MONTE CARLO SIMULATION - THE BANK ACCOUNT SELECTION IN THE CZECH REPUBLIC ACCORDING TO THE BANK CHARGES

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ABSTRACT
Simulation methods belong to the suitable instruments that can be used in the real world situations to better understand the reality or to make a responsible decision. Monte Carlo simulation is a method for iteratively evaluating a deterministic model using sets of random numbers as inputs. This method is often used when the model is complex, nonlinear, or involves more than just a couple of uncertain parameters. As in the Czech Republic the situation with the selection of the appropriate bank account is complicated (because of the non-transparent bank charges), we have created a simulation model to find the best account for 3 different types of retail clients. We compare our results with the solution obtained from MS Excel, Crystal Ball and the multi-criteria evaluation of alternatives model.

Keywords: Monte Carlo Simulation, Bank Account, Bank Charges

1. INTRODUCTION
Simulation nowadays means a technique for imitation of some real situations, processes or activities that already exist in reality or that are in preparation – just to create a computer model (Banks 1998). The reasons for this are various: to study the system and see how it works, to find where the problems come from, to compare more model variants and select the most suitable one, to show the eventual real effects of alternative conditions and courses of action, etc. Simulation is used in many contexts, including the modeling of natural or human systems in order to gain insight into their functioning (manufacturing, automobile industry, logistics, military, healthcare, etc.), simulation of technology for performance optimization, safety engineering, testing, training and education.

As simulation models use principles taken from mathematics and statistics, they are sometimes added to the problematic of the operational research or management science (Turban Meredith 1994) where different models are constructed to find the optimal solution or the optimal choice. Simulation itself usually has not the main aim to find the best alternative but it might help in this process.

In economy we must face a lot of decisions that have to be made, and pay a lot of money afterwards often without knowing whether we have done right or wrong. When everything is given, the solution or decision can be based on the common sense or on the solution of some mathematical model (optimization on or as a result of the decision-making model). But the problem is that a lot of things not only in economy are not certain – especially when we think about money spent for something. People are usually able to describe the expenses as "something between 8 and 12 thousand crowns" or "15 thousand crowns at a medium". Although it seems to be vague, inaccurate and insufficient, with some knowledge of statistical distributions we are able to use given information and even make a decision or recommendation via Monte Carlo simulation model.

Monte Carlo simulation can be used in any situation where we would like to calculate some outputs that are dependent on random inputs. This is typical situation for various decision-making processes. Simulation in finance and banking is not still widely spread (especially in the Czech Republic in real-life situations). As we face an increasing problem with high bank charges, we have decided to use Monte Carlo simulation to find out the cheapest bank according to the charges and random amount of demanded services. We describe the situation in the banking sector, the simulation model and we compare the results with the results taken from the static decision-making model when the WSA method is used.

2. CZECH BANKING SECTOR
The banking sector of the Czech Republic is formed by 44 subjects (CNB 2012), where 17 are the real banks (4 big, 4 middle, 9 small ones), the rest includes foreign bank branches and building societies. The structure of the market is nearly steady but during the last two years the situation has changes because 3 new banks came to the Czech market – Fio Bank, Air Bank and Zuno Bank AG. These small banks (the first of this type was mBank) have different strategies especially in small or zero fees and they are aimed at the usage of the internet banking. The main part of the sector is still hold by the group of four big banks (KB, CSOB, CS, UniCredit)

whose share of the actives of the whole banking sector was nearly 58% in 2010. The announcement of the Czech National Bank (2012) says that nearly 74% of the non-interest profit of the Czech banking sector is made by the profit taken from the bank charges and bonuses. As you can see on the Figure 1, the profit from these fees is still rising (between the years 2009 and 2010 the increase was more than 5%).
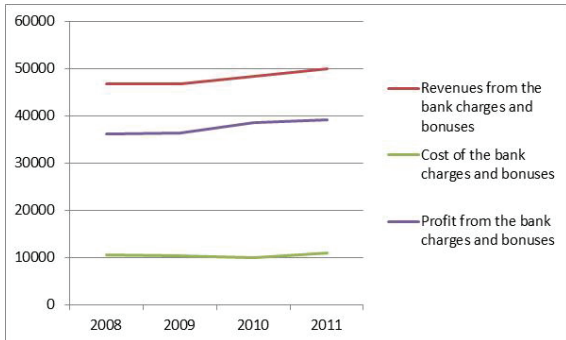

