

Factors of Attrition among Computer Science and Engineering Undergraduates in Russia

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Abstract. STEM education has been a priority in present-day Russia, nearly half of all the government-funded places in colleges being provided in STEM majors. At the same time, attrition rates have been the highest in this field. The present study aims to estimate the attrition rates in computer science and engineering education at the beginning of and midway through instruction and to determine the factors associated with college dropouts. Our research uses the results of a survey of over 4,000 computer science and engineering students from 34 Russian colleges, composing a representative national sample, and ad-

ministrative data on student withdrawal. Vince Tinto's student departure theory is used to analyze the determinants of student attrition during the first three semesters. According to Tinto's theory, social and academic integration are critically important to the retention and success of students in the chosen university. Our findings confirm the key role of academic integration (specifically class attendance and interactions with faculty) in preventing dropouts but refute the hypothesis of social integration significance. Students with low USE scores in mathematics and those mismatched to their major were found to be at higher risk of dropping out. No evidence has been found to prove the hypothesis of dropout rates being higher in more selective institutions. Recommendations for universities for reducing college attrition rates are discussed in the final part of the paper.

Keywords: higher education, college dropout, college attrition, student withdrawal, academic integration, social integration, college institutional characteristics.

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STEM (science, technology, engineering and mathematics) education plays a significant role in national economic growth, being considered as a driver of innovation [Blackie, le Roux, McKenna 2016; Kardanova et al. 2016]. In response to today's global trend of knowledge-based economy [National Academy of Science 2007], the gov-

ernment of Russia has made STEM a priority of higher education development¹. About a third of all Russian undergraduates are enrolled in STEM programs [Gokhberg, Kovaleva, Kuzminov 2018]; 47% of government-funded places were allocated to STEM majors in the academic year 2018/19².

Despite the focus on STEM disciplines and the extensive discussion of relevant issues in academia, the quality of STEM education in Russia could hardly be called satisfactory. STEM majors do not attract many candidates and seem to be largely chosen by low performers—a quarter of applicants have a mean USE³ score below 56 [Kuzminov, Froumin, Ovcharova 2018]⁴. International comparative assessments demonstrate that a minority of Russian undergraduates receives high quality training in elite institutions that allows them to be competitive in the global labor market, while the majority of students receive low quality training in non-elite institutions [Loyalka et al. 2014]. However, even graduates from elite STEM programs of Russia are skilled less than graduates from elite programs of China, India or the United States⁵ [Loyalka et al. 2019].

The situation is aggravated by higher attrition rates in STEM majors as compared to non-STEM programs [Kondratjeva, Gorbunova, Hawley 2017].

In particular, the data obtained at two Russian colleges show that attrition in STEM fields (25%) was considerably higher than in non-STEM fields (19%) during 2.5 years after enrollment [Kondratjeva, Gorbunova, Hawley 2017]⁶. Researchers suggested that this result could be due to lower selectivity, curriculum difficulty and the lack of academic services for academically struggling students in computer science and engineering departments. However, this hypothesis has not been tested empirically.

As computer science and engineering education in Russia is losing its quality and attractiveness, it is critical to find resources to en-

¹ Klimov A. (2013) *Kolichestvo byudzhetnykh mest dlya obucheniya v vuzakh sokhranilos' na urovne 2012 g.* [The Number of Government-Funded Places in Universities Has Remained at the Level of 2012]. Available at: <https://минобрнауки.рф/новости/3389>

² Report of the Government of the Russian Federation to the Federal Assembly of the Russian Federation on Implementing the National Education Policy, 2019: <http://static.government.ru/media/files/VGZkuVnp1h5rLAAIBZ1AsP5z-v4zhl79t.pdf>

³ Unified State Exam

⁴ These students had “C’s in high school mathematics and life sciences” [Kuzminov, Frumin, Ovcharova 2018:22].

⁵ The study assessed and compared computer science skills among undergraduates in Russia, China, India and the United States using tests designed specifically to measure computer science competencies.

⁶ Differences between STEM and non-STEM fields are statistically significant at the level of $p < 0.05$. Data on attrition was obtained directly from the authors (the significance level was not specified in the publication).

hance the internal efficiency of universities, in particular to understand the reasons behind student attrition. This study makes an advance in that direction, seeking to solve two problems:

1. Measure attrition rates in STEM majors at the beginning of (during the first three semesters) and midway through instruction (between the 3rd and 4th years); and
2. Identify the factors of attrition during the first three semesters.

