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A Prototype of Investment Decision Making in an Integrated Investment Framework

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Abstract: In stock markets, the performance of traditional technology-based investment methods is limited because they only take into account single-dimensional event factors. The study shows how the synthesis of multi-dimensional stock market dynamics can improve performance and proposes a three-layer integrated investment decision-support framework. In this study, we discussed the design of a prototype to implement the three-layer integrated investment decision support system. The integrated investment framework with incorporating this prototype is promising and our experimental results showed that it outperformed single-dimensional traditional methods and benchmark indices.

Key words: Multi-dimensional, market dynamics, integrated investment framework

INTRODUCTION

While there are a crowd of finance methods (such as fundamental analysis, technical analysis, contrarians' theory) in stock markets to help identify investment opportunities, they have different strengths and weakness[1]. There is an increasing need to integrate the different methods in stock markets and it is becoming more and more common for finance practitioners to adopt different methods simultaneously to get an optimized investment result[2]. However, some research problems have been observed in existing technology-based methods. Here is a problem that we shall consider throughout the study:

Single-dimension VS integration of multi-dimensions: Existing technology-based methods mainly focus on technical analysis, with a few which consider other dimensions. However, none of integration-related methods covers different dimensions of stock market structures as a whole to reflect the whole market situation, nor are different conventional methods integrated in a systematic way to incorporate their advantages. As a result, integration-based methods can not help investors to thoroughly and comprehensively understand the market and to identify all potential investment opportunities.

Because of this problem, existing methods can not assist investors to identify investment opportunities very well and their performance is regarded as limited. In this study, we address these problems and propose a novel three-layer integrated decision-support framework composed of Analysis, Synthesis and Investment Decision Support, in which we emphasize synthesis methods for multi-dimensional dynamics.

DESCRIPTION OF A THREE-LAYER INTEGRATED INVESTMENT DECISION-SUPPORT FRAMEWORK

In our previous studies[3], based on surveys on multi-dimensional stock market structure[4-6], we propose a novel three-layer integrated framework analyzing and synthesizing multi-dimensional stock market dynamics and supporting investment decisions. This three-layer integrated investment decision support framework is illustrated in Fig. 1.

This integrated framework consists of three layers

Analysis of stock market structures: Since stock price formation is the result of integrated enforcement of multiple event factors within market structures, it can be decomposed into multi-dimensional dynamics, in which we focus on a two-way reflexivity dynamics between investors' behaviors and market reactions. To model these multi-dimensional stock market dynamics, we proposed concepts of pattern components, which represent basic unit components that derive from each dimension of stock market structures, with features of being understandable, interpretable, usable and reusable for finance practitioners and academics

Synthesis of stock market structures: After individual pattern components being identified and modelled from

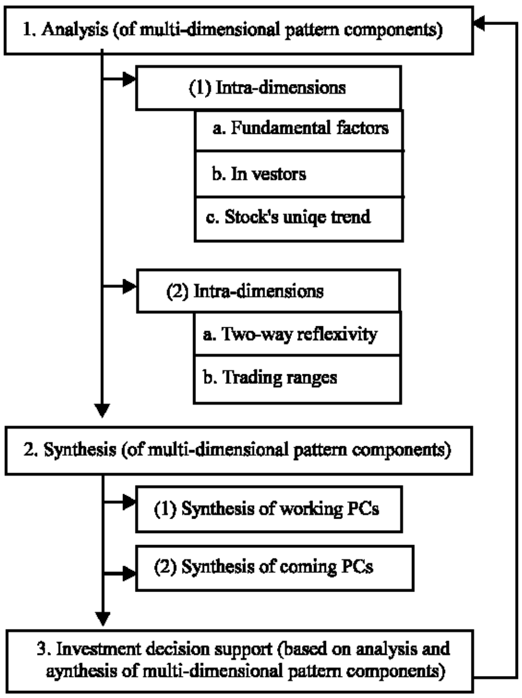

Fig. 1: A three-layer integrated decision-support framework

historic data set at the first layer, working and upcoming pattern components can synthesize to reflect current and potential market situations

Investment decision support based on analysis and synthesis: Once potential investment opportunities are identified and trading strategies are created based on the result of the second layer, they can be inputted to investors' knowledge base and then be used to help investors optimize their decision making.

