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E. I. Borisova, A. A. Peresetsky¹

Do secrets come out? Statistical evaluation of student cheating

We suggest an original method of student cheating evaluation based on the comparison of students' grades in exams in class, home assignments and experimental homework. The data for the study is collected from the survey of 2012–2013 sophomores of the International College of Economics and Finance at the National Research University Higher School of Economics in Moscow, Russia. At the end of the course in Statistics in addition to standard assignments (homework and exams) students were given experimental homework with a ban on cooperation among them. The violation of this rule was qualified as cheating. The scale of cooperation is measured and then tested through the stochastic frontier technique; it reveals connection with the GPA level, students' expectations of the cheaters' share and students' moral norms. We also find different behavioral patterns for high and low performing students as well as country specific context of student cheating behavior.

Keywords: student cheating; take home assignment; stochastic frontier; Russia.

JEL classification: A13; A22; C50; C91; I21; I23; K42; Z13.

1. Introduction

Numerous studies show that student cheating is a widely spread phenomenon both in developed and developing countries. According to some reports (Fendler, Godbey, 2016) more than half of students are involved in some kind of dishonest academic behavior, which makes it crucial to determine and punish cheating. Our paper offers an original method of indirect evaluation of student cheating. In addition to classical exams and homework assignments, we gave the students an experimental homework assignment with a ban on their cooperation, and then proposed a measure of the violation of this rule.

In literature on student cheating the authors most often use the measure of self-reported cheating, i.e. behavior stated by students themselves (see, for example, literature review in (Crown, Spiller, 1998)). In such a case, however, the problem of uncertainty of answers due to different interpretations of the notion «observed» and the desire to conceal violations is evident. This uncertainty results in underestimating the scale of student cheating. Another limitation of the analysis based on subjectively measured value of compliance with rules may be the impossibility to establish cause-effect links between violations and factors which bring them about. Thus, the expectations of cheater's share could be dependent on the reporting student's behavior.

¹ **Borisova Ekaterina** — National Research University Higher School of Economics, Moscow, Russia; eborisova@hse.ru.

Peresetsky Anatoly — National Research University Higher School of Economics, Moscow, Russia; aperesetsky@hse.ru.

One of the rare examples of papers with objective measures of academic dishonesty is Jacob, Levitt (2003) research. The authors, however, analyze not a sample of students, but a sample of public school teachers of Chicago and determine the scale of their assistance to students in violation of existing rules, but in answer to incentives to reward. The authors propose two measures of cheating which in combination allow identifying prevalence of cheating. One measure is based on unexpected fluctuations of students' scores (i.e. high scores for the students' class in one year followed up by comparatively low scores), while the other focuses on suspicious patterns in students' answers (similar patterns across students in the class, presence of the answers for difficult questions in the absence of answers for easier ones, etc). Arnold (2016) adopts Jacob, Levitt (2003) method for the measurement of student cheating and suggests a measure of the likelihood of cheating for every student; the author also proposes a system of regressions with the comparison of scores for summative exams and formative online tests² to estimate overall probability of cheating.

Another example of statistic measurement of student cheating is the study by Weber et al. (1983). The author compares differences in students' answers randomly distributed between three groups: the first wrote an open book test, the second a closed book test and the third had a take home test. Cheating is measured on the basis of similar patterns in student's answers in every type of test.

An interesting method of detecting cheating in multiple choice exams is offered in the study by McManus et al. (2005). Analyzing a sample of 11500 UK postgraduate medical students who took 11 exams, the authors demonstrate computer algorithm of detecting similar patterns in students' answers (a variant of Angoff's method) which allows making conclusions about the likelihood of cheating. There are also studies in which violations are detected with the method of students' self-grading (Antion, Michael, 1983; Ward, 1986). Thus, Ward (1986) calculates cheating as the deviance of students' actual scores from those obtained by students' self-grading. Finally, Fendler, Godbey (2016) offer a special design of the exam that makes it possible to detect cheating and thus punish a cheater. In doing so they distribute two versions of the exams that have only minor differences that could not be caught by students at a quick glance.

