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AN EXPERIMENTAL STUDY OF FINANCIAL INCENTIVES' IMPACT ON ACCURACY OF COMPLEX ECONOMIC CHOICES
(USING DECISIONS BASED ON APPLICATION OF BAYESIAN UPDATING)

Introduction

The standard models of neoclassical economics describe the static, macroscopic states of equilibrium arising from the optima of economic individuals. The standard models are not focused on explaining the processing of information and the ways the decisions are made by imperfectly rational firms and consumers. However, economists make investigations and try to show how these processes influence observed economic phenomena. The laboratory experiments, simulating real economic choices, are one way of making such researches. The scientific success of such simulations depends on whether people being examined have a motivation to make optimal choices[1].

This paper presents the results of the experimental study (carried out with students of Wroclaw School of Banking) of financial incentives' impact on accuracy of complex economic choices[2]. The simulated problems being solved demanded application of Bayes' rule. Many studies have revealed[3] that people are not able to cope well with such probabilistic problems[4]. The objective of the experiment was to test if people are able to become skillful in using the Bayesian updating given strong financial motivation and an opportunity to learn.

Construction of the experiment

Most of the experiments testing the abilities of application of Bayes' rule are based on abstract, mathematical questions[5]. There are misgivings that this kind of problems may be incomprehensible because of their abstractness. Therefore it seems that the better way is to ask people being examined to solve real-life problems[6]. According to that, students

[1] Precisely, the decisions taken by the participants of an experiment should maximally approximate choices made by real economic individuals.

[2] That is in situation when proper decisions can not be taken intuitively without any calculations based on a specific knowledge.

[3] Kozielecki J.: *Psychologia procesów przeddecyzyjnych*, PWN, Warszawa, 1969; Tversky A., Kahneman D.: *Judgement under uncertainty: Heuristics and biases*, Science 185 (4157), 1974; Grether D.M.: *Testing Bayes rule and the representativeness heuristic: Some experimental evidence,* Journal of Economic Behavior and Organization 17(1), 1992; El-Gamal M.A., Grether D.M.: *Are people Bayesian? Uncovering behavioral strategies*, Journal of American Statistical Association 90 (432), 1995.

[4] When solving exercises in which the Bayes' rule has to be applied people make systematic errors which have been given the name of representativeness heuristic. See e.g. Tversky A., Kahneman D.: *Judgement under uncertainty: Heuristics and biases*, Science 185 (4157), 1974; Grether D.M., 1992.

[5] The form of given problems is for instance the following: "What is the probability that the drawn, white ball is from the first urn" (first, participants of the experiment get information about the proportion of balls in the particular urns). See e.g.: Grether D., 1992; El-Gamal M.A., Grether D.M. 1995; Holt C. A., Anderson L.R.: *Classroom games: Understanding Bayes' rule*, Journal of Economic Perspectives 10 (2), 1996.

[6] The studies have shown for example that participants of the experiments have much less problems with solving

participating in the described experiment were asked to process probabilistic information relative to credit risk analysis (described in detail in the annex). This way of presentation of the problem was a better approximation of the real economic conditions, and so the results obtained this way are of a greater scientific value.

The problem of most laboratory experiments is that the persons being examined should be properly motivated to put enough effort in solving the given tasks. The decisions taken by individuals without such motivation can be easily questioned[7]. The matter of economic incentives in the laboratory experiments has widely been examined in the economic literature[8]. Even if the conclusions of scientific research are not univocal[9] then generally the importance of an economic (and especially financial) motivation for credible results is rarely questioned. In most cases a stronger financial motivation at least causes a decrease of dispersion of given answers (there is less answers indicating a total lack of engagement in the process of decision making), but is also accompanied in many cases by convergence of answers to the theoretical value. Moreover that particular motivational system itself may influence the behavior of the participants of the experiment. For example Grether[10] describes the results of laboratory experiments testing the representativenes heuristic. After the end of the experiment one of each student's answers was randomly selected, and if the given answer was right then the participant obtained 10$ bonus. This system should theoretically motivate each participant to put maximal effort in answering every question as precisely as possible (because none of them knows which question may be drawn). However it turned out that the described system was not of great importance because the wrong answers caused the decrease of expected value of the payoff of 5 to 20 cents (so relatively not too much). Additionally it is important that choosing the theoretical answers was in the interest of people being examined regardless of their risk attitude. So the system of incentives and the form of solved problems should be constructed in such a way that participants had no potential gains from any strategy of diversification of risk or whatsoever.

