Impact of Risk and Utility Discounting Factors on Behavioral Economics Models in Addiction Groups

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Abstract

This paper examines the attitude towards risk and the benefit to be received in various experimental and control groups. Analysis of the literature shows that risk-related and myopic decisions are typical to addiction groups which in the context of various alternatives conduct risky and less risky benefit analysis, two experiments have been conducted to determine these factors, which have shown that groups with addiction behavior are prone to risky behaviors. The main question of the research was to determine whether the decision on stopping taking drugs affected the risk factors. The results showed that there is no significant difference in these factors with respect to the persons involved in the replacement therapy, on the one hand, and the drug users who have not applied for treatment, on the other hand, which means that the decision on discontinuing use of drugs does not change the attitude towards risky decisions. This leads us to introduce a variety of choices to the consumer market in implementation of result-oriented drugpolicy to create alternatives with higher opportunity costs.

Key Words: Behavioral Economics, Decision models, addiction, replacement therapy.

Introduction

Behavioral addiction, drug dependence, gambling, are often considered as psychological or criminal problems such as illness or as a crime, but in economic terms this problem can be considered in the context of decision theory as choice between risky and for-sure benefits, current, immediate utility and tomorrow's discounted utility (DU). Decision-solving problem is characteristic for all areas of human life and can be used to explain different behaviors, including adaptive habits.

As a starting point we refer to the fact that any action of human beings (as a reward-hunter) is directed towards making the best choice between different alternatives. Consequently, choice between alternatives is related to risk analysis and immediate / tomorrow's utility measurement. We will consider the utility in general, which includes not only quantitative characteristics, but also the state of pleasure and satisfaction.

Generating utility (pleasure) is associated with a certain investment (refusal to receive today's utility, which is the initial investment expenditure), which has the corresponding returns in time as earned benefit. When making decisions, a person faces a dilemma – he/she evaluates what is the opportunity cost of the pleasure he/she has received. Such judgment is also applicable when making decisions about use of alcohol, drugs and cigarettes. It is widely recognized that cigarettes are harmful to health. However, in most cases, a cigarette smoker does not warry that smoking causes lung cancer after regular exposure for 40 years, and for him it is far more important to get a guaranteed satisfaction with a cigarette smoke at the moment, which he/she receives by tradeoff of the current and future utility.

We believe that in developing a single addiction policy the natural factors of human behavior in the context of different alternatives of pleasure should be taken into consideration bearing in mind the risk and time factors. This paper is aimed at finding out the risky decisions of individuals with behavioral addictions and introducing the obtained results in the addiction policy.

The goal of the research is to determine whether the decision made for treatment or quitting the substance dependence by drug-dependent individuals affects the changes of such factors. The research hypothesis is that the decision taken for treatment by the substance (drug)-dependent persons and quitting the behavioral dependence does not affect the risk factors of these persons towards dependence and these factors remain substantially unchanged.

The risky factors of comparable groups of students and gamblers were simultaneously studied with the drug-dependent persons within the framework of the experiment. Analysis of economic models of risk factors proved our hypothesis and showed that these factors in the vulnerable groups (gamblers, drug addicts) are significantly different from the similar parameters of the student control groups. The determined risk factors of vulnerable groups have shown the preferences to risky behaviors more than it was expressed in the group of students.

Research

In order to identify risk preferences, we have chosen target groups to which the same research methodology has been applied. Several target groups were selected:

Group I - students (n = 35), which we, based on the results of the survey, divided into two risk-seeking and risk-averse behavioral subgroups (marijuana, drug use/non-use, game in the betting house);

Group II – the so-called gamblers (n = 15), persons engaged in gambling games;

Group III - drug users (n = 15) who are involved in methadone replacement therapy courses in order to reduce dependence.

Group IV - drug users (n = 15) with intensive narcotics use history treating themselves as drug addicts and who has never applied for treatment or replacement therapy;

Participants were awarded with cash prizes - GEL 5 for students; one of Tbilisi gambling house users selected for participation in Group II, and were awarded GEL 10 for participation in the experiments; as for the subsequent groups of persons involved in the methadone program, who agreed to take part in the experiment, we asked them if they invited any additional person who would satisfy the requirements of Group IV (an intensive user who did not apply for replacement or treatment therapy) would receive GEL 10 and the money generated in a lottery game. We also promised members of Group IV to participate in the same cash prize

In order to elicit risk preferences in the first experiment, Holt and Laury low- and high-payoffs lottery method was used. Since we were limited in the budget, the prize money was awarded to the participants only by low-payoff lottery results.

