# PREDICTING MARKET VALUES OF STOCKS TRADED ON THE KOREAN STOCK EXCHANGES

Kee S. Kim

Finance Dept., Southwest Missouri State University, Springfield, MO 65804

Many brokers and investors seem to believe that stock prices in Korea are unpredictable because they are determined largely by socio-political factors instead of fundamental factors of the firm. In this research the author intends to examine if stock prices on the Korean Stock Exchange (KSE) market are primarily determined by fundamental factors such as the current and future financial condition of the firm. Several accounting and non-accounting variables that represent risk and return of the firm are used as input variables to the model. An artificial intelligence technique is used to build a prediction model. The result indicates that stock prices on the KSE are largely determined by the variables that represent risk and return of the firm.

## 1. Introduction

Investors and managers have been searching for measures that reveal accurately and intelligently how much individual companies have been successful in creating their values. Common candidate measures are accounting data, including sales, profits, return on shareholders' equity, financial leverage, and other accounting variables. Although it has been established in the finance and accounting literature that various aspects of financial condition of a firm should directly influence the value of a firm, there are few empirical studies that reveal how these variables are related to the market value of the firm.

The purpose of this research is to build a model to examine factors that determine market value of the firms that have been traded actively on the Korean Stock Exchange (KSE). This paper also intends to examine if financial and non-financial data can be used to estimate market price of the stocks. It is a well-known fact that financial variables such as profitability, leverage, liquidity, and asset utilization variables should have a large influence on the market values of firms. The Stern Stewart & Company (STC) provides a measurement of Market Value Added (MVA) as the amount of wealth a firm's management created from the capital that was entrusted to management. The STC also creates a measure of Economic Value Added (EVA) as the amount of wealth a firm creates for its shareholders in a given year. Although many brokers and researchers in Korea seem to believe that security prices on the KSE are largely determined by other attributes such as socio-political and international factors, major financial variables should have a large impact on a firm's market values. In this research the author intends to identify the pattern of relationships of these input variables with the company's market value. Since the pattern of the contributing factors will depend on market conditions and investors' behavior, this research intends to extract the pattern of the critical factors that contribute to the market value formation on the KSE.

## 2. The Adaptive Learning Networks

The Abductive Learning Network (ALN) (Barron, et al., 1984) is an artificial intelligence technique and was developed from almost three decades of statistical modeling, neural network, and artificial intelligence research. The ALN technique (Barron, et al., 1984) automatically generates the trained network from the database and performs a traditional task of fitting model coefficients to the bases of observational data. It uses a network structure that consists of a number of processing units and interconnections between the units, and its network structure resembles neurons and synapses of a human brain. The power of the network lies in its ability to decompose complex problems into much smaller and simpler ones, and to solve them. The network structure also makes decision making simpler because the number of factors to consider and the alternatives to evaluate become much smaller with the use of a network structure.

ALN uses nodes that represent knowledge on each processing unit via a homogeneous multinomial of degree 2 or 3 in m variable functions. It is also well known that a suitably high degree multinomial, in which all cross products appear and combinations of variables to different degree are included, can approximate arbitrary functions of many variables very accurately (Barron et al., 1984) while maintaining the number of coefficients to a manageable size. Consequently, the network structure of models can provide a practical solution to this combinatorial problem.

The final ALN model obtained from the synthesis process is a layered network of feed-forward functional elements, in which the coefficients, number and types of network elements, and the connectivity are learned inductively and automatically. The abductive network consists of arcs and nodes, and each node has unique multi-variable configurations: singles, doubles, triples, normalizers, white elements, unitizers, and wire elements (Montgomery, 1989).

