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An intelligent business advisor system for stock investment

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Abstract: *This paper presents an intelligent system to assist small investors to determine stock trend signals for investment in stock business. A pilot system is built providing three main categories of technical analysis theories, namely momentum, moving average, and support/resistance line. It has extensive graphic interface design to facilitate the usage of the system. For novice investors, the system is associated with tutoring features and it supports analysis study of the rationale behind some system recommendations. Skillful investors can explore the various theories for the prediction by means of adjusting the weightings, combinations and even some independent variables allocated by the intelligent system. General users can therefore formulate their investment strategies upon system recommendations under different investment criteria accordingly.*

Keywords: business computing, expert systems, financial market analysis, stock prediction

1. Introduction

Hong Kong (HK) stock market is one of the largest markets in the world. The average daily turnover of Hong Kong stock market amounts to more than five hundred million dollars. Many HK people make use of this facility to try to protect their savings from shrinking due to high inflation in the territory. The majority of the people attempt to beat, if possible, the average market for extra gain. However, the analysis of the financial market is a time-consuming, complex, and error-prone process. Theoretically, more information can help solve the problem better if time constraint is not an important factor. Nevertheless, it does not apply to stock investment even though information about a stock is readily available in HK nowadays. On the contrary, people are provided with lots of news, financial data and rumors that often confuse them when making a clear and prompt decision. In addition, most technical analysis techniques for stocks are strange to the general public and small investors often get frightened of applying the said techniques consistently and effectively in their investment.

The present paper applies an intelligent expert system (Liu and Yung, 1996) in the hope that the system can relieve the burden of carrying out a lot of technical analysis and promote the awareness of the analysis by means of rules tracking. The paper consists of seven major sections. The next section will describe the rationale of stock analysis and features of technical analysis. Section 3 gives the architectural model involving a knowledge-based system. The prototype development is discussed in Section 4. This is followed by a case study in Section 5. The system is then evaluated in Section 6. The last section gives a conclusion and discussion on the developed methodology.

2. Background

There are typically two stock analysis approaches, namely 'Fundamental Analysis' and 'Technical Analysis' (Black, 1982; Refenes *et al.*, 1993). The first and most powerful approach depends on the exact knowledge of laws underlying a given phenomenon. Expressing this knowledge in terms of precise equations and then solving them, can result in predicting the future behaviour of the system once the initial conditions are completely specified. The main problem with this approach is that the knowledge of the rules governing the behaviour of the system is not readily available. Parameter instability and lack of non-linearity in the models are the weakness of this approach (Chin, 1990; Fuller and Farerell, 1987; Hui, 1993a, 1993b, 1994; Pring, 1985). The second, albeit less powerful, method for prediction relies on the discovery of strong empirical regularities in observations of the system. There are problems in that regularities are not always evident, and are often masked by noise. The supporters of this approach emphasize that it is a study of the action of the market and is concerned only with the identification of major turning points in the market's assessment of these factors. It is essentially a reflection of the idea that the stock market sets a trend determined by the changing attitudes of investors to a var-

iety of economic, monetary, political, and psychological forces. The present study focuses on the latter approach that forms the theoretical foundation of the system. Pattern recognition of trend signals and the use of heuristics form the basis of expert knowledge. In general, the basic strategy used for analysing an investment is to identify:

- the direction of the major trend of the market
- how far along the market is the major trend
- the direction of the intermediate trend
- how far along the market is the intermediate trend
- the short-term trend of the market
- how far along the market is in the short-term trend
- the turning points of the market

The following theories are considered as part of the technical analysis for the study:

2.1. Stochastic

Stochastic is essentially a momentum indicator that indicates overbought and oversold conditions. The formula shall be:

$$\%K = \frac{\text{Current Close Price} - \text{Low Price of Period}}{\text{High Price of Period} - \text{Low Price of Period}} \times 100$$

$$\%D = \text{3-Day Simple Moving Average of } \%K$$

The number calculated is between 0 and 100. It can be used as both a trending system or as an overbought/oversold oscillator when prices are consolidating. It is designed to show when prices are relatively high or low. The time period can be varied from 1 to 200 days.

This indicator is used to help customers buy low, sell high or vice-versa. The proper use of stochastic also requires that there be divergence between %D and price in order to generate a buy signal.

2.2. Relative Strength Index (RSI)

The RSI is one of the most widely used technical indicators. It is highly effective in aiding a technical analyst in chart interpretation. Some factors to consider when using the index are:

- TOPS and BOTTOMS are indicated when the RSI goes above 70 or drops below 30.
- FAILURE SWINGS above 70 or below 30 on the RSI are strong indications of market reversals.
- SUPPORT and RESISTANCE often show up clearly on the RSI before becoming apparent on the bar chart. DIVERGENCE between the RSI and the price action on the chart is a very strong indicator that a market turning point is imminent.

The theoretical basis of Relative Strength Index is the momentum concept. A momentum oscillator is used to measure the velocity or rate of change of price over time.

