

FORECASTING STOCK VALUE

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ABSTRACT

When a stock market is less than perfectly efficient and investors are less than perfectly rational, investors can profit by trading the stock whenever its price differs from its true value. The true value can be obtained by forecasting the book value of the stock to the time of the next transaction opportunity, and then adjusting for under and over valuation of assets and liabilities. In making a forecast based on the previous book value, this study asks if using data on market share and production experience available at the same previous time can improve the forecast, finding that the answer, as supplied by firms of a computer-assisted gaming simulation, is affirmative. Caution is suggested in generalizing the results obtained from the gaming-simulation setting to the everyday-world settings. In the field of business strategy, however, the error of relying too little on gaming simulation research may exceed the error of relying too much.

INTRODUCTION

Investors commonly distinguish between the market price of a stock and its true value. Stock that is trading for less than its true value is said to be underpriced by the market. This stock should be bought, because its price is likely to rise to its true value. Conversely, stock that is trading for greater than its true value is said to be overpriced. This stock should be sold because its price is likely to fall to its true value. The investor is therefore most interested in an accurate measure of the true value of a stock.

Reasoning along the lines set forth by Miller and Modigliani (1961), the true value of a stock may be defined as the price at which the stock will trade when the market is perfect and all investors are rational. A perfect market is one where tax effects and transaction costs are negligible, and where no party is dominant enough for that party's transactions alone to have an appreciable effect on the price. A rational investor is one who always prefers more wealth to less, and who is indifferent as to whether the wealth is in the form of cash or equity. To the extent that these two conditions are not met, gaps will appear from time to time

between market prices and true values that are big enough to enable astute speculating investors to realize profits by trading the stock.

The argument that equity markets in the United States are so efficient and investors so rational that stock prices at any one time incorporate all the information available at that time, so that prices move without pattern as in a random walk (Malkiel, 1999), is well known. On the other hand, Lo and MacKinlay (1999) have pointed out that market efficiency is a relative concept, and that the residual "inefficiency" can be seen as fair reward for investors who may either have searched more diligently for good information or are willing to accept higher risks, or both.

Inasmuch as a perfectly efficient market is not possible, the rational investor will consider the true value of a stock. One way of arriving at a reasonable measure of a stock's true value is to take its last known book value, project it to the time of the next trading opportunity incorporating into the projection other information that may be available, and then adjust for the under- and over-valuation of its assets and liabilities (Thavikulwat, 2004a). As most of the variables that affect book value in one period are likely to remain stable from period to period, a reasonable forecast of the stock's book value at the next trading opportunity will be its book value at the last trading period, adjusted for any seasonal pattern that may be present. In the absence of seasonality, a linear forecasting model may be applied. Thus, if V_t is the desired book-value forecast for the next trading opportunity at period t , its relationship to the current book value (V_{t-1}) can be approximated by the autoregressive linear form, where α and β are parameters and ε is the random-error term, as follows:

$$V_t = \alpha + \beta V_{t-1} + \varepsilon. \quad (1)$$

The question of interest is the extent to which the forecast of book value can be improved by including other variables whose values are available at time $t-1$. In this respect, the question is not simply which variables affect book value, for the number of variables affecting it is undoubtedly very large. Rather, the question is which variables are so extraordinary in their effects on book value that their effects spill over into the following period.

STRATEGIC VARIABLES

Two variables, market share and production experience, would seem to be especially good candidates for investigation. Market share was identified as a key strategic variable by Buzzel and Gale (1987) in their path breaking study using data from the well-known PIMS database, which contained information from about 3,000 companies. Production experience was considered even earlier by the Boston Consulting Group (Henderson, 1984). Buzzel and Gale, however, asserted that production experience was not of strategic importance, because:

many of the declines in costs over time that occur as cumulative volume builds ... are not proprietary but available to *all* competitors who can use the new technology.... And even when learning or internally developed technology result in lower costs, what is learned can be transferred to competitors by equipment suppliers, departing employees, and competitive intelligence (p. 78).

