Chapter 2
Asset Management Strategies: Risk and Transaction Costs in Simulation

Roman Šperka

Abstract In recent years, there has been rising interest in a field called behavioral finance, which incorporates psychological methods in analysing investor behavior. The aim of this chapter is to study the technical and the fundamental investing strategy of financial market participants dealing with assets. The motivation of the presented research is to simulate the financial market in the form of agent-based model and to investigate various impacts of risk and transaction costs on its stability. Computational social science involves the use of agent based modeling and simulation to study complex social systems. It is related to a variety of other simulation techniques, including discrete event simulation and distributed artificial intelligence or Multi-Agent Systems (MAS). In practice, each agent has only partial knowledge of other agents and each agent makes its own decisions based on the partial knowledge about other agents in the system. For purposes of this chapter, a MAS will be implemented as a simulation framework in JADE development platform. The hypothesis was that transaction costs introduction will stabilize the financial market. The results obtained show that in the case of risk involvement into the system the hypothesis can be fulfilled only partially.

Keywords Simulation · Modelling · ABMS · JADE · Tobin tax · Risk · Transaction costs

2.1 Introduction

As the globalization proceeds, financial markets follow this process in the way of integration and growth. In the asset management area different participants invest their capital into financial markets. The reward for the investments is the revenue they could cumulate. It is obvious that these investors have important impact on the

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J.W. Tweedale et al. (eds.), *Intelligent Decision Technology Support in Practice*, Smart Innovation, Systems and Technologies 42,
DOI 10.1007/978-3-319-21209-8_2

asset prices. The speculations they could realise influence the stability on financial markets in both ways: positively, and negatively. Technical investment strategy tries to maintain an average return using benchmarks based on market indices. It is one of the most popular investment strategies in the asset management business and is consistent with traditional asset pricing theories. This strategy is also considered to be an effective method in efficient markets [1].

Recently, there has been rising interest in a field called behavioral finance, which incorporates psychological methods in analysing investor behavior. There are numerous arguments in behavioral finance that investors' decision making bias can explain phenomenon in the financial market which until now had gone unexplained. Such arguments often point out the limit of arbitrage and the existence of systematic biases in decision-making [2–4]. Behavioral finance has examined a wide range of phenomena in the market and among investors, drawing a number of provocative conclusions.

This research employs a Multi-Agent Systems (MAS) to deal with unpredictable phenomena surrounding every company nowadays able of agents behavior investigation. MAS will be developed and managed as a simulation framework in the JADE development environment (JAVA programming language). This chapter deals with the agent-based simulation of the Tobin tax introduction together with the risk analysis and their impact on the stability of financial market. The motivation is to investigate the reaction of financial market on the higher transaction costs and risk application. A multi-agent financial market model and simulation is introduced. Intelligent Agents (IA) follow technical and fundamental trading rules to determine their speculative investment positions. The authors consider direct interactions between speculators due to which they may decide to change their trading behavior. For instance, if a technical trader meets a fundamental trader and they realize that fundamental trading has been more profitable than technical trading in the recent past, the probability that the technical trader switches to fundamental trading rules is relatively high. In particular the influence of transaction costs and risk is studied. This chapter is structured as follows. Some literature background is given in Sect. 2.2. Section 2.3 firstly describes the original mathematical model, secondly informs about previous simulation results, and lastly represents the hypothesis. In Sect. 2.4 is the JADE environment and JAVA implementation presented. Section 2.5 discusses the original simulation results of the agent-based model of financial market.

2.2 Literature Background

Computational social science involves the use of Agent-Based Modeling and Simulation (ABMS) to study complex social systems [5, 6]. ABMS consists of a set of agents and a framework for simulating their decisions and interactions. ABMS is related to a variety of other simulation techniques, including discrete event simulation and distributed artificial intelligence or multi-agent systems [7, 8] Although many traits are shared, ABMS is differentiated from these approaches by its focus on finding the set of basic decision rules and behavioral interactions that can produce the complex results experienced in the real world [9]. ABMS tools are designed to simulate the interactions of large numbers of individuals so as to study the macro-scale consequences of these interactions [10]. Each entity in the system under investigation is represented by an agent in the model. An agent is thus a software representation of a decision-making unit. Agents are self-directed entities with specific traits and typically exhibit bounded rationality, that is, they make decisions by using limited internal decision rules that depend only on imperfect local information. In practice, each agent has only partial knowledge of other agents and each agent makes its own decisions based on the partial knowledge about other agents in the system [11, 12].