While constructing the experiment and planning the studies all scientific findings described above were taken into account. The students, participating in the experiment, became the team of 29 experts working for a big, multinational bank. Their task was to assess probabilities of some events regarding to different populations of bank clients who were granted a revolving credit (the solved problems are described in detail in the annex). The students were informed that the level of bank reserve (for the unpaid part of revolving credits) depends on the results of their calculations[11]. Besides they were given information that both too low and too high level of bank reserve is undesirable and because of that the management of the bank decided to settle the bank reserve experts depending on the accuracy of their calculations. If the given expert (i.e. student) makes an error which is higher than the average error of the team then he will get financial punishment proportional to a positive deviation of

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tasks of a probabilistic nature if they have a chance of observing the process of generating the random events. See e.g.: Gigerenzer G., Hell W., Blank H.: *Presentation and content: The use of base rates as continuous variable*, Journal of Experimental Psychology: Human Perception and Performance 14, 1988.

[7] Many economists prove that the results of psychological experiments can not be used to build theories of functioning of firms or consumers. First, in real economy the economic individuals are much more strongly motivated. Second, they usually take decisions not relating to abstract and incomprehensible riddles. See e.g.: Friedman D.: *Monty Hall's three doors: Construction and deconstruction of choice anomaly*, The American Economic Review 88 (4), 1998.

[8] Beattie J., Loomes G.: *The impact of incentives upon risky choice experiments*, Journal of Risk and Uncertainty 14, 1997; Camerer C.F., Hogarth R.M: *The effects of financial incentives in experiments: A review and capital-labor production framework*, Journal of Risk and Uncertainty 19(1-3), 1999.

[9] There are examples of experiments when the financial motivation does not cause (statistically significant) improvement of given answers.

[10] Grether D., 1992.

[11] So they decided indirectly of a level of the bank reserve.

his error from the mean error of the team. If the deviation of the given participant's error from the mean error of the team is negative (the expert's error is smaller than the average error of the team) then he will get financial bonus proportional to this deviation. It seems that the level of financial bonuses and punishments was set properly because on the one hand it was high enough to motivate students to improve their calculations (see next part of the paper) and on the other hand the risk of a bankruptcy of a participant was minimized[12]. The way in which financial bonuses and punishments were being calculated was explained in detail to the participants of the simulation. The students were rewarded or punished after every single analyzed question and they were able to observe a balance of a payoff account[13], and so they could know whether their current payoff was greater or smaller than the one they got at the beginning of the experiment.

There were four phases in the experiment. During first three phases the student solved a set of three interrelated problems of:

- type a: in which it was demanded to estimate only a simple, total probability;
- type b: where it was needed to apply a Bayes' rule;
- type c: similar to type b, but of a higher degree of difficulty.

So first the relatively easy problem was solved in each phase. Then the participant's task was to analyze more difficult questions where it was necessary to use Bayesian updating. The questions of the given type were a bit different in each phase, but they were at the similar level of difficulty. The fourth phase (of auxiliary character) was not connected with the simulation of a work of the team of bank experts (described above). Every phase of the experiment had a special objective:

- The first phase of a measurement of the possessed knowledge (see annex: phase 1): this part of the experiment was to show what analytical skills were possessed by the examined students. After each problem the students got the information of a right answer.
- The second phase of a learning (see annex: phase 2): when the students could learn most effectively the Bayesian updating rule as they were given an exhaustive solution of each problem.
- The third phase of a control of the results of learning (see annex: phase 3): this phase had to show how the accuracy of probabilities' estimation by students has changed throughout the experiment. The third, most difficult problem (of type c) of this part was considerably modified (compared to the similar one of the previous phase) to avoid a danger that students repeated automatically the solution given to them in phase 2.
- The fourth phase of a measurement of risk aversion: it was carried out to test how the modifications of the financial incentives' system influenced risk aversion of the participants (more about this in the fourth part of the paper).

