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# "Smart University" Project: fair matching of students to academic trajectories

**Yu. M. Vasiliev[1], E. V. Glazunova[2], G. M. Friedman[3]✉**

[1, 2, 3] St. Petersburg State University of Economics, 21 Sadovaya str., 191023, St. Petersburg, Russian Federation

**Subject.** The goal of "Smart University" information system is to increase the efficiency and quality of the academic process at Saint Petersburg State University of Economics through the automation of its various aspects and phases which is based on mathematical modelling. The optimization model of finding a fair matching of students to academic trajectories is discussed in the paper as a mathematical kernel of one of the information system's components.
**Objectives.** The goal of the paper is to provide an exact mathematical formulation and corresponding numerical results to the problem of finding a fair matching of students to academic trajectories, their preferences and academic performance was taken into account.
**Method.** The optimization model was developed to find a matching in the many-to-one two-sided market, the corresponding concept of stable matching and conflicts was discussed.
**Results.** The optimization model of finding a fair matching was verified by numerical simulations with the full-scale data for the students of the "Economics" academic program of the Saint Petersburg State University of Economics. Numerical results demonstrated the effectiveness of the proposed model in finding a fair matching with a minimum number of conflicts and with a maximal level of satisfaction of agents from both sides of the market (students and academic trajectories) with the matching obtained.

**Key words:** matching problem of students to academic trajectories, two-sided matching market, stable matching, lower quota, mathematical programming.

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## Introduction

*The goal* of the "Smart University" project is to improve the quality, efficiency and controllability of the educational process of the university via the use and implementation of mathematical methods and approaches to solving problems that arise during the implementation of its various stages:

*Matching search problems:*

– establishing an effective process for matching students according to academic trajectories;

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– creation of a curriculum designer for basic professional educational programs;

– automation of the process of matching the teaching load of the department, taking into account the preferences of teachers (Ivanchenko, 2021).

*Schedule Planning Tasks:*

– formation of an optimal schedule of classes at the university for the semester.

*Analytic tasks:*

– analysis of the university’s admissions campaign;

– Predictive learning analytic for the university.

The result of the project is a collection of mathematical models, the totality of which represents the mathematical core of the “Smart University” information system for automating the solution of these problems as part of the educational process at the St. Petersburg State University of Economics.

In 1962 D. Gale and L. Shapley (2013) proposed a two-sided market model and an algorithm for the marriage problem and college admission problem, where colleges have an upper quota on the number of students admitted. Since then, two-sided market models have found wide application in various problems. (Manlove, 2013; Manlove et al., 2002).

This study considers the proposed process of matching students according to the academic trajectory of the university, which will generate a fair solution based on two-sided markets. Let the university have areas of training where students after the first year of study can choose a further academic trajectory. In their personal accounts, students rank academic trajectories in order of greatest attractiveness: the first academic trajectory in the student’s preference list is the most attractive academic trajectory for the student, the last profile in the student’s preference list is the least attractive academic trajectory for that student. The student also has the option not to rank academic trajectories. academic trajectories, when selecting a student for their training program, consider the student's Academic performance. Each academic trajectory has the ability to open several groups with minimum and maximum number of students specified for the academic trajectory. An academic trajectory group cannot accept more students than the specified upper quota. Also, if no groups have opened for an academic trajectory, then this academic trajectory must be closed for a year. If the required number of students have chosen an academic trajectory as the first priority, then this academic trajectory must be opened. Based on the input information, it is necessary to find a fair matching of students across training academic trajectories, while maximizing student satisfaction, taking into account the quotas of the academic trajectories.

This problem can be considered as a problem of finding a stable matching in a two-sided market, where students and academic trajectories with loose preferences will act as market sides.

In the study (Gale & Shapley, 2013) an algorithm that allows finding a stable matching for the college admission problem, where colleges have an upper quota on the number of applicants they can accept was proposed for the first time. Further research on the number of applicants assigned to each university and the possibility of adding a lower quota were carried out. Thus, in the study of A. Roth (1986) it was shown that in all stable matching the number of applicants assigned to colleges is the same, thus it is impossible to find a matching where more applicants would be assigned to less popular colleges. In addition, it was shown that when a lower quota is introduced, a stable matching may not exist at all (Fragiadakis et al., 2015).

