Agent-Based Simulation of the Influence of Customers' Behaviour on the Bank's Failure

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Abstract: In Lithuania like in other states there are different capital credit institutions and banks (from 10 to 20) operating in the country. Even in small towns with the population of nearly 20 000, there are up to five operating banks and credit unions. Nowadays, the success of commercial banks depends upon their image and the opinion of the interested groups of the society about the quality of provided bank services. Being rather high competition among banks, there are cases when there appears rumours about poor economic situation in one or another bank. The key of such canard might be caused by negligence at work, for example, untimely loaded ATMs. The bank has a possibility to observe the amount of money in the ATM, therefore, it can't be empty in normality. However, there are cases, when due to the staff negligence or other reasons, commissions aren't carried out in time, also, crediting official registration takes too long, sometimes, lack of money in the branch of the bank to pay off the money after the term of the deposit expires. Rumour spreads really fast. Disbelieving in canard is the state's rather significant policy in respect of the bank. Unfortunately, people take canard easier. However, in the cases, when it's impossible to get their money back whenever a person wants, it might cause panic and, in spite of the fact, that the bank operates normally, serious problems can appear. The *aim* of the research and the article was to investigate influence of canard on banks customers' behavior and effects of various bank decisions regarding of giving back to depositors their money. The *research methodology* was agent-based modelling of impacts of canard/rumour spreading and bank's decisions. Simulation and its *result*s showed that the possibility for bank customers to get back their money suppresses rumours, but limitations intensify the panic. Authors suppose that the *significance* of the model and its results' lies in demonstration of possibility of agent-based models to investigate the banks and its customers' behavior without real-life experiments. The agent-based modeling can be used in university in consumer behavior courses as well.

Keywords: agent-based modeling, customer behaviour, banks, failure, university education.

Introduction

In Lithuania like in other states there are different capital credit institutions and banks (from 10 to 20) operating in the country. Even in small towns with the population of nearly 20 000, there are up to five operating banks and credit unions. In Lithuania or the country where there is a credit institution, usually, there are one or two national banks, others – foreign capital banks, however, stability, trustworthiness and capital sufficiency often depend upon the country's, which owns the credit institution, economic situation. In case of economic recession in the country, the parent bank and also bank branches in other countries fail as well. Risky loans, self-wilfulness and abuse as well as panic of depositors and other factors were the main reasons why the banks in Lithuania collapsed in 1994 – 1996 (Šadžius, 2004). E. Martinaityte, V. Matutis (2012) presented the review about the crisis of banks in different Central European countries.

Nowadays, the success of commercial banks depends upon their image and the opinion of the interested groups of the society about the quality of provided bank services (Druteikiene, Marcinskas, 2000).

Being rather high competition among banks, there are cases when there appears rumours about poor economic situation in one or another bank (Bank customers …, 2013). The key of such canard might be caused by negligence at work, for example, untimely loaded automated teller machines (ATM). The bank has a possibility to observe the amount of money in the ATM, therefore, it can't be empty in normality. However, there are cases, when due to the staff negligence or other reasons, commissions aren't carried out in time, also, crediting official registration takes too long, sometimes, lack of money in the branch of the bank to pay off the money after the term of the deposit expires. Rumour spreads really fast. Disbelieving in canard is the state's rather significant policy in respect of the bank. Several banks have already gone insolvent in Lithuania but fortunately the depositors got their money back. Therefore, it is natural, that people take canard easier. However, in the cases, when it's impossible to

get their money back whenever a person wants, it might cause panic and, in spite of the fact, that the bank operates normally, it serious problems can appear.

M. Gallegati, G. Gulioni and N. Kichiji (2003) in their article asserted: "The lack of analytical tools able to cope with heterogeneous interacting agents and their aggregate dynamics is one of the goals of future economic research". Z. He and A. Manela (2016) analyzed rumour-based bank run using analytical models.

