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METHODS AND OPTIMIZATION TECHNIQUES OF THE CAPITAL MARKET MODELING

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Abstract: *The current research looks to offer an image over the developments in the last years in the domain of automated transactions on the financial markets around the world, exposing the needs of those processes in the context of markets globalization and the growth of the competition among players, knowing the fact that a major part of the information related to the trading algorithms and the real dimension of this sector remain partially unknown because of the politics of confidentiality. The modeling of the markets, processes and transactions is done by means of software modeling tools such as UML diagrams (use-case, activity, sequence, and component).*

Keywords: *capital market, economical modeling, stock exchange, transactions types, automated transactions, financial derivate instruments, active support.*

1. INTRODUCTION

The main goals of the current research are to construct software models of the Capital Market with the aim to use artificial intelligence methods for investment decisions.

Capital Market represents the set of relations and mechanisms which make possible the directions of the capitals towards the entities that required the funds. On the Capital Market, financial instruments are used for transactions realization, serving as support for the capital exchange on different types of terms (short, medium, long). One of the most important concepts related to the Capital Market, the anglo-saxon concept, state that it is a component of the Financial Market.

The main characteristics of the Capital Market are:

- open market: the transactions with financial instruments have a public nature
- the products of the market are instruments on medium or long terms
- financial instruments are characterized by negotiability and transferability
- trading of the financial instruments is an intermediary, not direct operation

Types of Capital Market:

- on the emission and commercialization of financial instruments: primary and secondary market
- on the trading objects: actions market, bonds market, derived instruments market
- on the mode of formation of the price of financial instruments: bids market, negotiations market
- on the moment of transactions finalization: visible market, terms market
- on the configuration and trading admission requirements of the financial instruments: regulated market, alternative transactions system

The main role of the Capital Market represents its contribution to the financing on medium and long terms of the economy. The request and offer represent two dimensions of the saving-investing process being under the direct and indirect influences of some risks. The capital request belongs to some operators

such as: public and private commercial societies, financial-banking institutions and assurances, governments, international authorities. Capital offers are the consequence of the saving process and are represented by the available money temporary free for which the most advantageous placements are searched. The economies become offers on the Capital Market only if the market guarantees the profitability requested by investors.

Economical modeling is a discipline that takes care of the fundament of the managerial decision in conditions of efficiency for the organization, making use of some flexible mathematical-economical models and with the possibility of using calculus techniques. Thereafter, economical modeling offers to managers the possibility of a strictness in taking decisions according to the material , human or financial resources and organizational objectives. These quantities represent the elements of the input vector in the mathematical-economical models. From the precision point of view, quantities (indicators) that characterizes the economical processes are classified in three main categories: deterministic: rigorously established, with a unique value; aleatory (stochastic): have a set of values each of which have assigned a probability; fuzzy: don't have a unique value, but a set of values to which is associated a degree of membership to a certain criteria.

Considering the applications on the financial data, the current study goal is headed towards the analysis of the traded data. The exploration of such king of data assumes some difficulties and sources of confusion. Taking into account the theory of efficient markets (Fama, 1965), a long term trend is improbable to be found, but with the aids of Artificial Intelligence and Genetic Programming, short term trends can be identified, validated and is identified the moment when they are not valid anymore. Another utilization with large impact is the portfolio management and the optimization of choosing the component products.

The transactions with options appeared at the beginning of the XII-th century and were related to the commerce with tulips in Netherlands. The most well-known evaluation models on the Capital Market at that time were the Black-Scholes Model and the Binomial Model. After 25 years the Forward and Futures Contracts appeared, that had at their basis the options trading. The Futures Contracts represent standardized contracts that creates for the trading parties (buyer and seller) the engagement to buy or sell a certain quantity from the active support at a future date and at a negotiable price at the moment when the transaction was done.

These instruments and models of protection against financial risks doesn't always have the desired effect. A good example would be the world financial crisis in year 2009 for which the possible causes are thought to be the excessive generation of derived financial instruments.

2. RELATED WORKS

UML diagrams have the power to describe and model almost every situation, aspect and process from the real world. The current proposed models of the processes from the Capital Market use mostly the UML activity, use-case and sequence diagrams. Partially, Time Petri Nets (TPN) are used to formally describe some processes by means of places and timed transitions between them. The advantage of Petri Nets over the UML diagrams is the possibility to simulate the net and show the results, and actually enhance the model until better (or best) results are achieved.