Monte (2013) proposed non-manipulated Pareto-efficient algorithm for matching workers among company projects, where for each project it is necessary to assign number of workers within the specified lower and upper quotas, or not assign them at all, but only project workers have preferences. This problem is an extension of the well-known house allocation problem. (Hylland & Zeckhauser, 1979).

However, if agents' preferences are not strict, then the number of applicants assigned to universities may vary (Diebold & Bichler, 2017). An integer optimization model for solving the allocation determination problem with the maximum number of agents participating in the allocation was proposed in (Rothblum, 1992), however, such a problem is NP-complete (Manlove et al., 2002). There are various approaches allowing to find a matching on a two-sided many-to-one markets with a lower quota, for example in the study (Fleiner & Kamiyama, 2016) a matroid-based approach for matching search was presented. However, it has been shown that algorithms used to find allocations with constraints by the number of agents that must be assigned to one of the sides are often not Pareto efficient (Kamada & Kojima, 2015).

This study proposes an approach based on integer programming for the solution of the problem of finding the matching of students according to academic trajectories.

The study consists of the following parts: description of the problem, which presents the formal problem statement; research methods, which describe the research methodology, as well as the proposed mathematical model; results, which provide numerical results for the proposed mathematical formulation; discussion of the results, which compares existing approaches with the proposed one and conclusion.

## Problem description

Given a university that has many academic trajectories $C$. There are a number of students studying at the university $S$, who need to rank academic trajectories in order of preference. This is the way used to define non-strict complete preferences $P_s(C)$ for each student $s \in S$ across multiple academic trajectories. Based on student performance results $S$ non-strict overall preferences can be obtained $P_c(S)$ academic trajectories for a variety of students, where $c \in C$.

A university for every academic trajectory $c \in C$ defines the maximum number of groups $g_c$, which can be opened for the profile $c \in C$. The university also determines the lower and upper quotas $\underline{q}_c$ and $\overline{q}_c$ for each opened academic trajectory group $c \in C$ (Roth, 2008). Each open academic trajectory group cannot have fewer students than $\underline{q}_c$, if the group cannot be assigned at least $\underline{q}_c$ students, then the group cannot be open. If no academic trajectory group opens, then this academic trajectory should be closed for the considered academic year. Also, each group cannot have more than $\overline{q}_c$ students.

Some training academic trajectories must be open. Let $C_{open} \subset C$ is a subset of academic trajectories that must be open.

It is necessary to find the matching of students according to training academic trajectories in a way which will allow to maximize the value of the following optimization criteria:

– satisfaction of students and academic trajectories from matching;

– number of open academic trajectories, in this case, each student must be assigned to one academic trajectory, and students must be assigned to each academic trajectory within the quotas determined by the requirements of the university.

## Research methods

If an academic trajectory can recruit several groups of students, then the maximum number of groups $g'_c$, which can be opened on the academic trajectory $c \in C$, is defined as follows:

$$g'_c = \min\left\{ g_c, \frac{|S| - \sum_{c' \in C_{open} \setminus \{c\}} \underline{q}_{c'}}{\underline{q}_c} \right\}.$$

The matching $\mu \subset S \times C$ is subset of pairs; $\mu(s) \in C$ is a variety of academic trajectories to which the student is assigned $s$; $\mu \subseteq S$ is set of students who are assigned to the academic trajectory $c$.

Matching μ is valid if it is true that:

1) $|\mu(s)| = 1$, $\forall s \in S$ – each student is assigned to exactly one academic trajectory;

2) for each student academic trajectory group assigned within the quota, e. g., there is a non-negative integer $z_c$, indicating the number of open groups on the academic trajectory $c \in C$ such that $\underline{q}_c z_c \le |\mu(c)| \le \overline{q}_c z_c$ and $1 \le z_c \le g'_c$, if $c \in C_{open}$, and $\underline{q}_c z_c \le |\mu(c)| \le \overline{q}_c z_c$ and $0 \le z_c \le g'_c$, if $c \notin C_{open}$ – for each open academic trajectory, the number of students assigned to each academic trajectory group, within the quota.