Intelligent agent technology used in this chapter has deeper roots in economic theory history, mainly in the ideas of Hayek and Simon. One of the main ideas of Hayek is that the economic system should be studied from bottom. He stresses the need to look at the market economy as to a decentralized system consisting of mutually influencing individuals (the same goes for financial markets) in his work. In "Individualism and Economic Order" Hayek [13] writes: "There is no other way to understand social phenomena such as through the understanding of the actions of individuals who are oriented towards other people and management according to their expected behaviours." He opposed mainly against collectivist theories which claim to be able to fully understand the social right, regardless of the individuals who constitute them. This approach builds a contrast with the assumption of perfect information, which is used in traditional equilibrium analysis. In the theory of complex systems, where Agent-based Modelling and Simulation (ABMS) clearly falls, is this idea the primary principle [14]. Agents, unlike classical equilibrium approach have not perfect information about all processes in the system.

No strict rules are conducted to the agents. They themselves select those practices that lead to the best results according to the success of strategies and rules. They are not looking for universal general rule. They are governed by a method that has proven in the environment under given conditions in the past. Multi-agent approach uses various scientific methods for introducing the adaptive behavior of the program structures [15]. The basic feature of complex adaptive systems is that their global properties can be easily derived from the characteristics of individual units. Although each agent structure is simple, the behavior of the system as a whole can be very difficult. A complex system is not the same as a chaotic system. Generally, a complex system tends to evolve away from both extremes—full of randomness on the one hand and absolute order on the other. Kochugovindan [16] MAS are based on the selection of behavior rules that are subjectively optimal in certain environment for each agent functioning. MAS implemented through ABMS consists of two types of rules—spontaneous and created. The agent should be determined what their purpose is, what variable or group of variables to be monitored and optimized. On the other hand the way for reaching goals, is already left full of them.

The transaction costs on the financial market are mainly the costs of the obtaining and the interpreting of the information, the time required for decision making, various types of fees. Transaction costs according to Burian [17] are often viewed as negative phenomena, but there are cases where the increase in the transaction costs can be viewed positively and can contribute to the stability of the market. The increase in the transaction costs may also occur in the form of non-market regulation such as the taxes. In the early seventies the Nobel laureate in the economics James Tobin drafted the regulation of currency markets. Tobin suggested that all short-term transactions should be taxed at a low fixed rate (the proposal was later identified as the so-called Tobin tax). The results according to Tobin would avoid short-term currency speculation and stabilize the market. Currency speculation can lead to the sudden withdrawal of the currency from the circulation in order to artificially increase the price. The consequence for the economy of the countries that use this currency may be a temporary reduction in liquidity, problems in obtaining loans and other phenomena that can lead to the reduced growth or even to the recession.

Tobin suggested his currency transaction tax in 1972 in his Janeway Lectures at Princeton, shortly after the Bretton Woods system of monetary management ended in 1971 [18]. He summarized his idea like follows: "The tax on foreign exchange transactions was devised to cushion exchange rate fluctuations. The idea is very simple: at each exchange of a currency into another a small tax would be levied—let's say, 0.5 % of the volume of the transaction. This dissuades speculators as many investors invest their money in foreign exchange on a very short-term basis. If this money is suddenly withdrawn, countries have to drastically increase interest rates for their currency to still be attractive. But high interest is often disastrous for a national economy, as the nineties' crises in Mexico, Southeast Asia and Russia have proven. My tax would return some margin of manoeuvre to issuing banks in small countries and would be a measure of opposition to the dictate of the financial markets" [19]. More variations on Tobin tax idea occurred. According to Paul Bernd Spahn in 1995, "Analysis has shown that the Tobin tax as originally proposed is not viable and should be laid aside for good." Furthermore, he said: "...it is virtually impossible to distinguish between normal liquidity trading and speculative "noise" trading. If the tax is generally applied at high rates, it will severely impair financial operations and create international liquidity problems, especially if derivatives are taxed as well. A lower tax rate would reduce the negative impact on financial markets, but not mitigate speculation where expectations of an exchange rate change exceed the tax margin" [20].