This three-layer integrated framework has a cyclic process: After the third layer, the results of investment decision-support can be used to adjust or optimize both the models of pattern components identified at the first layer and the models of integration at the second layer. In the cyclic process, parameters of pattern components and their synthesis can be optimized and so optimal investment decisions can be achieved.

FIRST LAYER: IDENTIFICATION OF MULTI-DIMENSIONAL DYNAMICS

In the first layer, we focus on identification of multi-dimensional dynamics. Please see our previous studies[3,7,8].

SECOND LAYER AND THIRD LAYER: SYNTHESIS AND DECISION SUPPORT

The price formation is the result of integral co-enforcement of multiple forces (or pattern components). We can treat each pattern component as an individual force with attributes of strength (its quantity side, or how much it is), direction (its quality side, or where it goes) and length (how long it lasts). Based on these attributes, integration can be achieved either by simple summing up strength of working and upcoming pattern components, or by using Hermite's interpolation of both strength and directions of working and upcoming pattern components, which include two-way reflexivity model of investors' decisions and market reactions we discussed in previous sections.

THIRD LAYER: INVESTMENT DECISION SUPPORT

I develop investment strategies based on the functions or results of identification and synthesis of multi-dimensional pattern components, which are different from conventional methods. In previous chapters, multi-dimensional pattern components were analyzed and synthesized and synthesis results were obtained. These synthesis results, with their unique attributes, reveal market situations and so they can locate investment opportunities. For example, the attributes of synthesis identified include *directions, strength, effect period and effect stages*. These attributes of pattern components and their synthesis can be used as an aid to investors' decision-making. Some examples list below.

Direction: This is classified as Up, Down, or Neutral. Accordingly, investors can make the following decisions: Buy at the beginning (or ending) of Up (or Down), sell at the ending (or beginning) of Up (or Down), Hold in the period of neutral.

Strength: This is classified as Strong, Weak, or Neutral. Accordingly, investors can make the following decisions: Trade (buy or sell) with high volume at Strong, trade (buy or sell) with low volume at Weak, Trade (buy or sell) at medium volume at neutral.

Effect period: This is classified as Long, Short, or Medium. Accordingly, investors can make the following decisions: Adopt trading long-term strategies within a period of Long, but in a period of Short or Medium, they need to react promptly to markets or trade quickly to catch opportunities and to make use of reasonable trading range concepts.

Stages: This is classified by Strongest, Strong, Shallow, Vanishing. Accordingly, investors can make the following decisions: Start trade (sell or buy) at the Strongest or Strong stage; hold or close trade at the stage of Shallow or Vanishing.

Therefore, these decisions derive from results and functions of the synthesis and can tell investors what to invest, when to invest, how much to invest and how long to invest. These decisions can be incorporated in a prototype of Integrated Three-layer Framework Investment Decision Support System (ITFIDSS. Proposed prototype is a KB-DSS in essence and we adopted a KB-DSS methodology proposed by Klein and Methlie[9]. The initial prototype was implemented by mainly using C++. An industry partner, Tricom Australia Ltd, contributed expert domain knowledge and involved in the prototype implementation.

The kernel of ITFIDSS, a simplified architecture, was depicted in Fig. 2. Inputs of ITFIDSS include stock list, historic stock prices, news, announcements of ASX and all other information related to different dimensions of stock market structures and related conventional investment methods. ITFIDSS include three major modules-analysis, synthesis and investment decision-making, which are compatible with the three layers of the framework. The inputs were processed through these three modules and created outputs, including more investment opportunities being identified and more accurate, efficient and profitable investment decision being made accordingly. There is an interactive process between DSS system and users, through user profiles, expert domain knowledge and other factors. These modules and processes are illustrated in Fig. 2.

The architecture of ITFIDSS prototype comprises three basic modules:

- Analysis of multi-dimensional pattern components;
- Synthesis of working and upcoming pattern components
- Investment decision-making. These three modules are fully compatible with the three layers of the integrated framework Fig. 3.

Taking into account the details or components of each layer of the integrated framework (such as identification of different dimensions in layer 1), the flow chart in Fig. 3 can be further extended in Fig. 4.