The Relative Strength Index Equation is

$$\text{RSI} = 100 - \frac{100}{1 + \text{RS}}$$

$$\text{RS} = \frac{\text{Average of L day's close UP}}{\text{Average of L day's close DOWN}}$$

where L is a variable which can be varied from 1 to 30. The ideal setting for Relative Strength is exactly one half the period of the cycle.

It has been suggested that levels of 70 and 30 respectively signify tops and bottoms. The index usually leads the market and peaks before the actual top or bottom. Extreme values such as 90 or 10, signify unusual strength or weakness. Therefore, RSI can be used as an early warning signal.

2.3. Money Flow

It is noted that certain indicators such as the Relative Strength Index place equal weight on the same difference in closing prices regardless of the number of contracts or shares traded.

Money Flow may be used to measure the strength of capital entering and leaving the market. When today's average price is greater than yesterday's average price then it is an up day for money flow.

$$\text{Average Price} = \frac{\text{High} + \text{Low} + \text{Close}}{3}$$

A time period is chosen and positive and negative money flow is calculated as follows:

$$\text{Positive Money Flow} = \text{Sum of Positive Money Flow for Time Period}$$

$$\text{Negative Money Flow} = \text{Sum of Negative Money Flow for Time Period}$$

$$\text{Money Flow} = 100 - \frac{100}{1 + \text{Money Ratio}}$$

$$\text{Money Ratio} = \frac{\text{Positive Money Flow}}{\text{Negative Money Flow}}$$

This ratio can be used in a similar fashion as that of Relative Strength Index.

Tops and Bottoms are indicated when Money Flow goes above 80 or drops below 20. Failure Swings above 80 or below 20 on the Money Flow Index are strong indications of market reversals. Divergence between Money Flow and

price action on the chart is a very strong indicator that a market turning point is imminent.

2.4. Moving average

Moving averages are calculated from historical price information. In flat or consolidating markets, moving averages would closely track the current prices. In trending markets, they can be used in buy and sell decisions. A long-term trend indicator can be obtained by comparing a short-term moving average with a longer-term average. The trend is rising when the short term is above the longer term, and vice-versa.

The formulae for moving averages are as follows:

$$\text{Exponential Moving Average} = \sum_{K=0}^{L-1} \frac{\text{ClosingPrice}}{\frac{\beta - \beta^K}{1 - \beta}}$$

If $\beta = 1.00$, then the average is a simple moving average.

$$\text{Simple Moving Average} = \frac{\text{Sum of L day's ClosingPrice}}{L}$$

Valid range for $L = 1$ to 200 (Setting = 20)
$\beta = 0.0$ to 1.0 (Default Setting 1 and 0.75)

2.5. Support and resistant lines (trendlines)

A review of stock trading will quickly that prices usually move in trends. Quite often a series of ascending bottoms in a rising market can be joined together by a straight line, and so can the tops of a descending series of rally peaks. These lines, known as trendlines, are a simple but invaluable addition to the technical arsenal.

Significance of trendlines It has been established that a break in trend caused by penetration of a trendline results in either an actual trend reversal or a slowing in the pace of the trend. It is important to understand the significance of a trendline penetration; the guidelines described below provide help in evaluation.

Length of the line The size or length of a trend is an important factor, as with price patterns. If a series of ascending bottoms occurs over a 3- to 4-week span, the resulting trendline is of only minor importance. If the trend extends over a period of 1 to 3 years, its violation marks a significant juncture point.

Number of times the trendline has been touched or approached A trendline derives its authority from the number of times it has been touched or approached; that is the larger the number, the greater the significance.

Angle of ascent or descent A very sharp trend is difficult to maintain and is liable to be broken rather easily. All trends are eventually violated, but the steeper ones are likely to be ruptured more quickly. Penetration of a steep line usually results in a short corrective movement, following which the trend resumes but at a greatly reduced and more sustainable pace. Usually the penetration of a steep trendline represents a continuation rather than a reversal break.

3. Architectural model

Figure 1 is the conceptual framework of the intelligent system, named StockAdvisor:

The StockAdvisor is composed mainly of two sub-systems. The first one is the data and chart manipulation system which calculates and draws charts in order to prepare symbolic data for the second KBS sub-system. The second sub-system is the reasoning system with the expert knowledge base.

3.1. Intelligent expert system

The intelligent system, StockAdvisor, employs human knowledge captured in a computer to solve problems that ordinarily require human expertise. It uses specialized knowledge about the particular problem domain: technical analysis for stock rather than just the general knowledge that would apply to all problems. In addition, it adopts symbolic (and often qualitative) reasoning rather than just numerical calculations (a pre-requisite set of experts' opinions is required). The system will generate good but not necessarily best solutions using heuristic reasoning.

A frame-based expert system building tool, KAPPA, was used in the prototype development. The software works on an MS Windows platform that allows developers to write applications in a high-level graphical environment and attractive GUI.

3.2. Data and graphic manipulation

The purpose of this system is to provide users with a graphic interface to manipulate raw data and prepare series of information for chart presentation. Humans' eyes and brains are far more efficient in judging images than computers', even using parallel processing super-computers.