Wrobel's paper [21] highlighted the Swedish experience with financial transaction taxes. In January 1984, Sweden introduced a 0.5 % tax on the purchase or sale of an equity security. Thus a round trip (purchase and sale) transaction resulted in a 1 % tax. In July 1986 the rate was doubled. In January 1989, a considerably lower tax of 0.002 % on fixed-income securities was introduced for a security with a maturity of 90 days or less. On a bond with a maturity of five years or more, the tax was 0.003 %. The revenues from taxes were disappointing; for example revenues from the tax on fixed-income securities were initially expected to amount to 1,500 million Swedish kronor per year. They did not amount to more than 80 million Swedish kronor in any year and the average was closer to 50 million [22]. In addition, as taxable trading volumes fell, so did revenues from capital gains taxes, entirely offsetting revenues from the equity transactions tax that had grown to 4,000 million Swedish kronor by

1988 [23]. On the day that the tax was announced, share prices fell by 2.2 %. But there was leakage of information prior to the announcement, which might explain the 5.35 % price decline in the 30 days prior to the announcement. When the tax was doubled, prices again fell by another 1 %. These declines were in line with the capitalized value of future tax payments resulting from expected trades. It was further felt that the taxes on fixed-income securities only served to increase the cost of government borrowing, providing another argument against the tax. Even though the tax on fixed-income securities was much lower than that on equities, the impact on market trading was much more dramatic. During the first week of the tax, the volume of bond trading fell by 85 %, even though the tax rate on five-year bonds was only 0.003 %. The volume of futures trading fell by 98 % and the options trading market disappeared. On 15 April 1990, the tax on fixed-income securities was abolished.

The EU Financial Transaction Tax (EU FTT) is a proposal made by the European Commission in September 2011 to introduce a financial transaction tax within the 27 member states of the European Union by 2014. The tax would only impact financial transactions between financial institutions charging 0.1 % against the exchange of shares and bonds and 0.01 % across derivative contracts. According to the European Commission it could raise €57bn every year [24], of which around €10bn (£8.4bn) would go to Great Britain, which hosts Europe's biggest financial centre [25]. It is unclear whether a financial transaction tax is compatible with European law [26].

The difference between Tobin tax and financial transaction tax is particularly in the tax subject. Tobin tax concentrates on the currency operations, while financial transaction tax deals with assets like shares, bonds and derivative contracts. Both terms are used within this chapter, however only assets were used for calculations during this research.

2.3 Mathematical Model

2.3.1 Original Model

The model developed by Westerhoff [27] was chosen for the implementation. It is an agent-based model, which simulates the financial market. Two base types of traders are represented by agents:

- **Fundamental traders**—their reactions are based on fundamental analysis—they believe that asset prices in long term approximate their fundamental price—they buy assets when the price is under fundamental value.
- **Technical traders**—decide using technical analysis—prices tend to move in trends—by their extrapolating there comes the positive feedback, which can cause the instability.

Price changes are reflecting current demand excess. This excess is expressing the orders amount submitted by technical and fundamental traders each turn and the rate between their orders evolves in a time. Agents regularly meet and discuss their trading performance. One agent can be persuaded to change his trading method, if his rules relative success is less than the others one. Communication is direct talk one agent with other. Communicating agents meet randomly—there is no special relationship between them. The success of rules is represented by current and past profitability. Model assumes traders ability to define the fundamental value of assets and the agents behave rationally.

The price is reflecting the relation between assets that have been bought and sold in a turn and the price change caused by these orders. This can be formalized as a simple log-linear price impact function.

$$P_{t+1} = P_t + a(W_t^C D_t^C + W_t^F D_t^F) + a_t \tag{2.1}$$

where a is positive price adjustment coefficient, D^C are orders generated by technical agents while D^F are orders of fundamental ones. W^C and W^F are weights of the agents using technical respectively fundamental rules. They are reflecting current ratio between the technical and fundamental agents. α brings the random term to the Eq. 2.1. It is an IID normal random variable with mean zero and constant standard deviation σ^α.