[12] The bankruptcy of a participant would be highly undesirable because in that case a motivation of this participant to give right answers would be limited. Before the experiment the participants were informed that they would not have to pay anything from their own money, and so in the worst case they would finish the experiment without any reward. For the person with a debit balance it wouldn't make any difference whether her final payoff was to be for example -20 or -10 and so she could start making random decisions. In the study all students being examined finished with a positive payoff although the balance of some accounts reached dangerously low levels.

[13] The special net software was used to carry out the experiment. The researchers could control a progress of the simulation through the central computer. The central computer gathered information from the computers of the participants and calculated financial bonuses and punishments. Such organization of the experiment enabled a proper run of the simulation and guaranteed the independence of answers of the examined students.

Testing the impact of the financial motivation on learning and optimalization of decisions

One of the most important arguments raised by the economists defending classical model of rational behavior is claiming that results of laboratory experiments (carried out mainly by psychologists) are irrelevant for the theory of economics, because they describe unrealistic situation. In market setting economic agents act under economic pressure, because of which there exists possibility and motivation to learn proper rules of behavior[14]. On the other hand it has to be admitted that Bayes' rule is for most people so difficult that teaching it even in case of university classes hardly brings any results[15]. Therefore is Bayes' rule too difficult to comprehend, or is it just the fault of inadequate motivational system used in academic setting?

In order to find out if the implanted motivational system brings effects which consist in increased accuracy of answers, the average students' responds in the following phases have been compared (so the responds of type a exercises in the 3 phases have been compared, then the responds of type b exercises in the 3 phases, and finally the responds of type c exercises in the 3 following phases have been compared). If the thesis that the motivational system has any influence on responds were to be true, the convergence of the responds to the theoretical values should be observed. The convergence measured by the mean absolute deviation[16] is presented on the Figure 1.

The bigger the value of the absolute deviation the worse (on the average, more deviated from the theoretical value) the responds of the students. As can be seen the figure seems to be presenting a strong proof of the thesis of the effectiveness of the motivational system. The mean absolute deviation drops significantly for all the types of exercises, both for type a exercises, where due to the relative easiness of the task this deviation hasn't been very big from the very beginning, and for the much more complicated type b and c exercises.

[14] Compare e.g. Smith V.L.: *Rational choice: The contrast between economics and psychology*, Journal of Political Economy 90 (4), 1991; Friedman D. 1998.

[15] During final exam from „Risk Management" carried out in WSB in Wrocław in 2004 one of the exercises demanded proper interpretation of the value of conditional probability. Even though the students had already had lectures about this topic, the correct answer has been given by 50% of students. It has to be underlined that in the exercise students didn't have to make any calculations, their task was only to interpret the meaning of value of P(A|B), given the meaning of A and B.

[16] For every exercise the mean absolute deviation of students answers from the theoretical value has been calculated.

