Research Memorandum

The effectiveness of corporate financial behavior prediction using a probability distribution table

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Abstract

It is a general way to predict accounting items on a profit loss statement (P/L) or a cash flow statement (CF), to forecast a company's future financial condition.

That is because these accounting items on P/L are relatively easy to predict with their strong relationship to economic indicators, such as GDP growth rate, and the methodologies are well-known and substantiated.

On the other hand, accounting items on a balance sheet statement (B/S), which are considered as important financial information to evaluate credit risks of companies, are not easily predicted because they are mainly determined by a company's own decisions. That is the reason why the effective methodologies to forecast these have not been established.

This report proposes a novel approach to predict accounting items on B/S where the idea is applied that company's financial decisions, such as increase or decrease in equipment investments or debt, follow the transition matrix of corporate financial behaviors. As a result, we show that our proposed methodology is allowed to forecast accounting items on B/S with sufficient level of accuracy.

1. Introduction

Many investors or bankers make their decisions on investments or loan arrangements according to information regarding profitability or credit risks based on a company's reported financial statements. Some "sophisticated" investors make their decision by calculating net present value of the company from profit or free-cash flow projections with applying DCF approach.

Financial statements (balance-sheet (B/S), profit-loss (P/L), and cash-flow (CF) statements) are very important sources for corporate evaluation. If the prediction of the statements can be undertaken with a sufficient level of accuracy, it must be quite useful information for investors or loan arrangers to make their decisions.

Practically some financial institutions predict financial statements of their clients.

The most popular method of the prediction is based on an elaborated projection of future B/S and P/L of individual companies by considering their business plans and business circumstances. However, this method requires a heavy burden to makes such future projections. Furthermore, this process can be made only a company by company. Concerning a huge consumed time and human resources for such process, it is not feasible to make such process applying for their entire portfolio. For this reason, the financial statement predictions can be made only for a few key companies to be concerned.

The predictions of the most of conventional methods are based on the prediction of P/L statement only, such as Sales, Cost of sales, Profits, etc. Since these items show higher correlations with external factors of economic conditions, such as market demand, prices, exchange rates, etc, it is relatively easier to make predictions of these accounts with a certain level of accuracy.

In contrast, it is rather difficult to predict balance-sheet account items (Fixed assets, Liabilities, etc.) as they are depending on willingness or decisions of the company,. For example of raising some fresh money, it is a sole decision of the company whether they issue equity or borrow from bank. Without taking account of these companies' decisions, it is not an easy task to predict these B/S accounts.

This report proposes a novel approach to predict B/S account items where the idea is applied that company's financial decisions, such as increase or decrease in equipment investments or debt, follow the transition matrix of corporate financial behaviors, called a "Strategy Map", which were composed of past B/S statements over fifty thousands of Japanese companies.

This report demonstrates that B/S statements can be predicted with a sufficient level

of accuracy through the Strategy Map.

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2. Methodology of Creating Financial Accounting Statement Predictions

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In this section, we briefly explain the methods to predict each key accounting item.

Prediction of the balance sheet items strongly influenced by external factors

First, we will explain the method to predict the balance sheet account items which are strongly influenced by external factors such as macroeconomic conditions or competitors' actions. For example, accounts receivable, accounts payable, or inventories belong to this category. They are strongly relating with profit and loss account items such as sales, cost of sales or administrative expenses and also with macroeconomic conditions, and corporate management can control only a part of them[1]. That is the reason why we categorize them into the items strongly influenced by external factors. Thus these accounting items are comparatively easily to predict by using past trends or financial ratios (e.g. sales-cost ratio, sales-administrative cost ratio, etc.). Prediction methods used in this report have no difference from the ones which have been commonly used in a practice.

Prediction of balance sheet items under top management control

Next we cover the method to predict accounting items under top management control[2]. These accounting items are, for example, equipment investments or debt.

The method of their predictions applied in this report is quite different from the ones which have been used in a standard practice or traditional method.

To predict them under a traditional method, we have to collect and analyze business plans of each company and reflect them on future financial statements individually.

However, the lager the number of companies requires the more time to conduct this approach. So it becomes a serious issue to predict hundreds of thousands of companies at one time.

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[1] It is true that the corporate managers' efforts will affect sales or cost of sales in some degree. However, in most cases, it is impossible to double the sales or to cut into half the cost of sales only by managers' efforts. (Sales or cost of sales are strongly influenced by macroeconomic conditions, customer behavior, labor costs, cost of raw materials, etc.)