The method offered by us, is based on the econometric model with a comparison of students' scores in closed book exams, classical homework assignments and experimental homework assignment. As far as we know, such a method is not present in the literature. Conceptually, it is close to the practice of discovering plagiarism which is becoming increasingly common in universities when students' written assignments are loaded into a special system and compared with all the literary sources available through it. Besides, our method of detecting cheating is close to the one presented in (Arnold, 2016), as it pertains a comparison of scores for different forms of control. Finally, our method is also close to the one used by Weber et al. (1983) as we offer students an experimental take-home assignment which is then compared with other forms of control.

To test the validity of our student cheating measure we investigate its links with three most important factors of student cheating: student's «strength» expressed as his/her rating or some other analogous measure (see, e.g. Bowers, 1964, McCabe, Trevino, 1997), his/her expectations

² Formative tests are used in the process of learning, while summative tests are provided at the end to measure overall student achievement. For further distinction between formative and summative assessments see, for example, <http://edglossary.org/formative-assessment/>.

of the share of non-cheaters (Magnus et al., 2002) and his/her moral norms (West et al., 2004). Alongside this, we use the method of stochastic frontier approach with heteroscedastic random noise (a new one for the research area under discussion). The connection revealed between our measure of cheating and these three students' characteristics is in line with the literature which demonstrates ability of the proposed measure to evaluate whether a student cheats.

The data for the analysis was collected from the experiment that involved second-year students of the bachelor degree course of the International College of Economics and Finance at the National Research University Higher School of Economics. In the academic year of 2012–2013 at the end of the year-long course in Statistics the students were offered homework assignment³ with the following rules: 1) observation of the time limit; 2) a ban on all kinds of consultations; 3) a ban on using the Internet. Thus, it differed from the usual homework assignment in that it had additional restrictions, compliance with them was almost totally on the students' conscience because of the absence of professors' direct control. From now on, it will be referred to as experimental homework assignment, or HW22.

Scores in HW22 were considered together with scores for other homework assignments and their weight in the final score for the course was a little greater than the weight of the usual homework. Additionally, HW22 was supplied with a questionnaire which, when filled out, gave additional scores. Such bonuses were used to stimulate students to fill out the questionnaire and to do the homework⁴.

The paper proceeds in the following way. Section 2 contains description of the data. Section 3 presents our method of estimating student cheating, while Section 4 tests validity of the proposed measure of student cheating. Conclusions are summed up in Section 5.

2. Data

We analyzed a sample of 2012–2013 sophomores of the International College of Economics and Finance at the National Research University Higher School of Economics in Russia. It consists of 41 male and 61 female students, 73% of which graduated from school in Moscow. The most important information for us is about students' scores on the basis of which student cheating measures are built. Overall, we have all scores for the Statistics course: for 3 exams, 21 usual homework assignments and one experimental homework assignment.

We also have information about each student's rating, his/her moral norms and expectations of the share of cheaters. These are the key factors of student cheating (Borisova et al., 2014) and, as such, they serve for testing the validity of the student cheating measure offered by us. Students' rating is taken from the student academic performance data base, while the rest of the

³ On the whole, during the academic year students took 3 exams (in autumn, winter and spring) and were given 21 home assignments. The spring exam had greater weight than the others because of its status of the final one in the Russian program. Besides, at the end of the academic year the students had an external exam under the London program. Depending on their specialization, it was either Statistics-1 or Statistics-2 or both of them. The total weight of homework assignment in the final score was equal to 0.14; the weights of the three exams — 0.14, 0.14, 0.21; the weight of the London exam — 0.37. All the scores were graded on a 100-point scale.