A proposed method based on Genetic Network Programming (GNP) and Mean Conditional Value-at-Risk Model (CVaR) that proved to be a useful tool to construct portfolios and generate effective stock trading strategies with different risk attitudes was created by Chen and Wang. [1]

Markowitz's Mean - Variance Model performs the same as the CVaR Model of the original GNP, which can help investors make profitable decisions.

A hybrid evolutionary trend-following algorithm (eTrend) that combines trend following investment strategies (TF) with

extended classifier systems (XCS) was proposed by Hu,Feng,Zhang,Liu in [2].

This combination of stock investment strategies (TF) and evolutionary learning (XCS) can significantly improve computation effectiveness and model practicality and the XCS can automatically adapt to market directions and uncover reasonable and understandable trading rules for further analysis, which can help avoid the irrational trading behavior.

To evaluate these models, experiments were carried out on the daily trading data streams of three indexes in the Shanghai Stock Exchange. Experiments results indicate that the eTrend algorithm outperforms the buy-and-hold strategy and even the decision trees and neural network models of the Artificial Intelligence.

A multi-period fuzzy portfolio optimization model with minimum transaction lots was proposed by Liu, Zhang[3]. This model is a mean semi-variance model based on possibility theory with the objectives of maximizing the terminal wealth and minimizing the risk over the whole investment horizon. In the proposed model the return, risk, transaction costs, diversification degree, cardinality constraint and minimum transaction lots are taken into consideration. Then, a fuzzy decision technique is employed to transform the model into a single-objective mixed-integer nonlinear programming problem and the solution is found by a genetic algorithm. It is finally given to it an application in the Chinese Stock Market to demonstrate the effectiveness of the designed algorithm.

Techniques from the Artificial Intelligence including Support Vector Machine, Neural Networks, Genetic Algorithms and Genetic Programming are widely used in the financial field[3]. Among them GP has the advantage of systematic random search and derivative-free optimization, firstly introduced by Koza[4].

3. PROBLEM STATEMENT

3.1. Models for Forward and Future Contracts

The appearance of the Forward Contracts is dated back somewhere in the middle of 18th century. The main causes that led to their appearance were:

- lack of the means of transport that could make possible the transport of large quantities of cereals to markets located at large distances (railways, highways, etc.)
- lack of means to deposit the crops that could facilitate the stockpiling of cereals for long time

All these causes led to effects like:

- market could not face the over-saturation of the production
- shrinking of the crops prices
- realization of very small profits by farmers
- damaging of very large quantities of cereals

The farmers discovered that the avoidance of all these problems could be possible if they organize the selling of their goods at a future date. They enclosed a contract with a client for the selling of goods at a price, which had been done in a date in future. These types of contracts were later named Forward Contracts.

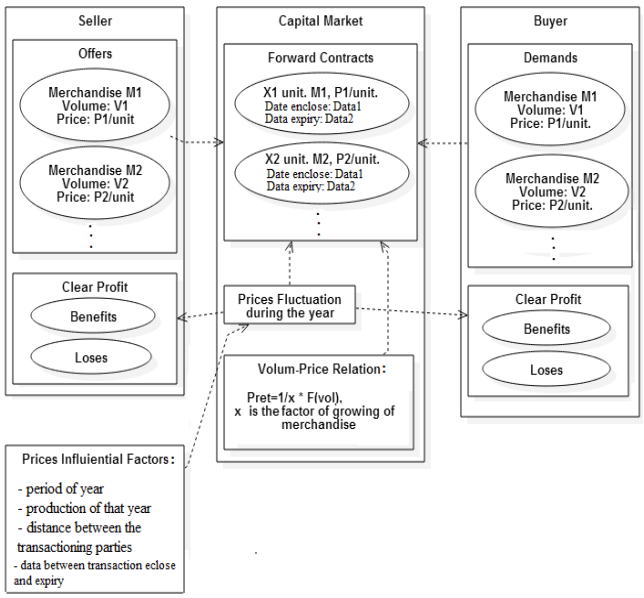

Fig.1: Model of Transactions with Forward Contracts

In Figure 1 is presented the model of the Forward Contracts by means of the UML Use-

Case diagrams. The main participants of the transactions are: the Producer; the Consumer; the Capital Market.