If agents' preferences are not-strict, then several types of stability are distinguished (Irving, 1994), in this study a weakly stable matching is considered.

Acceptable matching μ is called weakly stable if the following conditions are met:

1) there is no blocking pair $(s, c) \in S \times C \setminus \mu$ and $c$ are open academic trajectory:

a) $c \succ_s c'$, $c' \in \mu(s)$ – the academic trajectory of the blocking pair is strictly preferable to the academic trajectory assigned to the student *s* in matching;

b) $\exists s' \in \mu(c):\ s \succ_c s' \vee |\mu(c)| < \bar{q}_c z_c$ – a student from a blocking pair is strictly preferable to at least one of the students assigned to the academic trajectory *c* or upper quota *c* not exhausted;

2) there is no blocking coalition, e. g. closed academic trajectory *c* or an unopened group of the academic trajectory and a subset of students $S' \subset S : |S'| \geq \underline{q}_c$ such that $c \succ_s c',\ c' \in \mu(s)$, $\forall s \in S$ – the academic trajectory of the blocking coalition is strictly preferable to the academic trajectory to which each student of the blocking coalition is assigned.

In the study (Boehmer & Heeger, 2022) authors showed that the matching search problem, where each academic trajectory group can be assigned students within given upper and lower quotas or not assigned at all, is NP-complete.

This problem can be considered as an integer programming problem (Minu, 1990).

Let $weight(s)$, $\forall s \in S$ means a weighting factor calculated based on the student's weighted average score *s*. This coefficient characterizes the importance of minimizing the number of blocking pairs and coalitions in which the student participates *s*.

Let $util_{sc}$, $\forall (s,c) \in S \times C$ – utility for the student *s* from appointment to academic trajectory *c*. Utility is calculated based on the student's preferences.

The following variables are defined for the problem:

– $x_{sc}$, $\forall (s,c) \in S \times C$ is a binary variable that takes the value 1 if the student *s* assigned to academic trajectory *c*, and 0 otherwise;

– $w_{sc}$, $\forall (s,c) \in S \times C$ is a binary variable that takes the value 1 if the pair (*s*, *c*) a blocking pair for a weakly stable matching, and 0 otherwise;

– $z_c$, $\forall c \in C$ is an integer variable indicating the number of groups opened on the academic trajectory *c*;

– $f_c$, $\forall c \in C$ is a binary variable that takes the value 1 if for the academic trajectory *c* less than $g'_c$ groups open (e. g. blocking coalitions for the academic trajectory *c* can exist);

– $y_c$, $\forall\ c \in C$ is a binary variable that takes the value 1 if for the academic trajectory *c* there is a coalition blocking the weakly stable matching and 0 in the opposite case;

– $r_{sc}$, $\forall (s,c) \in S \times C$ is a binary variable that takes the value 1 if for the academic trajectory *c* less than $g'_c$ groups open and there is a blocking coalition (of weakly stable matching), which includes the student *s*, and 0 otherwise;

– $a_c$, $\forall c \in C \setminus C_{open}$ is a binary variable that takes the value 1 if at least one group is of the education programme *c* opened.

The optimization criterion that ensures the minimum number of blocking pairs and the number of students participating in blocking coalitions for a weakly stable matching has the form:

$$\sum_{s \in S} \sum_{c \in C} weight(s)(w_{sc} + r_{sc}) \to \min. \qquad (1)$$

The optimization criterion allowing to maximize the number of open academic trajectories can be formulated as follows:

$$\sum_{c \in C \setminus C_{open}} a_c \to \max. \qquad (2)$$

Maximizing matching utility for students:

$$\sum_{s \in S} \sum_{c \in C} util_{sc} x_{sc} \to \max. \qquad (3)$$

In this case, each student must be assigned exactly to one academic trajectory:

$$\sum_{c \in C} x_{sc} = 1 \qquad \forall\, s \in S. \qquad (4)$$

Each academic trajectory group either does not open, or students are assigned to each group within the quota:

$$\underline{q}_c \cdot z_c \leq \sum_{s \in S} x_{sc}; \qquad \sum_{s \in S} x_{sc} \leq \bar{q}_c \cdot z_c; \qquad \forall\, c \in C. \qquad (5)$$

