufacturing and 19 service companies which have a positive profitability ratio and a productivity index less than one, all have a negative ΔInventory. Similarly, of the four manufacturing and one service companies whose productivity indexes are greater than one and profitability ratios are negative, all have a positive ΔInventory, which supports this reasoning. To find the correct relationship between profitability and productivity, these abnormal cases must be excluded.

Based on the preceding discussion, it is noted that ΔInventory must be zero for the calculated profitability ratio to correctly reflect the real situation. Since the chance that ΔInventory is equal to zero is very low, this study allows companies whose absolute value of ΔInventory is less than 5% the total value of the inputs consumed, that is, the denominator of Equation (2), to be eligible for inclusion in finding the relationship between profitability and productivity. There are 274 manufacturing and 135 service companies which satisfy this condition, and Figure 3 plots the relation between profitability and productivity for the former in (a), and the latter in (b). The trend that profitability increases with productivity is clear in these charts.

Under normal conditions, the productivity index should be equal to one when the profitability ratio is equal to zero. Therefore, regression lines forced to pass through this point are fitted for these two industries. The scatter plots of Figure 3(a) and (b), show that positive and negative profitability ratios have different trends with productivity. Starting from the point (1, 0), the rate that profitability increases with productivity is lower than the rate that it decreases with productivity. The reason is because when a profit is earned, income taxes are levied, and no taxes are levied when the earnings before income tax (EBIT) are negative. Hence, two regression lines with different slopes passing through the point (1, 0) are fitted for the two cases. The regression model is:

$$\text{NPM} = (a + b \times I) \times (\text{Productivity} - 1)$$

where I is an indicator variable which is 0 for companies with positive NPMs and one for those with negative NPMs. The slope of the regression line for the positive part is a and for the negative part is $a + b$.

For the 274 manufacturing companies, 236 have a positive NPM and 38 have a negative one. The regression line obtained from these companies is:

$$\text{NPM} = (79.614 + 66.146 * I) * (\text{Productivity} - 1),$$
$$\qquad\quad (50.699) \quad (11.677)$$
$$\text{d.f.} = 272, \quad p\text{-value} < 0.0005$$

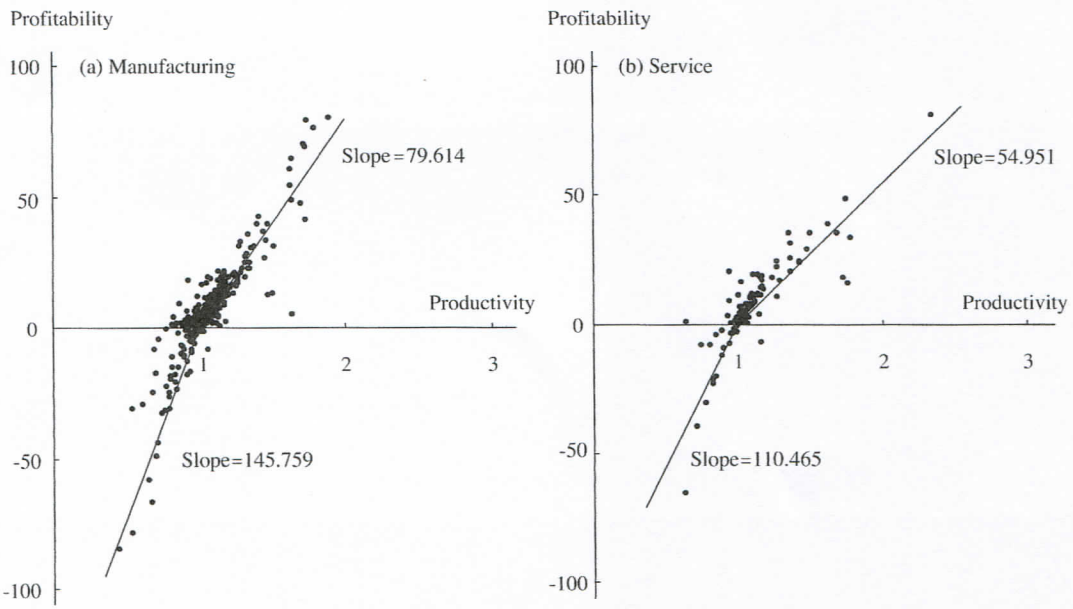

Figure 3. Scatter plots of profitability vs. productivity for the sampled companies.

There are two conclusions which can be drawn from this regression analysis. One is that the above regression line significantly describes the relationship between NPM and productivity, as is evident from the p-value of the model. The other is that two lines with different slopes are necessary to describe the relationship between NPM and productivity for companies with positive and negative NPMs, as is revealed by the t-statistics associated with a (50.699) and b (11.677). (As a reference, the tabulated value for the t-statistic for 120 degrees of freedom at the $\alpha = 0.0005$ significance level is only 3.373.) The slope for the positive part is 79.614 and that for the negative part is 145.759 (=79.614 + 66.146). To predict the NPM for companies with a productivity index greater than one, the slope of 79.614 is used, while for those with a productivity index less than one, the slope of 145.759 is used.