In order to achieve user friendliness, ITIDSS was developed as a dialog-based application. ITFIDSS's opening dialog provides access to the three major modules, inputs of identification of multi-dimensional pattern components and synthesis methods options and decision-making Fig. 5. Each of the modules caters for the

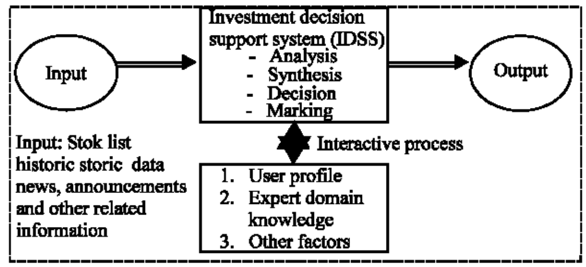

Fig. 2: A simplified architecture of ITFIDSS system

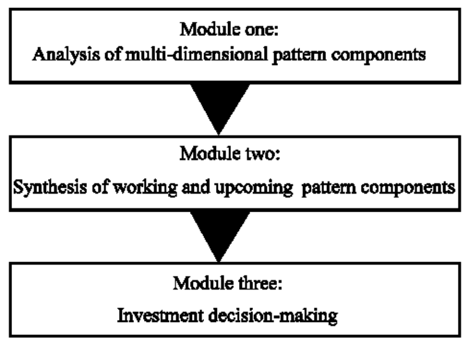

Fig. 3: A flowchart of ITFIDSS modules

creation of tab-delimited output files that can be opened in Notepad, Microsoft Word or Microsoft Excel for further analysis or printing.

The first module of the DSS is implemented in ITFIDSS as a 5-dimension data input process accessed via the "First layer" button on the main dialog. ITFIDSS provides the option to either edit (or update) an existing project data file, or create a new project. The Layer 1: Analysis of Multi-dimensional Pattern Components dialog, showed in Fig. 6, is then displayed. This module has sub-modules, including identification of fundamental pattern components, investors' potential supply and demand, unique trends of stocks, the two-way reflexivity model of investors' decision and market reactions. In each sub-module, different attributes of the pattern component are identified or inputted, through three ways, including direct import from files, manual import (or input) from the results of other methods (e.g. attributes are obtained by using a software package of Matlab), or manual input of users' opinion (or input of experts' knowledge).

The second module of the DSS is implemented in ITFIDSS as a synthesis control process accessed via the "Second layer" button on the main dialog. ITFIDSS provides the options of synthesis of working and upcoming pattern components at the decision-making points, including:

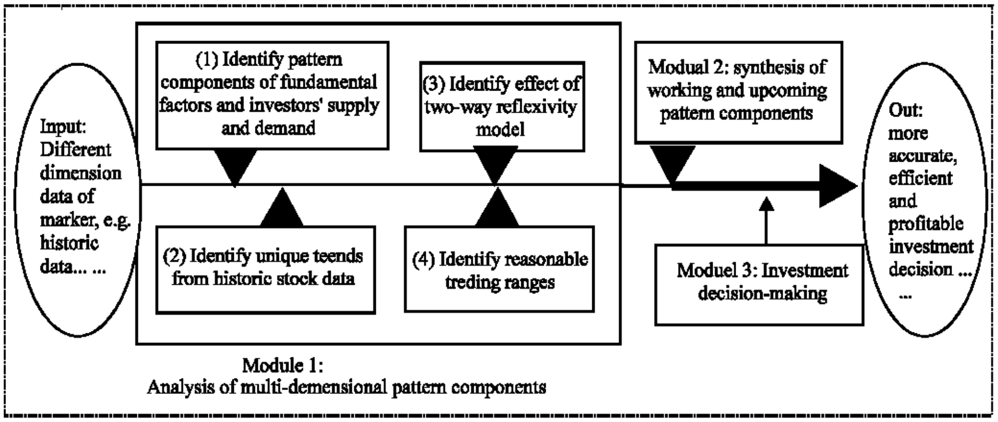

Fig. 4: A detailed flowchart of ITFIDSS

Fig. 5: A Demo of ITFIDSS modules

Fig. 6: Module 1-analysis of multi-dimensional pattern components

- Simple sum-up based on attributes of strength
- Hermite's interpolation based on attributes of both strength and direction
- The methods using Vector (or Autosplit) concepts. The Layer 2: Synthesis of Working and Upcoming Pattern Components dialog, showed in Fig. 7, is then displayed.