⁴ The perspective of bonuses stimulated students. This homework assignment was handed-in by 109 students (66% of the whole course), whereas on an average only 62% of students handed-in usual homework assignments.

data is collected from the questionnaire that was distributed among the students together with the experimental homework assignment. For clarifying students' expectations with regard to the share of those who observed the rules we asked them the question often used in similar studies, e.g. (McCabe, Trevino, 1997; Magnus et al., 2002). As for moral norms, because our survey was not anonymous, the question was asked in an indirect way, that is, about moral norms of other course students but not the respondent's own norms. It seems justifiable to think that student cheating measures like this correlate with direct measures of students' moral norms and behavior, particularly because every student adapts his/her norms to those expected by their environment. Among other things, it may be accounted for by the fact that students do not want to be deceived or to suffer because of his/her course mates' dishonest behavior (e.g. see (Butler et al., 2012) where interrelation between trust/credibility and ability to evoke it discussed).

Characteristics of variables of the analysis presented in Table A1, and their description — in Table A2; both are given in the Appendix. As follows from Table A1, mean scores for usual homework assignments and experimental homework assignment turned out to be very close to each other — 78 and 74 out of 100 points respectively. Analogous score for the exams came to 40 points only. However, on the basis of this seemingly great difference it is impossible to jump to conclusions about a better performance with the task in one format and a worse performance with the task in another. Distribution of scores may be shifted because of difference in the complexity of the tasks.

A quick glance at Table 1 gives some intuition for the following analysis. As one can see scores for the experimental homework assignment are only weakly correlated with the scores for exams and usual homework assignments. They are also weakly correlated with student's rating. On the contrary, correlation with the rating of the mean score for the exams is strong enough — 0.79. Thus exams are the best of three forms of control to represent student's knowledge, while experimental homework assignment seems to be not free from cheating.

Table 1. Pair correlations of scores for different forms of control

	Mean score for home assignments	Mean score for exams	Score for experimental homework	Rating
Mean score for home assignments	1			
Mean score for exams	0.51	1		
Score for experimental homework	0.37	0.28	1	
Rating	0.57	0.79	0.47	1

Note. All correlations are computed for the 89 observations that constitute our sample and are significant at 1% level.

3. Evaluation of the student cheating behavior

All three forms of performance control — usual home assignments, experimental homework assignment and exams — may not be free from student cheating. However, students' behavior during exams were strictly controlled by the authors of the paper. Besides, during the exams students were not allowed to use their materials or to consult anybody. Thus, the exam score may be looked upon as an indicator of students' true knowledge. At the same time, scores for usual homework assignments without any additional rules and for an experimental homework assign-

ment with the three main rules may reflect both students' true knowledge and assistance on the part of other students. It may also testify to a possibility to use learning materials and to a lower motivation (as contribution of any separate homework assignment to the final score for the course is far lower than contribution of the exam). To simplify the analysis, we disregard the latter of these factors and as for the possibility to consult each other and use different materials it will be called here cooperation and studied in more detail at a later stage.

Thus, the score for usual homework assignment includes true knowledge and the results of cooperation (supposedly, positive ones).

$$hw_i = \alpha + \beta Exam_i + cphw_i + \varepsilon_i, \quad (1)$$

here hw_i — mean score for usual homework assignments of student i (or — as an option — the sum of these scores); $Exam_i$ — the first principal component of the three exams (or, alternatively, the vector of scores for three exams); $cphw_i$ — measure of cooperation; ε_i — random noise.

Let $\hat{u}_i$ be the residuals of the regression:

$$hw_i = \alpha + \beta Exam_i + u_i. \quad (2)$$

Since the equation (2) does not include measure of cooperation $cphw_i$, the residuals include this measure. We name these residuals res_hw_i .

In a similar way, it is possible to estimate the difference between scores for the experimental homework assignment HW22 and exam scores:

$$hw22_i = \alpha + \beta Exam_i + u_i. \quad (3)$$

Let res_hw22_i be residuals of regression (3).

Density estimate of equations (2) and (3) residuals is given in Fig. 1.