10 lotteries were presented to the participants. Each lottery consisted of two options - A and B. In each lottery participants selected either A or B option. Participants were rewarded with a cash prize lottery in order to stimulate the behavior that is close to reality. Before start of the game, participants knew that only one choice should have been selected from 10 choices by random selection resulting from a throw of a 10-sided die to make real money. Below is the example of one of the choices.

Lottery #1:

Option A - 1/10 chance to win GEL 2 and 9/10 chances to win GEL 1.6

Option B - 1/10 chance to win GEL 3.85 and 9/10 chances to win 10 tetri

After participants have made their choices, the instructor throws a ten-sided dice to select one lottery from ten and then throws the dice again to determine the amount of prize. The faces of the dice are numbered from 1 to 10, where 1 serves a 10% chance, 2 - 20% chance, and so on. The last number was a 100% chance. The participant received the sum equal to the probability corresponding to the thrown dice.

Overall, 184.3 GEL was paid as earnings, which was GEL 2.8 GEL per participant on average. The essence of this experiment was to determine the attitude toward the risk in players' choices. If we look at the latter pairs and the differences between the winnings (EV (choice A) - EV (choice B), the rational and risk-neutral person will choose option A in row 1 to 4 because EV(A)>EV(B), and then switch over and choose option B in row 5 to 10 as EV(B)>EV(A). It is also noteworthy that anyone who switches earlier (in the first pair) to option B is classified as risk-seeking. Finally, even the more risk-averse individual will switch to option B in 10^{th} lottery as she higher expected value is guaranteed.

Consequently, selection of Option A in more than 4 rows indicates the risk aversion while selection of Option B in more than 6 rows - indicates the risk-seeking.

The next hypothetical part of the risk experiment consisted of similar questions from the first part, in contrast, that the amounts were increased and the award was not distributed.

10 pairs of lotteries presented to the participants are now comprised of the following options A and B:

Lottery #11:

Option A - 1/10 chance to win GEL 244 and 9/10 chances to win GEL 195

Option B - 1/10 chance of winning GEL 470 and 9/10 chances to win GEL 12

In this experiment our goal was to determine if the player's risk preference is heterogeneous in terms of increased bet. Here, as in the previous experiment, the choice of rational and the risk-neutral person falls between row 4 and row 5 of the lottery.

It is noteworthy that this approach to risk attitudes has its disadvantages, namely, to create an exact reflection of the reality that would make it possible for the participants to choose from the loss position. More specifically, in our experiment, and not only in ours, but also in all well-known laboratory experiments dedicated to measuring risk factors, individuals have to make choices between profitable options, according to the possible loss of profit standpoint, while in actual life, persons have higher awareness of loss and it is likely that their behavior towards the losing position and the risk preference may be different in reality. However, within the scope of this experiment, it is almost impossible to convince the participants to play for their own money with loss/profit expectations in laboratory conditions.

As for measuring the risk factor, we use the following utility function:

$$U(x) = \frac{x^{1-r}}{1-r}$$

where r is the relative risk aversion, and the lottery outcome x is more than zero (as reported in the article of Holt and Laury, however, other exposure indicators are also used to express the risk factor). The risk ratio of the participant is measured in a point of indifference when he switches from option A to B. While a participant stays om option A, he thinks that the expected payoff is higher than expected payoff from option B. Switching from option A to option B is a milestone where the participant reveals his indifference (neutrality) toward risk.

Risk-neutral subject who chooses option A in row 1 to 4 and then switches over and chooses option B, the following equation is used to measure the risk ratio:

$$0.4\frac{2^{1-r}}{1-r} + 0.6\frac{1.6^{1-r}}{1-r} > 0.4\frac{3.85^{1-r}}{1-r} + 0.6\frac{0.1^{1-r}}{1-r}$$

From this equation the risk-neutral subject's risk ratio falls between -0.1425 and 0.147 ((-0.1425<r<0.147). The risk coefficients are measured for all pairs similarly. Calculated coefficients are shown in Table # 1.

n A options	ky coefficient range	)	)
0-1	r<-0.95	1.42	1.41
2	-0.95<r<-0.485	1.42	1.43
3	-0.485<r<-0.142	1.51	1.51
4	-0.143<r<0.147	1.67	1.67
5	0.147<r<0.41	1.93	1.93
6	0.41<r<0.68	2.43	2.43
7	0.68<r<0.97	3.82	3.82
8	0.97<r<1.37	33.99	33.99
9-10	1.37<r	-2.11	-2.11

Table 1. Risk ratios and indifference points between options A and B

Risk Factors Assessment Experiment Results

Students

To analyze risk factors, experiment results, we provided experiment with 5 groups (two subgroups of students, gamblers, drug users, who are involved in treatment and users are not). Data for each group was summarized separately, and then statistical tests were conducted to determine whether the risk factor affects the way of human life.