In investigating the strategic role of market share and production experience, this study will examine time-series data from simulated companies of a gaming simulation exercise. Simulated companies are especially suited for this examination because of the well-controlled environment in which they operate. Accordingly, if a variable is of strategic importance, it should manifest itself more clearly in simulated companies than in everyday-world companies, where each company operates in an environment not readily comparable with the environment of another. Moreover, studying the roles these variables play in simulated companies contribute to our understanding of business gaming simulations, and therefore improves our ability to use them appropriately in educational settings.

A study of the relationship between market share and profitability in simulated companies has been reported by Faria and Wellington (2004). They found that monetary market share had more explanatory power than unit market share, but the relationship was not as strong as they had expected. Faria and Wellington used cross-sectional data from the ending period of companies of two different simulations. On the other hand, this study uses time-series data from the effective lifespan of companies of one simulation.

A cross sectional study sheds light on factors that may explain the dependent variable of interest. Its findings are valuable to managers who must decide which independent variable should be the focus of their concern in managing the dependent variable. For investors, however, the primary issue is not which independent variable explains the dependent variable, but which independent variable is so extraordinary that it contributes to a better forecast of the dependent variable given that the value of the dependent variable in the current period is known. For this purpose, time-series data are essential.

Using the well-known Standard and Poor's COMPUSTAT database, Zhang, Cao, and Schniederjans (2004) did an autoregressive study on earnings per share that is similar to this study. Different from this study, they examined the extraordinary contributions of accounting variables, namely inventory, accounts receivables, capital expenditure, gross margin, selling and administrative expenses, effective tax rate, and labor force, but did not consider either market share or production experience. Moreover, focused on comparing the relative accuracy of different forecasting methods, they did not report on the statistical significance of the independent variables in their regressions.

Expanding on Equation 1, this study will fit time-series data to the regression equation below, where α , β_1 , β_2 , β_3 , β_4 and β_5 are the regression coefficients whose significance is to be assessed; V_t and V_{t-1} represent the company's book value per share of the current and immediately preceding period, respectively; M_{t-1} and N_{t-1} represent the company's monetary market share and unit market share, respectively, at the end of the immediately preceding period; X_{t-1} represents the company's production experience, cumulated over the life of the firm up to the immediately preceding period; and I_{t-1} represents the company's product inventory, in units, at the end of the immediately preceding period. Thus,

$$V_t = \alpha + \beta_1 V_{t-1} + \beta_2 M_{t-1} + \beta_3 N_{t-1} + \beta_4 X_{t-1} + \beta_5 I_{t-1} + \varepsilon \quad (2)$$

Inventory was entered into the regression model as a reference variable, and not because it was thought to have comparable strategic significance. Inventory bridges this study and the one reported by Zhang, Cao, and Schniederjans (2004).

A pervasive problem in fitting autoregressive equations is that the coefficient of determination (R^2) may be very high even without other independent variables, because a large component of the autoregressed variable, V in this case, changes little from period to period. In this case, book value per share is composed of capital per share (C_t), last period's retained earnings per share (E_{t-1}), dividend per share of the period (D_t), before-tax net income per share of the period (Y_t), and income tax per share of the period (T_t), as follows.

$$V_t = C_t + E_{t-1} - D_t + Y_t - T_t. \quad (3)$$

Capital per share will generally be constant except for periods in which the company issues or buys back stock, an irregular and generally infrequent event. Retained earnings and dividends per share generally increase over time. Income tax depends upon before-tax net income, which is the component that varies the most. For this reason, the coefficients of market share and production experience are likely to be small and not significant when time-series data is fitted to Equation 2, because almost all of the variation in book value will be accounted for by its own value of the

previous period. Even so, the finding that market share or production experience or both are strategically important variables will be warranted if the data show that the coefficients of market share and production experience are statistically significant at a frequency greater than chance when fitted to the time-series of many companies. Thus, the null hypotheses are as follows:

Hypothesis 1: The coefficient of monetary market share in the autoregressive correlation of book value per share will be statistically significant at a frequency no greater than chance.

