Comparison between Crisp and Fuzzy Stock-Screening Models

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Abstract

Academic researchers and practitioners have proposed various stock-screening models that always contain more than one stock selecting rule and corresponding parameters. However, the criteria in traditional screening models employ crisp norms, which are unreasonable in reality. This paper proposes the fuzzy stock-screening model to select stocks in the portfolio. The screening rules consist of those regarding the price-earnings ratio, the earnings growth rate, market capitalization, return on equity, and the price-book ratio. Empirical studies with datum from Taiwan's stock market compare the performance of the proposed stock-screening models with the conventional one. Empirical results show that the portfolio selected by the proposed model outperforms the portfolio by the conventional models in terms of investors' expectations.

Keywords: stock screening model, fuzzy.

1. Introduction

Many studies have questioned the efficient market hypothesis and have discovered several systematic patterns which can increase the possibility to select stock portfolios with excess returns. Accordingly, academic researchers and practitioners have proposed various stock screening models to take advantage of these patterns (Gold and Lebowitz, 1999). The screening indicators in these models come from fundamental and technical analyses in general, including the price-to-earnings (or sales) ratio, firm size, moving average prices of stocks, trading volumes, etc. However, the criteria in these screening models, which contain more than one stock selecting rule and corresponding parameters and employ crisp norms, are unreasonable in reality. For example, assume one of the screening criteria in the model is "select stock with P/E (Price-earnings ratio) < 10 in the previous accounting year". One stock with P/E = 10 will then be screened out as being unqualified for the rule, even though it keeps superior performance from the viewpoints of the other screening criteria. This seems unreasonable. For such a reason, this paper applies the fuzzy screening criteria in the model to select stocks in the portfolio and compares the performance between the proposed model and the traditional model in terms of investors' expectations.

The paper is organized as follows. Section 2 selects promising investment criteria from fundamental indicators to form the screening model and reviews the fuzzy theory in brief. Section 3 describes the traditional crisp and proposed fuzzy stock-screening models and performs empirical studies in Taiwan's stock market. Comparisons between the two models are analyzed in this section as well.

2. Investment Criteria for the Stock-Screening Model and Fuzzy Theory

2.1 Investment criteria for stock-screening models

When screening for stocks, investors apply various indicators, such as fundamental analysis, technical analysis, industrial analysis, economy analysis, and so on. Different analyses have different reasonable philosophies, and investment strategies can be formed as a stock-screening model which can be validated by back-testing in the market. In turn, the investors can then apply the validated stock-screening model to select stocks in a portfolio. If the pattern implied by the screening model can be sustained from the past into the future, then investors can then reap profits in the market.

This paper does not attempt to uncover promising investment strategies. Instead, we question that the traditional screening model with crisp criteria may disappoint investors in terms of their expectations, no matter what screening criteria is used from which kind of analysis. The most popular indicators from fundamental analysis, as investigated by Chang (2003), are selected for establishing the screening model to be tested. The five most popular indicators are:

- Price-earnings ratio - the lower the better.
- Earnings growth rate - the higher the better.
- Market capitalization - the lower the better.

- Return on equity - the higher the better.
- Price-book ratio - the lower the better.

2.2 Fuzzy theory

In the past, the criteria in the screening model have maintained a crisp form, which is not reasonable under previous analysis. Zadeh (1965) first introduced the fuzzy set theory to tackle fuzzy characteristics. A fuzzy set can be denoted as:

$$\widetilde{A} = \left\{ \left(x, \mu_{\widetilde{A}}(x) \right) \mid x \in U \right\} \quad (1)$$

where U is discourse, x_i is the element in U, $\widetilde{A}$ is a fuzzy set in U, and $\mu_{\widetilde{A}}$ is the membership function for any $x_i \in U$ whose output is located between 0 and 1, representing the membership degree.

Equations (2) and (3) represent the membership degrees of a fuzzy set and crisp set, respectively.

$$\mu_{\widetilde{A}}(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le X \le b \\ 1, & b \le x \end{cases} \quad (2)$$

$$\mu_{\widetilde{A}}(x) = \begin{cases} 0, & x < c \\ 1, & c \le x \end{cases} \quad (3)$$

A generalized fuzzy membership function is a piecewise linear membership function as shown in Figure 1, which can be represented by Equation (4).

$$\mu_i(x) = \begin{cases} \dfrac{c_i(x) - l_i}{g_i - l_i}, & l_i < c_i(x) \le g_i \\ 1, & g_i < c_i(x) \le g_i' \\ \dfrac{u_i - c_i(x)}{u_i - g_i'}, & g_i' < c_i(x) \le u_i \\ 0, & otherwise \end{cases} \quad (4)$$

Here, l_i is the lowest value of the goal, u_i is the highest value of the goal, and the range from g_i to g'_j is the goal's satisfied interval.