Analysis of the data obtained from the risk factor experiments in the case of students showed that the total number of chosen safe options in the low-prize game is 127, and the number of risky variants is 223, which is different from the high-prize game responses - 183 and 167, respectively.

Summary of the safe option and analysis of the combined indicator over the likelihood of profit showed that respondents' answers are in line with increasing risk. The higher is the risk of option B, the more people stay on option A. The *x* axis in Figure #1 below shows probability, and the *y* axis is the total number of safe options in the relevant probability conditions. The dashed line curve - is the option of a risk-neutral subject, which means in the first four options it is better to choose Option A and then switch over and choose option B in the row 5 to 10. The option chosen by the students is somewhat repeating the curve line of the risk-neutral subjects. The blue curve shows a low-prize option in which awards will be presented, and the red curve reflects the curve of the hypothetical option.

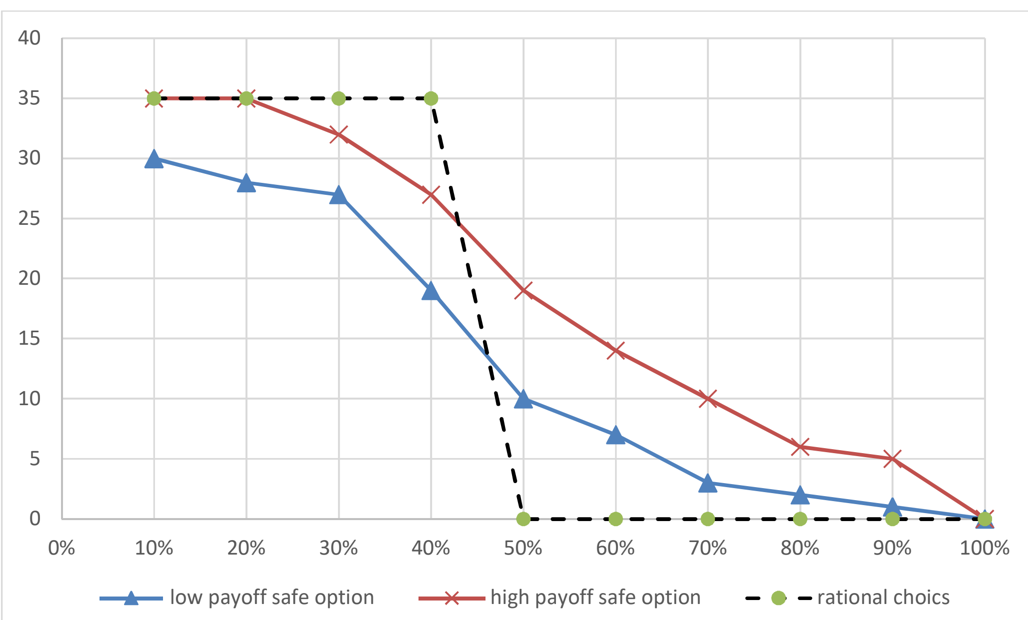


Figure 1. number of safe answers (Option A) of 35 students in different probabilities

Students have been divided into two conditional groups - students who do not have a history of risky behaviors and students who have a history of risky behavior to find a connection

between their responses and risky behaviors. On the one hand, we have compared the risk factors of students who have not been involved in at least three risk behaviors (cigarettes, marijuana, drug abuse and gambling) (in total it was 19 students), and the students who do not satisfy these conditions requirements (number of such students was 16).
Figure # 2 shows the curve of total safe options of students with less risk behaviors (blue and red curves) and students with risky behaviors (violet and blue curves). The diagram shows that it is clear that the total options of students with disabilities is not the same indicator for students with risk behaviors.