The study uses the results of a survey of over 4,000 computer science and electronic engineering undergraduates from 34 Russian colleges, composing a representative national sample, and administrative data on student withdrawal provided by the educational institutions.

The theoretical framework of research is based on Vincent Tinto's student departure theory [Tinto 1975; 1993], which postulates that social and academic integration are critically important for successful completion of postsecondary programs.

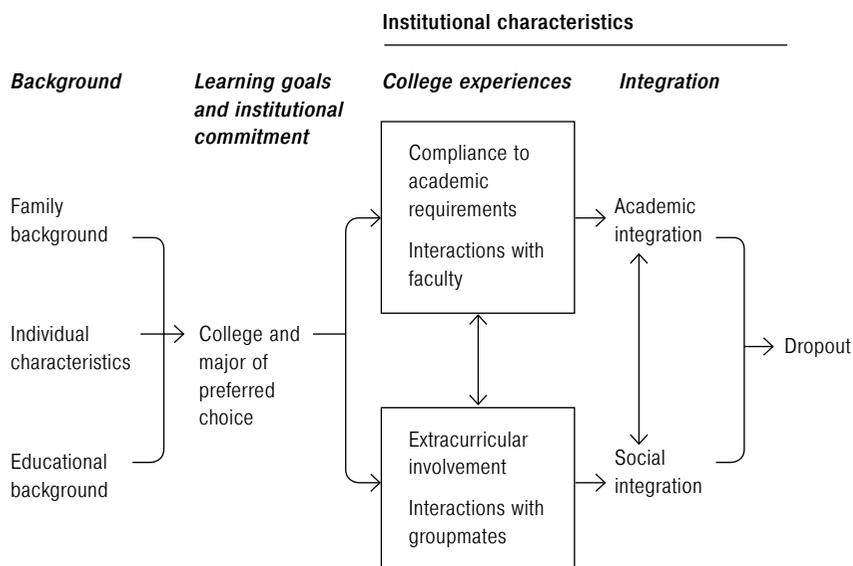
1. Conceptual Framework and Research Hypotheses

College dropouts have been studied globally since the 1970s [Spady 1970; Kamens 1971; Tinto 1975]. Scholars differentiate between system dropouts, when students leave the system of postsecondary education as such without getting a degree, and institutional dropout, when students leave the institution but reserve the possibility of enrolling somewhere else [Mayhew et al. 2016]. In this study, we focus on institutional dropouts.

Exploring the reasons for college dropouts and the factors of successful college completion, researchers use a variety of theoretical frameworks, including an approach highlighting the role of social and academic integration for undergraduate persistence [Tinto 1975; 1993; Spady 1970; Berger 2000], theories that consider certain psychological characteristics, motivation in particular, to be determinants of learning effectiveness [Deci et al. 1991; Bean, Eaton 2001], those that explore the impact of institutional parameters of programs and universities [Bean 1980], etc. Despite the differences in their focus, all the frameworks overlap in that successful completion of college programs is a product of interplay among student characteristics, institutional parameters and students' perceived level of academic integration [Mayhew et al. 2016].

Among all the theories used to analyze college attrition, Tinto's theory of student departure is the most well-reputed and influential [Melguizo 2011]. According to this theory, the likelihood of dropping out is closely related to students' educational background, expectations and levels of social and academic integration, the latter being largely contingent on the institution's retention effort [Tinto 1975; 1993].

Figure 1. **Conceptual framework of research based on Tinto's model** [Tinto, 1993]



Drawing on the conceptual framework of research based on Tinto's model of student departure [Tinto 1993] (Figure 1), we formulate six hypotheses about the factors of institutional attrition. Prior to hypothesizing, we describe the concepts analyzed, present the findings of earlier studies carried out in Russia and beyond, and provide a brief summary of postsecondary education characteristics that matter in the context of our hypotheses.

1.1. Background Characteristics

Variance in the risk of dropping out, according to Tinto's theory, may be explained by students' background, including social background (economic status of family, parental education), individual characteristics (gender, age) and previous educational experiences (e. g. in school) [Tinto 1993]. Empirical evidence has been obtained for Tinto's postulation that social background of students determines to a large extent their college experiences and success. Higher risks of dropping out were observed for students from low socioeconomic backgrounds [Swail 2004; Vignoles, Powdthavee 2009] and those whose parents had no college degree [Pascarella, Terenzini 2005; Brownstein 2014]. The risk is also high for students who performed lower at the secondary stage of education [Timofeeva, Avrunev 2016; Gorbunova 2018]—they find it particularly hard to overcome the gap between the quality of schooling and the college requirements [Terentev, Gruzdev, Gorbunova 2015].