The agent-based model of canard/rumour spreading using empirical facts has been presented in our article. The application of agent-based model in social research studies is not new. In his paper A. Getchell presented the review of the tools of modern agent-based modelling and, also, their comparison (Getchel, 2008). In their article D. Plikynas and A. Budrionis examined multi agent system application possibilities for social research studies and present the model of hybrid multi agent system, being able to convey dynamic agent interactions in changing environment (Plikynas, Budrionis, 2010). The authors made the conclusion, that the application of computer intelligence and multi agent systems might reduce the cost (price) of social experiments significantly and, also, enable forecasting and optimizing the consequences of social policy decisions. In the article the authors present the heterogenic agent model of a business cycle, where they model the bank performance under the conditions of enterprise bankruptcy.

The aim of the research and of the article is to investigate influence of canard on banks customers' behavior and effects of various bank decisions regarding of giving back to depositors their money.

Methodology

The research methodology was agent-based modelling of impacts of canard/rumour spreading and bank's decisions. The bank was modelled as single agent. The behavior of the agent was defined with its statehart and transition rules between states. These rules modelled bank decisions about filling frequency of the ATMs'. Similary, depositers were modelled by another kind of agents. These agents tried to take back their money using ATM. If the bank imposed extra limitations on the money amount or did not increase the initial ATM refill frequency then it saved money for a short time but increased panic of depositors. Depositors exchanded their panic with other people that increased attempts to draw out more money. The main research question was to investigate if the limitations on the amount of money allowed to draw out from ATMs and if not sufficient refill frequency of ATMs can help to reduce the decrease rate of bank's cash.

Results and discussion

The agent-based model set-up

Our model is focused on agent-based computer simulation and is devoted to verify the bank's actions when some false information spreads out about the possible bankruptcy. In such a case the depositors' fear might cause the bank irretrievable damage. Therefore, it's essential to choose right actions to dispel the bank clients' panic and return their confidence (He, Manela, 2016). Due to understandable reasons, it's impossible to carry out real-life experiments to choose and verify the action tactics of the bank. Therefore, the agent-based simulatiom *method* has been chosen. This method enables using the program entities called agents to simulate actions, decisions and interactions of many people, institutions and other kind of objects (Borshchev, 2013).

The key assumptions ot the model: in a small town there live 20 thousand people and there are 8 ATMs of the 4 banks there. This is a typical situation in Lithuania. Therefore, one bank with 2 ATMs and 5 thousand depositor activity and crisis-ridden solutions has been modelled under such conditions.

This means, that around 2500 depositors share 1 ATM, that corresponds to the data which are published by the Lithuanian Bank (Bendra banku…, 2016). Usually clients withdraw their money in ATMs. Therefore, it is modelled the money withdrawls only from ATMs.

Supposedly, the quantity of the client's deposit is in the interval from 200 EUR to 9 000 EUR and is modelled by the asymmetric beta distribution, where the maximum point is 1 160 EUR, however, the withdrawal limit is 1 000 EUR per day (Figure1).

The bank cash comprises depositor money and the money of paying off loans, including interest. The initial precondition is, that under normal conditions the ATM is refilled every 30 hours. 12 hours are modelled per day, since people use ATMs more or less half a day, though, ATMs are available the entire twenty-four hours

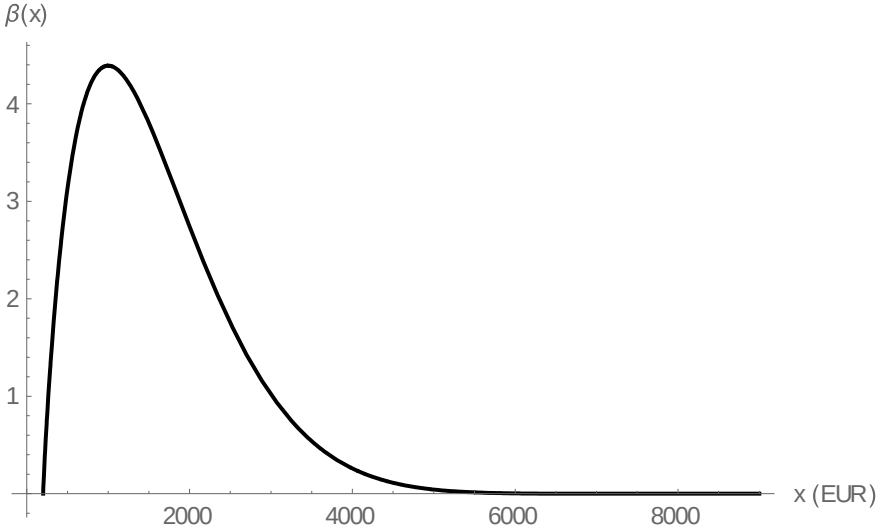


Figure 1. Deposit quantity in EUR, distribution β(x).