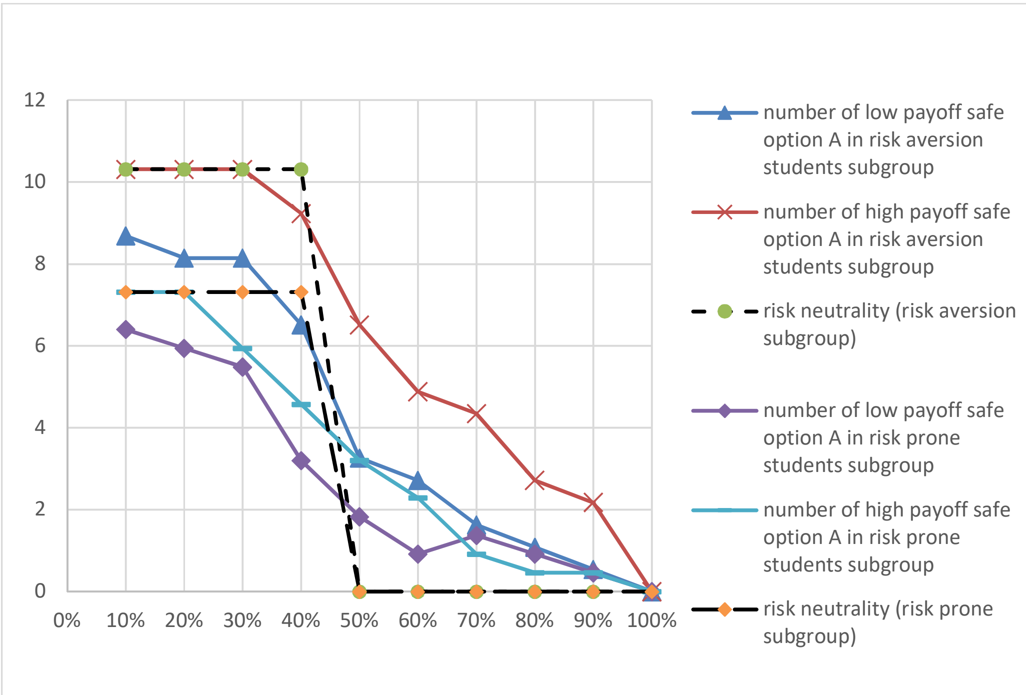


Figure 2. Summary of safe options by students with risk-aversive and risky behaviors in low and high prize games

We applied the *t test* for two-sample and tested an alternative hypothesis about the fact that the risk factor is much lower in the students with safe behavior in both low- and high-prize games. It was confirmed that there is a significant difference between risk option responses among students with risk-seeking and risk-averse behaviors (P=0.0004). In other words, students with risk-averse behaviors in both lotteries chose safe options compared to students with risk-seeking behaviors.

Experiment results of individuals with addictive behavior

Unlike students, the total number of safe options for participants with behavioral addiction (gamblers, drug users (TR group) who have been involved in the treatment and drug users who are not (DU group)), is significantly lower when the number of risky options has increased (see Table # 2).

	Low prized		High prized	
	% of safe answers	% risky answers	safe answers	ky answers
students	36.3%	63.7%	52.3%	47.7%
gamblers	24.7%	75.3%	25.3%	74.7%
TR group	27.3%	72.7%	41.3%	58.7%
DU group	28.7%	71.3%	40.7%	59.3%

Table 2 percentage of safe and risky options in different betting games according to the groups of participants

It should be noted that the number of safe options chosen by the gamblers in the low-prize game context was almost equal to the total number of safe options for high-prize hypothetical games, unlike students and drug users, where the number of paid low-prize safe options was lower as compared to the overall rate of high-prize safe options, which means that the presence of higher award has not affected the distribution of answers in case of students and drug users.

We conducted two-sample *t* tests within the three groups and tested hypotheses about the fact whether the risk factors and decisions made in the low-prize were different from the high-prize similar indicators. It was revealed that this hypothesis was not confirmed in gamblers answers (P = 0.441) and there was no difference, which means gamblers risky behavior stays the same in low and high aid games.