[2] Corporate managers can decide on fixed assets investments by the company's own cash or by using leverages, for example. Corporate managers can decide other financial management strategies. Corporate managers' decisions are strongly affected in those items, comparing to the sales or cost of sales for the company.

And another problem is that if a company announces the business plan just as a milestone of its business, the business plan has no feasibility and it is no longer any objective information on the company's future.

To overcome these difficulties, we introduce a novel approach to predict accounting items under top management control of hundreds of thousands of companies in what follow.

Prediction of the managers' decisions

We assume top management control, such as increase or decrease in equipment investments or debt follows the transition matrix of financial behavior which is composed of past records of companies' behaviors. Then we apply it to the prediction of accounting items under managers' control. In this report we obtained the transition matrix of financial behavior from over fifty thousands of Japanese firms, named as "probability table for financial decisions", or simply "(financial) Strategy Map".

・Figure 1 illustrates the basic idea of the Strategy Map simply.

An enterprise has taken a variety of combinations regarding financial decisions such as investments, loan arrangements, or others. Then we assume that an enterprise makes a decision not only by its own independent factors but also by a certain common tendency or decision pattern, according to which a future financial strategy of a company who took a financial strategy in the past will be decided. We represent that as a transition matrix.

Figure 1

"Strategy Map" assumes the pattern of corporate managers' behaviour in fixed assets investment, liabilities, current assets, are randomly distributed variables and can be explained statistically. We created the map by analysing thousands of Japanese companies.

Actions of the Corporate Managers

Which type of actions will be taken for the next

2 Years Ago to Last Year

Manager	Fix. Asset	Liabilities	Cur. Asset
A	decreased	increased	increased
B	increased	decreased	increased
C	decreased	increased	increased
D	increased	decreased	increased

actual

Last Year to Current Year

Manager	Fix. Asset	Liabilities	Cur. Asset
A	increased	increased	increased
B	increased	decreased	increased
C	decreased	increased	decreased
D	decreased	decreased	decreased

actual

Current Year to Next Year

Manager	Fix. Asset	Liabilities	Cur. Asset
A	?	?	?
B	?	?	?
C	?	?	?
D	?	?	?

prediction

?

To create the "Strategy Map", an index (or number) is given for each pattern of the managers' action in the beginning. Then a matrix is created with the index number for "2 Years Ago to Last Year" as raw and the index (number) for "Last Year to Current Year" as column. A "Strategy Map" is given as the each element is filled with the probability of taking the pattern order. Hence, the map defines the probablity of taking a strategy subject to the strategy taken in the previous year.

For example, if we define the pattern of manager "A " in "last year to current year" [increase in fixed assets investment, increase in liabilities, increase in current assets] as "Strategy #1"(S1), we can count the number of mangers taking S1 from the dataset. By defining all other patterns and counting the cases, we can create the "map".
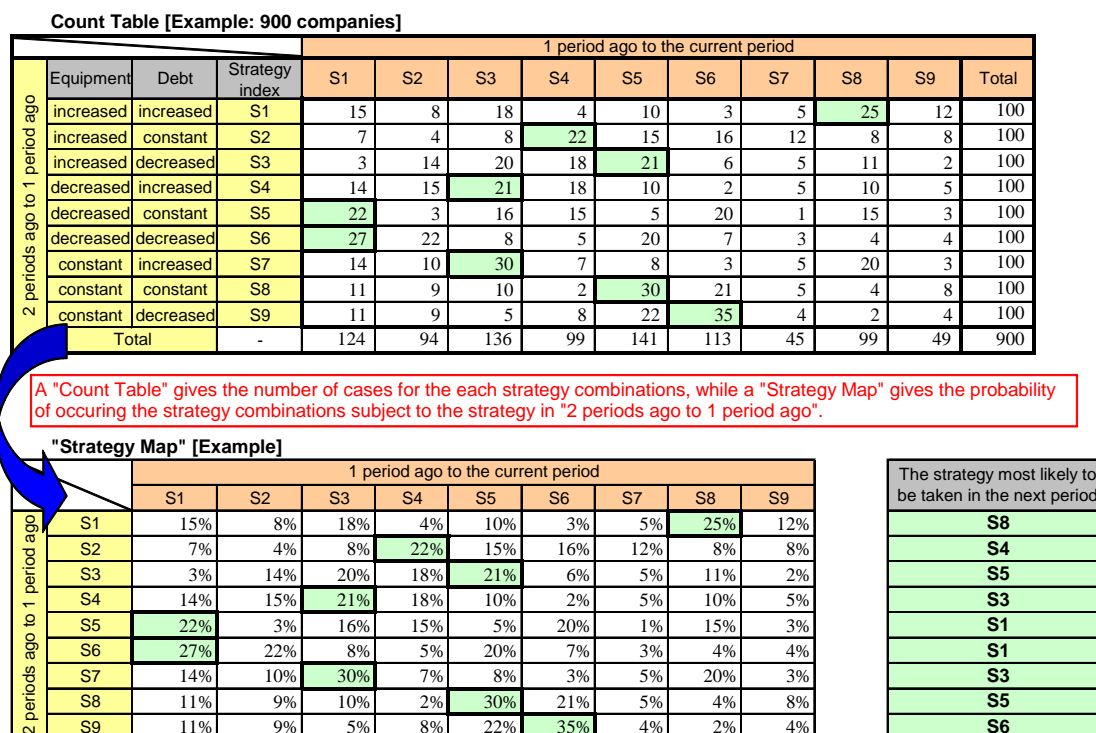
In sum, assuming the managers' decisions follow the transition matrix called a Strategy Map. We can predict the most or least plausible managers' financial decisions and then predict accounting items under top management control. That is about how we introduce a transition matrix in the framework of the prediction of these accounting items.