$$\text{Single} = W_0 + W_1*X_1 + W_2*X_1^2 + W_3*X_1^3$$

$$\text{Double} = W_0 + W_1*X_1 + W_2*X_2 + W_3*X_1^2 + W_4*X_2^2 + W_5*X_1*X_2 + W_6*X_1^3 + W_7*X_2^3$$

$$\text{Triple} = W_0 + W_1*X_1 + W_2*X_2 + W_3*X_3 + W_4*X_1^2 + W_5*X_2^2 + W_6*X_3^2 + W_7*X_1*X_2 + W_8*X_1*X_3 + W_9*X_2*X_3 + W_{10}*X_1*X_2*X_3 + W_{11}*X_1^3 + W_{12}*X_2^3 + W_{13}*X_3^3$$

where $X_i$ and $W_i$ denote input variables and coefficients, respectively. These elements are homogeneous multinomial of degree 3 in one, two, and three variables and allow interaction among input variables. Normalizers transform the original input variables into standardized normal variables with a mean of zero and a variance of one. The white element is a linear combination of all inputs to the current layer. Unitizers convert the normalized data back into the original data to assess the output data. The output of elements in one layer can feed subsequent layers, together with the original input variables to synthesize networks from layer to layer until the network model ceases to improve.

The objective of the ALN algorithm is to train and identify the model that minimizes the predicted squared error (PSE), the errors on as yet unforeseen data, without over fitting the data (A.R. Barron, 1984). PSE consists of the training squared error (TSE) and overfit penalty as shown in the following:

$$PSE = TSE + 2\sigma_p^2 \frac{K}{N},$$

where TSE is the average squared error of the model on the training sample observations, K is the number of coefficients that are estimated to minimize TSE, $\sigma_p^2$ is a prior estimate of true error variance, and N is the size of the training sample observations. The minimum PSE is always attainable because, as each coefficient is added to the model, TSE decreases at a decreasing rate while the overfit penalty increases linearly. If the abductive model is obtained by minimizing TSE alone, the model will perform well on the training data set, but it can perform poorly on evaluation samples. When the model has an overly complex structure and many coefficients, it will give a poor estimate of error on future data sets. By adding a term for overfit penalty, we can be certain to obtain the minimum expected squared difference between the estimated model and the true model on future data sets (A.R. Barron, 1984).

## 3. The Model and Result

The input data were collected from the Korean Stock Exchange. After deleting observations that have an incomplete set of data, a sample of 472 observations was obtained and used in this research. Financial companies were also deleted from this research because they were fundamentally different in characteristics of financial data structures. The total sample is next divided into a set of 356 randomly selected samples for training and another 116 for evaluating the trained model.

The model uses average stock price as an output (dependent) variable. The explanatory (input) variables include two types of variables: intrinsic value (or return) and risk related variables (See Appendix for details). An intrinsic value-related variable includes return on equity (ROE), earnings per share (EPS), sales growth rate (SG), enterprise value (EV) per operating income, economic value added