Client trust in the bank is modelled by scores: from 0 (absolute distrust) to 1 (absolute trust), the distribution is shown in Figure 2. Every client has been modelled as an agent.

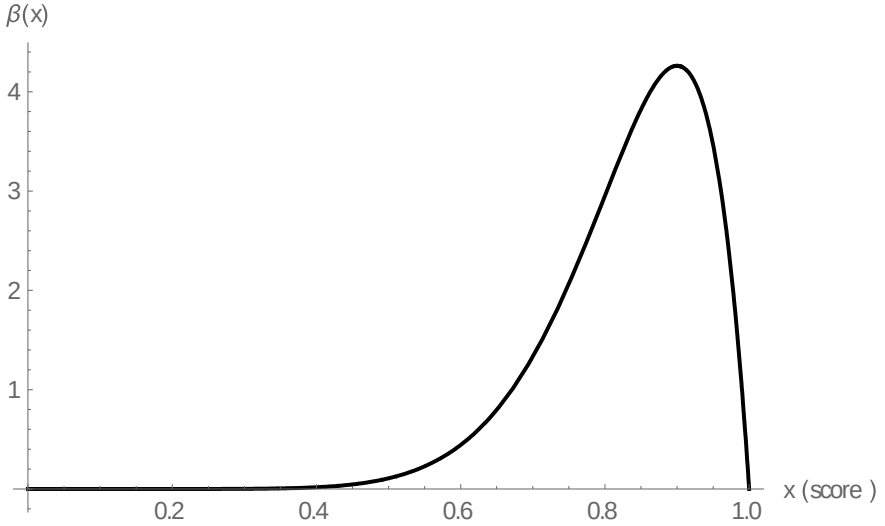


Figure 2. Distribution β(x) of consumer trust in the bank.

The initial customers' trust in the bank is assumed to be distributed by beta distribution. It is assumed, that a person trusts while his trust-score is higher than 0.5. As it is seen from Figure 2, initially, just a very small part of customers have lost their trust in the bank.

The behaviour of each out of total 5000 costumer-agent was modelled by the statechart given in Figure 3. The customer that has lost the trust decides to take his money back from the bank and also warns his friends, sending a message about his doubts. The number of friends is a random number from interval [4;8]. Each received message decreases the score of trust. When the score falls below 0.5, the customer takes a decision to withdraw his money from the ATM. If the ATM is already empty and out of service, then the person waits for one hour, continue spreading rumour messages and tries again after one hour. If the person succeeds in being served and gets money within his daily limit of 150 EUR, his trust increases by 0.1 score. If the increased score is still below 0.5, he tries to get another part of his money next day, yet, he recovers the trust above 0.5. If the customer withdraws all his money, he is out of model.