Figure 1: Revenues and Cost of the Bank Charges and Bonuses (www.bankovnipoplatky.com)

The growth rate of the profits is slowing down – there might be different reasons for this trend but one of them is the increasing competition (coming of the new banks) and also easier change of the bank by clients. The report of the Capgemini company (2011) created in cooperation with ING and EFMA shows the main changes and trends in retail banking sector in all over the world – and it shows that fees are the third most important reason for leaving a bank – 50% of customers change a bank because of the fees (Figure 2).
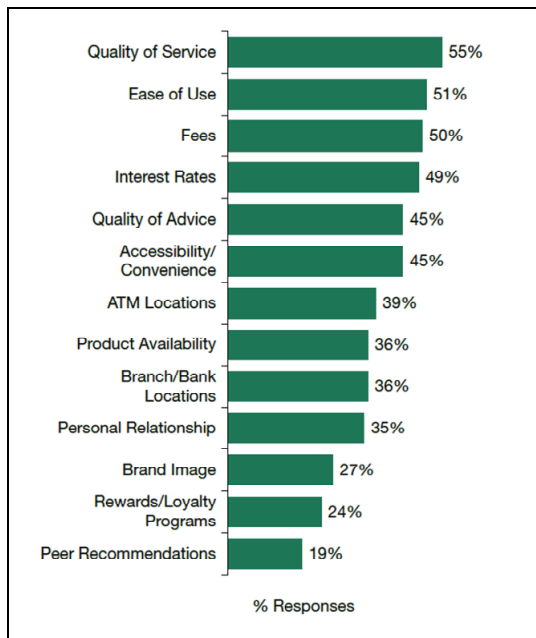

Figure 2: Factors That Affect Why Customers Leave a Bank Revenues and Cost of the Bank Charges and Bonuses (www.bankovnipoplatky.com)

From the previous information it is clear that the bank charges (or fees) are very important not only in the Czech Republic but all over the world. But there is still a lot of banks that things fees are not so high to persuade the client to leave. So our simulation model shows how different the real situation can be. One of the reasons why we use Monte Carlo simulation is the fact that it is not possible to state that each month the behavior of the person connected with the bank account transactions is the same. That is why we suppose this kind of calculations are more precise than the results you can have from various calculators aimed at the Czech bank account fees (www.bankovnipoplatky.com; www.penize.cz; web pages of the Czech banks).

3. MONTE CARLO SIMULATION

Monte Carlo simulation (or technique) is closed to statistics as it is a repeated process of random sampling from the selected probability distributions that represent the real-life processes (Turban, Meredith 1994). On the basis of the existed information we should select the type of probability distribution (that corresponds with our expectations about the values of the variable, and we are able to define all the parameters for).

The problem of some economic models is the lack of the information – especially in the retail sector sometimes only managers themselves know how the process works, what the typical number of customers during a period is etc. In this kind of situations we cannot use basic statistical or mathematical models as we do not have the strict or real data. That is why Monte Carlo simulation can help as it uses random variables from different distributions. The most typical and frequent distribution types are normal, triangular, uniform (discrete uniform), Poisson, lognormal and exponential ones. Mathematical specification of these variables and the calculations derived from them might be complicated (especially when non trivial distribution is chosen). But via the simulation Monte Carlo and via MS Excel and its add-ins (for example Crystal Ball) it is possible to analyze the problem and find a solution or a recommendation for each specified situation (Kuncova 2006).

3.1. MS Excel Usage for Simulation

MS Excel spreadsheet can be a good environment where to start Monte Carlo simulation, since almost nearly all people working with computer know how to work with it, although Excel is not the best place to run a scientific simulation, especially discrete or continuous one. Excel contains a pseudo random number generator that was tested for sufficiency in 1991 by Law and Kelton (Law 2000). The function is invoked using the Excel function =RAND(). It generates a uniformly distributed pseudo random number between 0 and 1. Its values can be easily updated by pressing the Calculation Key F9 (every press means new simulation experiment) or we can have more simulation experiments using data tables. Via this generator it is possible to generate

random variables having any other distribution – see Table 1.