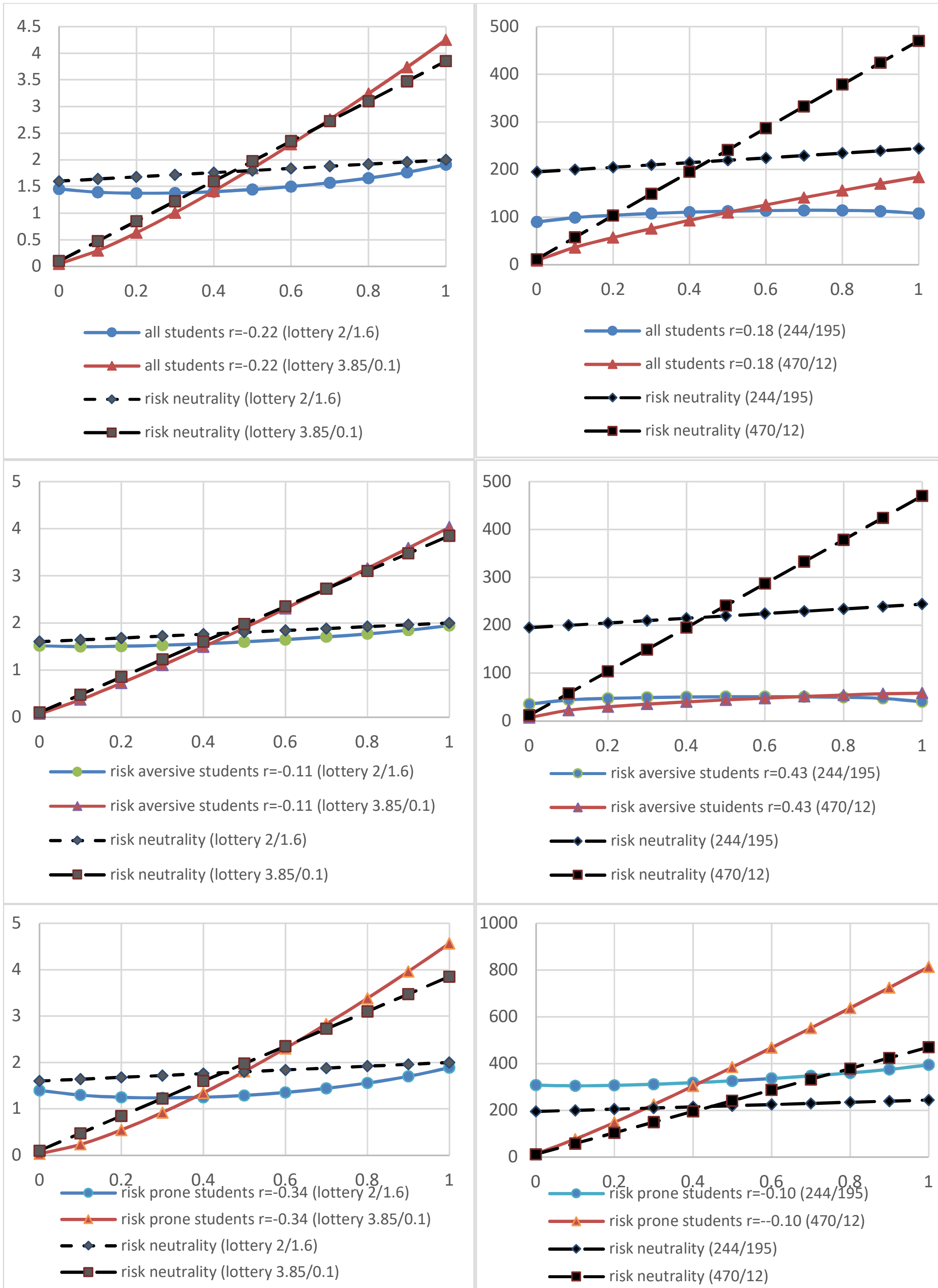
The answers of DU and TR groups differ significantly from low and high prize games. Drug users risk factor changes with a high probability (RT group - P=2.31696E-06 and DU Group - P=0.001824) and their risky behavior depends on the game outcome.

Modeling using Risk-Factors

Based on the risk factors indexed in Table # 1 and the experiment results, we were able to create behavioral models of the groups involved in the experiment. The estimated behavior of students, gamblers, DU and TR users with regard to different stake games was analyzed. Figure # 4 below shows risk-dependency models according to the average answers of all students in relation to the risk-neutral curve in low- and high-prize games. In addition, as in the previous case, we also divided students into sub-groups of students with risk-seeking and risk-averse behaviors and presented the relevant models. Figure # 5 is presented by decision models of persons with behavioral addiction.

The presented curves reflect the decision model and the value of utilities earned under the appropriate probability conditions according to $U(x) = \frac{(\Pr(A) * X_1 + \Pr(1-A) * X_2)^{1-r}}{1-r}$ function. The left column presents models according to the results of low-prize games and the right column presents models according to the results of high-prize games. Black dashed-line curves reflect the risk-neutrality. Blue and red curves show decisions of the participants. The crossing points are the place of decision changing. Blue and red curves and crossing points are determined by (r) risk factor that represents a statistical average for each group. The model presented in the Figure shows the human decision-making process. In the beginning a person follows the blue curve (a safe option – Option A in our experiment), because the possible benefit is much larger than in the red curve (a risk option - Option B in our experiment). After the decision is changed, the individual is guided by the red curve.