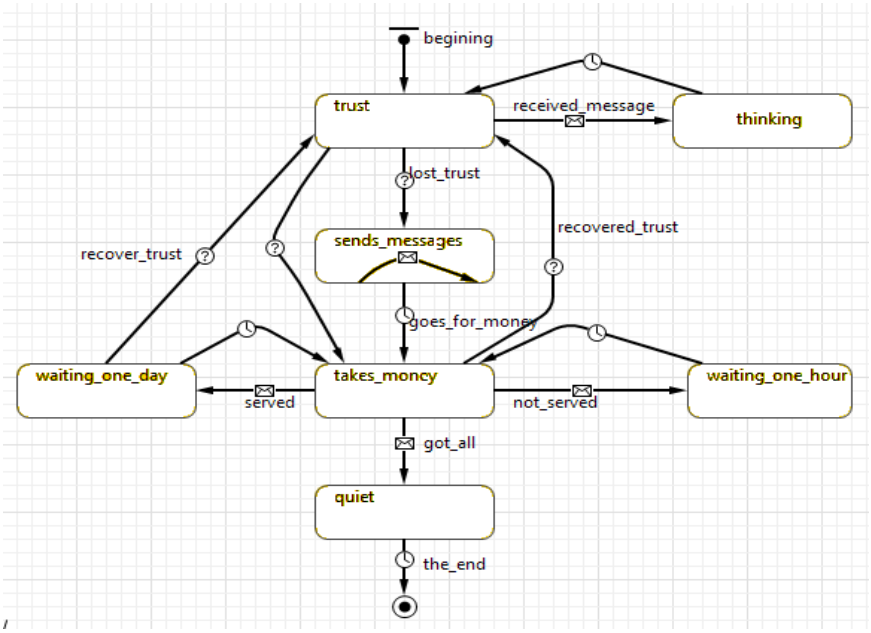


Figure 3. The statechart of the bank customer behaviour.

The bank was modelled as single agent. It collected information about the states of each ATM and took the decision to increase the initial ATM refill frequency with cash, if necessary. The bank‘s statechart is given in Figure 4.

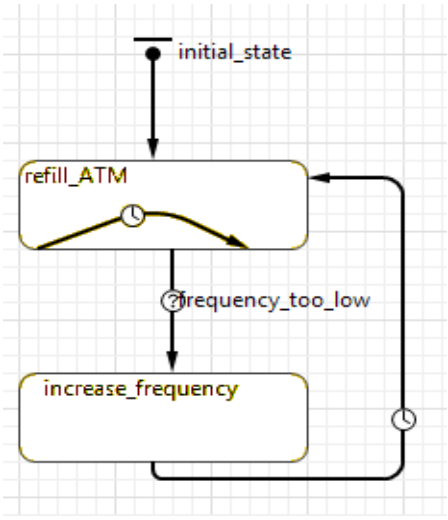


Figure 4. The bank decision statechart.

What is more, the state bank was simulated as one more agent in the model, which, in case of customer panic, publishes statements to weaken spreading canard (rumour). This information of the state bank increases every customer‘s trust score by 0.1.

Simulation results

The simulation was carried out with the multimethod simulation software Anylogic**.** This program is a tool that brings together system dynamics, discrete event, and agent-based methods.

For the first series of simulation experiments the refill amount of ATMs was set at 30 000 EUR and frequency 30 hours. Due to rather large amount of 5000 customers, the results did not differ significantly in different model runs, despite the randomness of agent parameters. The simulation revealed that the cash in ATMs did not run out (Figure 5). During the first 30 hours customers withdrew more cash than later. This indicates that canard did not cause the panic. During the next 30 hour period canard decreased even more, what reflected in the withdrawal of money from ATMs. This could be explained by the fact, that the possibility to take money back didn‘t encourage to spread canard.

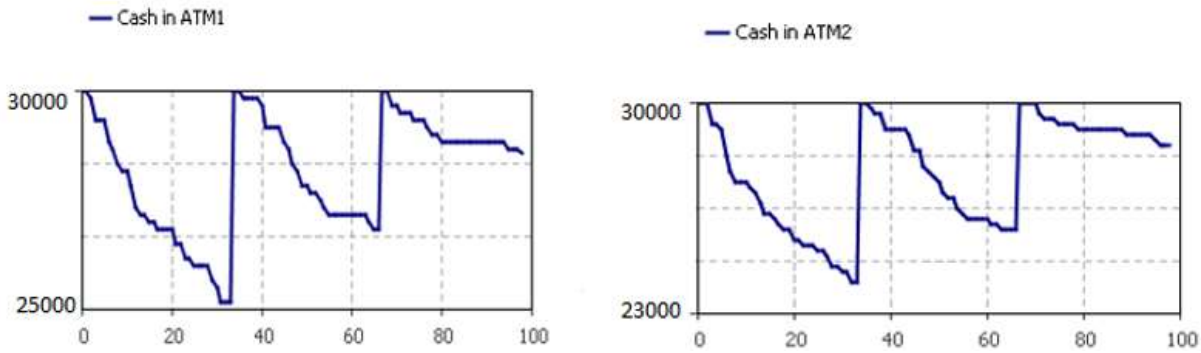


Figure 5. Change of cash in ATMs over 100 hours, when the refill amount is 30 000 EUR. Cash did not run out.