The slope of the negative part is almost two times that of the positive part, indicating that once a company is going to lose money, the effect is stronger than earning money for each unit of productivity change. Specifically, for those companies with a productivity index greater than one, every unit of increased productivity implies 79.614 units of increased NPM, which, in turn, is equal to $0.79614 \times$ Sales units of net income. For companies with a productivity index of less than one, however, the loss of net income is $1.45759 \times$ Sales units for each unit drop of the productivity index. Based on this equation, one can predict the profitability of a manufacturing company from its productivity.

Similarly, for the 135 service companies, Model (4) is applied to find the kinked regression line. There are 115 companies with a positive NPM and 20 with a negative one. The result is:

$$\begin{aligned} \text{NPM} &= (54.951 + 55.514 * I) * (\text{Productivity} - 1), \\ &\quad (20.949) \quad (5.481) \\ \text{d.f.} &= 133, \quad p\text{-value} < 0.0005 \end{aligned}$$

The p-value indicates that this regression model suitably describes the relationship between NPM and productivity. The t-statistics of 20.949 and 5.481 indicate that the two parameters, $a = 54.951$ and $b = 55.541$, are significantly different from 0. In other words, two different lines should be used for cases when the productivity index is greater than or less than one. The greater-than-one part has a slope of 54.951, indicating that the net profit will be increased by $0.54951 \times$ Sales units for each unit increase in productivity. For the less-than-one part, the slope of 110.465 (= 54.951 + 55.514) indicates that the net profit will decrease by $1.10465 \times$ Sales units for each unit drop of productivity. The effect of the latter is approximately two times of that of the former. A service company can use this equation to predict the net profit from its productivity index.

Compared to the manufacturing industry, the slope of the service industry for the greater-than-one part is 30.98% smaller, 79.614 vs. 54.951, and for the less-than-one part it is 24.21% smaller, 145.759 vs. 110.465. The productivity has a larger effect on NPM for manufacturing companies than for service ones. Based on the profitability–productivity relationship, one can not only predict the NPM from the productivity, but also plan for the productivity necessary to accomplish a desired profitability.

5. Conclusion

Productivity measures how efficiently a company converts inputs into outputs (goods and services), and it is basically related to technology. Profitability is a combined measure of technological and economic factors, and it is the aggregate effect of productivity and price recovery. Both productivity and profitability have different measurements. This paper uses TFP and NPM to measure the productivity and profitability, respectively, of the 1000 largest companies in Taiwan, 500 manufacturing and 500 service, for the year 2009. Only a company's balance sheet and income statement are needed to provide the data for these calculations, and thus data acquisition is not a problem. The relationships between these two measures are also investigated. There are several findings.

Concerning productivity, it is independent of the sales of the company for both manufacturing and service industries. In other words, a company does not need to be a specific size to be more productive. The average productivity in both the manufacturing and service industries is greater than one, indicating that more value of outputs is generated from the inputs. Although the service industry has a slightly higher productivity index than the manufacturing industry, this difference is not statistically significant. The variance is also larger, indicating that the service companies have wider variations. With regard to profitability, it has several things in common with productivity. First, it is independent of the sales of the company. Second, the average profitability ratios of both manufacturing and service industries are greater than zero, indicating that both earned a profit. Third, the service industry has a slightly higher profitability ratio than the manufacturing industry. However, different from the case of productivity, the service industry has a smaller variance of profitability, which means that service companies are more likely to make a larger profit than manufacturing companies.

As expected, profitability is highly correlated with productivity. Due to the effect of income taxes, the rate of change in profitability for cases of positive profitability is less than that of negative

profitability as productivity increases. In other words, when a company is earning a profit, the rate of earning is lower than when it is losing money. The results of this empirical study of Taiwan's 1000 largest companies shows that, for manufacturing firms, a unit increase in the productivity index leads to an increase of 145.759 units in NPM when the company has a negative profitability ratio. However, the amount changes to 79.614 when the company has a positive profitability ratio. For service companies, the situation is 110.465 for cases of negative profitability ratio, and 54.951 for those with a positive ratio. Based on the relationship obtained in this study, a company is able to predict its profits from its productivity, and thus suitable plans can be made to achieve the desired profit.

The profitability measure used in this paper is NPM, although there are other measures, such as return on assets, return on equity, and return on invested capital. By applying the same approach used in this study, a similar relationship between these types of measurement and productivity can be obtained. The corresponding profitability measures can then be predicted from the productivity index.

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