Microsoft Excel 5 was employed in developing this subsystem. The software serves as a front end of the system for data capturing, graphic presentation and a procedural programming tool, through its embedded Visual Basic for application programming language, for connecting the two

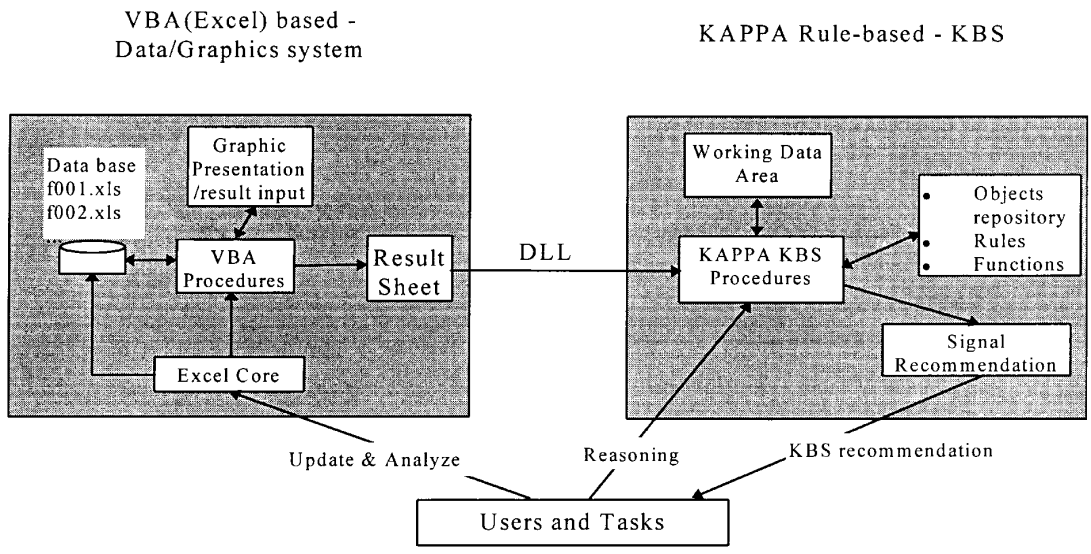

Figure 1: *Conceptual framework of StockAdvisor.*

forms of information representation - numerical data points and graphic charts.

Such graphic features are like getting a high-level drawing program.

4. Prototype development

4.1 Hierarchy of the domain

The system adopts a hierarchy of objects for representing the knowledge domain. These structural classes, subclasses, instances, and associated methods provide a more clear, accurate and easy way to build up the KBS. As shown in Figure 2, three categories of theories are grouped under the classes Momentum, MA and TrendLine. Another class is named as OverAllResult that integrates the effects of the three classes of theories. Finally, the StockAdvisor is in fact a container of the results that the investors may want to know. In addition to the objects defined above, the system has a lot of other supplementary objects including menu objects, window objects, image objects and some global variable objects.

Table 1: *Degree of certainty from rate of divergence of %D price for Stochastic Theory.*

Rate of Divergence/%D	*Fast*	*Moderate*	*Flat*
[0–10]	VH	H	H
(10–20]	H	M	M
(20–30]	M	L	L
[70–80)	M	L	L
[80–90)	H	M	M
[90–100]	VH	H	H

where VH = Very High, H = High, M = Moderate, and L = Low

4.2. Recommendation of the stock advisor

Figure 3a shows the overall results of the system obtained from one or more of the determinants -Momentum, Moving Average and Trend Line. The cooperation of the three categories of theories is governed by the weighting factor assigned to them by the users. For Momentum category, three theories are used which are Stochastic, Relative Strength Index and Money Flow Index. Similarly, Granville's 200-day moving average, and other moving averages with different parameters are used in the moving average category. The trend line category simply consists of its long-, mid-, and short-term characteristics.

Figure 3b provides more detail of decision-making by the intelligent system based on the application of different theories. Using the two levels of dependency diagrams, we could easily clarify the hierarchy of the overall system and its components.

A set of decision tables was designed in accordance with the rules of the above theories. Results were then derived from the set of appropriate values assigned to individual variables. Such results were compared with the said theories for identifying any discrepancy. Since it was a pilot system, a full verification of the rules became possible.

Table 1 demonstrates one of the decision tables deriving from the recommendation.

4.3. Database

There were a total of 33 worksheets for the 33 stocks in our study. Each stock database is separately filed under