H1: Institutional dropout is more typical of students from lower socio-economic backgrounds.

H2: Institutional dropout is more typical of students who performed lower at the secondary stage of education.

1.2. Institutional Commitment Students may drop out due to the lack of positive expectations, sense of belonging and attraction to a particular institution. All these characteristics of personal college experience correspond to low levels of institutional commitment [Tinto 1993; Strauss, Volkwein 2004; Gorbunova 2018]. For instance, students whose choice of institution does not match their initial preferences show lower levels of social integration and are more likely to withdraw [Braxton, Milem, Sullivan 2000].

This factor may be especially powerful in the context of Russia, as Russian college students have to choose their specialization at the very start and have very limited opportunities for horizontal mobility—between majors or institutions—later on [Kuzminov, Yudkevich 2007]. Being unsatisfied with their choice of major or college, they have fewer opportunities for a seamless transition as compared to students in education systems where specialization choice occurs at later stages—and thus face a higher risk of dropping out [Braxton, Milem, Sullivan 2000].

H3: Institutional dropout is more typical of students whose choice of institution or major mismatches their initial preferences.

1.3. Academic Integration Academic integration involves compliance to formal academic requirements of the institution, such as attending classes, completing assignments or getting grades, as well as the quality of in- or out-of-class student–faculty interactions [Tinto 1993].

Studies show that academic performance, reflected in grades, is the main factor of attrition [Pascarella, Terenzini 2005; Mayhew et al. 2016]. Compliance to academic requirements, such as regular class attendance, makes it easier for freshmen to adapt and facilitates social contacts [Bernardo et al. 2016]. Russian studies based on quantitative [Kondratjeva, Gorbunova, Hawley 2017] and qualitative [Gorbunova et al. 2016] data demonstrate that low academic integration is the most probable reason for college dropouts in Russia.

H4: Institutional dropout is more typical of students with low levels of academic integration.

1.4. Social Integration Students not involved in extracurricular college activities (e. g. student associations) or social contacts with peers have lower levels of social integration and face higher risks of dropping out [Tinto 1993, Mayhew et al. 2016].

Social integration is a serious challenge for most Russian universities, which is proved by the limited choice of extracurricular activi-

ties offered by colleges. As a consequence, students in Russia exhibit low involvement in extracurricular activities [Bekova, Kasharin 2018], which are supposed to be a driver of social integration [Mayhew et al. 2016]. Besides, little is invested in academic support services, such as tutoring, mentoring and other assistance practices. As a result, low-performing students lose their social contacts and connections with time and find themselves at a higher risk of dropping out [Valeeva, Dokuka, Yudkevich 2017]. However, Russian undergraduates study in groups that change little in their composition throughout the whole period of instruction, which may foster closer friendship ties and thus ensure social integration through interactions with groupmates.

H5: Institutional dropout is more typical of students with low levels of social integration.

1.5. Institutional Characteristics

Student attrition may also be associated with institutional characteristics. For example, selectivity (average GPA of students admitted) and student–faculty ratio are considered to be key institutional factors of college dropouts in the United States [Mayhew et al. 2016]. Highly selective and academically demanding Western universities, American for example, were found to show higher timely graduation rates [Alon, Tienda 2005; Gansemer-Topf, Schuh 2006; Melguizo 2008; Sneyers, De Witte 2014]—a finding that appears to be surprising at first glance.

In the United States, low dropout rates are an indicator of effective student retention strategies and high quality instruction, enhancing the institution’s attractiveness and competitiveness [Cook, Hartle 2011; Sneyers, De Witte 2014]. In Russia, conversely, low dropout rates are associated with low quality of educational services [Gruzdev, Gorbunova, Froumin 2013].

Russian studies show that attrition rates may be higher in selective universities [Kondratjeva, Gorbunova, Hawley 2017] than in non-selective ones. In elite institutions, the dropout rate reflects the attrition among academically struggling students. Lower dropout rates in non-elite colleges could probably be explained by the higher education funding mechanisms in Russia. Colleges whose funding depends essentially on enrollment—which constitute the vast majority [Sokolov 2017]—may exhibit low selectivity in both admission and retention to maintain the level of funding. In addition, public institutions should not exceed the maximum dropout rate allowed—if enrollment declines by more than 10% during the period of study, the university will be deemed to have failed its government order [Zagirova et al. 2019]. In case the maximum dropout rate allowed is exceeded, the institution will have to pay the funding back to the government and face the risk of state budget cuts in the future.

