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Cognitive Intelligence based Expert System for Predicting Stock Markets using Prospect Theory

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Abstract

Objectives: Design of Expert Systems to assist the investors in stock markets is gaining significant importance in the area of financial investments. The rapid explosion of globalization has armed the investors with the ability to invest their money in the stock markets across the globe. Thus the need for rationalized decision making by psychologically analyzing the behaviour of stockholders has become inevitable. **Method/Analysis:** This concept of behavioural economics integrated the emotional, intellectual and socio-economic factors in decoding the complex economic decisions. Under these circumstances, the traditional finance theory which highlights the rational and calculative decision making setup, contradicts with the new behavioural finance theory which is marked by irrational and high uncertainty based resolutions, that involves cognitive and emotional errors. In the light of these factors, designing a suitable expert system to assist the investors by combining the financial factors, investor sentiments and the information technology using Prospect Theory is the need of the day and this paper proposes to design and develop an efficient expert system using C#.NET. **Findings:** The stock values of leading banks like State Bank of India, Indian Bank, Indian Overseas Bank and Punjab National Bank were chosen as the experimental data sources. The experimental results clearly show that a relatively low error levels have been achieved when the expert system utilizes the Prospects to predict the results. **Applications/Improvement:** The value of normalized mean square error has been reduced to 1.1028 from the pre-prospect value of 1.1510 with respect to the share value of State Bank of India and similar results have been predicted for the other bank shares

Keywords: Expert Systems, Prospect Theory and Investment Decision, Stock Market Predictions

1. Introduction

With the dawn of information age where computers have virtually invaded our everyday life, the stock markets are not a place of exceptions. With billions of money being traded every day across the World, the computers have revolutionised the way the businesses are being carried out in the stock markets. Novel expert systems are finding their places to assist the users in deciding about the stocks to buy or sell. In these expert systems, the technology always takes the back seat, with importance being given to the sound financial knowledge about the functioning of the stock markets and the investors sentiments associated with them. Prospect theory is one such significant method which virtually rules the stock markets.

Prospect Theory was first proposed by[1] and since then it has gained tremendous significance in design and development of suitable suggestion systems helping the people for investing in various financial instruments. It was developed to provide accurate results in decision making by involving several psychological factors. This theory went through successive moderations with Daniel Kahneman being awarded a Nobel Prize in Economics in the year 2002. Though it is known that, investing is nothing but a careful judgement, we miserably fail as our decisions always go astray thereby ending up in losses. With the concept of introducing psychological factors in business analysis, the field of Behavioural Economics is improving in leaps and bounds. Traditionally we were of the view that, the 'overall effect' of the losses and gains

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from a business venture in stock market is the deciding factor for our investment reasons. Assume that in one case you had a direct gain of 50. In another, you gained 100 and lost 50 so as to retain 50. This means that from an investment, a gain of 100 is achieved and by subsequently losing 50, we will have 50 as end gain[3]. Daniel Kahneman has proved that, the investment choices were based on perceived gains and losses on 'individual basis', rather than collectively. Therefore gaining 50 on a single transaction is more worth than gaining 100 and subsequently losing 50, though the net result is 50. This sentiment of the investor is the deciding factor to opt for a particular stock or equity.

With more number of Indians getting into foray with the stock markets, the number of Demat Accounts being the basic necessity for stock trading has also increased. The number of Demat accounts with the National Securities Depository Limited and Central Depository Services Limited were 23.3 million in February 2015. This showed an increase of 6.8 per cent when compared with the financial year 2013–14 were 21.8 million accounts[2–3]. As more and more number of people venture into the stock markets for investing purposes, proper guidance is the need of the day and this research is targeted in providing an insight into the investment decisions using Prospect Theory.