As was already said, technical analysis extrapolates price trends—when they go up (price is growing) agents buy the assets. So the formalization for technical order rules are expressed in Eq. 2.2.

$$D_t^C = b(P_t - P_{t-1}) + \beta_t \tag{2.2}$$

The parameter b is positive and presents agent sensitivity to price changes. The difference in brackets reflects the trend and β is the random term—IID normal random variable with mean zero and constant standard deviation σ^β.

Fundamental analysis permits the difference between price and fundamental value for short time only. In long run there is an approximation of them. So if the price is below the fundamental value—the assets are bought and vice versa—orders according fundamentalists are formalized in Eq. 2.3.

$$D_t^F = c(F_t - P_t)\gamma_t \tag{2.3}$$

The parameter c is positive and presents agent sensitivity to reaction. F represents fundamental value—the authors maintain a constant value to keep the implementation as simple as possible. γ is the random term—IID normal random variable with mean zero and constant standard deviation σ^γ.

If we say that N is the total number of agents and K is the number of technical traders, then Eq. 2.4 defines the weight of technical traders.

$$W_t^C = K_t/N \tag{2.4}$$

And the weight of fundamental traders in Eq. 2.5.

$$W_t^F = (N - K_t)/N \tag{2.5}$$

Two traders meet at each step and they discuss about the success of their rules. If the second agent rules are more successful, the first one changes its behavior with a probability K. Probability of transition is defined as $(1 - \delta)$. Also there is a small probability ε that agent changes his mind independently. Transition probability is formalized in Eq. 2.6.

$$K_t = (K_{t-1} + 1) \text{ with probability } p_{t-1}^{+} = \frac{N - K_{t-1}}{N}\left[\varepsilon + (1-\sigma)_{t-1}^{F\to C}\frac{K_{t-1}}{N-1}\right],$$

$$K_t = (K_{t-1} + 1) \text{ with probability } p_{t-1}^{-} = \frac{K_{t-1}}{N}\left[\varepsilon + (1-\sigma)_{t-1}^{C\to F}\frac{N - K_{t-1}}{N-1}\right],$$
$$K_t = K_{t-1}, \text{ with probability } 1 - p_{t-1}^{+} - p_{t-1}^{-}. \tag{2.6}$$

where the probability that fundamental agent becomes technical one is shown in Eq. 2.7.

$$\begin{aligned}\left(1 - \delta_{t-1}^{F\to C}\right) &= 0,5 + \lambda \quad \text{for } A_t^C \rangle A_t^F,\\ \left(1 - \delta_{t-1}^{F\to C}\right) &= 0,5 - \lambda \quad \text{otherwise}\end{aligned} \tag{2.7}$$

Respectively that technical agent becomes fundamental one is shown in Eq. 2.8.

$$\begin{aligned}\left(1 - \delta_{t-1}^{C\to F}\right) &= 0,5 - \lambda \quad \text{for } A_t^C \rangle A_t^F,\\ \left(1 - \delta_{t-1}^{C\to F}\right) &= 0,5 + \lambda \quad \text{otherwise}\end{aligned} \tag{2.8}$$

Success (fitness of the rule) is represented by past profitability of the rules that are formalized in Eq. 2.9.

$$A_t^C = \left(\exp\left[P_t\right] - \exp\left[P_{t-1}\right]\right) D_{t-2}^C + d A_{t-1}^C \tag{2.9}$$

for the technical rules see Eq. 2.10.

$$A_t^F = \left(\exp\left[P_t\right] - \exp\left[P_{t-1}\right]\right) D_{t-2}^F + d A_{t-1}^F \tag{2.10}$$

for the fundamental rules. Agents use most recent performance (at the end of A^C formula resp. A^F) and also the orders submitted in period $t-2$ are executed at prices started in period $t - I$. In this way the profits are calculated. Agents have memory, which is represented by the parameter d. Values are $0 \leq \mathrm{d} \leq 1$. If $d = 0$ then agent has no memory, much higher value is, much higher influence the profits have on the rule fitness.