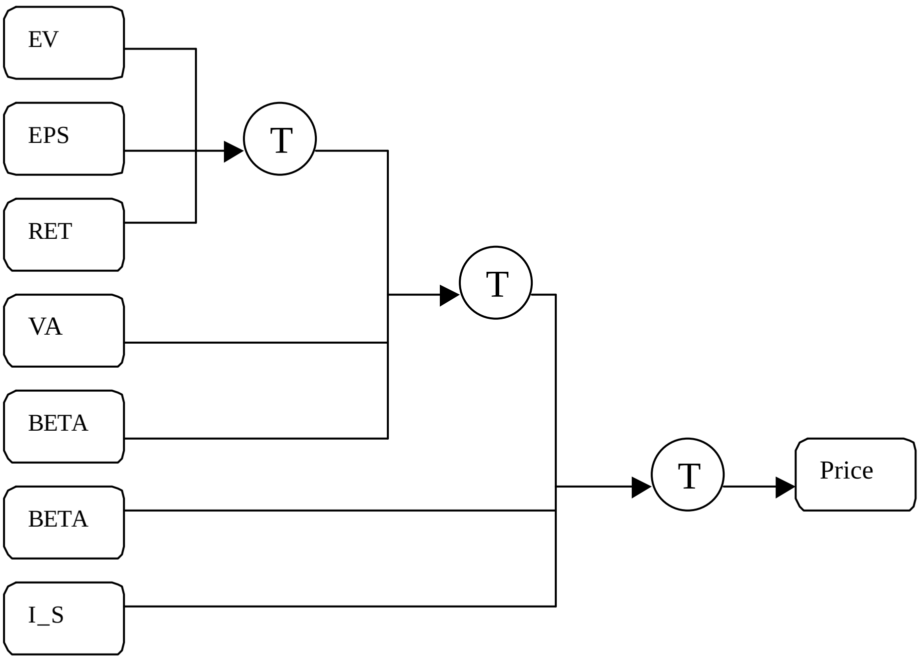


**Figure 1. Trained ALN Model**

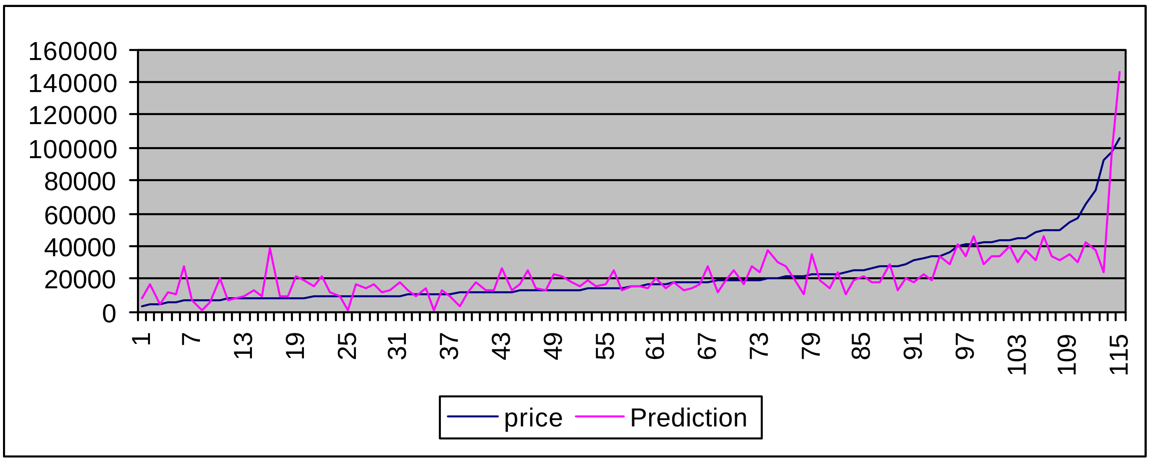


**Figure 2. Prediction Result**

(EVA ), value added (VA), and retention (RET). The risk related variables are beta, debt to equity (D/E), and debt (or interest) burden (I_S). These input variables are related to the output variable to find if there exists any relationship between price and various input variables. The main concern is to find if these input variables can be used to estimate an average common stock price of individual firms.

The final ALN model is synthesized from the training data set as shown in Figure 1. This model has a layered network of feed forward functional elements, which contains the best network structure, node types, coefficients, and connectivity to minimize the predicted squared error (PSE) without outfitting the data. It uses six input variables; EV, VA, EPS, BETA, RET, and I_S, and has a network structure of four layers. The model shows that four return (EV, VA, EPS, RET) and two risk (BETA and I_S) variables are used to estimate the market price of the firm. In Figure 2, the prediction result using an evaluation sample is shown after sorting the data set in an ascending order of actual price data. The prediction result indicates that the trained model provides fairly accurate estimates of prices when the price is less than 25,000 won, although it has a tendency to underestimate actual prices. On the other hand, the price estimation is less accurate if the actual price is greater than 25,000 won. The model also tends to underestimate stock prices when the actual price is higher than 25,000 won per share. Figure 2 clearly shows that market price can be estimated by using fundamental data such as enterprise value (EV), value of products (VA), earnings per share (EPS), retention, and two risk variables: Beta and I_S.

**Table 1. Sensitivity Analysis of the Model**

| **Input Variable** | **Input Mean Values** | **Local Importance** | **Global Importance** |
|---|---|---|---|
| EV | 218.42 | .787 | .00 |
| VA | 1062.69 | .029 | .07 |
| Beta | .84 | .003 | .04 |
| EPS | 2052.70 | .119 | .08 |
| RET | 533.76 | .050 | .76 |
| I_S | 7.47 | .011 | .06 |