2. Materials and Methods

[14]Have designed a automatic stock market categorisation system for the benefit of individual investors and financial experts. A three phase clustering model is adopted to categorise the companies based on the similarity of the stock options and their variations over a series of time intervals. Similarly Patel et.al[5] analysed the Bombay Stock Exchange and CNX Nifty to design an expert system that utilizes the Support Vector Regression (SVR) in the first phase and in next phase uses Artificial Neural Network (ANN), Random Forest (RF) and SVR. These methodologies results in obtaining various fusion prediction models like SVR-ANN, SVR-RF and SVR-SVR.

Behavioural finance has been emerging as a high profile solution for the volatile stock market environments. Fund managers, financial consultants are facing tough waters in guiding the clients towards non-failing stocks thereby improving the profitability of the investments. Contributing to the wealth generation using various psychological factors has become more common and several research works have already been done in this area[6-11]. [12]Used the Big Five Personality test to profile the investors and their investment patterns were studied to find correlations if any. The investors were grouped under various parameters like openness, conscientiousness, extraversion, agreeability and neuroticism. These parameters in conjunction with investments are used to create a tailor made portfolio for the investors. A study by Rajarajan[13] has revealed that there exists an association between demographic profile of the investors and their risk bearing capacity. Chaudhary[14] investigated the behavioural patterns of investors and have discussed about these patterns guiding the investment decision. Rajeev Jain[15] has highlighted that, investors' learn from their mistakes and capitalize their investments during the next rise. Investors who take the right decision needs experience which comes from bad decisions. Anli Suresh[16] conceptually revealed that understanding various behavioural key biases and traits can help individual take sound financial decisions and in turn make him a better trader/investor. Accounting Information, Self-Image, Neutral information, Firm-Image coincidence, classical wealth maximization, social relevance, Advocate recommendation and personal financial needs were influencing the individual investors' behaviour in a significant manner as proposed by [17].

Financial planning for retirement has been analysed by [18]by developing a Human Computer Interaction Interface using behavioural economic principles. User interface is designed by incorporating loss aversion, goal setting for investments, endowment effect and asset allocation. It was found that, this approach had a positive effect on the users' behaviour and guided them successfully towards retirement savings. Research by Antoinette Nicolle et al.[19] revealed that regret of an investor was higher after an erroneous status quo rejection when compared with that of acceptance. According to Harikanth et al.[20], investors invest in different investment avenues for fulfilling financial, social and psychological need. Financial investment avenues should be designed by seeing the geographical horizon of the investors, their age, income, occupation, gender and risk tolerance capacity etc. Ali Sorayaei[21] probed the efficiency of Fuzzy Neural Network on forecasting Stock Exchange of the Automobile Industries in Iran and have demonstrated the increase in the efficiency of the expert system. Lerner et al.[22], have studied the difference between emotion and cognition and emphasized that dimensional and discrete frameworks has to be

created representing the same models so that different aspects of the same underlying phenomena can be analysed to yield better results. Karle et al.[23] did an extensive research on consumer choice model by considering the factors like loss aversion, uncertainty in pricing schemes and finally reference points based on expectation. Their work has concluded that models with rational expectations are more significant than that of irrational ones.

In[24] has studied the stock market's bearish situation wherein, the disposition effect has been put into a jeopardy with the negligent investor failing to split adjust his shares thereby leading to a situation of winner or loser. The emotional level of the individual has dipped low leading to a cumulative fall of stocks which led to the losses of higher magnitude. Murthy and In[25] found that investors are irrational with different investment options, investors were found overconfident. The findings also support the disposition effect theory and regret theory. In[26] used volatility as a leading indicator and Punita Soni[27] revealed that Investors' decisions are more influenced by Behavioural Finance. Various behavioural biases such as Overconfidence, Representativeness, Herding, Anchoring, Cognitive Dissonance, Regret Aversion, Gamblers' Fallacy, Mental Accounting and Hindsight Bias influencing investment decision of investors under uncertainty were analysed. The study found out that, with the exception of Cognitive Dissonance Bias, investors suffered from all biases in a significant manner[28].