Hypothesis 2: The coefficient of production experience in the autoregressive correlation of book value per share will be statistically significant at a frequency no greater than chance.

Considering that before-tax net income per share is the most independent component of book value per share, a more sensitive test of the strategic importance of market share and production experience will consider before-tax net income per share alone, leaving out company capital, retained earnings, and income tax. For this purpose, the revised regression equation is as follows:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 M_{t-1} + \beta_3 N_{t-1} + \beta_4 X_{t-1} + \beta_5 I_{t-1} + \varepsilon. \quad (4)$$

The null hypotheses for this case parallels those of the previous case, and are as follows:

Hypothesis 3: The coefficient of monetary market share in the autoregressive correlation of before-tax net income per share will be statistically significant at a frequency no greater than chance.

Hypothesis 4: The coefficient of production experience in the autoregressive correlation of before-tax net income per share will be statistically significant at a frequency no greater than chance.

METHOD

The data for this study came from simulated companies founded by 60 undergraduate business students enrolled in two sections of an international-business course at a comprehensive university. The gaming simulation package was GEO, a computer-assisted clock- and activity-driven simulation (Thavikulwat, 2004b) of a global economic environment. Three nations made up this environment. As the participants registered themselves into the simulation, the computer program assigned each to the lowest-population of the three nations.

The exercise advanced through 338 periods, segmented into 11 phases that were spread over 14 weeks. Each of the first 9 phases took place in one week, with participants allowed to migrate from one nation to another beginning

with the fourth phase. At the conclusion of the exercise, the number of participants in the three nations, named North, South, and East, were 20, 19, and 21, respectively.

Beginning with the second phase of the exercise, participants were able to found companies whenever they wished, provided they had sufficient funds to pay the founding fee when it was required. Thus, unlike traditional computer-controlled simulations used in business education, participants were not given companies to manage from the start of the exercise and assigned to management teams. Instead, each participant received a periodic income that each could save or use to invest in a business, and to consume the products produced by the businesses that were created. Participants received points for products they consumed, which is how their performance was scored.

The number of companies each participant was allowed to found increased from one in the second phase to five in the eighth phase, but as each founded company also could found five subsidiary companies and each subsidiary company could found another five companies and so forth without limit, the actual number of companies that a participant could be responsible for founding was unlimited. The companies founded fell into three industrial sectors: service, single-resource manufacturing, and multiple-resource manufacturing.

Companies in the service sector all produced service units that were identical. Each service unit was worth 1 point when consumed. These companies required no resource for their production process. The number of service units each service company could produce in a period, that is, its production capacity, was constrained by a limit conforming to a 98% experience curve, calculated using the well-accepted learning-curve formula (Gaither, 1994).

Companies in the single-resource manufacturing sector produced material units, energy units, and chemical units. These products were assigned point values that varied by product and nation, ranging from 3 to 6 points when consumed. Each of these firms could produce products of only a single line, but regardless of which line the firm produced, the production process required service units, which the service companies supplied. The firm's production capacity increased in steps depending upon the number of participant-executives it employed, moderated by its production experience in accordance with an experience curve of either 91.5% or 98%, depending upon the firm's product line and nation. The firm's resource requirement conformed to an experience curve of 98%.

Companies in the multiple-resource manufacturing sector produced food units only. These were worth 40 points each when consumed. The required resources for production were material, energy, and chemical units supplied by the single-resource manufacturing firms. A schematic diagram of a food company's supply chain is given in Figure 1. As with single-resource firms, the capacity of multiple-resource firms increased in steps depending upon the number of participant-executives employed, moderated by an experience curve of 98%. Resource requirements conformed

Developments in Business Simulations and Experiential Learning, Volume 32, 2005

to an experience curve of either 91.5% or 98%, depending upon the resource and the supplying firm's nation.