In the meantime, highly selective universities and institutions that obtain additional sources of funding, e. g. as a result of their research and expert assessment activities, can afford dismissing the poorest

performers who do not cope with the curriculum. Besides, such universities develop a highly demanding environment, high attrition rates being regarded as a distinctive feature thereof. At the same time, however, they can also afford implementing academic support mechanisms to identify and assist students at risk of dropping out, such as remedial courses, tutoring, etc.

H6: Institutional dropout is more typical of students enrolled in highly selective universities.

2. Data As its empirical basis, this study makes use of the data obtained by the international longitudinal project SUPER-test⁷, within the framework of which two cohorts of first-year (2,607 students, Cohort 1) and 3rd-year (2,096 students, Cohort 2) computer science and engineering undergraduates from 34 Russian universities were sampled in the fall semester of 2015 (November–December). Using stratified multi-stage random sampling, we first sampled universities, then academic departments/schools, and then student groups to ensure data representativeness. During the survey, students provided answers to questions about their college experiences, pre-college educational background, academic and career plans.

The second round of the survey occurred at separate times for the two cohorts (Figures 2 and 3). Ten students in Cohort 1 and 38 students in Cohort 2 were excluded from analysis due to technical impossibility of bringing together data from both rounds⁸ and also because one of the student groups in Cohort 2 had graduated by the time the second round took place. The resulting sample was composed of 2,597 undergraduates in Cohort 1 and 2,057 undergraduates in Cohort 2. In the second round of the survey carried out in 2016 (November–December), 72% of Cohort 1 students were in their second year of study. The rest of the first-round respondents had either withdrawn from their initial program (24%) or taken an academic leave⁹ (4%). Cohort 2 students were surveyed again in the spring semester 2017 (April–May). By then, 92% of them were in the 4th year, 6% had withdrawn, and 2% were taking a gap year. Among those who

⁷ The SUPER-test is an international comparative study aimed at measuring gains in academic, higher order thinking and specific professional skills among computer science and engineering students and identifying factors that affect skill gains. It was organized by researchers at Stanford University in collaboration with partner institutions, in particular universities in Russia, China, and India. For more details on the project, see the Russian website of the project (<https://ioe.hse.ru/cshe/supertest/>) and [Loyalka et al. 2019].

⁸ As a result of errors in respondent ID coding data.

⁹ Students at Russian universities are granted with an opportunity to interrupt their studying for usually an academic year in case of health impairment or other serious personal reasons.

Figure 2. **Trajectories of students in Cohort 1**

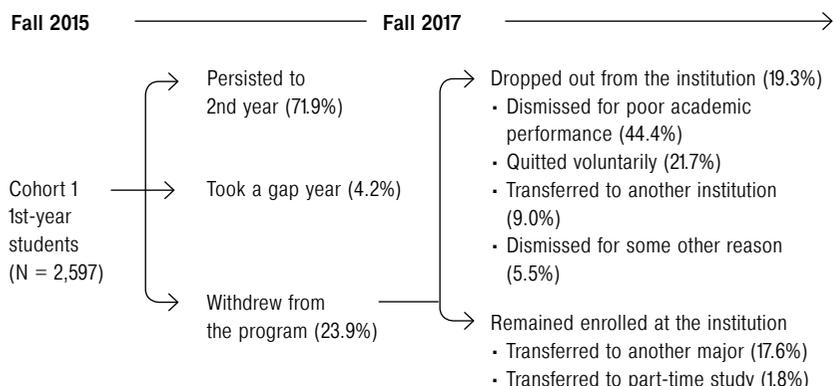
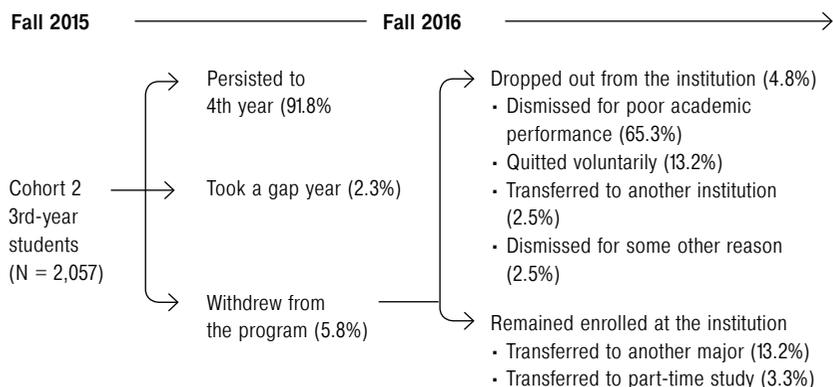


Figure 2. **Trajectories of students in Cohort 2**



had dropped out from their initial programs, 19% in Cohort 1 and 5% in Cohort 2 had left the institution, which we classify as institutional dropout in this study¹⁰.