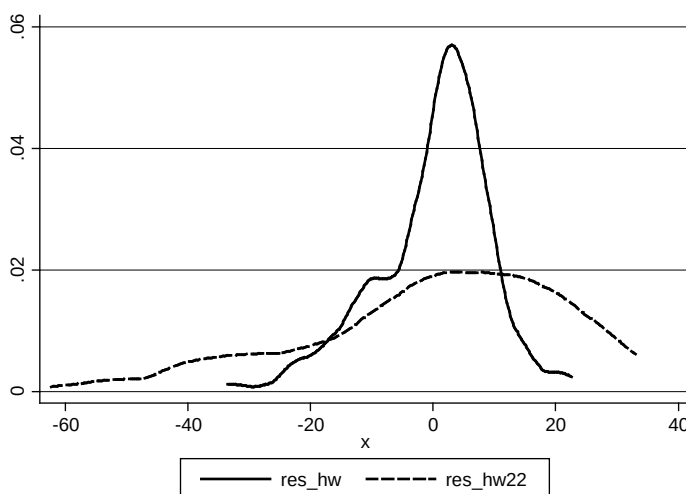


Fig. 1. Density estimate of equations (2) and (3) residuals

It should be pointed out, that when doing usual homework assignments the students could consult each other and use the Internet, whereas the rules of experimental homework assign-

ment did not allow it. That is why, in case of compliance with the rules of HW22, «cooperation» may include only consultation of learning materials and it must be less in scale than cooperation in case of the usual homework assignment (1). In other words, positive difference between res_hw_i and res_hw22_i signifies observance of the rules of HW22.

Next, we estimate regression:

$$res_hw_i = \beta \cdot res_hw22_i + u_i, \quad (4)$$

and let the obtained residuals be $dcoop_i$ — student cheating measure. Positive values of this variable show that the student likely observed the rules, and negative values — that the student did not observe them. It is worth noting, however, that if the student observed the rules of HW22, but when doing it, was especially diligent, it is difficult to distinguish from student's violation of the rules of HW22 — the value of $dcoop_i$ will be negative. Figure 2 shows estimate of the density of $dcoop_i$.

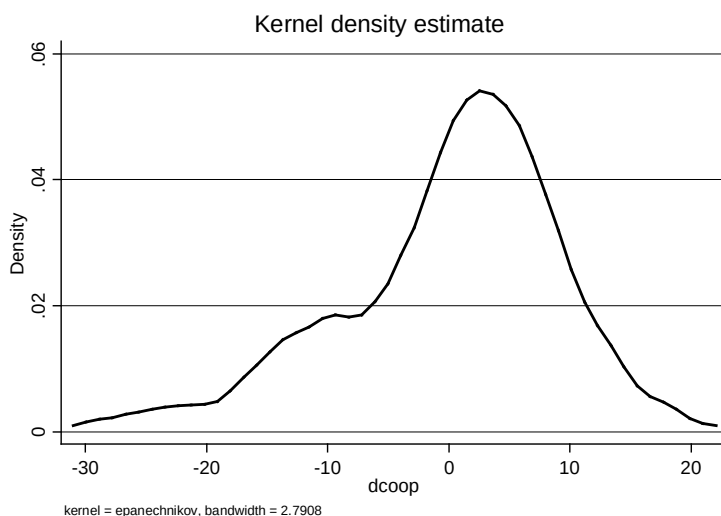


Fig. 2. Estimate of $dcoop_i$ density

4. Testing validity of student cheating measure

4.1. Students' «strength» measure

According to the literature rating or its analogue allowing to measure student's «strength» is considered to be one of the main variables of the analysis. Strong students just don't have to violate the rules — they have sufficient knowledge and skills, and, also, they may be interested in testing their knowledge and skills as well as in preserving their good reputation among same course students. Many empirical papers demonstrate the role of high rating in observing the rules (see, for example, (Bushway, Nash, 1977; Crown, Spiller, 1998) for the review of related studies).