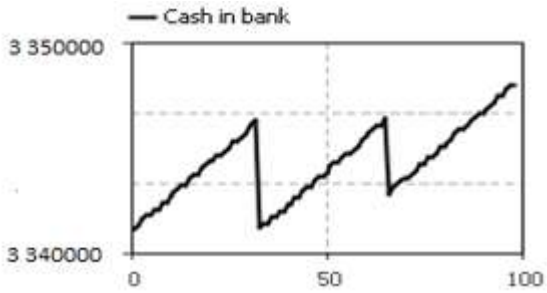


Figure 6. Change of cash in the bank over 100 hours, when the refill amount is 30 000 EUR and he bank has income.

The amount of cash in the bank increased because of coming cash flows as interest from loans (Figure 6). In the graph the leaps down correspond to the moments of cash increases in ATMs as the money in the bank‘s cash desk is shown here.

However, as ATMs are refilled with a lot smaller amounts of money, there isn‘t enough money left till next refill (Figure 7). So, it‘s seen here, that after every refill, which corresponds to the graph peaks, the curves go down much quicker. That means, because of panic, ATMs are emptied a lot faster.

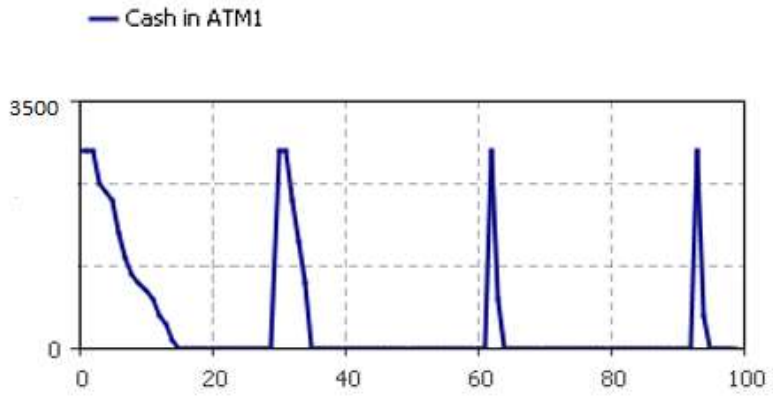


Figure 7. Amount of cash in ATM over 100 h when the refill is 3 500 EUR.

Figure 8 demonstrates, that, when there is a lack of money, trust in the bank decreases very fast (curve *Trust*). Its local maxima correspond to the time moments, that the state bank publishes calming statements.

However, these calming statmements are temporary and the number of depositors, having decided to take their money back from the bank, is growing (Figure 8, curve *Go for money*) and the number of distrustful people is also rising (Figure 9). Therefore, after 100 modelling hours, one/fifth of the clients trust the bank and the distrust is increasing. So, the bank prospect can‘t be taken as positive.

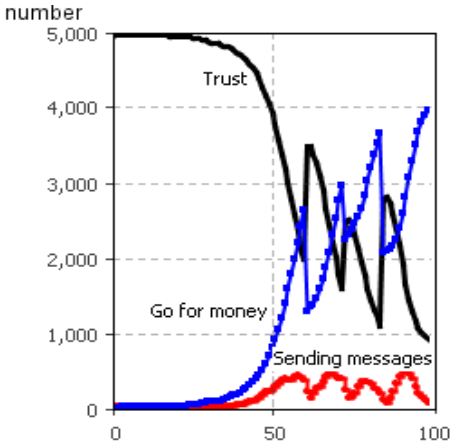


Figure 8. Behaviour of 5 000 customers over 100 h when the refill is 3 500 EUR.