The third module of the DSS is implemented in ITFIDSS as a decision-making command accessed via the "Third layer" button on the main dialog. In module 3, users can adjust the decisions, either by returning to Module 1 and Module 2 to adjust attributes of working and upcoming pattern components at decision-making points, or by direct adjustment. The Layer 3: Investment Decision-making dialog, showed in Fig. 8, is then displayed.

I use a RDP (Requestor-Dispatcher-Provider) model to depict a detailed system structure of ITFIDSS Fig. 9. The DSS decides which of the above three major modules

Fig. 7: Module 2 of ITFIDSS-synthesis

Fig. 8: Module 3 of ITFIDSS-investment decision-making

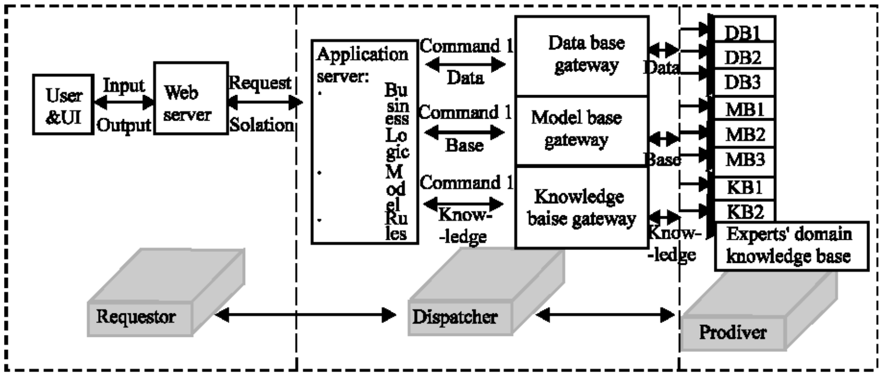

Fig 9: A system structure of ITFIDSS by using RDP model

Table 1: The performance evaluation of the prototype ITFIDSS and its comparison with baselines

Measurement (1): Success rate of prediction of stock movement direction	Success rate (in the evaluation period)	Success rate (in the training period)	Success rate (in the testing period)
ITFIDSS prototype	92%	87%	90%
Conventional method (MACD)	16%	57%	62%
Excess success rate	76%	30%	28%
Measurement (2): Mean prediction error variance (of returns)	In the evaluation period	In the training period	In the testing period
ITFIDSS prototype	0.11	0.09	0.12
Conventional method (MACD)	2.33	3.21	2.86
Excess mean prediction error variance	-2.22	-3.12	-2.74
Measurement (3): Aggregate returns	In the evaluation period	In the training period	In the testing period
ITFIDSS prototype	55%	62%	48%
Compared with following baselines:			
S and P/ ASX 200 accumulation	4.33%	22.57%	4.16%
Excess returns (1)	50.67%	39.43%	43.84%
Median returns of fund management	7.1%	13.1%	4%
Excess returns (2)	47.9%	48.9%	44%
Australian hedge funds	11%	12.2%	5.7%
Excess returns (3)	44%	49.8%	42.3%
Top 5 performing funds	17.6%	45%	20%
Excess returns (4)	37.4%	17%	28%
Conventional methods (MACD)	12%	29%	14%
Excess returns (5)	43%	33%	34%

(or the six sub-modules) and other knowledge source can be used, how to use and how to integrate and optimize the results from individual module to get an ideal output (e.g. more accurate and profitable investment decisions).

As shown in Fig. 9, once the *Requestor* sends users' requests to the *Dispatcher*, *Dispatcher* chooses an appropriate *Provider* and then the *Provider* examines the model-base, knowledge-base, data-base and expert domains to find an appropriate solution. When the process is reversed, the solution will be passed to users. As depicted in Fig. 9, ITFIDSS has the following important components:

Investment requestor: It contains user interfaces and web servers and covers all aspects of the communications (e.g. input and output, problems and solutions) between a user (e.g. brokers, individual investors) and ITFIDSS; as a result, it derives much of the power, flexibility and ease of use of ITFIDSS.