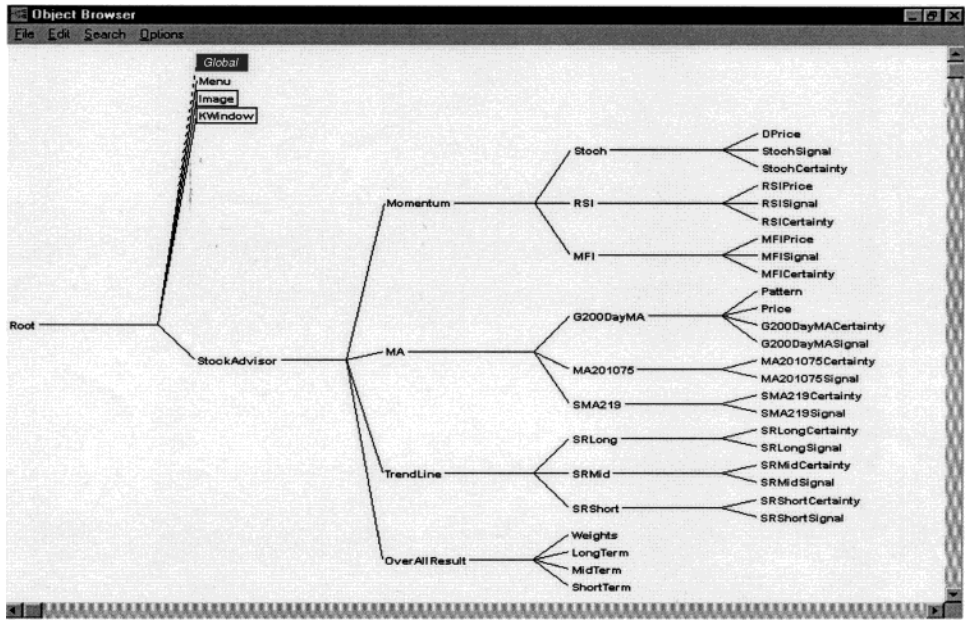

Figure 2: *Hierarchy of the domain.*

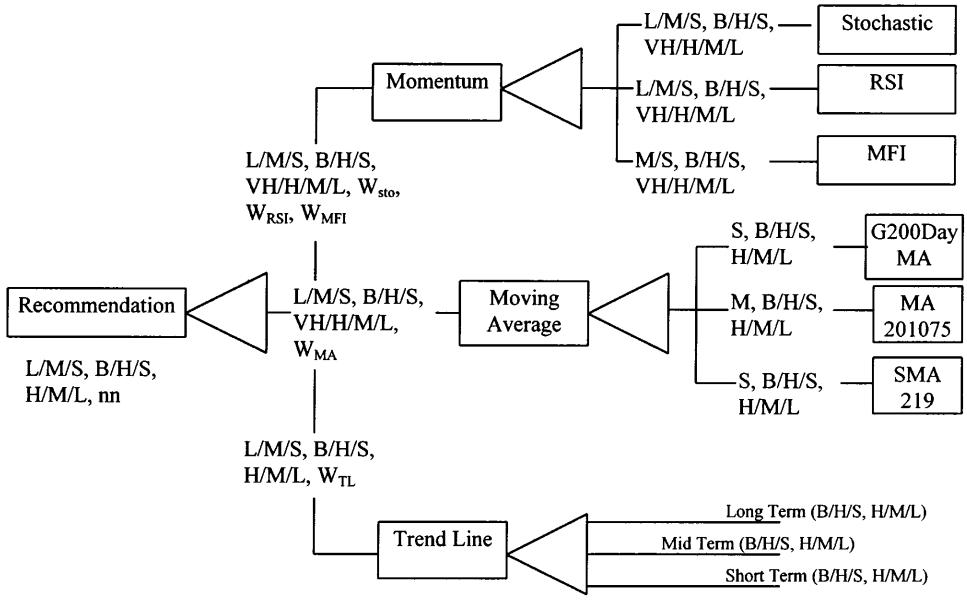

Figure 3a: *Dependency diagram for StockAdvisor (level zero).*

individual file names such as f001.xls for Cheung Kong stock, f002.xls for China Light stock and so on (see Figure 1). The users can update or maintain the database through the Excel software. The updating of the worksheet follows the normal operations of worksheets by adding, deleting and editing data. Figure 4 shows the data structure of the database, which includes the date, high, low and close prices, and the trade volume.

4.4. Graphic presentation/Result input

Before making use of the KBS for reasoning, users have to prepare qualitative information through the data and graphic presentation sub-system. Figure 5 depicts the main menu and Figure 6 shows the chart analysis and data input for KBS.