Figure 3 shows scatterplot of cooperation $dcoop_i$ against the rating; the line corresponds to non-parametric estimate of the function $dcoop_i = f(raticef_i) + \varepsilon_i$, where $raticef_i$ represents stu-

dent's rating⁵. It is clear that the values are positive for students with average values of the rating. Students with low or high rating either violated the rules or attached special importance to successful fulfillment of HW22. Both may be explained by strong competition among such students. In the lower part of the rating scale we observe struggle for survival, in the upper part — struggle for getting to the top. The latter has a financial motivation — discounts on tuition fees are graded and about half the students (with the highest rating) get them. On the whole, the presence of connection between student's rating and the students cheating supports the validity of this measurement⁶.

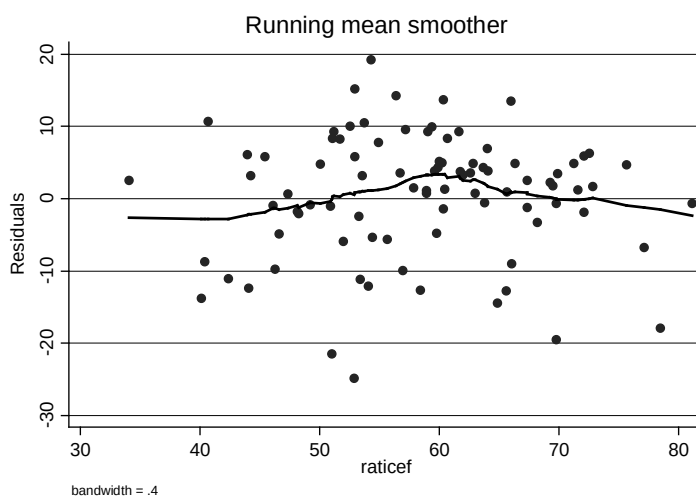


Fig. 3. Non-parametric estimate of student cheating measure as a function of the rating

4.2. Norms and expectations

Students' norms and their expectations of the share of those observing rules belong to important potential factors of student cheating. Norms prevent antisocial behavior because of inner motivation to avoid it formed by parents, teachers and simply by their environment. To measure student's norms mostly direct questions are used, but the non-anonymous character of our survey predetermined the inclusion of an indirect measuring instrument — opinions about the norms of the same course students which reflect the norms of a concrete student. As for expectations, the optimism about the share of honest students, as numerous empirical studies show (see, for example, review in (Crown, Spiller, 1998)), leads to a greater share of those observing the rules — students choose the same behavior as that of the majority in their environment. The basis of such behavior may be conformity (Bernheim, 1994), lowering the moral costs of violations because of their prevalence (Murdock, Anderman, 2006) or reluctance to give undeserved ad-

⁵ Dependence of cooperation measure (violation of the rules) on the rating is not significant at the level of 10%, that is why we present graphic interdependence but not a table with regressions.

⁶ It is interesting that connection with the suggested student cheating measure reveals a measure which in essence is similar to the rating — the number of homework assignments which were handed-in. This number is the indicator of student's ability to work and his/her diligence and thus could be treated as student's «strength» measure.

vantage to those students who are inclined to violate the rules. The latter leads to violations of those students who have sufficient knowledge and would not break the rules in case of honest competition. A more detailed description of these motives is given in (Borisova et al., 2014).

Cooperation among students $dcoop_i$ turned out to be linked to expectations of the share of students who did the experimental homework assignment with no exterior help, that is, observed two of the main rules. To reveal this connection we used the stochastic frontier model (Kumbhakar, Lowell, 2000):

$$\begin{cases} dcoop_i = v_i - u_i, \\ \ln \sigma_{u_i}^2 = \alpha + \beta \cdot expectations_i, \\ \ln \sigma_{v_i}^2 = const. \end{cases} \quad (5)$$

Here v_i — symmetrically distributed error $v_i \sim N(0, \sigma_v^2)$; and $u_i \geq 0$ — heteroscedastic random noise with asymmetric distribution $u_i \sim N^+(0, \sigma_{u_i}^2)$. We assume that a standard deviation of u_i depends on students' expectations about the share of those who did the homework on their own. Heteroscedastic model like this is often used to estimate efficiency factors of commercial firms, for example banks and, also, educational and healthcare institutions; for details see, for example Battese, Coelli (1995).