Similarly, In[29] made an empirical study on China Stock Market based on Fama-French Model and yielded a better projection results when compared with other similar models. From the study by[30] it was evident that there was a relationship between the saving objectives with the age, occupation and income level of the small and medium household investors. Brad M. Barber and Terrance Odean[31] found that investors buy the shares which happen to catch their attention. Farzaneh Heidarpoor et al.[32] made an indepth study on unsystematic risk and internal control quality by using volatility profits index in the stocks traded in the Tehran Stock Exchange.

Stock market movements are the barometer of the nation economy. The economic (investment) decisions made by investors are influenced by various psychological factors which in turn affects the nation's economy. Hence it is important to understand and study the various psychological factors influencing the investment decisions. Understanding of the investment behaviour of investors' will help investors to correct their mistake and financial advisors to advice their clients in such a way that helps them to avoid behavioural biases. By doing so, a wealthy economic condition will sustain in the economy. For this purpose the research objective has been set using prospect theory, by relying on the biases such as Loss Aversion, Regret Aversion and Mental Accounting.

3. System Design

The proposed expert system typically consists of an inference engine and a knowledge base coupled together as shown in the Figure 3.1. This inference engine utilizes the Prospect methodology to arrive at meaningful solutions. A real time knowledge acquisition system is also present, which continuously acquires data from the stock markets and the user investment patterns and updates the knowledge base. A user input module is provided through which the user can access the expert system and interact with it by feeding the input values.

4. System Implementation

In this research, a novel expert system for predicting the optimum stock value is designed in a .NET environment using C# with the back end database as MySQL. This operational setup has been putforth for efficient operation in a web based environment which can be scaled up to fit in a Cloud based application in future. The pseudo code for the program is given below in Figures 4.1 and 4.2:

This model has been designed by incorporating the agent based approach wherein, separate autonomous agents work in coherence between the user and the knowledge base thereby evaluating the results on the fly. The stock values of leading banks like State Bank of India, Indian Bank, Indian Overseas Bank and Punjab National Bank were chosen as the experimental data sources. For each dataset, the date is divided into Reference training data and Test data and these are presented in the Table 4.1.

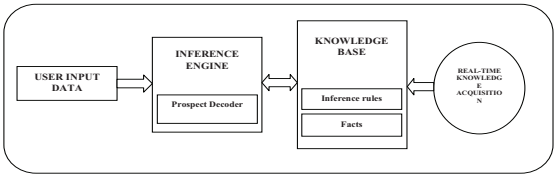

Figure 1. Block diagram of the Expert System.

```
Let M=1000
///Number of investors
N=1000
///Number of Stocks issued
r_f = 0.05/200
///risk free rate
type_K
///investors type k=1 to M
∂=0.1 / 200
///stocks discount rate
σ_y =0.2/
///standard deviation of the profit fluctuation
σ_y =0.01
///standard deviation of the dispersion of the short
term expected rate of return the stock
```

Figure 2. Pseudo code for initialization.

```
P^ref = P_t-10
trend=(1/10)
P^ref, f=P_t-1(1+trend)^2
If P^ref, f<=P^ref
then
P^f=2.25P^ref, f-1.25P^ref
else
P^f=P^ref, f
end if
fori=0 to 100
P_t-100 = Y_t-100 / ∂
///based on dividend discount model
nexti
Function investment-agent(type_k, Y_1, σ_y-1, r^im,P, P_t-1,
P_t-2, .....)
```

Figure 3. Pseudo code for prediction.