To create strategy maps, classification of financial decisions of a corporate manager is an important issue. The strategy maps used in this report are created by assuming the changes in: (1) Fixed assets, (2) Liabilities, (3) Current assets, which are the key decision issues for managers. Figure 2 illustrates how to create a Strategy Map. In this figure, fixed assets and liabilities are assumed to be key factors considered by managers, and the decision patterns are classified into nine from S1 to S9. These categorized decision patterns are defined as "strategy" in this report.

Note that Figure 2 is a simple example to explain the basic idea of a Strategy Map, and the actual Strategy Map used in this report will explain late in this section.

Figure 2

Count Table [Example: 900 companies]

Equipment	Debt	Strategy index	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total
increased	increased	S1	15	8	18	4	10	3	5	25	12	100
increased	constant	S2	7	4	8	22	15	16	12	8	8	100
increased	decreased	S3	3	14	20	18	21	6	5	11	2	100
decreased	increased	S4	14	15	21	18	10	2	5	10	5	100
decreased	constant	S5	22	3	16	15	5	20	1	15	3	100
decreased	decreased	S6	27	22	8	5	20	7	3	4	4	100
constant	increased	S7	14	10	30	7	8	3	5	20	3	100
constant	constant	S8	11	9	10	2	30	21	5	4	8	100
constant	decreased	S9	11	9	5	8	22	35	4	2	4	100
Total	-		124	94	136	99	141	113	45	99	49	900

Left axis: 2 periods ago to 1 period ago; Top: 1 period ago to the current period

A "Count Table" gives the number of cases for the each strategy combinations, while a "Strategy Map" gives the probability of occuring the strategy combinations subject to the strategy in "2 periods ago to 1 period ago".

"Strategy Map" [Example]

	S1	S2	S3	S4	S5	S6	S7	S8	S9	Most likely next
S1	15%	8%	18%	4%	10%	3%	5%	25%	12%	S8
S2	7%	4%	8%	22%	15%	16%	12%	8%	8%	S4
S3	3%	14%	20%	18%	21%	6%	5%	11%	2%	S5
S4	14%	15%	21%	18%	10%	2%	5%	10%	5%	S3
S5	22%	3%	16%	15%	5%	20%	1%	15%	3%	S1
S6	27%	22%	8%	5%	20%	7%	3%	4%	4%	S1
S7	14%	10%	30%	7%	8%	3%	5%	20%	3%	S3
S8	11%	9%	10%	2%	30%	21%	5%	4%	8%	S5
S9	11%	9%	5%	8%	22%	35%	4%	2%	4%	S6

For example, a company reserved net profit after dividends tax as retained earnings 2 years ago and also positively carried out fixed asset investments with leverage. To create a Strategy Map, we have to obtain such information as what strategy it took the last year.

In Figure 2, the strategy taken two years ago is on the vertical axis and the strategy taken last year is on the horizontal axis. From this table, for example, 100 companies took the strategy "S1" two years ago, and 25 out of them took the strategy "S8" last year. And also there are 15 companies of them to have taken "S1" throughout the observed periods.

A strategy map is derived by each cell's proportion for the sum of the each corresponding row.

Figure 3 is an example of the Strategy Map used in this report.