2.3.2 Extension of Original Model

Original model [27] has (in the authors parameterization) tendency to stabilize itself in a long term—if the fundamental trading rules are overbearing the technical trading method, although the bubbles and the crashes occur, their values are going to be smaller because the price is targeting near the fundamental value and the volatility is going to be less too.

After introduction of the transaction cost influence on the price—the price is going up to the bubble while technical traders are overtaking the market. Then possible two scenarios can occur:

- Transaction costs value is low—the price starts to be falling according the fundamental traders' weight growth. In this moment volatility falls down and the market stabilizes.
- Transaction costs value is high—fundamental traders' weight = 0, the system destabilizes and the price grows without limit.

The authors incorporated the risk into original model. The risk was implemented as a price risk percentage (*RP*) which is generated each turn from given interval according uniform random distribution <-1, 3>. So for risk influence the price formula has changed as shown in Eq. 2.11.

$$P_{t+1} = (P_t + \alpha(W_t^C D_t^C + W_t^F D_t^F) + \alpha_t)^* RP \tag{2.11}$$

Transaction costs were implemented in the same way as in previous simulations with adding constant value 0.001 to the price (Eq. 2.12).

$$P_{t+1} = (P_t + \alpha(W_t^C D_t^C + W_t^F D_t^F) + \alpha_t)^* RP + TC \tag{2.12}$$

The hypothesis was that transaction costs (Eq. 2.12) will bring the same effect to the market as in the case of pure model without risk involvement—with small amount of TC it will stabilize the market as in Figs. 2.1, 2.2, and 2.3 [28]. The agent-based simulation of the financial model implemented in Šperka and Spišák [28] has the tendency to stabilize itself in a long term, if the fundamental trading rules are overbearing the technical trading method. Although the bubbles and the crashes occur in the model, their tendencies are going to be less dangerous, because the price is targeting near the fundamental value and the volatility is going to be less. This description is similar to the current situation on the financial markets (Fig. 2.1).

By adding transaction costs (Tobin tax) to the model an observer can observe price changes. In the first situation Tobin tax was defined to be equal to 1, 5 %. The price grows up with the transaction costs to the bubble, while technical traders overtake the market. But the price starts to fall down according to the technical analysis growth. In this moment the volatility falls down and the market stabilizes. This is the main positive contribution of Tobin tax introduction into financial market in this agent-based simulation (Fig. 2.2). On the other hand when the value of the transaction

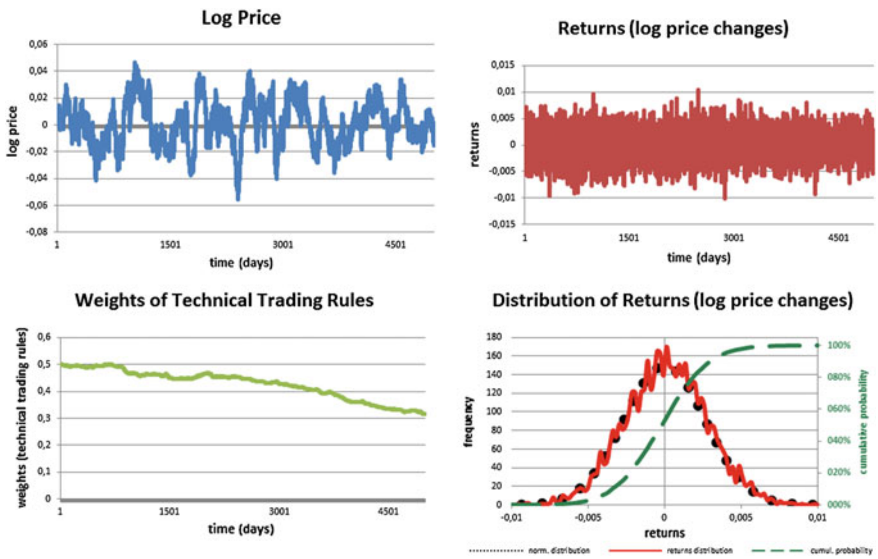

Fig. 2.1 Simulation results in original model. *Source* [28]