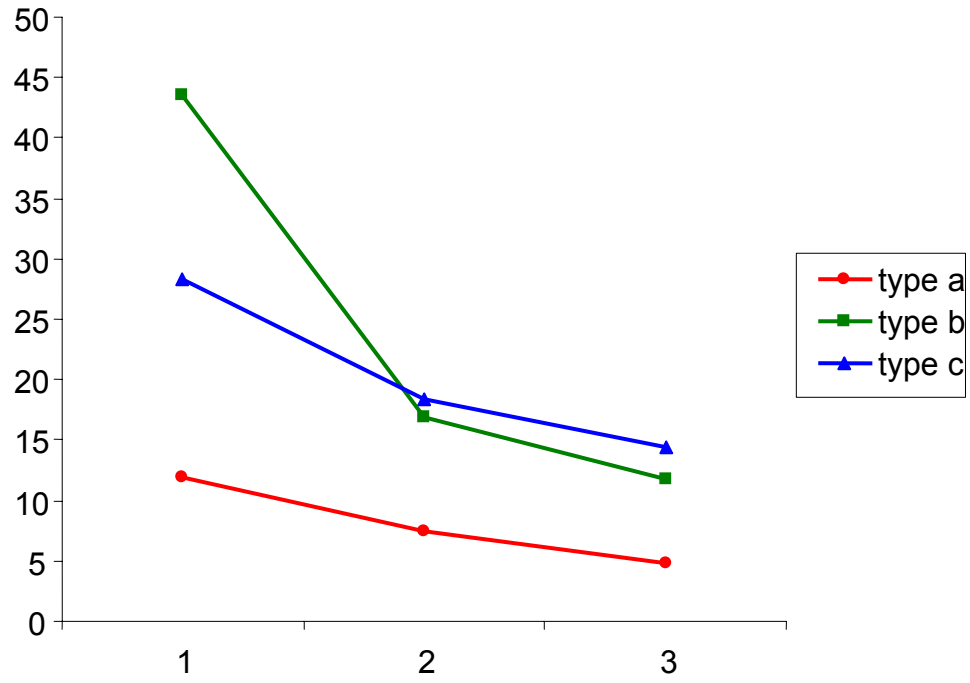

Figure 1. Mean absolute deviation from the theoretical values
Source: own calculations

In order to verify statistically the hypothesis that the students' responds have become more accurate the test of the equality of mean square deviations have been carried out. The tests were based on the mean square deviations, and not on the absolute deviations, because the standard Bartlett's test of the equality of 3 variations could been used in this case. The theoretical values have been used as the expected values and so in effect the hypothesis of the equality of mean square deviations was tested. The null hypothesis is the: $\sigma_1^2 = \sigma_2^2 = \sigma_3^2$, with the alternative hypothesis that at least one of the variations (mean square deviations) is bigger than the others. The test statistics M has the distribution which strongly converges to the Chi-square distribution with 2 degrees of freedom. The calculated values of the statistics along with the p level are presented in the Table 1. As can be noted the null hypothesis is strongly rejected. The Bartlett's test confirms the conclusions drawn from the observations from the Figure 1. The implementation of the financial motivation and the possibility of learning resulted in the strong convergence of students' responds to the theoretical values. The participants of the experiment were therefore able to learn quite well the difficult rules of Bayesian updating. The arguments of the economists underlining the importance of the economic motivation (i.e. Vernon Smith[17]) have been clearly supported.

Table 1. Bartlett's test values for the equality of mean square deviations

	M	*p*
type a	23,9	$6,4 * 10^{-6}$
type b	68,2	$1,6 * 10^{-15}$
type c	22,2	$1,5 * 10^{-5}$

Source: own calculations

[17] Compare e.g. Smith V.L., 1998.

Analysis of the impact of modification of the payment system on the behavior of the participants of the experiment

In the real economy many decisions made in the situation of uncertainty bring the risk of losses for the economic agents. In the methodology of laboratory experiments this leads to a great problem if one wants to simulate the real life incentives system, because if one wants to enroll students to the experiments he has to guarantee them, that they won't suffer financial losses due to the participation in the experiment. Normally in the laboratory experiments this problem is being solved by starting the experiment with some initial financial endowment. Each student gets at the end of the experiment what's left from this amount; if his responds were good he could have increased the given amount and if his responds were poor he could have lost part (or all) of the initial endowment[18]. Poor decisions lead in effect to the financial losses as the participants lose money from the given, opening amount. But it has to be stressed that this solution isn't perfect. From the logical point of view the described system perfectly solves the mentioned methodological problem but from the psychological point of view this isn't necessarily so. There exists a serious doubt if the participants of the experiment really treat the diminishing state of the "counter" as the real loss of their wealth. There is a risk that participants may be considering this money as some abstract sum and therefore losing some part of it may be considered as losing some fictitious money. Many psychological studies have proved the existence of a so called endowment effect, which consists in higher valuation of a good in case of being its physical owner, which can be also explained as a loss aversion[19]. Therefore risking your own money and risking the experimenters money (and as long as the participant doesn't get the money he can treat this amount in this manner) is something different and leads to a different motivation.

In order to make students more motivated not to lose the earned money we decided to implement a different motivational system, based on the conclusions from the studies on the endowment effect. As has been found the effect starts working quite quickly; it merely suffices to hand somebody a good to observe him treating it as his own and valuating higher[20]. Therefore we decided to hand some of the students the money a couple of weeks before the start of the experiment. The total group of 58 students participating in the experiment has been divided into two groups. One of them were to get the money after the end of the experiment (the "ex-post" payment method), while the other got the average ("opening") payment of 30 zlotys about one month before the start of the experiment (the "ex-ante" payment method). The second group's students were settled after the end of the experiment; they either got and additional bonus or had to pay back some of the previously given money. The first group's students with the identical "opening" payment were to get the payoff according to the counter' state at the end of the experiment. The goal of this part of the experiment was to find out if the groups with different payment systems will reveal different attitude toward risk resulting in different decisions. The 58 student who took part in the experiment were randomly chosen from the group of over 80 volunteers. The distribution of average grade (and therefore possibly of intellectual potential) was statistically similar in both groups. Most of the participants of the experiment were first year students with no knowledge of Bayes' rule[21].