Figure 3

		strategy descriptions			1 period ago to the current period								
		[1]	[2]	[3]	1	2	3	4	5	6	7	8	Total
		ΔNet Asset	ΔFixed Asset	ΔLiability	ΔLiquidity								
2 periods ago to 1 period ago	1	>=0	>0	>0	>0	18.78%	12.67%	7.12%	15.69%	10.04%	5.31%	11.95%	18.43%	100.00%
	2	>=0	>0	>0	<=0	22.13%	8.34%	9.63%	8.66%	15.35%	4.46%	18.98%	12.45%	100.00%
	3	>=0	>0	<=0	>0	16.63%	11.69%	9.68%	14.07%	10.44%	6.83%	13.62%	17.04%	100.00%
	4	>=0	>0	<=0	<=0	20.23%	7.87%	9.96%	11.18%	15.28%	4.55%	17.43%	13.52%	100.00%
	5	>=0	<=0	>0	>0	13.28%	10.26%	5.90%	15.76%	10.56%	6.38%	12.28%	25.58%	100.00%
	6	>=0	<=0	>0	<=0	17.06%	6.73%	9.64%	7.65%	17.40%	5.96%	20.87%	14.70%	100.00%
	7	>=0	<=0	<=0	>0	11.62%	8.27%	7.07%	11.12%	11.42%	5.89%	19.51%	25.10%	100.00%
	8	>=0	<=0	<=0	<=0	14.10%	5.52%	7.31%	7.35%	17.23%	4.78%	23.83%	19.87%	100.00%
	9	<0	>0	>0	>0	11.65%	9.62%	6.52%	16.22%	9.34%	5.09%	16.06%	25.49%	100.00%
	10	<0	>0	>0	<=0	15.07%	5.65%	8.89%	9.07%	14.01%	3.59%	27.02%	16.71%	100.00%
	11	<0	>0	<=0	>0	12.19%	10.64%	7.93%	12.38%	10.83%	7.93%	15.28%	22.82%	100.00%
	12	<0	>0	<=0	<=0	16.25%	5.88%	9.76%	10.53%	15.07%	3.99%	22.53%	15.99%	100.00%
	13	<0	<=0	>0	>0	8.34%	7.27%	5.10%	15.44%	10.37%	4.70%	17.01%	31.78%	100.00%
	14	<0	<=0	>0	<=0	11.02%	4.81%	9.41%	6.88%	15.32%	5.28%	25.71%	21.57%	100.00%
	15	<0	<=0	<=0	>0	8.02%	6.53%	6.43%	10.91%	11.37%	5.76%	21.14%	29.84%	100.00%
	16	<0	<=0	<=0	<=0	11.04%	4.05%	6.77%	7.14%	15.67%	4.18%	28.76%	22.40%	100.00%

		strategy descriptions			1 period ago to the current period								
		[1]	[2]	[3]	9	10	11	12	13	14	15	16	Total
		ΔNet Asset	ΔFixed Asset	ΔLiability	ΔLiquidity								
2 periods ago to 1 period ago	1	>=0	>0	>0	>0	14.66%	21.57%	1.95%	12.62%	10.76%	13.05%	4.87%	20.52%	100.00%
	2	>=0	>0	>0	<=0	20.20%	14.44%	3.59%	8.18%	16.52%	10.25%	11.97%	14.85%	100.00%
	3	>=0	>0	<=0	>0	11.44%	20.49%	2.52%	11.25%	11.96%	15.90%	5.43%	21.01%	100.00%
	4	>=0	>0	<=0	<=0	17.46%	14.19%	2.79%	9.08%	19.82%	10.99%	8.90%	16.76%	100.00%
	5	>=0	<=0	>0	>0	11.03%	17.09%	1.67%	13.62%	11.99%	11.76%	5.60%	27.25%	100.00%
	6	>=0	<=0	>0	<=0	17.01%	11.19%	4.23%	7.33%	18.29%	11.79%	13.45%	16.70%	100.00%
	7	>=0	<=0	<=0	>0	9.37%	16.22%	1.81%	9.12%	12.10%	14.95%	8.11%	28.32%	100.00%
	8	>=0	<=0	<=0	<=0	13.34%	11.54%	2.32%	5.48%	20.43%	11.98%	11.47%	23.44%	100.00%
	9	<0	>0	>0	>0	11.50%	18.60%	1.57%	13.48%	10.05%	14.17%	5.50%	25.13%	100.00%
	10	<0	>0	>0	<=0	16.18%	13.92%	2.82%	6.61%	18.94%	12.70%	9.77%	19.04%	100.00%
	11	<0	>0	<=0	>0	9.73%	18.39%	2.96%	13.11%	9.94%	17.12%	7.19%	21.56%	100.00%
	12	<0	>0	<=0	<=0	16.75%	12.90%	3.58%	10.53%	17.48%	11.48%	9.27%	18.01%	100.00%
	13	<0	<=0	>0	>0	8.09%	13.05%	1.50%	11.68%	12.57%	16.89%	5.44%	30.77%	100.00%
	14	<0	<=0	>0	<=0	11.37%	9.66%	2.59%	5.83%	23.07%	15.09%	10.93%	21.47%	100.00%
	15	<0	<=0	<=0	>0	6.84%	11.82%	1.74%	8.17%	12.51%	15.53%	10.20%	33.20%	100.00%
	16	<0	<=0	<=0	<=0	10.33%	7.89%	2.04%	6.81%	19.27%	14.13%	13.09%	26.45%	100.00%