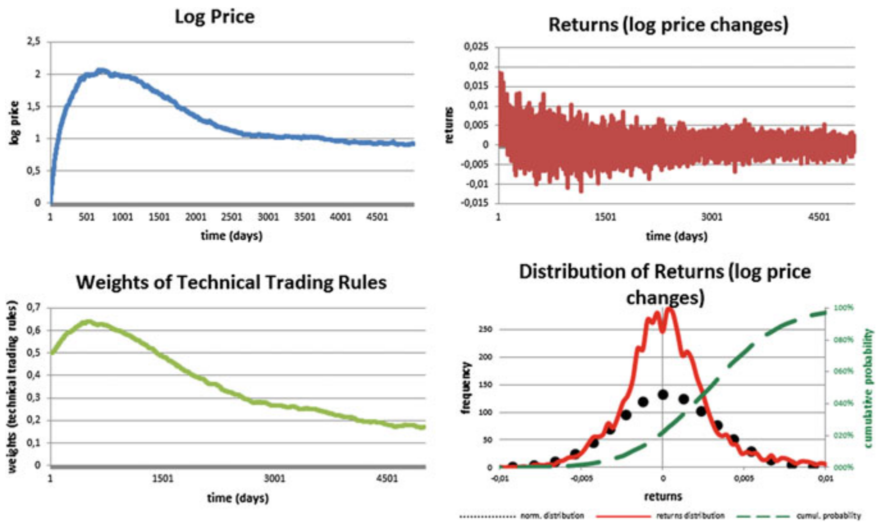

Fig. 2.2 Simulation results with transaction costs 0.015. *Source* [28]

costs is disproportionately high (3 % and higher), the system destabilizes and the price grows without limit (Fig. 2.3).

Two types of simulations were done in Sect. 2.4 using (Eq. 2.11) and (Eq. 2.12)—one only with risk percentage and the second one with transaction costs to see the difference.

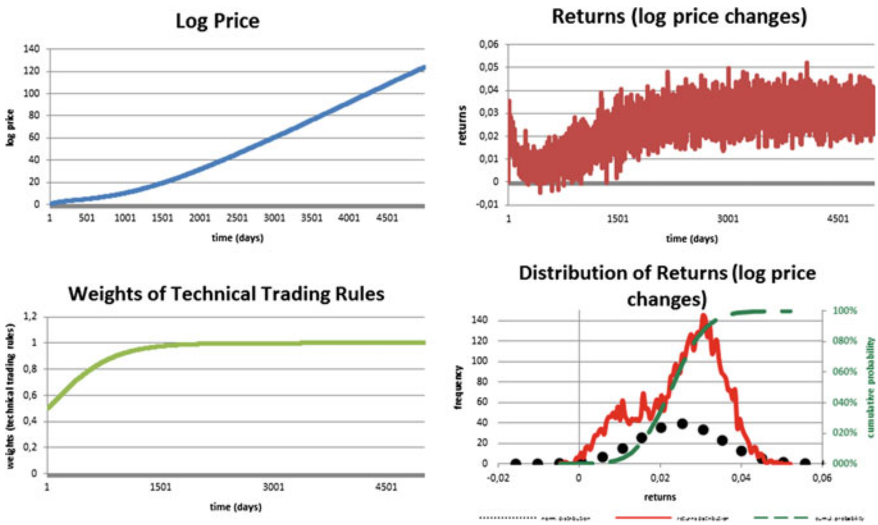

Fig. 2.3 Simulation results with higher transaction costs 0.03. *Source* [28]

2.4 JADE Implementation

JADE (Java Agent Development Framework) integrated development environment (IDE) was used for the implementation. JADE is the sophisticated solution, which is an implementation of the runtime agent environment and a communication platform. It includes runtime environment, where agents exist, libraries to write them and also graphical tools to administrate them and monitor their state. Wooldridge [29] says that it is best-known and the most widely used platform for agent modeling. Agent communication language is FIPA ACL [30].