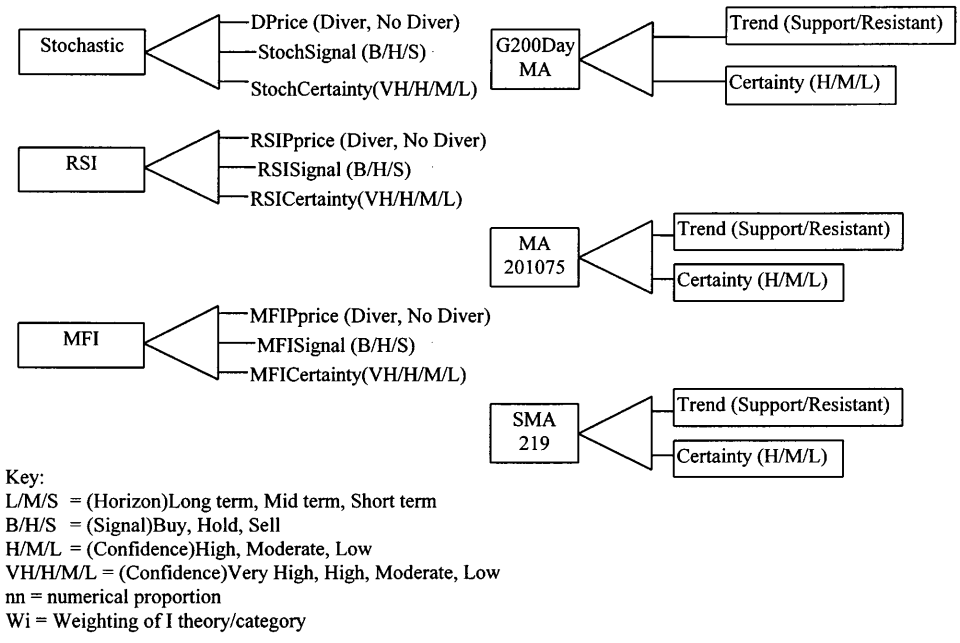

Figure 3b: *Dependency diagram for StockAdvisor (level one).*

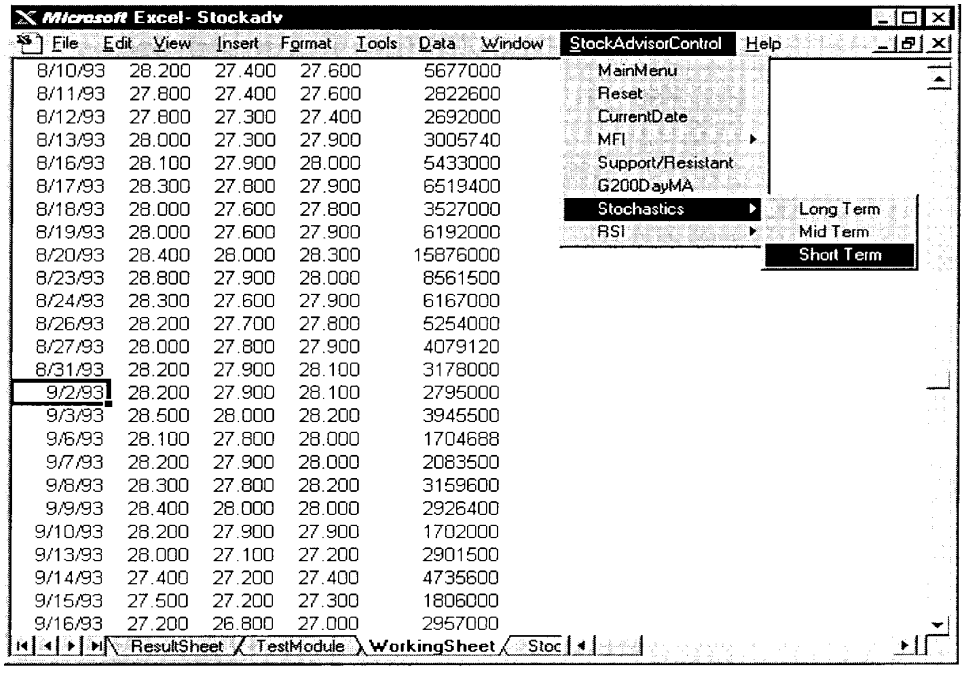

Figure 4: *Database structure.*

4.5. KBS functions

The KBS retrieves data from the Excel sub-system. It becomes very convenient for users who want to study the effect of the whole decision affected by some of the parameters. By allowing manual adjustment of the data, such a system can be used as a training tool for new investors and as an exploring tool for experienced investors. Signal Recommendation also simplifies and makes the result direct and understandable. Figures 7–9 show the main menu, the adjustable proforma and the recommendation table respectively.

5. Testing

In order to validate the prototype, a typical sample stock is used for the testing. The following list shows the steps of the validating process:

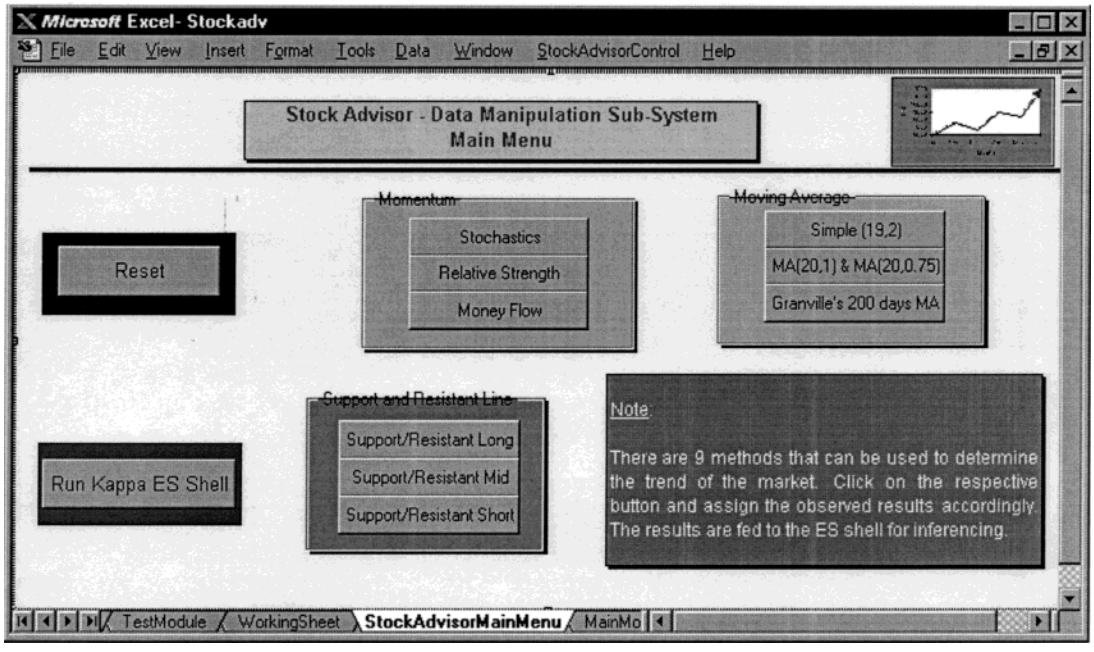

Figure 5: *Data/Graphic manipulation main menu.*

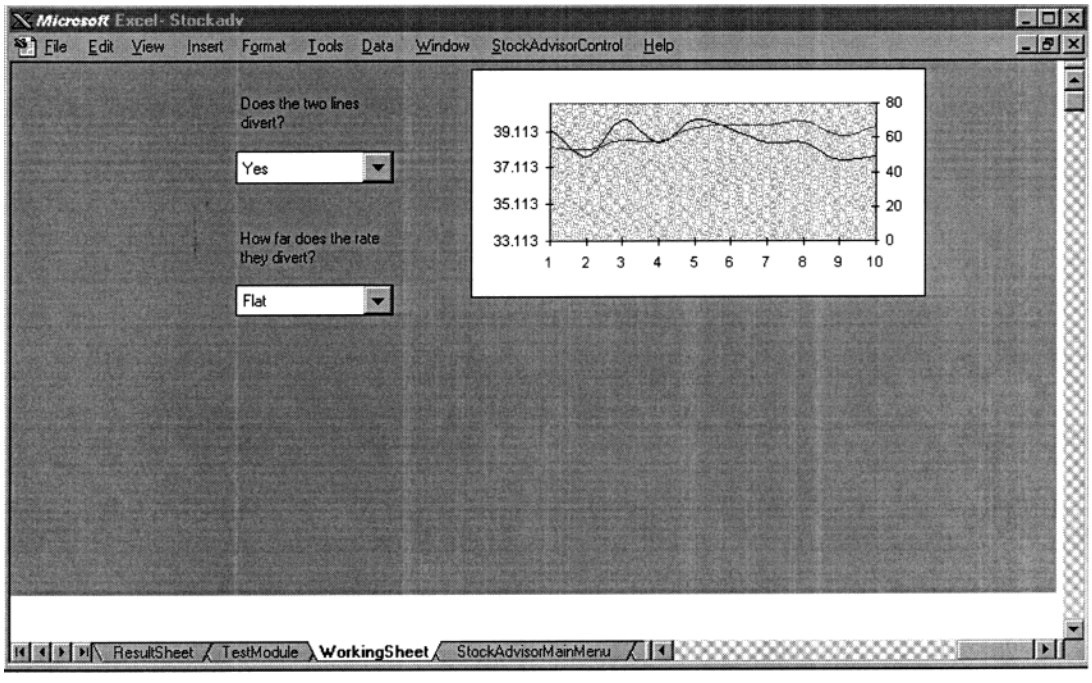

Figure 6: *Chart process.*

(1) Use a pseudo-investment exercise within a period of one year (about 250 days);
(2) Acquire the qualification results through the Data/ Graphics Manipulation System with the stochastic model and short term analysis;
(3) Repeat step 2 above with other models: RSI, MFI, Granvelle's 200-day moving average;
(4) Resulting data are fed into the KBS and used for reasoning. The recommendations are recorded;
(5) Repeat step 4 above with different weightings in order to test:
    (a) individual performance of each theory;
    (b) the combined performance of the theories with the same categories;