The component on which it can be observed the influence of Forward Contracts is the Capital Market. It records the data of each transaction that had been done between a Buyer and a Seller for a specific good, data that describes specific things:

- the name of the good that was traded
- the quantity (volume) traded for that good
- the unit price of the good
- the date at which the contract was enclosed (Enclosing Date)
- the date at which the good will be delivered (Delivery/Expiration Date)

Though it solves all the problems of the production supra-saturation, this model of transactions has itself a big disadvantage: prices fluctuation. As it can be thought, between the contract enclosing date and goods delivery date the prices of the goods may change.

If at delivery date the prices of the goods on the market is smaller, then the seller is in the situation of profit, which is equal to the difference of the price at enclosing date minus price at delivery date multiplied by the quantity traded for that good.

$$Profit(S)=(P_E-P_D)*X_1. \quad (1)$$

The buyer lies itself in the situation of loss, which is equal to the profit of the seller but in negative absolute value.

$$Loss(B)=(P_D-P_E)*X_1. \quad (2)$$

Another factor that could influence the price of transactions is the relationship between the volume and the unit price. For large quantities of goods the unit price will decrease as a function of volume and a growing factor α:

$$Price=1/\alpha*F(V). \quad (3)$$

In Figure 2 is presented the UML Activity Diagram describing the transactions realization with Forward Contracts. The 4 components that interact in making the transactions are delimited by 4 swim-lanes inside which are described the activities specific to each one of the parties and the way they influence the activities of the neighbor components. Conditional blocks are used to model decisions, conditions that could have two possible values (true or false). Fork blocks are used to model the separation of one activity into two or more activities that execute concurrently. The behavior is same as discussed earlier for the Use-Case diagram.

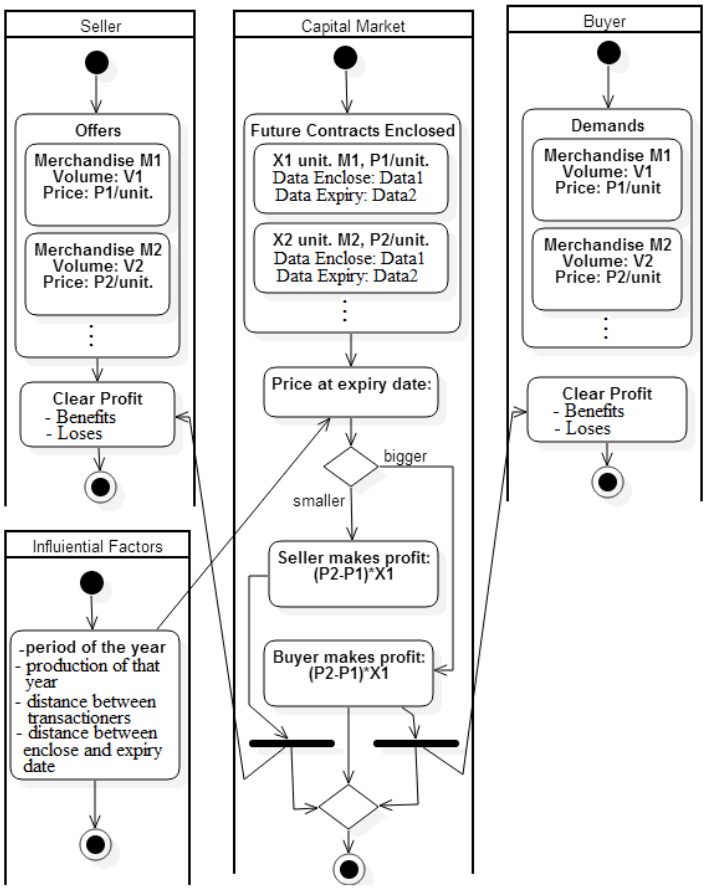

Fig.2: Activity diagram of the transactions with Forward Contracts

In the absence of a regulated market, the realization of transactions by means of Forward Contracts was a difficult and risky business. For example, a buyer could hold a contract for delivery of corn at a specified price but because of the fact that was not specified a standard for quality, it never knows what he was buying only at the moment of delivery. It was probable

that the delivered corn to have an inferior quality. Moreover, it was not possible that a buyer or seller to know that the price of the Forward Contract was correct because the prices were held secret.

The organization that takes care of the proper transactions realization is, since 1848, Chicago Board of Trade (CBOT). Since 1865 it created standards for quality, quantity, delivery dates as well as a set of rules for the trading of contracts. This date marks the beginning of trading with Future Contracts in the United States. The Forward Contracts became now Future Contracts on the goods.