If the distributions described in the Table 1 are sufficient to describe all uncertain variables that we have, it is possible to use an Excel sheet to solve the problem – only define the interconnections between the variables and specify the decision function. If other distributions are necessary it is better to use some add-in application such as Crystal Ball, @Risk, Lumenaut, Simtools, Formlist, MonteCarlito, Simulacion 4.0, SimulAr, Risk Analyzer, etc. For our analysis we use Excel and Crystal Ball.

Table 1: The Excel expressions for generation of random variables from given distribution (Kuncova 2006)

Distrib.	Parameters	Excel Expression
Uniform	a,b	=a+RAND()*(b-a)
Normal	μ,σ	=NORMINV(RAND(), μ, σ)
Lognormal	μ,σ	=LOGINV(RAND(), μ, σ)
Exponential	$1/\lambda$	=(-1/ λ)*LN(RAND())

3.2. Crystal Ball

Crystal Ball is one of the MS Excel add-in applications for the Monte Carlo simulation models. "Oracle Crystal Ball solutions begin with Oracle Crystal Ball, the base package for predictive modeling, Monte Carlo simulation and forecasting. Oracle Crystal Ball Enterprise Performance Management builds on that set of tools by adding the power of Oracle Crystal Ball to your Oracle Enterprise Performance Management (EPM) and Oracle Business Intelligence (BI) applications" (www.oracle.com). The advantage of this software is the usage of Excel tables, so it is possible to use models created before but change the distribution for random inputs generation. Then usually 1000 trials are run and afterwards the programme gives all statistics (and histogram) of the selected decision cell. Figure 3 shows all the possible statistical distributions that can be chosen.
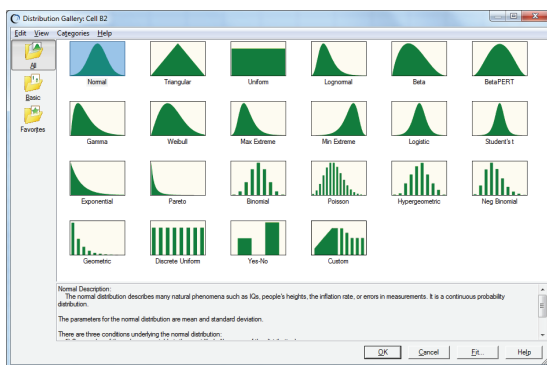

Figure 3: Crystal Ball – Distribution Gallery (www.oracle.com)

4. MATERIALS AND METHODS

Before we start the analysis we have to select the alternatives (bank accounts), the criteria and the distributions for the random variables generation. As we would like to compare the results with the order of the accounts created by the WSA method, we shortly describe also principles of this method.

4.1. Bank Accounts

Each from the 17 banks offers different types of accounts. As we are interested in the retail market (the accounts for the physicians) we have selected following 12 banks that offer this type of account:

- Komercni banka (KB) (www.sazebnik-kb.cz)
- CSOB (www.csob.cz)
- Ceska sporitelna (CS) (www.csas.cz)
- mBank (www.mbank.cz)
- Fio Bank (www.fio.cz)
- Raiffeisenbank (www.rb.cz)
- City Bank (www.citybank.cz)
- Airbank (www.airbank.cz)
- GE Money Bank (www.gemoney.cz)
- Volksbank (www.volksbank.cz)
- UniCredit Bank (www.unicreditbank.cz)
- LBBW Bank (www.lbbw.cz)

According to the up-to-date scale of charges we have found out all the fees at the web pages of the banks.

4.2. Criteria Selection

The main aim is the comparison of the bank accounts according to the various bank charges. We have found 20 cases when bank wants a fee for something – usually for the cash withdrawal, incoming or outgoing payments (it differs if it is to or from the own bank or another bank). As the cash deposit made at the desk is free of charge for all selected bank accounts, we have following 19 criteria where it is necessary to pay a fee:

1. monthly account charges
2. electronic debit card
3. cash withdrawal from ATM of own bank
4. cash withdrawal from ATM of another bank
5. incoming payment (from another bank)
6. incoming payment (from own bank)
7. outgoing payment to the own bank (at the desk)
8. outgoing payment to the own bank (via internet)
9. outgoing payment to another bank (at the desk)
10. outgoing payment to another bank (via internet)
11. permanent order for payment to the own bank (at the desk)
12. permanent order for payment to the own bank (via internet)
13. permanent order for payment to another bank (at the desk)