This framework was developed by Telecom Italia in 1998 and it is still in development progress. The current version used is 4. Runtime environment running instance is called a container. At once it is possible that more than one container is running. All active containers are called a platform. Agents are located in these containers. The agent is a Java class—descendant of base JADE class Agent. Its behavior is implemented in private subclasses of the concrete Agent class extension. This behavior extends JADE class *Behaviour* [30].

Two levels of agent hierarchy were implemented. FMM base agent (*BaseFmmAgent*) contains base functionality, such as registering to the yellow pages, searching for other agents, clean-up and so on. There exist two descendants:

- **Trading agent**—represents trader in the market with his decision making.
- **Market agent**—represents market itself. Manages the turns begin and start, price making calculation, rules fitness and their weights, analysis market volatility via price differences each turn and also writes these values to result output.

Fig. 2.4 Class model of implementation

Market agent communicates with trading agents—they are informed about the rules fitness. To understand each other, agents need ontology. "Ontology is a specification of a set of terms, intended to provide a common basis of understanding about some domain" [29]. JADE offers the base Ontology class that is extended by the implementation of singleton class *FmmOntology* (Fig. 2.4).

2.5 Simulation Results and Discussion

Simulation was done with 1 marketing agent and 500 trading agents. The rest of the parameters remained same as in original Westerhoff model [27]:

$a = 1, b = 0.05, c = 0.02, d = 0.95, \varepsilon = 0.1, \lambda = 0.45, \sigma\alpha = 0.0025$, $\sigma\beta = 0.025$, and $\sigma\gamma = 0.0025$

With these parameters the model is calibrated to the daily data. Number of ticks, resp. time steps is 360 days, which represents one year. Each generation (risk only and risk with transaction costs) was done 25 times. Results were aggregated to obtain more accurate results. In graphs are shown average data. Interval for price risk percentage values was decided as <–1, 3>; when 1 (as 100 %) means not changed price, the result is that price can change ±200 % each day. Results can be seen in the Fig. 2.5.

In Figs. 2.5 and 2.6 on the top left position the price values can be seen. Top right graph represents changes of the price in a time. The bottom left graph shows the weights of technical trading rules (in a long time there is a tendency to prefer fundamental than technical trading rules). Bottom right graph includes the distribution of returns (log price changes) compared with the normal distribution.

Fig. 2.5 Results for risk involvement

Fig. 2.6 Results for risk involvement together with TC

In the next step the authors added TC to the model formalization. All the parameters are the same. Newly added TC is the constant value equal to 0.001. From the following graphs in Fig. 2.6 it can be declared that transaction costs have partial influence on the model. The price refers to no changes in a time. The technical weights evolution is other. In a short time it grows, but after it starts to fall—as the agents prefer the fundamental strategy. Results are depicted in the Fig. 2.6.

2.6 Conclusion

Agent-based simulation of financial market was introduced in this chapter. Intelligent agents representing financial market participants followed fundamental and technical rules. The probability that agent switches from the fundamental to the technical behavior depends on the historic trend of asset's prices. The hypothesis for this research was based on previous simulation results proving that transaction costs influence (Tobin tax) stabilizes the financial market. The authors incorporated the risk into original model and assumed that transaction costs introduction would lead to the predominance of fundamental rules, which will automatically cause price lowering and market stability (measured by volatility in price changes).

The hypothesis was fulfilled only partially—the fundamental rules have growing tendency in time, but the prices and their differences are nearly the same in both simulations. The authors will focus on the risk and parameterization of the model in future research steps in order to prove that Tobin tax has positive impact on the stability of financial market.

Acknowledgments This work was supported by grant of Silesian University no. SGS/6/2013 "Advanced Modeling and Simulation of Economic Systems".

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http://www.springer.com/978-3-319-21208-1

Intelligent Decision Technology Support in Practice
Tweedale, J.W.; Neves-Silva, R.; Jain, L.C.; Phillips-Wren, G.; Watada, J.; Howlett, R.J. (Eds.)
2016, XXIX, 261 p., Hardcover
ISBN: 978-3-319-21208-1