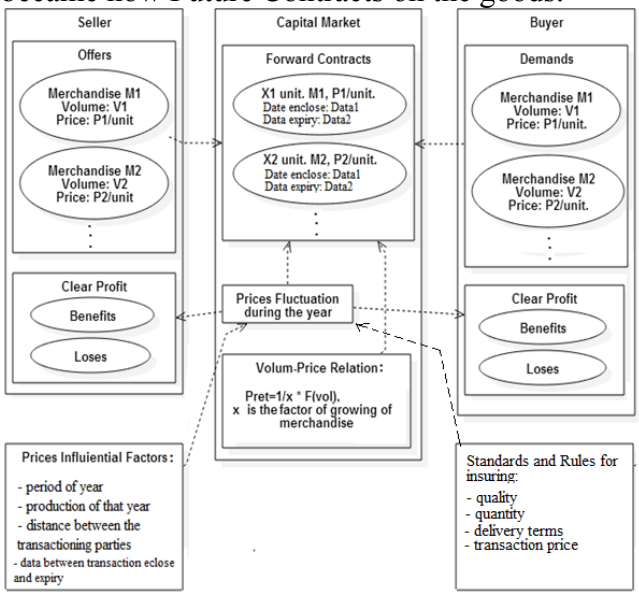

Fig.3: Model of transactions with Futures Contracts

One of the definitions on the stock market for the Future Contract is: "a private accord to buy or sell, deliver and pay at a specific time in future a good, foreign exchange or financial active at a price established in the moment when the transaction was done". What differentiates the two types of contracts is mainly the standardization.

The standardization refers to:

- nature of the active support
- trade unit (the traded quantity)
- delivery date (the term of contract execution)
- the price of execution at delivery
- first and last day for trading