14. permanent order for payment to another bank (via internet)
15. collection (own bank, at the desk)
16. collection (own bank, via internet)
17. collection (another bank, at the desk)
18. collection (another bank, via internet)
19. cash withdrawal (at the desk)

4.3. Decision-Making and WSA Method

Multi-criteria evaluation of alternatives belongs to the category of discrete multi-criteria decision-making models where all the alternatives and criteria are known. To solve this kind of model it is necessary to know the preferences of the decision maker. These preferences can be described by aspiration levels (or requirements), criteria order or by the weight of the criteria (Evans 1984). WSA (Weighted Sum Approach) method belongs to the group where the importance of the criteria is given by their weights. This method sorts the alternatives based on the values of their utility functions which in this case are assumed to be linear. Higher value of utility means better alternative. The calculations are easy and can be made is MS Excel or in some add-in applications like Sanna (Jablonsky 2009).

4.4. Random Variables for 3 Client Types

On the various web pages you can find a lot of calculators that should help you to find the best account for your needs (usually with the lowest fees). Sometimes not only fees are important so it is not comparable with our case – but the problem of the calculators is that they need exact data (such as number of transactions, number of ingoing and outgoing payments etc.). But these numbers are not fixed in real-life situations, they usually differs from month to month. That is why we think that Monte Carlo simulation is better than the calculators.

Inspired by Hedvicakova and Soukal (2011), we have created 3 types of the clients for whom we are looking for the best account with the minimum bank charges. Each client has its own frequency of withdraws and its communication channel. These clients are:

- Active Client
- Branch Office Client
- Average Internet Client

The differences can be seen from the Table 2 where number of each activity is specified.

An active client uses all the paid services more frequently than the others. Branch office client usually prefers the cash withdraws at the desk (in the branch office) than from ATM. Average internet client takes advantage of the internet banking. As the description of the clients' behavior is given by two numbers (minimum and maximum) we started the random generation of the numbers of each activity with the uniform distribution.

Table 2: The types of the clients and monthly numbers of each activity

Number of the activites per month	Active Client	Branch Office Client	Avg.Internet.client
monthly account charges	1	1	1
electronic debit card	1	1	1
cash withdrawal from ATM of own bank	2 to 6	1 to 4	2 to 5
cash withdrawal from ATM of another bank	0 to 3	0 to 1	0 to 2
incoming payment (from another bank)	2 to 6	1 to 3	1 to 4
incoming payment (from own bank)	1 to 4	0 to 2	0 to 2
outgoing payment to the own bank (at the desk)	0 to 1	1 to 3	0
outgoing payment to the own bank (via internet)	2 to 7	0 to 2	1 to 3
outgoing payment to another bank (at the desk)	0 to 1	1 to 4	0
outgoing payment to another bank (via internet)	3 to 7	0 to 2	2 to 6
permanent order for payment to the own bank (at the desk)	0 to 1	1 to 3	0
permanent order for payment to the own bank (via internet)	2 to 4	0 to 1	0 to 2
permanent order for payment to another bank (at the desk)	0 to 1	1 to 4	0
permanent order for payment to another bank (via internet)	3 to 6	0 to 1	2 to 5
Collection (own bank, at the desk)	0 to 1	0 to 2	0
Collection (own bank, via internet)	1 to 3	0	0 to 1
Collection (another bank, at the desk)	0 to 1	0 to 3	0
Collection (another bank, via internet)	1 to 3	0	0 to 3
cash withdrawal (at the desk)	0 to 1	0 to 2	0

5. RESULTS

First we summarize the task: to compare 12 selected accounts according to the 19 criteria with respect to three different types of clients. Table 3 summarizes the bank charges for each of the selected criteria (mentioned above).