Data on the reasons for non-participation in the second round of the survey was obtained from institutional directives concerning dismissals, transfers and academic leaves as well as students' explanatory statements.

¹⁰ There is no possibility of demarcating between institutional and system dropout in this study, as the available data does not allow predicting whether a student will withdraw from postsecondary education without getting a degree at all.

Poor academic performance is the main cause of dismissal, accounting for 44% of dropouts in Cohort 1 and 65% in Cohort 2 (Figures 2 and 3). Low performance is followed, in descending order of prevalence, by voluntary withdrawal (22 and 13%, respectively), transfer to another major within the same institution, transfer to another institution, and transfer to part-time study.

Some groups of questions about educational background were not asked to all students, so data from a random subsample was used during the first three semesters. As the subsample was selected randomly, it was still representative.

Female students accounted for 23% of that subsample; the majority of the respondents (68%) had at least one college-educated parent; 59% studied computer science¹¹, and 41% were enrolled in electronic engineering programs¹²; the vast majority of students were subsidized by the government (91%)¹³; 36% had had subject-oriented instruction in secondary school; average USE score in mathematics in the subsample was 59 (out of 100); 29% of the students were enrolled in highly selective universities.

3. Measurements The dependent variable in this study is institutional dropout as an indicator of quitting the institution for either of the following reasons: poor academic performance, voluntary withdrawal or transfer to another institution. The institutional dropout rate within the subsample was found to be 16.7% (Table 1).

Table 1 presents descriptive statistics on the independent variables used for analyzing the factors of dropout during the first three semesters (Cohort 1).

3.1. Background Characteristics Individual characteristics of students and their families analyzed in the study include gender, major, economic status of family¹⁴ and parental education. USE score in mathematics as well as physics and

¹¹ The following majors were included in this category: Mathematics and Computer Science, Fundamental Informatics and Information Technologies, Software and Administration of Information Systems, Informatics and Computing, Information Systems and Technologies, and Applied Informatics.

¹² The following majors were included in this category: Software Engineering, Information Security, Radio-Frequency Engineering, ICT and Communications Systems, Electronics Design and Technology, Electrical and Power Engineering, Electronics and Nanoelectronics, Instrumentation and Control Engineering, Optics and Laser Technology, Photonics and Optoinformatics, and Opto-Engineering.

¹³ This parameter was omitted in subsequent analysis due to its low variance within the sample.

¹⁴ The index "economic status of family" was constructed using Polychoric Principal Component Analysis based on binary variables indicating the presence/absence of various household items (e. g. refrigerator, microwave, etc.). As a result, we identified one factor that explained 56% of the vari-

Table 1. Descriptive statistics for variables in the Cohort 1 subsample (N = 1,049)

	Share or mean value / standard error
Institutional dropout	16.7
Individual and family background characteristics	
Female	0.23
Computer science	0.59
Electronic engineering	0.41
At least one college-educated parent	0.68
Economic status of family	0.0 / 0.8
Economic status of family: bottom quartile	0.29
Educational background	
Physics and mathematics oriented instruction	0.40
USE score in mathematics	59.4 / 15.0
USE score in mathematics: bottom quartile (below 50)	0.31
Institutional commitment	
Major of preferred choice	0.82
Institution of preferred choice	0.79
Academic integration	
Attendance of over 80%	0.88
Factor reflecting the frequency of interactions with faculty	0.03
Social integration	
Number of groupmates with whom students prepared for class or discussed study-related issues	3.11 / 2.8
Involvement in at least one extracurricular activity at college	0.62
Institutional characteristics	
Highly selective university	0.29

mathematics oriented instruction were used as indicators of educational background. Economic status and USE scores were converted into quartiles, and only the bottom quartile variables were used in analysis, i. e. the variables reflecting the lowest socioeconomic backgrounds and the lowest level of math performance. The bottom quartile for USE scores was represented by students who scored below 50.

3.2. Institutional Commitment Institutional commitment of students that reflects their loyalty to the university and intention to persist in their major was assessed using the following Yes/No questions: “Did you enter the college of your preferred choice?” and “Did you enroll in the major of your preferred choice?” A similar assessment method was used in the study [Braxton, Milem, Sullivan 2000].