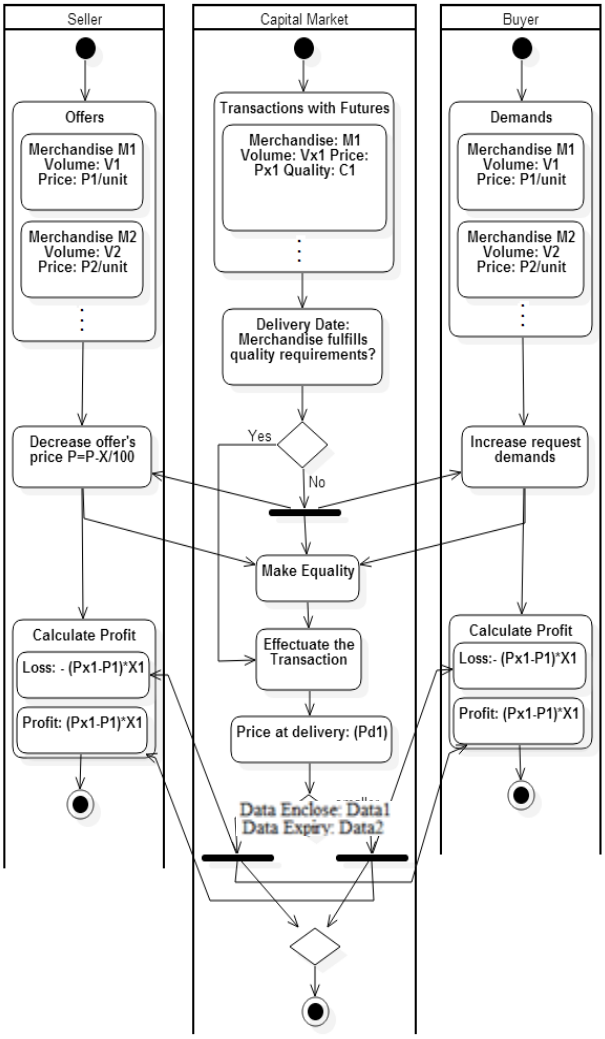

Fig.4: Activity diagram of the transactions with Future Contracts

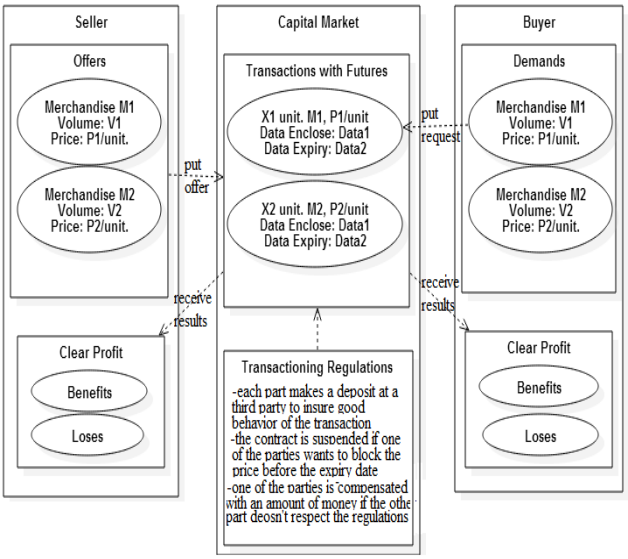

Fig.5 Model of Futures Contracts in which transactions are made by rules

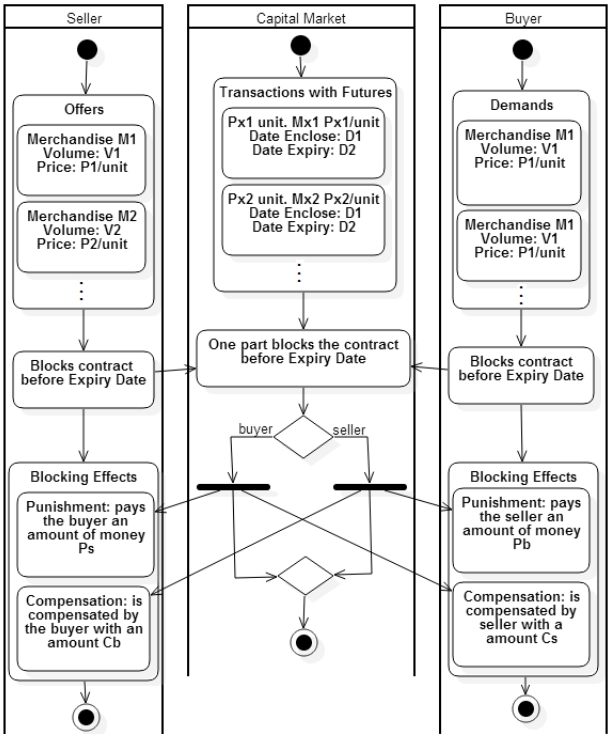

Fig.6: Regulated Futures Contracts transactions

The price of a Futures Contract is established in the stock exchange and is a function of the request and offers of contracts of the same type and varies everyday depending on the market. The value of the Future Contract is variable, changes from one day to another, it is not fixed as it is that of Forward Contracts. Besides that, Forward Contracts cannot be bought or sold, so cannot circulate from one investor to another, as they do with the Futures.

3.2. Transactions with Futures on Stock

A transaction made on a stock requires an exchange between two trading parties. Thus, as some authors define the term, transactions at stock exchanges are a form of buying-selling contracts of primary titles or other financial actives which are enclosed according to the regulations of the stock institution and are mediated by some agents authorized to effectuate these operations. Because the degree of risk is extremely high on the market of financial derivative instruments, caused particularly by the high volatility of the quotations, it is always the case that some strategies have to be adopted in the purpose of minimizing the risks and maximizing the investments.