Accordingly, every participant was necessarily a consumer, because each participant earned points based on that participant's consumption. Service, material, energy, and chemical products could be sold either to consumers or to downstream firms. Food, however, could be sold to consumers only.

The numbers of companies founded and profitably productive, by industry sector, product line, and nation are given in Table 1. As the table shows, participants founded many companies that were not profitably productive, that is, companies that concluded the exercise either with no production or with a cumulative net income of zero or less. These companies were excluded from the study.

The measurement of market share in a global economy presents two dilemmas. First, market share can be measured globally or competitively. Second, market share can be segmented by industrial sector or taken across sectors.

Globally measured, a company's market share is its sales of the period divided by global sales of the same period. Competitively measured, its market share is its sales of the period divided by the combined sales of all companies that share its nationality. The competitive measure is used in this study, based on the reasoning that a company's competitive strength is the basis for considering market share as a strategic variable and that competitive strength is most meaningfully measured by comparing its sales with the sales of other companies that share its environment, which are those of the same nationality. Companies of other nationalities may be hindered or helped to a different degree because of their different environments, so a comparison of the sales of companies of different nationalities would tend to be misleading.

Segmenting market share by industrial sector is sensible if the sectors differ in resource requirements, production process, and markets, and if the number of firms within each sector is large enough to yield meaningful results. In this case, the resource requirements of three of the five sectors

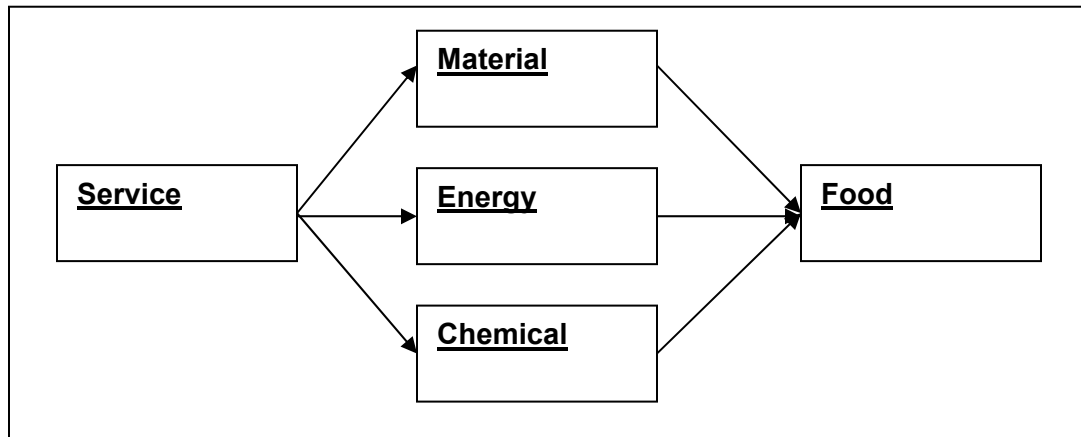


FIGURE 1
SUPPLY CHAIN OF FOOD COMPANY

TABLE 1
NO. OF COMPANIES FOUNDED AND PROFITABLY PRODUCTIVE BY
INDUSTRY SECTOR, PRODUCT, AND NATION

Industry Sector	Product Line	Nation					
		North		South		East	
		Founded	Profitably Productive	Founded	Profitably Productive	Founded	Profitably Productive
Service	Service	29	19	27	20	27	21
Single-Resource Manufacturing	Material	6	1	3	0	8	4
	Energy	10	3	9	2	7	1
	Chemical	8	1	2	2	1	1
Multiple-Resource Manufacturing	Food	1	0	2	1	2	0

Developments in Business Simulations and Experiential Learning, Volume 32, 2005

are identical, a simplified production process applies to all sectors, all sectors compete in the same consumer marketplace, and the maximum number of firms in a sector other than service is only 6. Thus, market share was computed by pooling together the sales of all sectors.