It should be pointed out that because $\frac{d}{d\sigma_u} E(u) \geq 0$ (Kumbhakar et al., 2015), with $\beta > 0$

increase of expectations implies increase of variance σ_u^2 , and, hence, increase of $E(u)$, that is, decrease of $E(dcoop)$, that is decrease of mean value of student cheating measure. Thus, increase of expectations leads to the decrease of the likelihood that the student observed the rules.

As follows from Table 2, less optimistic expectations of the share of honest students increased the likelihood of student's compliance with the rules while more optimistic expectations increased the likelihood of violations. Usually, researchers discover that more optimistic expectations lead to a greater compliance. However, these results were obtained for subjective measures of cheating based on students' own answers, see (Crown, Spiller, 1998). The results obtained by us could be explained by student's worse opinion about other students and his/her actions not being in the spirit of conformity (which, in point of fact, was discovered in the majority of studies), but in the spirit of protest when the student's behavior is different from the behavior of other students. The likelihood of this type of behavior is demonstrated by works of Poltorak (1995) and Magnus et al. (2002) which analyze samples of Russian students.

We also find a connection between cooperation indicator $dcoop_i$ and students' norms, (provided, the rating is taken into account) (Table 2). This connection was modelled with the help of the stochastic frontier differing from equation (5) by assumption that $\sigma_{v_i}^2$ depends on rating:

$$\begin{cases} dcoop_i = v_i - u_i, \\ \ln \sigma_{u_i}^2 = \alpha + \beta \cdot MedicalCertificate_i, \\ \ln \sigma_{v_i}^2 = \gamma_1 + \gamma_2 \cdot raticef_i. \end{cases} \quad (6)$$

Here v_i — symmetrically distributed error $v_i \sim N(0, \sigma_v^2)$, with the variance that depends on the rating $raticef$; u_i — heteroscedastic random noise with asymmetrical distribution

$u_i \sim N^+(0, \sigma_{u_i}^2)$, with the variance that depends on the student's attitude to buying a Medical Certificate⁷. Special attention to buying a certificate as a measure of the student's norms is explained by its specific role in the context of Russian students' behavior — more often than not it is taken not because the student is really ill but because of the desire to get some serious justification of non-appearance at the exam.

Table 2 shows that the less tolerant the student is to buying a Medical Certificate⁸ the less he/she is inclined to violating the rules of HW22.

Table 2. Links between measures of cooperation, expectations and norms

	(1)	(2)
Constant	9.719*** (1.382)	8.628*** (1.136)
lnsig2v		
Raticef	—	−0.0732** (0.034)
Constant	2.991*** (0.420)	7.387*** (1.881)
lnsig2u		
Expectations	0.0163* (0.009)	—
Attitude to buying a Medical Certificate	—	0.406** (0.187)
Constant	4.071*** (0.670)	3.288*** (0.704)
Number of observations	92	88
Log likelihood	−324.5	−305.9

Note. Dependent variable — measure of cooperation when completing special homework — $dcoop_i$. In brackets are given standard errors. *, **, *** — estimate is significant at 10, 5, 1% levels, respectively.

Thus, the student cheating measure offered here not only demonstrates connection between norms and expectations but also allows to reveal country specific dependence — a better observation of the rules coupled with worse expectations of the share of non-cheaters.

5. Conclusion

Our study suggests a novel method of measuring student cheating. The sample under analyses is made up of second-year students of the International Institute for Economics and Finance of the National Research University Higher School of Economics in Russia. In addition to standard forms of control, the students were given experimental homework which they were

⁷ We use student's attitude to buying a Medical Certificate as a measure of the student's norms. Details about rating measure and student's attitude to buying a Medical Certificate could be found in Tables A1 and A2 in the Appendix.