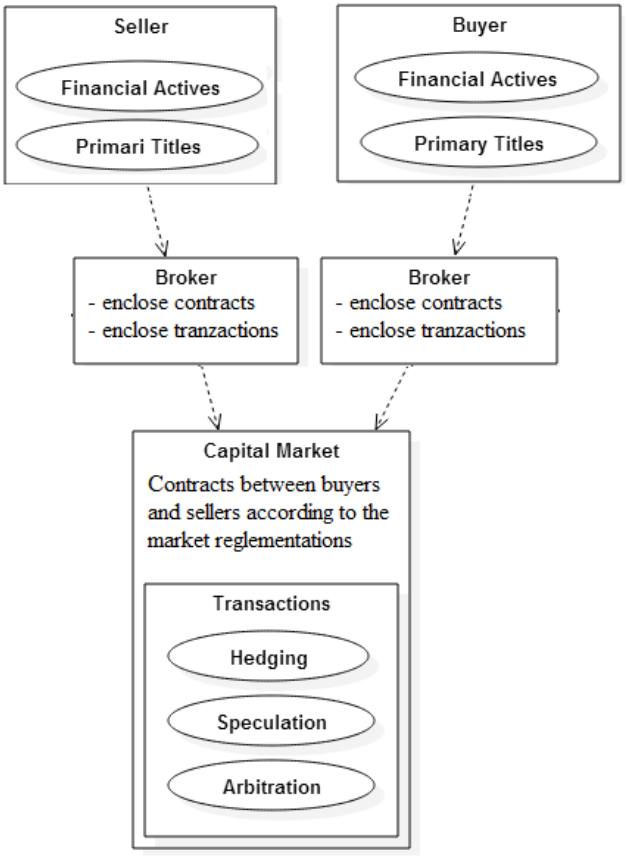

Fig.7: Model of Stock Transactions

Thereafter, besides the aspect of evaluating the risk at every client, it is necessary to observe for each investor in particular which is the right operation for him and what are his objectives regarding the expected efficacy.

Depending on the purpose followed by the investor, there are three types of transactions:

a. Hedging
b. Speculation
c. Arbitration

3.2.1. Hedging

Hedging is the best modality for the investors to protect against the risks created by the use of financial derivative instruments. The correct meaning of the term is "assurance against the fluctuations of the price". The main role of such operation is to fix the currency value, the price of goods, rates of interest, values of actions and so on long time before effectuating the operations of buying-selling of the respective products. It is a modality of protecting against the increasing of production costs and/or decreasing of selling prices.

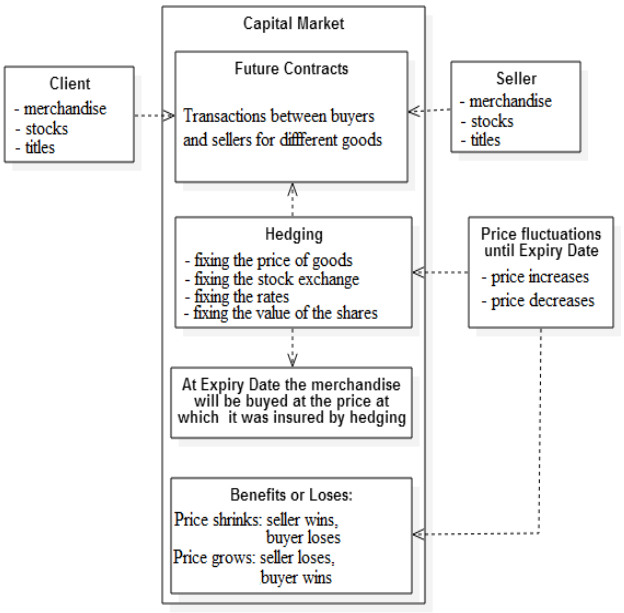

Fig.8: Model of transactions insured by hedging

Hedging is the main economic function of the Futures Markets. The hedging process represents buying and selling Futures Contracts to compensate the risk of price changes on the cash market. This mechanism for risk transfer made that Future Contracts be indispensable to financial companies and institutions around the world. Hedgers are persons, companies, societies that hold some actives, from agricultural products to currencies or mobiliary values, and are preoccupied of an eventual modification of the costs of goods before they buy or sell it.

Thereafter, hedgers utilize Futures Market to protect their businesses against unfavorable evolutions of the prices. Prices fluctuations can be found in a stable economy but also in a transition economy.

The process of hedging is realized in two steps: first, depending on the position taken by hedger on the spot market to protect himself so that he can buy and also sell Futures contracts on the stock market, and second, he must have in sight the closing of the position in which he is before the contract expiration, closing which will be realized by adopting the opposite position of the first one related to the same contract.