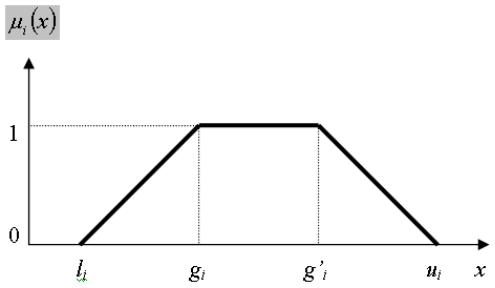

Fig. 1: Piecewise linear membership function

3. Empirical Test and Comparison between Crisp and Fuzzy Stock Screening Models

3.1 Crisp stock-screening model and its empirical test result

The crisp stock-screening model contains the following five screening rules:

- The price-earnings ratio of selected stock shall be less than the market's average value and greater than 0.
- The earnings growth rate of the selected stock shall be greater than the market's average value.
- The market value of the selected stock shall be less than the market's average value.
- The return on equity of the selected stock shall be greater than the market's average value.
- The price-book ratio of the selected stock shall be less than the market's average value and greater than 0.

After screening the data from Taiwan's stock market in 2003, 134 stocks qualified for the above model.

3.2 Fuzzy stock-screening model and its empirical test result

To transfer the original crisp criterion into becoming a fuzzy criterion, four candidate methods can be considered as shown in Figure 2. Due to normalization, method d is selected in this paper. The fuzzy goals for the five criteria are shown in Table 1.

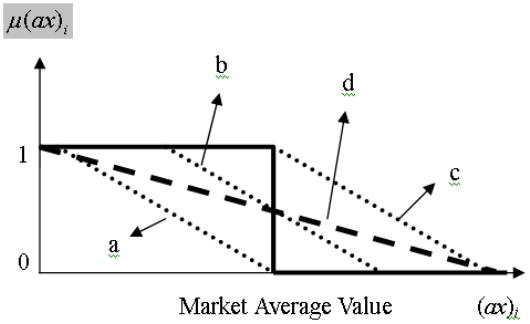

Fig. 2: Four kinds of fuzzy membership function

Table 1 Fuzzy goals for the five criteria

Criterion	Fuzzy goal			
	l_i	g_i	g_i'	u_i
PER	0.00	0.00	0.00	38.46
Earnings growth rate	0.00	24.96	∞	∞
Market value (NT$ billion)	0.00	0.00	0.00	248.73
ROE	0.00	15.02	∞	∞
PBR	0.00	0.00	0.00	2.96

After screening the data from Taiwan's stock market in 2003, 475 stocks qualified for the above model. They can be further ranked by $\sum \mu_i$. To compare with the result in the crisp stock-screening model, 134 stocks are selected by their rank.

3.3 Comparison between crisp and fuzzy stock-screening models

We observe that the 134 selected stocks by the crisp and fuzzy stock-screening models are somewhat different. Only 81 stocks among them are the same. Some stocks are filtered out in the crisp stock-screening model just because some of their criteria make them unqualified - for example, the stock coded as 8080 in Table 2. Compared to the stock coded as 1904, which is qualified in the crisp model but unqualified in the fuzzy model, the overall performance of stock code 8080 as calculated by $\sum \mu_i$ is better and is presented in Table 2.

Table 2: Performance comparisons between stocks coded 8080 and 1904

Stock	PER	Earnings growth (%)	Market value	ROE	PBR	Crisp model decision
8080	**4.51**	**111.17**	**10.06**	**42.31**	*1.65*	Qualified
1904	9.37	15.39	120.71	8.96	**0.81**	Unqualified
Market average	19.23	12.48	124.36	7.51	1.48	

Stock	Membership degree					$\sum \mu_i$	Rank in fuzzy model
	PER	Earnings growth (%)	Market value	ROE	PBR		
8080	0.88	1	0.96	1	0.44	4.29	35
1904	0.76	0.62	0.51	0.6	0.72	3.21	377

The average characteristics of the portfolios selected by applying the crisp model, denoted by (M1), and the fuzzy model, denoted by (M2), are shown in Table 3. Observing the data in Table 3, the fuzzy model is better than the crisp model in the criteria of PER, market value, ROE, and PBR, meaning that the fuzzy screening model is superior to the crisp model in terms of investors' expectations.

Table 3 Average characteristics of portfolios selected by applying the two models

Characteristics	PER	Earnings growth (%)	Market value	ROE	PBR
Average value of (M1)	8.90	187.46	29.83	16.44	1.11
Standard deviation of (M1)	3.19	480.67	25.70	13.81	0.22
Average value of (M1)	7.55	132	21.17	22.4	1.35
Standard deviation of (M1)	2.07	240	17.23	14.2	0.37
Average value of market	19.23	12.48	124.36	7.51	1.48
Standard deviation of market	93.06	546.74	518.37	45.95	0.89

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