RESULTS

The time-series data from each of the 76 profitably productive companies extended from the last period of the gaming simulation to the first period with outstanding shares. The length of this interval in number of periods ranged from 76 to 328 ($M = 305.105$, $SD = 53.855$). The R^2 from fitting the book-value-per-share multiple-regression function of Equation 2 was, as expected, very high, ranging from 0.89465 to 0.99996 ($M = 0.9915$, $SD = 0.0167$). In contrast, the R^2 from fitting the before-tax-net-income-per-share multiple-regression function of Equation 4 was, also as expected, lower, ranging from 0.0106 to 0.9484 ($M = 0.336$, $SD = 0.280$).

As for the coefficients of the independent variables, the results for Equations 2 and 4 are given in Tables 2 and 3, respectively. In both tables, a coefficient was counted as observed to be statistically significant if it was positive and achieved an upper-tail probability level of 0.05 or better. The expected number of statistically significant coefficients is therefore 0.05 of 76 regressions, that is, 3.8 in all instances. Thus, Table 2 shows that out of the 76 autoregressions, 19 resulted in statistically significant coefficients for the monetary-market-share independent variable of the previous period (M_{t-1}), but only 3.8 such observations were expected. Accordingly, the χ^2 of the

difference is 59.895, which corresponds to a probability value rounding to 0.000.

The main results are unambiguous. The coefficients of both monetary market share and production experience are statistically significant at frequencies substantially greater than chance in the autoregressions of book value per share and net income per share. Accordingly, all null hypotheses are rejected.

The coefficient of the reference variable, inventory, is not statistically significant more frequently than expected by chance in the autoregression of book value per share (Table 2), a finding consistent with those of Zhang, Cao, and Schniederjans' (2004), who found that including financial variables into autoregressions of earnings per share added little or nothing to the accuracy of forecasts. The result is as it should be, because inventory is an asset and assets are one component of book value per share. Accordingly, any information contained in the inventory figure also will be contained in the book value figure, so inventory should show no independent contribution to the autoregression. Even so, its inclusion in the regression is a benchmark to which the contributions of monetary market share and production experience can be compared.

The coefficient of inventory, however, is statistically significant more frequently than expected by chance in the autoregression of before-tax net income per share (Table 3). Unlike book value per share, the relationship of before-tax net income to inventory is loose. As such, inventory contains information not embedded in book value that allows it to contribute independently to the autoregression. Even so, its frequency of statistical significance in the

TABLE 2
SIGNIFICANCE OF COEFFICIENTS IN THE AUTOREGRESSION OF BOOK
VALUE PER SHARE

	M_{t-1}	N_{t-1}	X_{t-1}	I_{t-1}
Observed No. of Statistically Significant Coefficients	19	2	22	5
Expected No. of Significant Coefficients	3.8	3.8	3.8	3.8
χ^2	59.859	0.468	86.784	0.136
Statistical Significance	0.000	0.494	0.000	0.713

TABLE 3
SIGNIFICANCE OF COEFFICIENTS IN THE AUTOREGRESSION OF BEFORE-
TAX NET INCOME PER SHARE

	M_{t-1}	N_{t-1}	X_{t-1}	I_{t-1}
Observed No. of Statistically Significant Coefficients	23	2	46	10
Expected No. of Significant Coefficients	3.8	3.8	3.8	3.8
χ^2	97.069	0.921	518.660	30.102
Statistical Significance	0.000	0.337	0.000	0.000

autoregression of before-tax net income is less than that of monetary market share ($\chi^2 = 5.574, p = 0.018$), and much less than production experience ($\chi^2 = 31.025, p = 0.000$).