Figure 4. students' decision-making model



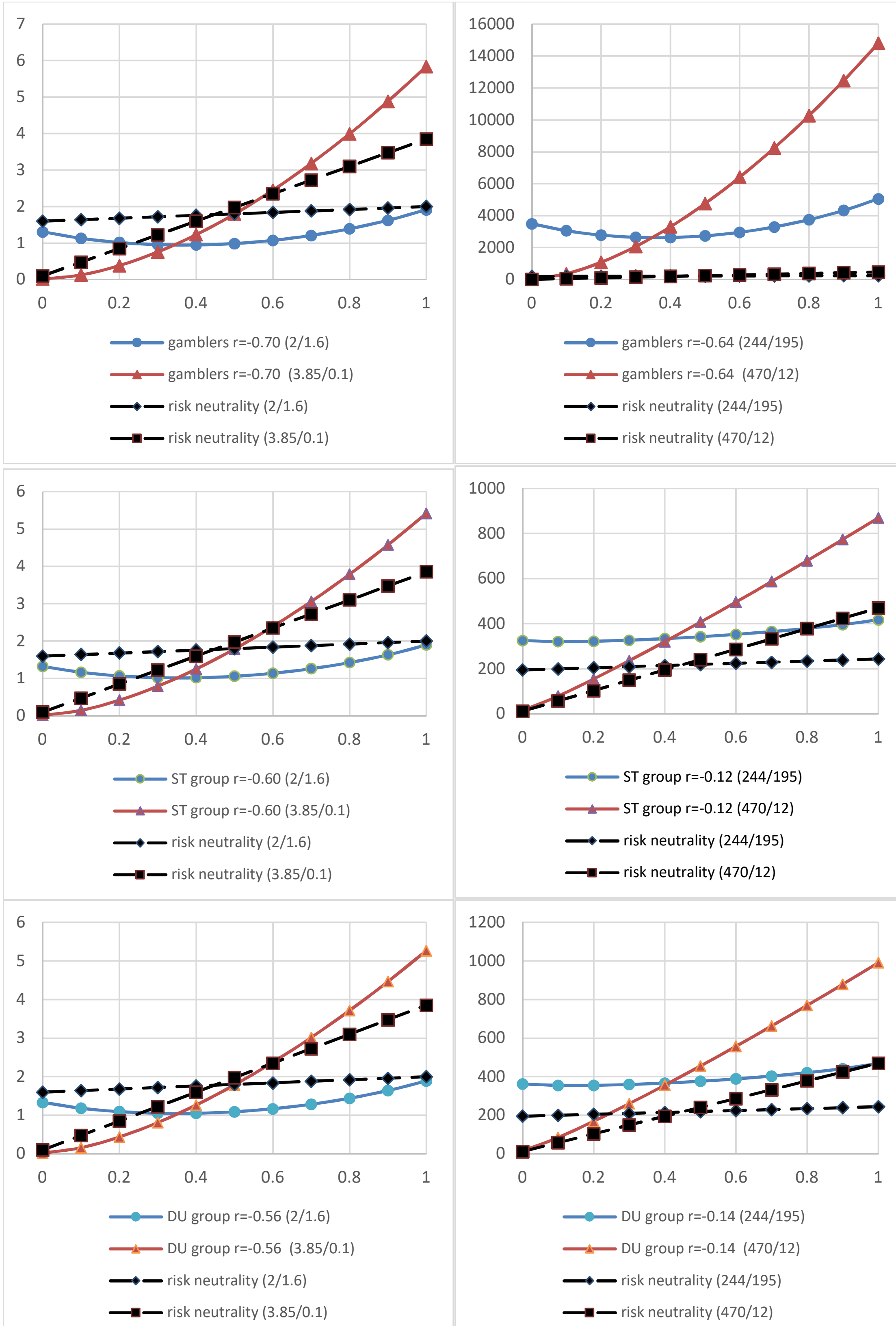


Figure 5. decision models in addictive groups

If we look at the points of changing decisions by individuals involved in the experiment in each model, they differ from the points crossing the curves reflecting the risk-neutrality (as well as from the risk curves) and in terms of a high-prize game are at a significant distance from each other. The neutral curves are crossed when the probability of profit is 40%. However, the participants in the experiment do not follow the rational behavior of this model. Decision models differ from each other according to the size of prizes. The higher the prize is, the more distinctive are the color curves towards the risk-neutrality. In case of students, this was especially visible when we separated paths for students with risk-seeking and risk-averse behaviors. If we look at (d) and (f) curves of Figure # 4, we find that in case of high-prizes, the utility function of students with risk-averse behavior is significantly lower and is below the risk-neutrality curves, whereas the utility function of students with risk-seeking behavior is above the risk-neutrality curves. This means that a high-risk factor pushes them to make decisions for the benefit which is above the rational level, while the benefits of risk-averse individuals fall under rational curve.

Such a discussion can explain why the utility curves of drug users and especially gamblers sweep up. First of all, it is noteworthy that in low-prize models the decision curves of the experiment participants are below the risk-neutrality curves, however, in the context of high-prize game, the picture changes and the blue utility curve sharply moves above.