3.3. Social Integration Indicators of social integration include involvement in extracurricular activities and the number of groupmates (up to ten) with whom students prepared for class or discussed study-related issues. Students were asked to choose the college extracurricular activities they engaged in from the list: student associations, sports clubs, arts (music, choir, student theater, etc.) and volunteering [Tinto 1993]. The analysis used a binary variable indicating involvement in at least one of the activities listed, which applied to 62% of the students.

3.4. Academic Integration Formal compliance to academic requirements—class attendance and frequency of interactions with faculty—were used as indicators of academic integration. Class attendance was assessed using the question, “What is the share of classes (lectures, seminars) that you usually miss?” Students could choose a quintile from 0–20% to 81–100%. This variable was dichotomized due to small numbers of respondents in some categories, so only the variable indicating the attendance rate of over 80% was used in regression analysis.

The frequency of in- and out-of-class interactions with faculty was measured using four questions, such as, “On average, how often math professors ask you personally to answer their questions in class?” and “On average, how often do you communicate with math professors during the break or right after the class?” Students were asked to assess the frequency of their interactions on the four-point scale, choosing among “Never or almost never”, “At least once a semester”, “At least once in every 4–5 classes” and “At least once in every class”. Using principal component analysis, we identified one factor that explained 55% of the total variance and was of sufficient internal consistency (Cronbach’s alpha = 0.72). High levels of this factor reflect a high frequency of student–faculty interactions.

ance, which we then divided into quartiles to facilitate interpretation in the regression model.

3.5. Institutional Characteristics Selectivity was the only institutional characteristic of colleges measured. In our sample, the top 25% (the top quartile) of colleges with the highest minimum USE score in mathematics required for admission, according to data obtained from the 2015 Monitoring Study of the Quality of Enrollment to Russian Universities¹⁵, were classified as highly selective.

4. Data Analysis Strategy In this study, we assess the factors of institutional dropout among computer science and engineering undergraduates in Russia during the first three semesters (Cohort 1), as this is when they face the highest risk of departure from the institution or major [Gruzdev, Gorbunova, Froumin 2013; Ishitani 2016]. Series of binary logistic regressions with subsequent addition of variable sets were used to evaluate the risk of institutional dropout. Model 1 contains only educational background characteristics. Model 2 also includes variables reflecting students' institutional commitment. Model 3 features indicators of academic integration. In Model 4, indicators of social integration are added. Finally, Model 5 also has a variable that describes the level of college selectivity. Each model reflects the odds ratios (OR) of the risk of dropping out as a function of the independent variables. As the analyzed student characteristics may vary across student groups, standard errors were estimated using the Huber–White sandwich estimator to prevent observations from violating the independence assumption [Freedman 2006].

5. Factors of Institutional Dropout during the First Three Semesters Table 2 shows the results of regression analysis. The mean variance inflation factor (VIF) of 1.09 indicates no multicollinearity. Insignificance of the Hosmer–Lemeshow test statistic ($\text{Chi}^2=10.81$; $p = 0.21$) means that the full model (model 5) is well-calibrated and allows making quite accurate predictions. The only module of questions significantly affecting model quality (judging by the significant decrease in the Bayesian Information Indicator (BIC)) was the one concerning academic integration. The other groups of variables contribute relatively little to explaining the attrition. The model classifies 84% of observations correctly.

Background characteristics. The risk of dropping out by the second-year midterm is associated with the level of secondary school performance, students with the lowest USE scores (the bottom quartile) being 50% more likely to drop out than students in the other quartiles (OR = 1.61, model 5). Subject-oriented instruction and other individual characteristics, in particular economic status, are not related to the risk of departure.

¹⁵ <https://ege.hse.ru/>

Table 2. Factors of institutional dropout, Cohort 1, binary logistic regression, odds ratios (OR)