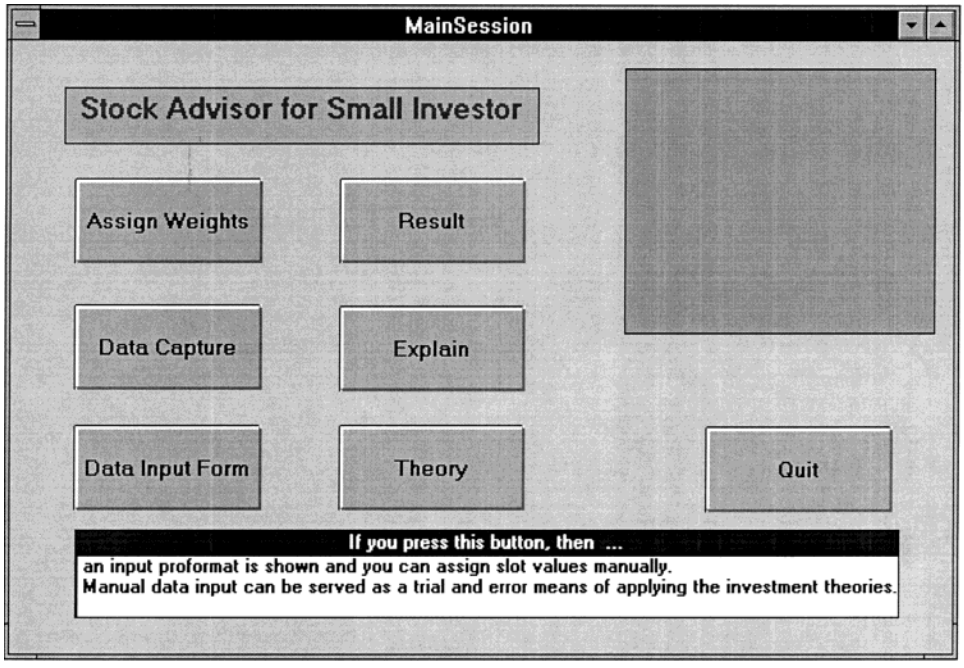

Figure 7: *KBS main menu.*

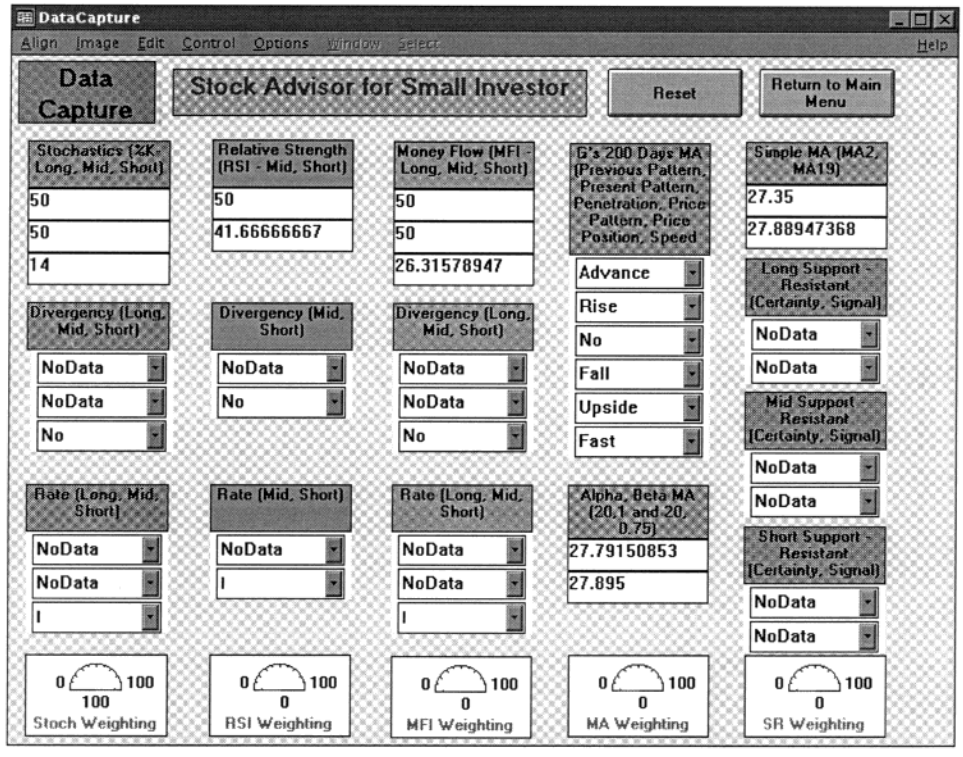

Figure 8: *Adjustable proforma.*

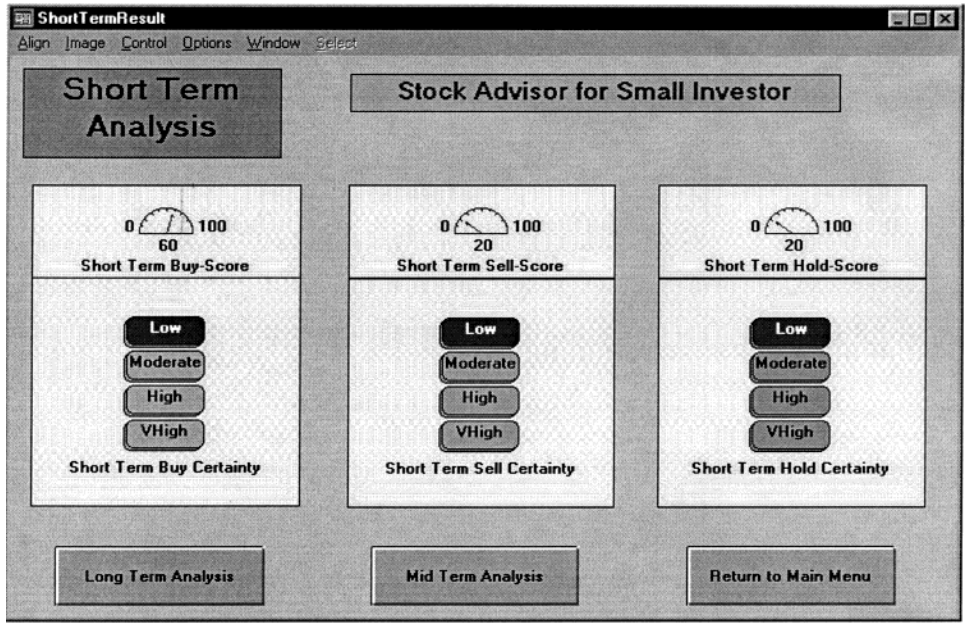

Figure 9: *KBS recommendation.*

(c) the combined performance of all the theories.