Consistent with Faria and Wellington's (2004) findings, monetary market share displays more power than unit market share, which shows no predictive effect in either autoregression. As to the expected higher sensitivity of before-tax net income per share over book value per share, the frequency of statistically significant coefficients is not higher for monetary market share in the autoregression of before-tax net income per share than it is in the autoregression of book value per share ($\chi^2 = 0.296, p = 0.586$), but the corresponding frequency for production experience is higher ($\chi^2 = 14.077, p = 0.000$). Accordingly, the expectation that before-tax net income would be more responsive to market share and production experience is partially confirmed.

Production experience is statistically significant about as frequently as monetary market share in the autoregression of book value per share ($\chi^2 = 0.134, p = 0.715$), but it is statistically significant more frequently in the autoregression of before-tax net income per share ($\chi^2 = 12.846, p = 0.000$). This latter finding is supportive of Henderson (1984) and contrary to what would be expected given Buzzle and Gale's (1984) criticism of the experience curve concept.

Autoregressions often produce positively correlated residuals that bias results (Neter & Wasserman, 1974). The bias can give rise to statistically significant coefficients when they are not warranted, or vice versa. To assess the seriousness of the problem, the Durbin-Watson test for autocorrelation was performed on every autoregression. Of the 76 autoregressions, 9 had positively correlated residuals ($D < 1.57, \alpha = 0.05$). In the worst-case scenario, the autocorrelational bias will all be in the direction of greater statistical significance. To determine the consequence of this worst-case scenario on the results, autocorrelations with statistically significant coefficients whose residuals might be positively autocorrelated ($D \leq 1.78, \alpha = 0.05$) were removed from the frequency counts. Table 4 presents the counts after the deletions. Replacing the observed numbers of statistically significant coefficients with these reduced counts does not change any result.

CONCLUSION

The results of this study unequivocally support the proposition that monetary market share and production experience are extraordinarily powerful strategic variables. They add predictive power to book value per share and before-tax net income per share. These conclusions may be clear with respect to gaming simulations, but some caution is warranted in generalizing the results.

One problem in generalizing from simulated firms to everyday-world firms is that the concepts of market share and production experience are ambiguous in the everyday-world setting. Products are identical in simulations, but they are not identical in the everyday world, either across firms at any one time or over time in any one firm. Judgment must always be exercised in deciding if the products of two everyday-world firms share the same market, and if the products made by one firm at two different times fall along the same experience curve.

But if an error can arise from generalizing too much, it also can arise from generalizing too little. The field of business strategy may suffer more from generalizing too little than it does from generalizing too much. Unlike medicine, chemistry, and other more established fields, business strategy studies seem to be ensnared in continuous cycles of fad-and-fade, for new ideas are rarely subjected to rigorous testing in simulated settings before they find their way into textbooks and the popular press. An insistence that new ideas must first be tested in simulated settings before they will be generally accepted by the academy may give the discipline more credibility.

Finally, one argument against using gaming simulations for research should be put to rest. It is the argument that simulated firms are not real firms. Certainly, if the firms are computer-directed (Crookall, Martin, Saunders, & Coote, 1986) as in an animation, or computer-based as in an interactive model, the firms are pure products of the programmer's imagination, and are therefore unreal. But firms in computer-controlled and computer-assisted gaming simulations involve real people in their compositions, so if a firm is understood as an organized collection of people engaged in trade, then these are real firms. Like laboratory mice, they are laboratory firms, free of the substantial variability present in the uncontrolled setting. Like laboratory mice, these laboratory firms can address basic questions particularly well. They therefore can be especially suitable for teaching and researching the basic principles of commercial life.

TABLE 4
OBSERVED NO. OF STATISTICALLY SIGNIFICANT COEFFICIENTS WITH
UNCORRELATED RESIDUALS

	M_{t-1}	N_{t-1}	X_{t-1}	I_{t-1}
Book Value per Share	10	1	17	3
Before-Tax Net Income per Share	18	2	40	8

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