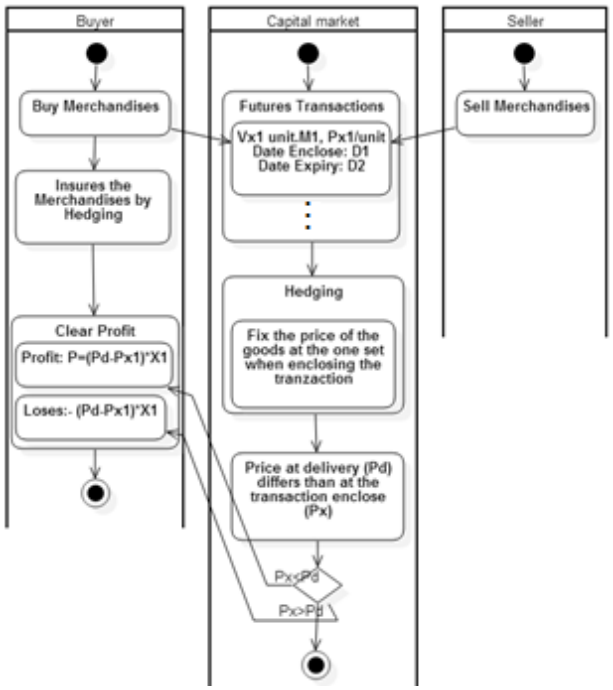

Fig.9: Activity diagram of transactions insured by hedging

4. APPROACH

The problem being stated above, the current goal is to describe the most important techniques in present for solving it. There are probably hundreds of solutions and approaches created by now and many other ways being currently under research. In what will follow are presented, as theoretical aspects only, two of the proposed solutions for solving the problems on the capital market. Also, an excellent tool for algorithms testing and order simulation, of buying and also of selling, is the Fuzzy Logic and Genetic Programming.

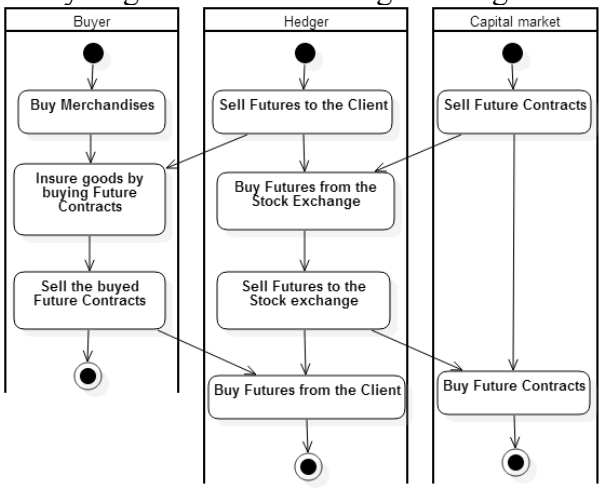

Fig.10: Hedging process and involved parties

4.1.Evolutional Methods

The continuous growing of the quantity of data from databases led to the necessity of automatic processing analysis of them. In this scope are proposed evolutional methods with Genetic Algorithms. The evolutional algorithms are represented by stochastic methods for searching based on the abstraction of biological evolution (reproduction, mutations, re-combinations, selections). Each individual of a population is considered candidate for the solution. An evaluation function calculates the quality of the solution. In this way, using natural selection, the individuals evolve by means of a selection procedure. The mutations can give birth to genes that doesn't exist in the individuals of the first population.

Evolutional algorithms can be used in solving problems from diverse domains of research, the main difficulties are choosing the representation of the individual and evaluation function.

4.2.Automated Trading

Quantitative trading represents the process of automatically trading mobiliary values based on some algorithm without direct human interaction. [3] A report made in 2009 by Aite Group showed that ~70% of the volume of transactions made in the United States were realized automatically. According to a report FixProtocol made in 2008, the total of benefits realized annually from the automatic trading was ~20 billion dollars in USA. The algorithms are developed based on the strategies used by specialists, making use of historical data, tested and enhanced.

In this way there were created competitive strategies, obtaining automatically solutions that can rapidly react to conditions changes on the market. A consequence of the development of automated trading is that the markets on which they activate become more efficient.

Trading algorithms tend to explore more of the inefficiencies of the market, new information being absorbed more quickly. Another consequence is the growing of the liquidity generated by frequent trading in the benefit of the markets.

4.3.Fuzzy Logic

This technique represents the try to copy by means of software programs the behavior of a stock agent that executes the orders on different markets. Fuzzy logic uses special variables called "Fuzzy" quantities, creating a workspace different from the real, characterized by exact numerical values. The goal is to reduce the complexity of the exterior world to a finite number of variables with which it can be operated intuitively. The mode of operating with these variables is under the form of logical implication rules.

IF(variable IS {fuzzy_setl}) THEN (action IS {fuzzy_set2}) (4).

where *fuzzy_setl* is the set of values which *variable* can take and *fuzzy_set2* the set of possible values for *action*.

A Fuzzy variable can take more values at a certain time. A rule can be fulfilled in a greater or smaller proportion, depending on how its condition is fulfilled. Multiple rules can be fulfilled at some time and the value of action takes multiple Fuzzy values in different proportions. The proportion in which is fulfilled a logical compound proposition is calculated by taking the maximum of the proportions of the constituent propositions for logical "OR", minimum for "AND" and the 1-proportion for "NOT".