(6) Individual performance is compared and expressed in terms of return on investment.

6. Evaluation and analysis

The result of the performance test is summarized in Table 2. With the assumption that the cost of transaction is 1% of the stock value for each transaction, the net return by using the StockAdvisor was very good for the typical sample stock, Cheung Kong, under our examination. The net result was a 22% return which far exceeded the inflation rate (about 10%) at the time. Although individual results were not as good as the combined one, Stochastic and Granville's 200-day moving average were able to give favorable results, which were well above the inflation rate. Except using RSI alone, the combination approach gave a positive earning which was better than the rate offered by the bank (about 5% at the time).

The developed system is quite conservative in that it gives up chances until it is quite sure that it should take the decision action. This may be good for those who are risk averse but the risk rider may not prefer to be so conservative. However, those risk riders can try their own weighting in order to find out the portfolio of theories that suits them. It was found that applying all the theories is far better than using a group or one of the theories. The synergy effect applies in this system seemingly.

7. Conclusion and Discussion

With the common windows platform and graphical user interfaces, the system mimics the daily charting methods. It is easy to use and learn in operation. It provides users with a consistent, effective and efficient way of making an investment decision. Because the rules are extracted from well-founded theories, the research serves as an intelligent advisor in stock investment. In fact, this research provides

Table 2: *Typical performance test of StockAdvisor.*

	Mm'tum and MV	*Mm'tum Only*	*Stoch Only*	*RSI Only*	*MFI Only*	*G200-Day MA Only*
Earning	10.85	3.85	9.60	1.15	4.00	7.15
Mean Investment	36.34	38.03	39.12	38.48	36.2	37.00
Annual Return (%)	30	10	25	3	11	19
No. of Transaction	8	6	14	4	4	6
Transaction Rate (1% per transaction)	8	6	14	4	4	6
Net Return (%)	22	4	11	–1	7	13

a good example of integrating the commercial spreadsheet and ES shell to build a useful KBS. The insufficiencies of reasoning power of spreadsheet software and the deficiency of numeric operation power of most expert shells can supplement each other. In summary, this paper:

- Provides a handy and inexpensive tool for small stock investors in assisting decision-making. It applies several well-known theories of technical analysis as the knowledge or rule base in the pilot system. It demonstrates how expert knowledge can be stored up and applied to support stock investment. Also, the flexibility in expanding the knowledge base is easy and the power of the system can be augmented.
- Extends the application of rule-based reasoning techniques in the area of stock investment. In the past, most of the applications are based either on statistical analysis of the fundamental approach or ruler-and-pencil charting method.
- Integrates VBA(Excel) and KAPPA-PC giving a powerful weapon for the future development of ES which heavily demands numerical analysis. KAPPA-PC is a reasoning tool for KBS and its generic weakness is the ability to process problems with a lot of numbers and functions. Numeric data should be first digested into meaningful information for the expert system before processing any reasoning. The successful integration minimizes a lot of programming from basics and means saving lots of manpower in encoding.

The system prototype covers only the technical analysis. There is still room for future improvement. First, the acquisition of expert knowledge from the theories is limited which reduces the validity of the system. Second, only the technical analysis approach is applied in the system and the fundamental analysis approach remains intact. It is far from perfect as the fundamental analysis provides invaluable knowledge in financial investment. There is valuable work done by previous scholars in this area. If such knowledge can be included in the system, it would be no doubt a great enhancement to the system. Third, this system did not make use of the advantage of case-based system (e.g. Gonzalez and Laureano-Ortiz, 1992), which lists the various conditions governing the happening of an event. It is particularly useful in stock investment. It is well known that the collapse of the stock market is nothing but the result of psychological effects and formula-based plans. Under such a situation, all the technical analysis and fundamental analysis will fail and the investors will suffer from a serious loss. However, although such a situation is not frequent, there are indicators which can predict it. A case-based system will then be an invaluable detector for the occurrence of this disaster and its early detection can warn the investors away from the catastrophe. Fourth, there is no learning ability of the system on its own. Unless the user knows how to program KAPPA-PC, he cannot incorporate more useful functions and rules or even classes and methods so as to increase the reasoning power. Finally, intelligent systems that adopt hybrid methodologies including the integration of fuzzy logic and neural networks (e.g. Funabashi *et al.*, 1995; Jun *et al.*, 1993) may help strengthen the system's intelligent power in resolving some complex and uncertain behaviour within the business environments for investment purposes.

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