Table 3: Bank charges for the account and criterion

crit.	KB	CSOB	CS	mBank	Fio	Raiffeisenbank	City Bank	Airbank	GE Money Bank	Volksbank	UniCredit Bank	LBBW Bank
1	50	30	69	0	0	75	169	0	59	47	50	100
2	200	540	200	0	0	540	0	0	708	492	200	600
3	5	6	6	9	0	10	0	0	15	4	5	6,5
4	35	35	40	35	35	40	30	25	40	35	30	6,5
5	5	6	7	0	0	5	0	5	5	0	6	2
6	5	6	5	0	0	7	0	0	5	0	6	0
7	29	40	0	0	0	48	49	0	50	0	45	35
8	6	6	5	0	0	4	0	0	6	0	0	5
9	29	40	0	0	0	50	0	5	50	50	45	40
10	6	6	7	0	0	6	0	5	6	5	0	5
11	39	6	5	0	0	40	0	0	0	0	40	5
12	6	3	5	0	0	9	0	0	0	0	0	0
13	39	6	7	0	0	40	0	5	0	50	40	5
14	6	6	7	0	0	9	0	5	0	6	0	5
15	39	6	5	0	0	7	0	0	0	0	40	5
16	0	6	5	0	0	7	0	0	0	0	0	5
17	39	6	7	0	0	7	0	5	0	50	40	5
18	0	6	7	0	0	7	0	5	0	6	0	5
19	100	60	0	35	30	60	49	0	60	60	55	55

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5.1. Results from Monte Carlo Simulation in MS Excel

We have generated the numbers of the transactions for each client according to the Table 2 (from the uniform distribution). We compare the results of 24 experiments that show us the amount paid by the client for 2 years. Table 4 shows the results for the active client - minimum, maximum and average fee per month, sum per 2 years, order of the bank accounts and difference from the best account. You can see that the best current account offers Fio bank and the customer should pay about 1530 CZK (Czech koruna) per two year at average. On the other hand in GE Money Bank it should be more than 25 thousand CZK, so the difference between the best and the worst two-year's fee is more than 23 thousand CZK which is nearly the average monthly salary in the Czech Republic.

The same situation we have for the branch office client and average internet client – all the results with the average monthly fee are on the Figure 4.

Table 4: Simulation results for the active client

| Bank account	MIN	MAX	AVG	SUM	order	dif.
KB	471	751	604	14486	7	12866
CSOB	761	997	884	21210	9	19590
CS	412	624	527	12647	6	11027
mBank	18	194	102	2454	2	834
Fio bank	0	135	68	1620	1	0
Raiffeisenbank	876	1132	1017	24411	11	22791
City Bank	199	357	267	6410	4	4790
Airbank	65	180	119	2865	3	1245
GE Money bank	916	1196	1055	25327	12	23707
Volksbank	639	856	766	18386	8	16766
UniCredit Bank	384	599	500	11995	5	10375
LBBW Bank	814	977	908	21793	10	20173
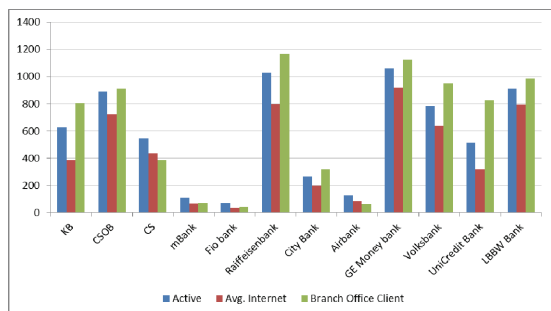
Figure 4: The average monthly fees for all current accounts and three different client types

5.2. Results from Monte Carlo Simulation in Crystal Ball

For Monte Carlo simulation in Crystal Ball it is not necessary to change much in the Excel file – only instead of random generation in Excel we have to define assumption for each cell where random variables should appear. As the next step the cells that contain our results (monthly fees) should be defined as forecast. Afterwards Crystal Ball runs 1000 simulation experiment and gives us all the statistics and histograms for all 12 accounts. Figure 5 shows the comparison of

the average monthly fee for Fio bank current account and GE Money Bank current account (when discrete uniform distribution for the number of activities has been used) for the active client.

It is also possible to view statistics for each result or for more – at Figure 6 you can see the comparison of the best three accounts. The results are similar to the Excel ones.
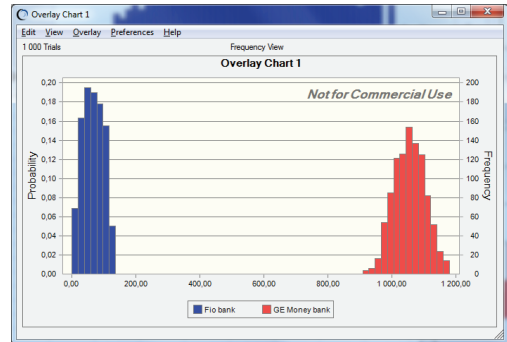