Risk-neutrality curves can be considered as a rational margin in which the profit can be obtained: in the context of our experiment, this profit is the expected value of the game. However, unlike the expected profit, the participants are exposing the profit with the calculated risk factors, which gives the game a much larger value than it is expressed in expected value. With this respect, the decisions of both risk-averse students and individuals with behavioral addiction are irrational, but in case of students, their risk factor guarantees that their expected utility does not exceed the margin of rationality, while the expected utility of the addicted individuals sharply exceeds any outcomes to be received within rational curves.

It is interesting that decision curves of the risk-averse students in high-prize game have convex shapes (see Figure 6b) which indicates that marginal benefits from the game decreases when probability of winning decreases and student change their decision when the chances of losing the benefit is minimal.

As for a low-prize game, the curve has a relatively high rate and it goes upward (red curve, Figure 6a). The only explanation for risk-averse students between these two decisions may be that, despite the fact that participants were awarded in a low-prize game, unlike the high-prize game, the small amount of this reward led to its low opportunity cost and students were tended to get a higher-paid reward.

In Figure 6 and in the next figure, we have presented the curves that describe the behavior according to the decisions of the participants involved in the experiment. For each group we combine the curves in the decision point drawn according to Options A and B.

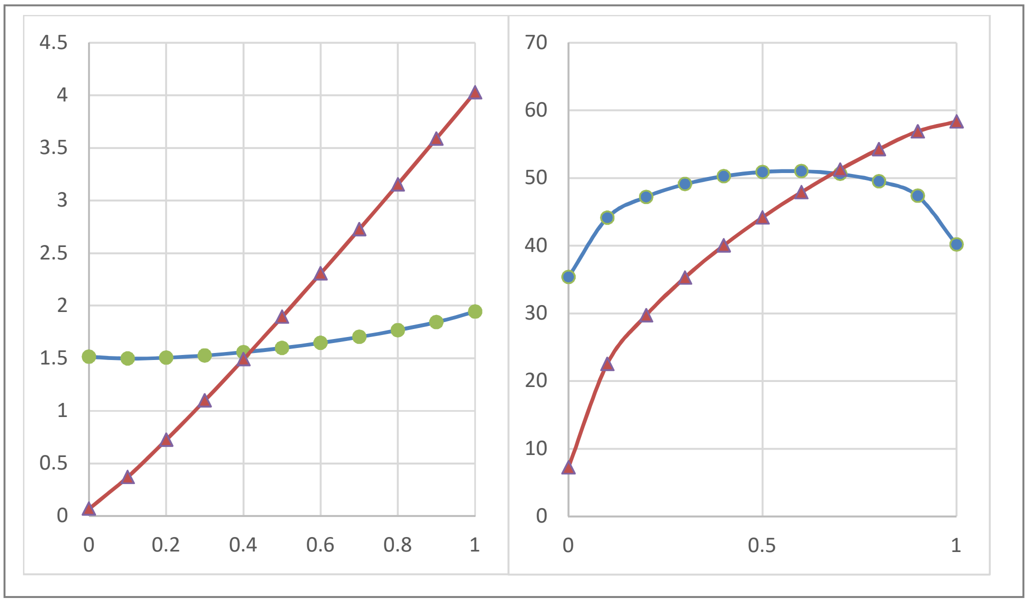


Figure 6. Decision curves of risk-averse students: a – in case of low-prizes, b – in case of high-prizes

Decision curves of the gamblers and DU and TR groups are concave in terms of low-prize and high-prize games. In the context of low-prize game all the curves more or less follow each other, and are not at a big distance from the rational, risk-neutrality curve (Figure #7a). In contrast, there is a significant difference in the high-prize game. The decision curves of addicted groups are above the neutrality curve, while the curve of all students goes bellow (Figure #7b), at the same time the gamblers curve pushes up sharply (due to high negative risk factor) and it is presented separately for more visibility (Figure #7c).

Analysis of the risk factor experiment results allows us to answer one of our main research questions - whether or not the attitude of the drug-dependent person towards risk had been changed after involvement in the treatment.

To answer this question, we again tested the hypothesis for two independent samples, we compared risk factors of DU group and RT group participants.