The first clear mark showing that the method of payment might influence behavior of

[18] Compare e.g. Experiment II in Kozielecki, op. cit.

[19] Compare e.g. Kahneman D., Knetsch J.L., Thaler R.H.: *Experimental tests of the endowment effect and the Coase theorem*, The Journal of Political Economy 98(6), 1990.

[20] Op. cit..

[21] WSB students don't have to pass any math exams to enroll in the school. Also, as our experience shows, their knowledge form the fields of probability theory is highly "superficial".

the participating students was the attendance during the experiment. Let's remind that students of both groups were promised an average payoff of 30 zlotys and the only difference in the motivational system was that one group got the average payoff in advance. Their engagement in the experiment and therefore their attendance should be the same. However out of 30 students enrolled for the experiment in the "ex-post" payment group 5 didn't show up whereas in the "ex-ante" payment group only 1 out of 30 was lacking[22].

The basic way of testing the influence of the changes in the motivational system was the analysis of the results of the Phase 4. The aim of the task given in this phase was to check the risk attitude. The participants of the experiment had an opportunity of betting from 0 to 5 zlotys (depending on their decision) in a lottery. If the endowment effect hypothesis were to be true the bigger amount should be risked in the "ex-post" payment group[23]. This hypothesis has been tested using the Student's t-test of the equality of means. The null hypothesis was the one of equality $\mu_1 = \mu_2$ with the alternative hypothesis that the amount risked in the first group (paid in advance) was lower i.e. $\mu_1 < \mu_2$. Before that the Fisher test had been run to figure out if the variance of both distributions was identical. The results are presented in Table 2. As can be seen even though the group paid in advance did bet less money on the average the difference isn't statistically significant (p=0,241) and there are no grounds to reject the hypothesis of the equality of means.

Table 2. The results of the F-test of the equality of variations and the Student's t-test of the equality of the mean of the risked amounts

	„ex-ante" group	„ex-post" group
N	29	28[24]
S^2	1,7935	1,7540
F-test	F = 1,0225, p = 0,478	
mean	3,193	3,443
Student's t-test	t = -0,707, p = 0,241	

Source: own calculations

The most complex method of testing the impact of differentiation in the motivational systems is to compare the distributions of responds to the probabilistic tasks, i.e. testing the hypothesis of the equality of statistical distributions in both groups. To do it the test of equality of two multivariate distributions would have to be run. The random variable consists of answers to the 9 tasks and its realizations are the students' results and therefore testing the hypothesis of equality of such distributions is rather complicated. To simplify this task we constructed a statistic being an arithmetic mean of responds to all 9 tasks and decided to compare its distribution in both analyzed groups. The realization of this statistic don't have

[22] On the day of the experiment the group of students paid in advance couldn't have been filled in with the students from the reserve list, because this group's participants had to be given the "opening" payment in advance. Only the missing persons from the "ex-post" payment group could have been filled in. That's why finally (to have equally numerous groups) we ended up with two 29 person groups.

[23] Participants who had got money in advance should tend to assign more value to the earned money and therefore be less willing to risk it. Hence we can draw a conclusion that they should bet lesser amounts. This conclusion is true if we assume that both group had the same distribution of financial endowments in the moment of deciding how much money to risk. Even though this was a zero-sum game and so the average financial endowments of both groups were the same in each phase of the experiment we cannot be sure of the equality of distributions because different system of financial motivation could have theoretically lead to a different distribution of payments.