Figure 5: Results for the average fees for Fio bank and GE Money Bank accounts – active client
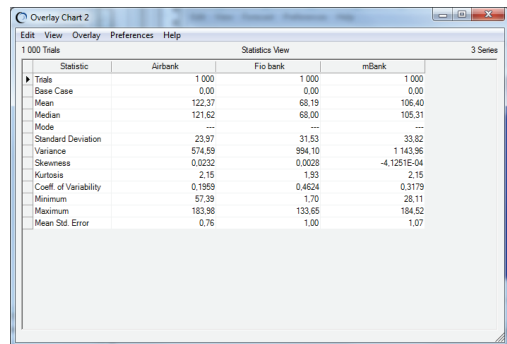

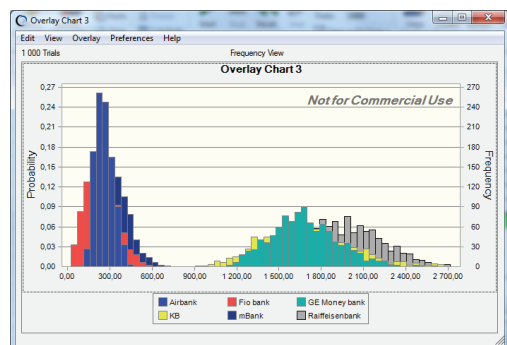Figure 6: Statistics for 3 best accounts – active client

Figure 7: Results for three best and three worst bank accounts (triangular distribution) – active client

As there are a lot of possibilities while using Crystal Ball, we have tried an extreme case when an active client may need each transaction 10 times a month at maximum. For this situation we have chosen triangular distribution where minimum was the same as in previous case, maximum is 10 and the likeliest value is the mean taken from the previous (uniform) distribution for the number of transactions. On the figure 7 you can see the difference between the best and the worst accounts – the situation is still the same, for

the active client it is good to have a current account in Fio bank, mBank or Airbank.

Back to the first asumptions we have tried the simulation with the uniform distributions for the three types of clients – and for all of them Fio bank account seems to be the best one – see Figure 8.

For the branch office client and average internet client the situation is the same – the best three accounts are from Fio bank, mBank and Airbank – Figures 9 and 10. So if we think only about the fees (not about the number of offices or number of years the bank is on the Czech market) we may say that the small new banks compete succesfully with the 4 biggest. The best from the big four banks are Unicredit Bank (for active and average internet client) and CS (for brach office client).
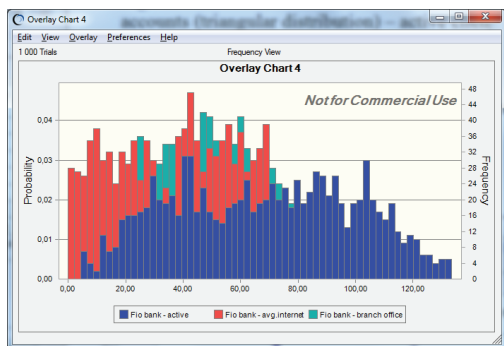

Figure 8: Results of the average monthly fee for all types of clients and Fio bank account
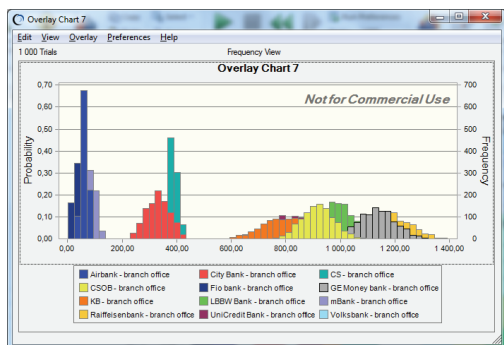

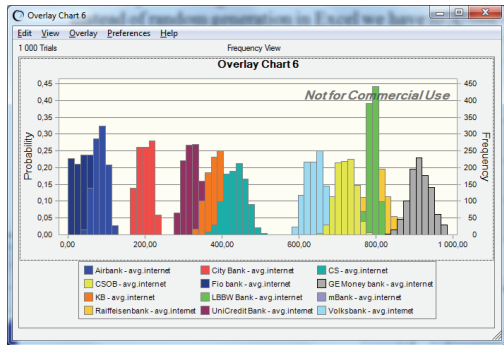Figure 9: Average monthly fees for the branch office client (Volksbank is hidden behind CSOB and GE)