The control rules as well as the numerical values that delimitates Fuzzy quantities can be determined by mathematical calculus that vise the system's performance or by use of some algorithms that generate these values. From these algorithms we specify: genetic algorithms, neural networks, Bayes Networks etc.

5. CONCLUSIONS

In a society based extensively on knowledge the term ‘intelligence’ becomes more important at each level, even if in many sectors the term is new and still unclear.

The current research main goals are to create techniques and models for automated trading on the international markets following the existing problems of the portfolio optimization, bankruptcy predictions, financial supervisions of the societies at the stocks, frauds detecting etc., distinguishing the main directions of interest and trends in the sector of intelligent computational methods.

It can also be used for the analysis of the price fluctuations, the use of intelligent methods such as Genetic Algorithms and in obtaining predictions with high degree of accuracy.

In the case of quantitative transactions the goal is to develop an automated strategy of trading, defining the parameters of performance and the integration with the use of evolving algorithms as solution for modeling the parameters of the indicators and for identifying new rules of trading.

The work in the current study is only the beginning of our main purpose, which is the creation of programs for automatic synthesis of instruments on the capital market employing well-known methods from the Artificial Intelligence which we will show in future work. For now the goal was only to set the field by creating models for different aspects of the Capital Market, models which we will use in next works.

REFERENCES

[1] Liu,Y., Zhang, W.. *A multi-period fuzzy portfolio optimization model with minimum transaction lots* Rapport LAAS, no. 88137, 1988.

[2] Chen,Y., Wang,W.. *A hybrid stock trading system using genetic network programming and mean conditional value-at-risk*, Management Science, vol. 24, pp. 441-450, 1977.

[3] Hu,Y., Feng,Y., Zhang,Y.. *Stock trading rule discovery with an evolutionary trend following model*, Proceeding of 17th IMACS World Congress Scientific Computation, Applied Mathematics and Simulation-IMACS, France, 2005.

[4] Cao,Q., Leggio,K., Schniederjans,M.. *A comparison between Fama and French's model and artificial neural networks in predicting the Chinese stock market.* Computers & Operations Research, 32(10), 2499–2512.

[5] Aite Group. (2009). *New World Order: The High Frequency Trading Community and Its Impact on Market Structure*. Boston,2009

[6] Babu,G.. *Clustering with evolution strategies. Pattern Recognition* , 27 (2), 3210-330, 1994.

[7] Aite Group. (2010). *The European Equity Electronic Trading Landscape: How Deep Is Your Pool?*

[8] Aldridge,I.. *High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems*. Wiley, London, 2009.

[9] Rajaraman,A.. *Mining of Massive Datasets. Retrieved2011*from http://infolab.stanford.edu /~ullman/mmds.htm

[10] Banzhaf,W., Nordin,P., Keller,R.,Francone, F.. *Genetic Programming: An Introduction*, Boston,2009

[11] Bauer,R.. *Genetic Algorithms and Investment Strategies.* Wiley, 2009

[12] Berthold,M., Hand, D.. *Intelligent Data Analysis.* Springer,2009.

[13] Bishop,C.. *Pattern Recognition and Machine Learning.* Springer,2006.

[14] Chan,E.. *Quantitative Trading: How to Build Your Own Algorithmic Trading Business*, IEEE Computer Society.Biology 3(5) , 1227-1242, 2006

[15] Chan,Z., Kasabov,N.. *Gene trajectory clustering with a hybrid genetic algorithm and expectation maximization method*, IEEE International Conference on Neural Networks (pp. 1669 - 1674), France, 2004.

METODE SI TEHNICI DE OPTIMIZARE A PIETEI DE CAPITAL

Rezumat: *Cercetarea curenta cauta sa prezinte o imagine asupra dezvoltarilor recente din ultimii ani in domeniul sistemelor de tranzactionare automata pe piatele financiare din intreaga lume, aratand nevoia acestor procese in contextual globalizarii pietelor si de crestere a competitiei intre participant,cunoscand fiind faptul ca o mare parte a informatiilor legate de algoritmii de tranzactionare si dimensiunea reala a acestui sector ramane partial necunoscuta din cauza politicilor de confidentialitate. Modelarea pietelor, proceselor si tranzactiilor este realizata in lucrarea de fata prin intermediul uneltelor de modelare software cel mai des utilizate: diagramele UML (use-case, activitate, secventa, componente).*

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