Note: Strategy Map in Figure 3 is created from approximately 50,000 Japanese companies. Based on the size of Sales, there are 3 types for the Strategy Maps actually used.

To categorize financial behaviors into patterns,

Figure 3 shows actual number of the strategy from 2 periods ago (P-2) to the last period (P-1) on the vertical axis and the strategy from P-1 to the current period (P) on the horizontal axis which is composed of each eight patterns of financial behaviors according to the sign of *ΔNet Asset,* which the net asset change is denoted as.

So we considered 16 strategies based on the change in (1) fixed asset (machinery and other depreciable assets), (2) Liabilities, and (3) Liquidity for the strategy map.[3]

Also we can extend 128 strategies[4] by concerning the comparison of the amount between the three factors (fixed asset, liabilities, liquidity).

Furthermore, it is possible to make exact strategy maps by using more detailed

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[3] It is rare that the current year value is the same with previous year for the three variables. Therefore, we classified the changes in the three variables by either "0 or over" or "below 0".

[4] I use 16 Strategy Map for explanation simplicity.

information, such as macroeconomic climate (boom, recession), region, industry, or whether default or non-default or longer periods than 3 years.

It is easy to make a "tuned" Strategy Map by imposing appropriate classification definitions about strategies, however there should exist a trade-off between the number of samples required and the number of strategies applied. The more the number of strategies applied, the more the number of samples is required for the effectiveness of the Strategy Map.

Application of Strategy Map to financial accounting statements prediction

The changes in net assets (*ΔNet Assets*) are calculated with the actual financial statements, but to predict future balance sheets future *ΔNet Assets* itself should be provided.

For the first step of the prediction of the future financial statement, profit-loss account statements should be predicted for this procedure, which are given through ordinary least square regression on historical Sales data in this report.[5] That is because sales are strongly influenced by external factors and should be independent from other part of the prediction process.

Then considering sales as exogenous variables, I applied ordinary least squares on historical data for the prediction of other profit-loss account statements (e.g. Cost of Sales, Distribution Costs, Administrative Expenses) or a part of balance-sheet statements (e.g. working capital).which depend on external factors.

However, some profit-loss account items don't depend on external factors. Profit-loss account items such as Depreciations or Interest Payable are considered to be influenced by accounting items under top management control.

In this report, prediction of these values will take two steps.

First, initial predicted values are derived by simple least square regressions on depreciation rate, interest rate, etc.. In this way, the effects of external factors are to be considered.

After considering the effects of external factors, their prediction should be reflected by accounting items under top management control, of which predictions are applied to the Strategy Maps in this report. As shown in the previous section, the Strategy Maps tell us the overall direction of the managers' decisions, but it does not tell us the size of the changes. To predict the magnitude of the changes, we focus on the ratios with respect to *ΔNet Assets,* which is obtained by prediction of P/L. In this report, we obtained the ratios

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[5] Regarding the prediction of Sales, it is better to apply time-series analysis (e.g. VAR) than ordinary least squares. Prediction of Sales by VAR model is available in AERIS.

of *ΔFixed Assets*, *ΔLiabilities*, and *ΔLiquidities* with respect to *ΔNet Assets* for each cell of the matrix of strategy maps. We derive the ratios from the statistical values in the same samples used to create strategy Maps. That is because the ratio obtained by calculation of each company is not reliable for predictions because the data sample available for each firm is quite limited. And also, we derive the ratio using statistic values by group of firm size (i.e. large, medium, small).

AERIS (Advanced Enterprise Risk Intelligence Simulator) is a patented product by Financial Technology Research Institute Inc. where the idea of Strategy Map is incorporated.

FTRI is a leading financial risk solution provider based in Japan. If you have any interest in our products and service, please contact with the followings.

TEL: +81-3-3276-3440
FAX:+81-3-3276-3439