Figure 10: Average monthly fees for the average internet client (mBank is hidden behind Fio and Airbank)

5.3. Results from WSA method

To be able to calculate the order of the bank accounts via WSA method we need weights of the criteria. As the sum of weights must be equal to 1, it is better to use points for each criterion and then recalculate it into weights. For each type of the client the most important criterion is the first one (monthly account charges), so we put there 10 points. Second important might be the debit card (5 points). For the rest of the criteria we have added as much points as the mean of the expected number of transactions is. The weight vector can look like in the Figure 11.

The order of the bank accounts according of the total utility (calculated by WSA method in Sanna add-in application) is similar to the simulation results. The order for the active client is on the Figure 12, other results are in Table 5. Also WSA method chooses Fio bank account as the best one for all the types of clients.
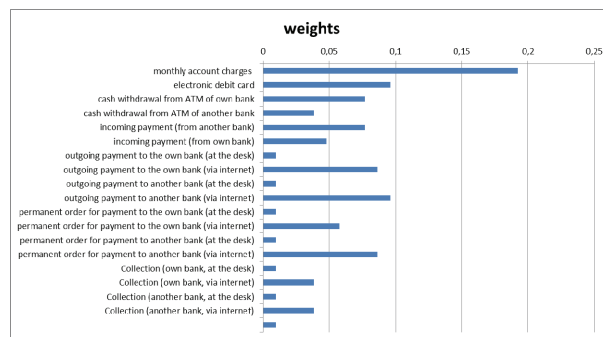

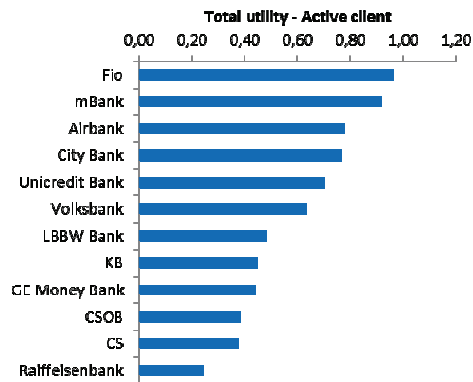Figure 11: The weights of the criteria (active client)

Figure 12: Total utility calculated by WSA method (active client)

	active client		avg. internet client		branch office client	
	utility	order	utility	order	utility	order
KB	0,4486653	8	0,5121974	7	0,4533868	10
CSOB	0,3837324	10	0,4183387	9	0,5322561	7
CS	0,3751688	11	0,3827847	11	0,6398752	5
mBank	0,9177598	2	0,9168804	2	0,937661	2
Fio bank	0,9643944	1	0,9760353	1	0,9801268	1
Raiffeisenbank	0,2423374	12	0,2779611	12	0,3212198	12
City Bank	0,7665772	4	0,6985495	5	0,6492946	4
Airbank	0,7766996	3	0,7687051	3	0,9083081	3
GE Money bank	0,4380828	9	0,4107128	10	0,4358596	11
Volksbank	0,6325093	6	0,5911011	6	0,5754712	6
UniCredit Bank	0,6989662	5	0,7397417	4	0,4814653	9
LBBW Bank	0,4815537	7	0,4286697	8	0,4969971	8

Table 5: Results from the WSA method

6. CONCLUSIONS

Monte Carlo simulation is a good tool that might help with the complicated decision especially when some factors that influence the decision are random. In this article we showed a simple model in MS Excel and Crystal Ball that uses Monte Carlo simulation to find the best current account offered on the Czech market from the bank charges (or fees) point of view. The results of all the models (included the multi-criteria evaluation of alternatives WSA method) show that the small new banks like Fio, mBank and Airbank are the best and all types of clients can save about 90% of money spent on fees. It is true that the situation can be different if we think about the number of branch offices of the bank, about the history the credibility or the time the bank operates on the Czech market. But as it has been mentioned, nowadays fees are very important for customers and our results show that the big banks should do something to be more competitive. The simulation model can be changed according to the different types of clients or by the selection of another statistical distribution that corresponds more with the client behavior – these facts can influence the results but the principle of the model stays the same.

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