Investment dispatcher: Once receiving particular user requests, *investment dispatcher* will process them immediately. It contains application server and gateways of database, model base and knowledge base. Note that this processing very well requires the *Investment Dispatcher* to draw on *Investment Provider* contents. The processing also changes the knowledge held in the *Investment Provider*. In either event, the *Investment Dispatcher* will issue a response to the user. Basically, the *Investment Dispatcher* has following abilities:

Knowledge acquisition: For example, an *Investment Dispatcher* acquires knowledge about what a user wants the DSS to do (e.g. request) or what is happening in the surrounding environment (e.g. fundamental information, investors' holdings factors, stock information and market reaction, expert's opinion).

Knowledge selection/derivation: *The Investment Dispatcher* is able to selectively recall or derives knowledge in the following *Investment Provider* and forms a solution.

Investment provider: In response to *investment dispatcher's* command, the *Investment Provider* provides requested knowledge from model base, knowledge base, data base and expert domains (with fuzzy logic), which together will form a solution. Investment Provider includes the following components:

Model bases: It contains models and building blocks used to develop applications to run ITFIDSS system. It contains conventional models (e.g. financial models-*DCF*, or Risk models-*VaR*) and customized models (e.g. the Two-way reflexivity model[3], Reasonable Turning Point and Ranges Models[10].

Knowledge bases: Knowledge in the prototype includes descriptive, procedural and reasoning knowledge.

Data bases: Data could flow from several sources such as Australian Centre for Advanced Computing and Communications and other sources (e.g. announcements from ASX) and the databases formed contain variety of data forms and types.

Expert domain knowledge with fuzzy logic: *Investment Provider* is also composed of expert (or other intelligent) domain knowledge and it provides the necessary execution and integration of the expert subsystems. The results of analysis and synthesis can be used directly as trading strategies and they can also be used as new inputs of investors' knowledge base, where they co-integrate other knowledge of multi-dimensions of stock market.

Based on our experiments of the prototype, we obtained following evaluation results:

Real transaction results: 10 real investors were chosen to use the prototype to identify real important trading points in ASX market in evaluation period (01/07/2005-30/08/2005) and thus real transaction results were obtained. Similar experiments were executed in training period (01/01/2004-31/12/2004) and testing period (01/01/2005-30/06/2005). Following table illustrates performance of the prototype and its comparison with market baselines.

Table 1 shows, the prototype of the integrated framework is promising and outperforms both market baselines (e.g. performance of Australian market index ASX and fund managers) and conventional investment methods (such as MACD) in ASX markets.

Table 2: Users' perception measures of prototype of ITFIDSS

Users' perception measures	Results
(1) Scoring of usefulness:	8.9
- P value	0.003
(2) Scoring of ease of use	7.7
- P value	0.012
(3) Scoring of conviction that decisions are correct	8.4
- P value	0.049
(4) Scoring of control of the decision process	7.7
- P value	0.038

Perception measures: In the experiments, users of the prototype (ten real investors and fund managers, including a broker from my industry partner Tricom.com) used and interacted with the prototype and evaluated it using perception measures. In the analysis, I tested the response average against the mid-point of the scale-5 which is noted as "Sometimes useful" (or "Sometimes ease of use", or "Sometimes convicted that decisions are correct", or "Sometimes the decision process is under control"). All proportional differences were tested by using the two-tailed Fisher's Exact Test. The users gave positive feedbacks on these aspects in both experiment and real trading practice and this is illustrated in following Table 2, where and the usefulness scores can simply be presented along with their statistical significance as indicated by the two-tailed p-value.

More importantly, the users indicated that the ITFIDSS could help them gain a competitive edge, because it provided a systematic framework to integrate their work with different investment methods and helped them understand stock market comprehensively and thoroughly.

CONCLUSION

In this study, we proposed a novel three-layer integrated framework of stock markets, composed of *Analysis*, *Synthesis* and *Investment Decision Support*. This integrated framework incorporates multi-dimensional stock market dynamics. In the framework, we emphasized on different synthesis methods for multi-dimensional market dynamics. Our studies showed that these synthesis methods play an important role in investment decision making. The framework incorporating this key aspect is promising, because our experimental results showed that it outperformed single-dimensional traditional methods and benchmark indices.

Our future study includes adopting more methods to model the analysis and synthesis of multi-dimensions and multi-levels of stock market dynamics and to further investigate their attributes and optimize related parameters.

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