	(1)	(2)	(3)	(4)	(5)
Individual and background characteristics					
Female	0.782 (0.179)	0.767 (0.171)	0.730 (0.164)	0.743 (0.170)	0.738 (0.167)
At least one college-educated parent	1.138 (0.209)	1.149 (0.209)	1.118 (0.213)	1.130 (0.215)	1.166 (0.223)
Economic status of family: bottom quartile	1.324 (0.250)	1.336 (0.246)	1.145 (0.206)	1.149 (0.207)	1.135 (0.203)
Computer science (base: electronic engineering)	1.277 (0.282)	1.452* (0.328)	1.292 (0.304)	1.278 (0.302)	1.271 (0.300)
Physics and mathematics oriented instruction	0.975 (0.179)	0.946 (0.176)	0.935 (0.183)	0.936 (0.183)	0.953 (0.189)
USE score in mathematics: bottom quartile	1.659*** (0.284)	1.595*** (0.273)	1.694*** (0.313)	1.723*** (0.317)	1.610** (0.305)
Institutional commitment					
Major of preferred choice		0.512*** (0.111)	0.560** (0.129)	0.555** (0.128)	0.550*** (0.126)
Institution of preferred choice		0.922 (0.208)	1.224 (0.314)	1.185 (0.304)	1.207 (0.308)
Academic integration					
Attendance of over 80% (base: below 80%)			0.206*** (0.045)	0.217*** (0.048)	0.217*** (0.047)
Frequent interactions with faculty			0.793*** (0.048)	0.809*** (0.054)	0.810*** (0.055)
Social integration					
Involvement in at least one extracurricular activity (base: no)				0.954 (0.188)	0.942 (0.186)
Number of groupmates with whom students prepared for class or discussed study-related issues				0.951 (0.033)	0.953 (0.033)
Institutional characteristics					
High selectivity ^a					0.696 (0.188)
Constant	0.130*** (0.032)	0.222*** (0.067)	0.663 (0.250)	0.771 (0.318)	0.845 (0.346)
BIC Log-likelihood	979.4 -465.3	982.3 -459.8	928.0*** -425.7	939.6 -424.6	943.6 -472.54
Adjusted pseudo-R ²	0.02	0.03	0.10	0.10	0.10
Number of observations	1,047	1,047	1,047	1,047	1,047

Notes: Standard errors adjusted for clustering in 139 student groups.

^a Along with selectivity, special status of the institution (Project 5–100, federal university) was also assessed as a possible factor of dropout. For the purpose of parsimony, the final model only included the selectivity variable, which produced a greater increase in the adjusted R^2 .

***— $p < 0.01$, **— $p < 0.05$, *— $p < 0.1$

Institutional commitment. Attending the institution of preferred choice is not related to the chances of dropping out—students who did not enter the institution of their preferred choice are not at risk of being dismissed within the first three semesters. Meanwhile, the chances are twice as low for students matched to their major (OR = 0.55, model 5). However, these results should be treated with caution, as adding the indicators of institutional commitment does not improve model quality.

Academic integration. The hypothesis on the relationship between academic integration and college dropouts has been confirmed. Regression results show that both attendance and frequency of interactions with faculty correlate with college attrition rates. Students attending over 80% of classes are 4.5 times less likely to drop out as compared to those with lower levels of attendance (OR = 0.22). The chances of dismissal are also higher for students less frequently interacting with faculty.

Social integration. Contrary to expectations, analysis results provide no evidence of socialization in college protecting against departure—both indicators of social integration were found to be insignificant.

Institutional characteristics. The variable indicating high selectivity of an institution is not related with the chances of dropping out, which points to the lack of significant differences in the attrition rates between highly selective and non-selective colleges.

6. Limitations

The most important limitation of this study is the problem of defining institutional dropout. On one hand, our study is the first to provide extensive and detailed information on the causes of departure from Russian universities, as it relies on administrative data. On the other hand, the reasons for withdrawal specified in institutional documents may have nothing to do with the actual student motivations or circumstances. For instance, a student facing dismissal may have transferred to another major, and a student who voluntarily decided to quit may have stopped attending classes and been later formally dismissed for poor academic performance. To obtain more accurate data on the motivations and circumstances of college withdrawals, studies must use qualitative methods, such as interviewing. No research of this kind has been attempted in Russia so far.

Another limitation is the lack of data on academic performance, which is considered to be a key predictor of dropping out [Pascarella, Terenzini 2005; Mayhew et al. 2016]. However, the analyzed indicators of academic integration may be even more helpful. Indeed, academic performance may reflect student effort just as well as course difficulty or college selectivity—being an A student in a non-selective university is easier than in a highly selective one due to the latter's higher quality standards [Roschin, Rudakov 2015].

Other factors possibly related to college dropouts but not covered in this study include place of residence and type of funding [Tinto 1993]. Students who move to another city or region for college may face additional challenges associated with accommodation expenses and adapting to the new location and lifestyle. Unlike data on enrollees from other cities and regions, information on the type of funding was available for analysis, but adding it to the models had little sense as most respondents (93%) were subsidized by the government.