[24] Because of some technical problems one of the students couldn't participate in this phase of the experiment.

any reasonable interpretation (the average of responds to different tasks) but it can be very instrumental in comparing the distribution of responds. If comparing the values of this statistic we found no grounds to reject the null hypothesis of equality of univariate distributions of average responds then it wouldn't prove anything about the multivariate distributions and we would have to find the other method. But if such hypothesis were rejected then we would have reasons to reject the hypothesis of equality of multivariate distributions as well. The equality of parameters of two distributions isn't a proof of equality of distributions but the inequality of these parameters suffices to reject the hypothesis of equality of distributions[25]. After the construction of the described statistics Student's t-test was used to test the hypothesis of equality of means of their distributions with the alternative hypothesis that these means differ. First the Fisher test had been run to check if the variations of the distributions were equal. Table 3 presents the results of the tests:

Table 3. The results of the F-test for the equality of variations and t-test for the equality of means to compare the distribution of responds in two groups with different motivational systems

	„ex-ante" group	„ex-post" group
n	29	29
S^2	36,79	30,71
F-test	F = 1,198, p = 0,318	
mean	40,96	36,11
Student's t-test	t = 3,179, p = 0,0012	

Source: own calculations

These results show that the hypothesis of the equality of means has to be rejected, i.e. there are significant statistical data (p=0,0012) proving that the distribution of responds in both groups differ[26]. This proves that changes in the system of payments did influenced the responds of the participants of the experiment (assuming that groups had the same intellectual potential which was guaranteed by the random allocation of students to two groups). But it has to be underlined that there are no unequivocal grounds to claim that the impact of changes in the motivational system was positive, i.e. there are no arguments to state that the better motivated students (those paid in advance) got better results. Such conclusions could have been drawn from the values of the analyzed statistic because the mean of the theoretical values which is 45,34 was much closer to the results of the "ex-ante" payment group (compare the values of the Table 3). However a closer analysis of the results doesn't prove the same thing. Actually the analysis of the mean absolute deviation from the theoretical values proves something opposite. The "ex-post" payment group's results are clearly better, for instance its average error in the 3b task was 7,36 with 16,32 in case of the "ex-ante" group and its results in the task 3c are 13,31 compared to 15,35 in case of the other group. Can we therefore draw a conclusion that the "ex-ante" payment had a negative influence on the level of responds? Even though the economic literature has already noted such cases[27], such thesis seems to go to far. Nevertheless these results cast some doubts and demand a further analysis.

[25] If two variables are to have the same distribution then their means have to equal. The equality of means isn't a proof of equality of distributions but it's a necessary condition.

[26] The same results have been obtained in the Kolmogorov-Smirnov test of the equality of distribution of the analyzed statistics. The value of the sup statistic equals 0,448 with n=14,5 and so the hypothesis of the equality of distributions is strongly rejected.

[27] Compare: Camerer C.F., Hogarth R.M., 1999.

Summary

The paper presents the results of studies on the impact of financial motivation on the accuracy of decisions in complex economic situations, the example of which is the application of Bayesian updating in credit risk analysis. Gathered data confirm that even though untrained participants have big problems with applying this type of analysis they are able to learn very quickly these rules given special conditions[28]. During the experiment they needed only one hour to start solving these type of exercises quite well. Even if they soon forget this just learnt skill there are no doubts that market's pressure can enforce the growing rationality of decision making. Therefore these results have undermined the arguments of psychologists who were questioning the practical usefulness of the rationality model.

The second important element of the research was the analysis of the new financial motivation system, which consisted in paying the participants the average payoffs a couple of weeks in advance. Basing on the results of psychological studies on the endowment effect (or aversion to loss) we could assume that the participants motivated in this way will value higher the gained payments and that this will influence their choices. The results showed that changes in the motivational system do affect the behavior of participants but it cannot be definitely said if this influence is positive or negative. Nevertheless these results cast some new light on the results of psychologists who used in their research a standard "ex-post" payment system. It could be interesting to repeat their experiments with the changed payment system to see if the abstraction of the payment system used in these experiments didn't affect the results. It might turn out that some of the known paradoxes are just the result of a poor motivational system. Maybe assumptions of the classical theory of economics aren't as fictitious after all?

Annex – the decision problems used in the experiment

Phase 1

1a. All clients can be divided into two groups: Reliable and Unreliable. Reliable clients are trustworthy – they don't repay on time only 10% of the granted credits. Unreliable clients cause more problems – they don't repay on time 40% of the granted credits. From the statistical studies it is known that on the average 50% of bank clients are Reliable and 50% are Unreliable. The management of the bank asked you to start analyzing the group of new clients, who have never been granted a revolving credit before (and of whom it's known that they were randomly chosen from the described population). Assess what proportion of them will not repay the credit on time in the first month.