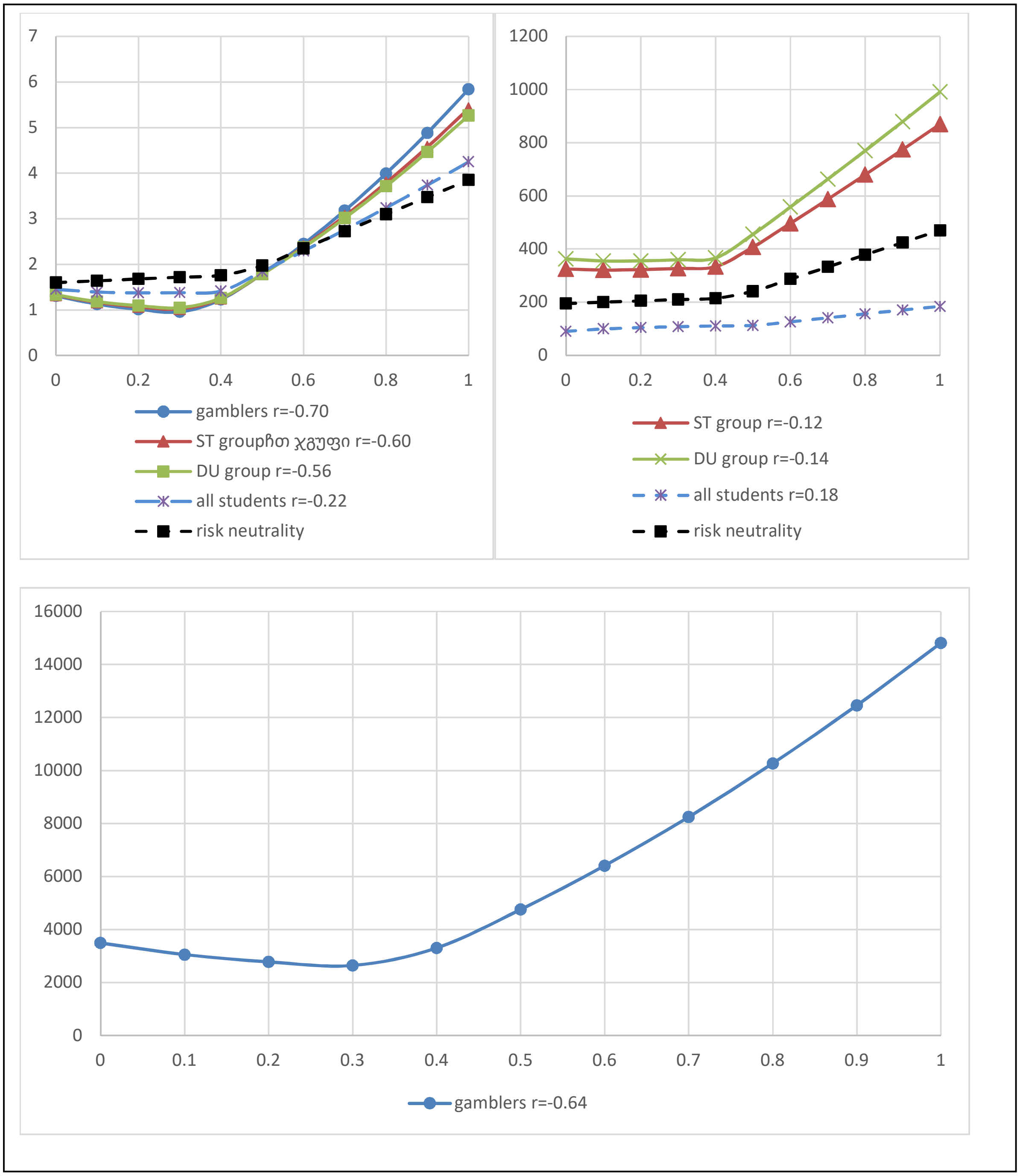


Figure 7. decision models

The zero hypothesis is as follows: decision to quit dependence on drugs and involvement in the substitution therapy would not affect the risk factors of drug users and it would remain the same. The alternative hypothesis is that the decision to participate in the substitution therapy should have an impact on the risk factor ($H_{0:}$ μ=0 - risk factor remains unchanged, $H_{1:}$ $\mu\neq0$ - risk factor changes).

In both cases, *t* tests of low- and high-prize risk factors have not confirmed alternative hypotheses: in case of low-prize game - P = 0.76 and in case of high-prize game - P = 0.80. According to hypothesis testing we refused alternative hypothesis and confirmed that risky behavior of drug users does not depended on the decision to quit with drug use.

Conclusion/Recommendations

Analysis of the economic models of risky behavior showed a significant difference in risky factors in experiment groups of drug users, gamblers and control group of students.

Drug users and gamblers have shown their preferences towards risky behavior more than it was expressed in the group of students.

Based on the results of the experiment, the main question of the survey - whether the decision of substance-dependent users on commencement of treatment and quitting use of drugs led to change their risk factor, we revealed that these factors remain unchanged.

This causes us to prove that treatment is not a precondition to stop drug use. In the appropriate encouraging environmental conditions, the users will still demonstrate preference towards risky behavior and return to drug use after treatment.

Our recommendation is to develop addiction policy, based on the economic nature of decision models and opportunity costs of expected values.

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