Table 1. Data sources

Stock Name	Time Period	Reference Training Data	Test Data
State Bank of India	03-08-2015 to 15-10-2015	3500	250
Indian Bank	03-08-2015 to 15-10-2015	3500	250
Indian Overseas Bank	03-08-2015 to 15-10-2015	3500	250
Punjab National Bank	03-08-2015 to 15-10-2015	3500	250

In order to maximise the training data, more number of samples are chosen and a moderate 250 samples are used as test data. These stock values were fed to the expert system so as to train the system to yield dependable profit making suggestions for stock trading. Performance indices like Normalized Mean Square Error, Directional Symmetry and Mean Absolute Error are evaluated for transactions utilizing the Prospects phenomenon and those involving direct trading without Prospects and the obtained results tabulated in the Tables 4.2 & 4.3:

Table 2. Performance of Expert System without Prospect Theory

Stock	Performance Metrics – Without PROSPECT		
	NMSE	DS	MAE
SBI	1.1510	43.72	0.0577
IB	1.3180	45.73	0.0475
IOB	1.2578	51.76	0.1322
PNB	1.0275	50.75	0.1191

Table 3. Performance of Expert System with Prospect Theory

Stock	Performance Metrics – With PROSPECT		
	NMSE	DS	MAE
SBI	1.1028	40.21	0.0422
IB	1.1100	43.27	0.0395
IOB	1.1056	49.57	0.1012
PNB	1.0512	48.63	0.1008

The experimental results clearly show that a relatively low error levels have been achieved when the expert system utilises the Prospects to predict the results. The value of normalized mean square error has been reduced to 1.1028 from the pre-prospect value of 1.1510 with respect to the share value of State Bank of India and similar results have been predicted for the other bank shares. The graphs depicting the results have been shown in the Figures 4.3, 4.4 and 4.5:

5. Conclusion

Financial markets across the world are in a turbulent stage. Investors lose several trillions due to the economic meltdown being witnessed across the world. Wise and efficient investing pattern is the only solution to protect the hard earned money of the investors. Decisions have to be taken by analysing the conflicts and trade-offs. Choices introduce conflicting values and goals, thereby increasing complexity to the decision making setup.

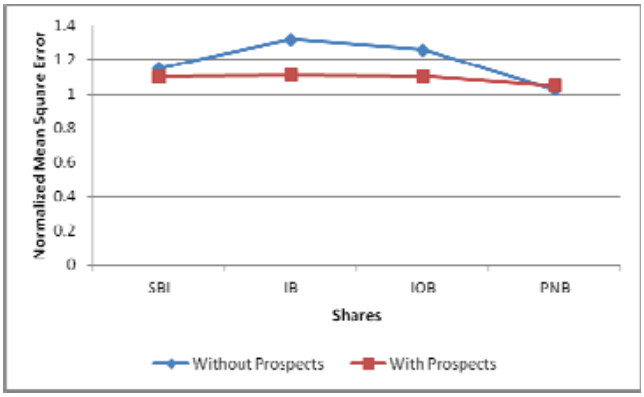

Figure 4. Indices for NMSE.

Figure 5 Indices for DS.

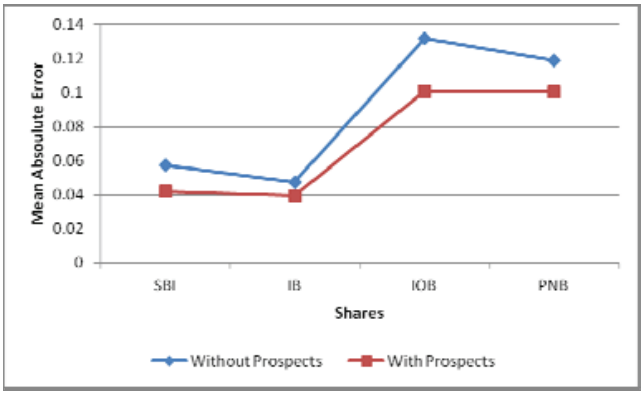

Figure 6 Indices for MAE.

Expert Systems using Prospect theory aptly addresses these concerns and aids in arriving at the most profitable solution. This research can be extended further by introducing Fuzzy Neural Networks in Cloud based environments, as such systems are highly scalable and dependable.

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