1b. You're still analyzing the same population of clients. The management of the bank have decided to grant the credit to all the clients, even those who hadn't repaid the credit the month before. But the group of those clients who hadn't repaid the credit in the first month deserves a special attention. The management asked you to assess what proportion of them are the

[28] Most of the students who participated in the experiment not only hadn't had any classes about conditional probabilities but hadn't had any probability theory classes as well. To see how big was their problem of proper application of the rule we can look at their results from the first Bayesian type exercise i.e. exercise 1b. The average of students' answers in this exercise was 36,41 with the theoretical value being 80; mean absolute deviation from the theoretical value was 43,6. On the other hand at the end of the experiment the average of students' answers in the exercise 3b of the similar difficulty level was 20,26 with the theoretical value of 8,7. The mean absolute deviation from the theoretical value dropped to 11,84.

Unreliable clients, with whom there might be problems in the future.

1c. Out of the group of clients who hadn't repaid the credit on time in the first month some repaid it on time in the second month. Assess what proportion of this group are the Unreliable clients.

Phase 2

2a. Now you're analyzing a different population of clients. Reliable client don't repay on time 20% of the granted credits, while Unreliable clients don't repay on time 50% of the granted credits. From the statistical studies it is known that on the average 70% of bank clients are Reliable and 30% are Unreliable. Assess what proportion of this group will not repay the credit on time in the first month.

Information given after completion of the task 2a: Suppose you've been analyzing 1000 credit applications. Out of this 700 (70%) came from the Reliable clients and 300 (30%) from Unreliable clients. Among the group of Reliable clients 20% of the clients i.e. 140 didn't repay the credit whereas among the Unreliable clients the credit was not repaid by 50% i.e. 150 clients. In total 290 out of 1000 credits haven't been repaid which is 29%.

2b. You're still analyzing the same population of clients. The management of the bank have decided to grant the credit to all the clients, even those who hadn't repaid the credit the month before. But the group of those clients who hadn't repaid the credit in the first month deserves a special attention. Your task is to assess what proportion of them are the Unreliable clients.

Information given after completion of the task 2b: Unreliable clients are just 30% of the population but because they have more problems with repaying the credit on time then their proportion in the group of clients who didn't repay the credit have to be bigger. Out of 290 clients who didn't repay the credit in the first month 140 were Reliable and 150 Unreliable. Therefore Unreliable clients formed 51,7% (150/290) of this group.

2c. Out of the group of clients who hadn't repaid the credit on time in the first month some didn't repay it on time also in the second month. Assess what proportion of this group are the Unreliable clients.

Information given after completion of the task 2c: The proportion of Unreliable clients in this group must be even bigger because Reliable clients rarely have problems with repaying the credit on time 2 times in the row. In the group which didn't repay the credit in the first month there were 140 Reliable clients and 140 Unreliable clients. Out of them in the second month the credit hasn't been repaid by 28 (20% out of 140) Reliable clients and 75 (50% out of 150) Unreliable clients. In total 103 clients from this group didn't repay the credit in the second month. Unreliable clients form 72,8% (75/103) of them.

Phase 3

3a. You have been given yet another population to analyze. Reliable client don't repay on time 10% of the granted credits, while Unreliable clients don't repay on time as much as 70% of the granted credits. From the statistical studies it is known that on the average 40% of bank clients are Reliable and 60% are Unreliable. Assess what proportion of this group will not repay the credit on time in the first month.

3b. You're still analyzing the same population of clients. The management of the bank have decided to grant the credit to all the clients, even those who hadn't repaid the credit the month

before. But the group of those clients who hadn't repaid the credit in the first month deserves a special attention. Your task is to assess what proportion of them are Reliable clients, with whom there won't be much problems in the future.

3c. Out of the group of clients who hadn't repay the credit on time in the first month some repaid it on time in the second month. Assess what proportion of this group are Reliable clients.

Phase 4

4. It is known that on the average 4 out of 10 clients who visit the bank are type A clients and 6 out of 10 are type B clients. In a moment the computer will randomly choose one client out of this population. You can bet an amount from 0 to 5 zlotys that the randomly chosen client is of type B. If you win you'll double your stake and if not you'll lose it.

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