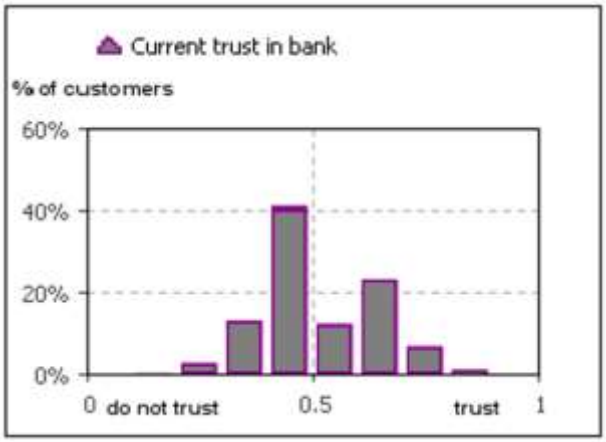
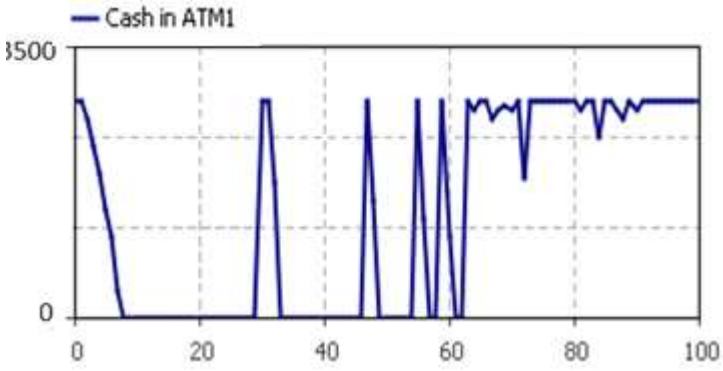


Figure 9. Distribution of 5 000 customers according to their trust after 100 h when the refill is 3 500 EUR.

The simulation experiment when the bank, having noticed that ATMs lack money, doubles the frequency of refilling until it is sufficient amount of money in the ATM has also been carried out (Figure 10).



Figue10. Amount of cash in the ATM over 100 h when the refill is 3 500 EUR, and the refill frequency is doubling.

In this case, around 2000 clients still trust the bank and the number doesn‘t go down (Figure 11). However, the clients, having decided to take their money back, take it within the daily withdrawal limit and their confidence doesn‘t recover. The formed balance must be kept stable as more or less after 60 modelling hours canard or rumour disappears.

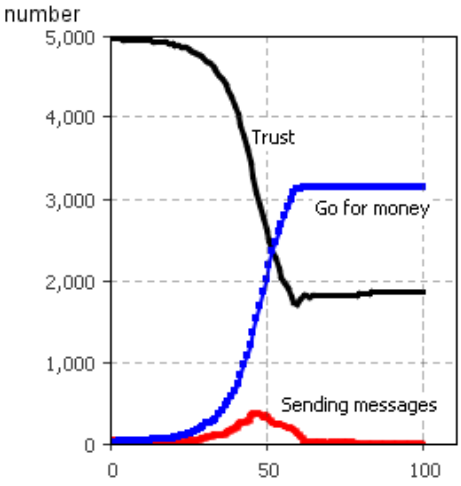


Figure 11. Behaviour of 5 000 customers over 100 h when the refill is 3 500 EUR and the refill frequency is doubling.

Conclusions

The outcomes of the simulation showed, that

- the initial number of the people distrusting the bank didn‘t cause panic if depositors were alowed to get their money, they didn‘t believe canard/romour;
- however, when organizational difficulties in the bank service last longer than one day, they stimulate starting rumours and panic;
- limitation could only delay outcome, but not remove it;
- public statements also have short positive social effect.

Simulation under given assumptions at work hasn‘t proved the opinion what sometimes happens, that in case of panic it is necessary to limit taking back deposits and in this way to maintain bank liquidity. Therefore, providing opportunities for depositors to dispose their money freely, what in the simulation was implemented as doubling the frequency of refilling ATMs, dispelled panic, though, the bank lost some part of its clients.

That there wasn‘t modelled the opportunity in the model to take money from the bank office directly because of simplicity, it should not be kept as limiting circumstance. Even though it is possible to get back all the deposit in the office at once, however, the service is slower and this should not change the key simulation outcomes/results.

The article also demonstrates the agent-based approach to customer behavior modeling that can be used in university courses.

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