7. Conclusion and Discussion

STEM education has been a priority in present-day Russia, which is in line with the global trend of increasing the population and quality of graduates from STEM programs to promote economic growth and a knowledge-based economy [National Academy of Science 2007]. Nearly half of all the government-funded places in higher education are provided in STEM majors. At the same time, attrition rates have been the highest in this field, indicating ineffectiveness of college retention strategies and unfeasibility of government investments [Kondratjeva, Gorbunova, Hawley 2017].

This study is the first to analyze the phenomenon of college dropouts in Russia on a large nationally representative sample of computer science and engineering undergraduates using administrative data on student dismissals. The findings shed more light on the factors of withdrawal among engineering students, who are at the highest risk of being dismissed as compared to other majors, according to earlier studies (e. g. [Schwab, Sala-i-Martin 2016; Kondratjeva, Gorbunova, Hawley 2017]).

It is shown that, during the first three semesters, 72% of undergraduates remain within their initial academic track, i. e. enrolled in the same major at the same university, and one in every five students drops out (19%). Average attrition rate between the 3rd and 4th years is only 5%, which is much lower. These results are consistent with earlier findings in which the highest attrition rates were observed within the first two years of college study [Bowen et al. 2009; Kolotova 2011; Kondratjeva, Gorbunova, Hawley 2017].

Analysis of the factors of college dropouts during the first three semesters relies on Tinto's theoretical framework [Tinto 1993], which postulates that social and academic integration are critically important to the retention and success of students in the university of choice. Our findings confirm the significance of academic integration, the risk of dropping out being much lower among students who attend most classes and engage in in- and out-of-class interactions with faculty more often.

An accessible practice to control college attrition rates in this case is to ensure monitoring and support for at-risk students who miss a lot of classes and interact little with the faculty. Because faculty members tend to adopt an accusatory attitude towards students, argue

for stringent dismissal policies [Terentev, Gruzdev, Gorbunova 2015] and handle heavy workloads, they should be provided with additional incentives and assistance in monitoring struggling students for attrition rates to actually go down. However, involvement in learning may decrease not only as a result of faculty's "negligence" but also because students may lack or lose interest or revise their goals. Otherwise speaking, the effects of monitoring and supporting low-involved students may be very moderate.

Significance of pre-college performance in the regressions indicates that colleges either apply little effort to retain undergraduates or have low admission requirements. Students with low USE scores in mathematics (50 or below) find themselves at risk of dropping out, regardless of their levels of academic and social integration or college selectivity. Such results may indicate that universities admit relatively low performers and apply little effort to bridge the gap between the low level of schooling and university requirements. To solve this problem, universities should invest in academic support mechanisms, such as remedial courses, mentoring and tutoring [Gorbunova, Kondratjeva 2013]. The prevalence of such practices in Russia's present-day higher education is obviously too low [Zagirova et al. 2019].

The hypothesis about the relationship between social integration and the risk of dropping out was not confirmed in this study. International studies on student involvement in university life focus a lot on and confirm the significance of social integration as a factor of departure decisions [Tinto 1993; Mayhew et al. 2016]. To some extent, this key role of social integration is explained by the great effort invested by Western universities to ensure an environment conducive to peer interactions, as they offer a variety of extracurricular activities to choose from and often design their campuses to naturally stimulate communication among students, which can rarely be found in Russia [Bekova, Kasharin 2018].

The hypothesis about the impact of institutional commitment—students' loyalty to their selected institution and major—has been partially confirmed. Students who did not enter the college of their preferred choice do not face a higher risk of dropping out. Meanwhile, being unmatched to one's major is a significant factor of withdrawal. Further research is needed to find out why institutional dropouts are associated with the wrong choice of major, but not institution.

The absence of variance in the chances of dropping out among students of different social backgrounds means that there is no reproduction of educational inequality in relatively low socioeconomic backgrounds, all other factors being controlled for.

We also expected to find higher attrition rates in highly selective universities [Kondratjeva, Gorbunova, Hawley 2017], as elite institutions with abundant funding can afford "discarding" the lowest performers. However, the correlation between the risk of dropping out and college selectivity was found to be insignificant, so it is not the

quality of enrollment that explains the differences in attrition rates among colleges but rather the factors described above as well as some factors left beyond the scope of this study. For instance, as faculty play a key role in student attrition, the differentiating factors may also include student–faculty ratio [Mayhew et al. 2016], size of college funding, availability of academic support initiatives, etc.

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