The contribution of each input variable to output change is different depending upon individual input variables as shown in Table 1. For example, at around mean input values, about 79 percent of output (Price) change is attributable to changes in EV value. The next significant variable is EPS that explains 19 percent of output changes. The rest of the variables are at best negligible in their contribution to output change around the mean input values. When the contribution of input variables is evaluated at all ranges of input spaces (see “Global Importance” in Table 1), the “retention” variable becomes the most important variable in its contribution to output variable change. For example, seventy six percent of output change is attributable to change in "retention" variable while EPS and VA contribute 8 % and 7% respectively. This implies that 91% of price changes are explained by three value-oriented variables: retention, EPS, and VA variables. A large contribution of the retention variable to the price change is very logical because RET represents the value of the investment that is obtained directly and indirectly from common shareholders. This result does not deny the fact that socio-political factors could be a major determinant of a specific stock price at a given point in time. But the majority of stock price seems to reflect fundamental facts of the firm involved. It is very interesting to observe that EV is the most significant variable locally when all input values were at around their mean values, but EV does not contribute to changes of the output variable at all in a global sense.

## 4. Concluding Remarks

The result of this research indicates that stock prices on the KSE market largely reflect financial variables of the firm involved. In spite of the common belief that security prices on the KSE are largely determined by socio-political attributes and therefore they are unpredictable, it is comforting to know that stock prices, in general, represent the financial condition of the firm and they are predictable. The research also indicates that two risk-related variables (Beta and I_S) are essential for building a final model, but their contribution to price changes are almost negligible. Instead, three return variables explained most of the price variation in a global sense. I believe that the prediction capability of the trained model could be improved significantly if additional input variables are used and the model input variables are refined.

## References


ModelQuest Expert Manual, Version 2, AbTech Corporation, 1998.

Barron, A.R., "Predicted Squared Error: A Criterion for Automatic Model Selection," *Self-Organizing Methods in Modeling: GMDH Type Algorithms*, edited by S.J. Farlow, Marcel-Dekker, Inc., New York, 1984.

Barron, R.L., et al., "Adaptive Learning Networks: Development and Application in the U.S. of Algorithms Related to GMDH," *Self-Organizing Methods in Modeling: GMDH Type Algorithms*, edited by S.J. Farlow, Marcel-Dekker, Inc., New York, 1984.

Hess, P., and G.J. Montgomery, "Abduction: Theory and Application," Proceedings of the 4th Annual Aerospace Applications of Artificial Intelligence Conference (AAAIC), October 1988.

Montgomery, G.J., "Abductive Diagnostics," Proceedings of the AIAA Computers in Aerospace Conference, Monterey, CA, October 1989.

Ramanujam, V., Venkatraman, N., and Camillus, J. C. Multi-Objective Assessment of Effectiveness of Strategic Planning: A Discriminant Analysis Approach. *Academy of Management Journal*, Vol. 29, No. 2 (1986): 347-372.

Ryne, L. C. The Relationship of Strategic Planning To Financial Performance. *Strategic Management Journal*, Vol. 7, No. 5 (1986): 423-436.

Singh, J. V. Performance, Slack, and Risk Taking In Organizational Decision Making. *Academy of Management Journal*, Vol. 29, No. 3 (1986): 562-585.

Varadarajan, P. and Ramanujam, V. Diversification and Performance: A Reexamination Using A New Two-Dimensional Conceptualization of Diversity in Firms. *Academy of Management Journal*, Vol. 30, No. 2 (1987): 380-393.

Walbert, L. The Stern Stewart Performance 1000: Using EVA To Build Market Value. Pamphlet published by Stern Stewart & Company and excerpted from the *Continental Bank Journal of Applied Corporate Finance*, Winter 1994.

## Appendix. Input and Output Variables Explained

**Output Variable:**

Average Price (P)

**Input Variables**:

**ROE** = Return on Equity

**EPS** = Earnings per Share

**SG** = Annual Sales Growth

**EV** = Enterprise Value / EBITDA

Where EV = Market Value + (Total Liabilities - Cash & MS), and

EBITDA = Earnings before Interest, Tax, Depreciation and Amortization

**EVA** = Economic Value Added (= Net Income – Capital Costs)

**VA** = Value Added, defined as the value of products. This value is equal to a sum of materials, labor, capital costs, depreciation, and lease payment.

**RET** = Retention Rate that is defined as [(Common Equities – Common Stocks at Par –Treasury Stocks) over (Common Equities)].

**Beta**

**D/E**:  Debt to Equity Ratio

**I_S** = Interest Burden = Interest Payment X 100 / Net Sales