⁸ It is interesting that deviations in scores for usual homework assignments are linked to students' attitude to buying a Medical Certificate — the more justifiable they think such an action is the lower their scores for usual homework assignments are. The size of the correlation in this case is 0.17, significance — 10%.

to do observing three main rules. In particular, they were banned from cooperating with each other — that is, from something that can be measured afterwards by comparing scores for different forms of control.

To test the validity of student cheating measure we investigate its connection with the students' characteristics that are usually studied in this literature: students' rating, their expectations of the share of same course students who observed the rules and moral norms. In doing so we employ stochastic frontier technique with an assumption of heteroscedasticity of the random noise. To the best of our knowledge it was not used in earlier studies of student cheating.

All factors of cheating prove to be significant, and, at the same time, the impact of the rating is different for the students in its upper, lower and middle parts. In particular, the rich club effect known from literature seems to manifest itself (see (Vaquero, Cebrian, 2013)) — when strong students form some kind of mutual help club, access to which is closed for the rest of the students. To this effect, it seems, that a comparatively better performance in experimental homework assignment by students from the upper part of the rating testifies.

We should also mention some limitations of the analysis that have consequences for the conclusions that may be drawn from it. To begin with, there is some difference in the conditions under which different kinds of assignments were done — for example, when taking exams, students were not allowed to use learning materials, but when doing their homework assignments they had an opportunity to do it. This means that there is, at least, one more factor which can influence students' scores (in addition to their cooperation) and which we cannot separate from student cheating. Furthermore, we cannot disregard students' greater diligence which they demonstrate when doing an experimental homework assignment (that is the factor of different stimuli when students are set different tasks). And finally, it appears probable that exams and homework assignments which students do in the conditions of time limit and unlimited time respectively, test students' different skills. In the first case, the most important requirement is to do the task in the shortest possible time, in the second case, deeper and «slower» analytical skills may prove to be more important. One solution to these problems may be a set of one-type assignments (for example, homework assignments) differing from one another in one rule only. Moreover, it should be possible to attribute deviations in student's scores to cheating (for example, students' cooperation). In this case, conclusions could be more clearly defined.

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Appendix

Table A1. Students' main characteristics (total sample — 41 male and 62 female students)

	Number of observations	Average	Standard deviation	Minimum	Maximum
Average score for homework	100	78	11	39	97
Average score for the experimental homework	97	40	13	13	79
Score for experimental homework	102	74	22	16	100
Degree of cooperation	100	$-2 \cdot 10^{-8}$	20	-55	42
Expectations	102	55.4	25.6	6	100
Attitude to buying a Medical Certificate	96	3.2	1.1	1	5
Rating	96	58.2	9.75	34.0	81.1

Note. Among the students who handed-in experimental homework, there were students who only filled out the questionnaire but did not do the homework. Some students, on the contrary, did the homework but did not fill out the questionnaire. Different number of observations are accounted for by gaps in students' answers or by absence of information about scores/rating of some of them.

Table A2. Description of variables

Name of measure	Formulations of questions from the questionnaire	Description of measure
Average score for home assignments		Averaged score for 21 usual home assignments
Average score for exams		Averaged score for 3 exams
Score for experimental homework		Score for the 22 nd (experimental) home work
Degree of cooperation (student cheating measure)		Our measure of student cheating. For details see Section 3.
Expectations	What percentage of students who handed-in HW22 do you think did it without outside help (though, probably exceeded the time limit)?	
Attitude to buying a Medical Certificate (Opinion about norms)	Answers to the item 7) of the following question: Please, evaluate how acceptable (in your opinion) for your course students are the following types of behavior (<i>on a scale from 1 to 5 where 1 means absolutely unacceptable and 5 means absolutely justified</i>): 1) evading paying public transport; 2) tax evasion; 3) getting benefits (for example, low fare ticket they are not entitled to); 4) non-repayment of debts; 5) non-return of library books; 6) giving bribes; 7) buying Medical Certificate; 8) buying driver's license.	Measure from 1 to 5
Rating		Exact value of student's rating with London exams taken into account.