Constraints that determine blocking pairs (weakly stable matching):

$$|S| x_{sc} + \sum_{\substack{s' \succeq_c s: \\ s' \neq s}} x_{s'c} + |S| \sum_{\substack{c' \succeq_s c \\ c' \neq c}} x_{sc'} \geq \bar{q}_c z_c - |S| w_{sc}; \qquad \forall (s,c) \in S \times C. \qquad (6)$$

Constraints that determine blocking coalitions (weakly stable matching):

$$\sum_{s \in S} \sum_{c \succ_s c'} x_{sc'} \leq \underline{q}_c - 1 + |S|(1 - f_c) + |S| y_c; \qquad \forall\, c \in C; \qquad (7)$$

$$r_{sc} \geq \sum_{c \succ_s c'} x_{sc'} + y_c - 1; \quad \forall (s,c) \in S \times C. \tag{8}$$

Constraints relating the number of open groups and the variable of type *f*:

$$g_c f_c \geq g'_c - z_c; \quad \forall c \in C. \tag{9}$$

Constraints that determine whether education programme is open:

$$g_c a_c \geq z_c; \quad \forall c \in C. \tag{10}$$

Subject to:

$$\begin{aligned} & x_{sc}, w_{s,c}, r_{s,c} \in \{0,1\} \quad \forall (s,c) \in S \times C; \\ & z_c \in \{1,\ldots,g_c\} \quad c \in C_{open}; \\ & z_c \in \{0,\ldots,g_c\} \quad c \in C \setminus C_{open}; \\ & a_c \in \{0,1\} \quad c \in C \setminus C_{open}; \\ & f_c, y_c \in \{0,1\} \quad c \in C. \end{aligned} \tag{11}$$

## Results

The implementation of the presented solution methods was carried out by Wolfram Mathematica 13.2[1] using commercial optimizer Cardinal Optimizer[2].

Calculations were made for initial data with the following characteristics:

– 316 students, where 123 students of state-financed education, 193 students of contract-financed education;

– 7 academic trajectories, four of which must open at least one group, but no more than five, exactly five groups must open for one academic trajectory, for the remaining two academic trajectories the maximum number of possible open groups is five;

– the ranges of the permissible number of students in a group for all academic trajectories are the same, from 25 to 36 people;

– the weighting coefficients of the disciplines are equal and identical for all academic trajectories;

– 9 students are indifferent in the choice between all academic trajectories.

[1] Wolfram Mathematica Documentation. URL: https://reference.wolfram.com/language

[2] Cardinal Optimizer (COPT) Documentation. URL: https://arxiv.org/pdf/2208.14314.pdf

According to the results of the calculation performed according to the mathematical formulation (1)–(11): 269 students were assigned according to the first priority, 26 students were assigned according to the second priority, 11 were assigned according to the third and one student to the fourth priority (88 % of students who voted were allocated to the first priority). The multi-criteria optimization problem was solved using the lexicographic method (Charnes & Cooper, 1962), the search for a solution by the optimizer took 353 seconds.

For the given calculation parameters, there is no weakly stable matching; in the solution there are 29 blocking pairs, while there are no blocking coalitions.

For the academic trajectory “Finance and Credit” 5 groups were opened, for the academic trajectories “Economics of Enterprises and Organizations” and “Mathematical Modelling and Data Analysis in Economics” two groups were opened, for the rest (except for the academic trajectory “Statistical Analysis and Modelling of Socio-Economic Processes”, which is closed) one group was opened. For each academic trajectory, the number of students assigned to it was: “Finance and Credit” – 125, “Economics of Entrepreneurship” – 31, “Accounting, Analysis and Audit” – 28, “Economics of Enterprises and Organizations” – 55, “Global Economy and International Markets” – 25, “Mathematical Modelling and Data Analysis in Economics” – 52, “Statistical analysis and Modelling of Socio-Economic Processes” – 0.

## Discussion

Usually, when solving problems of finding a matching for many-to-one markets, where the agents of one side can be assigned 0 or within the range from the minimum to the maximum quotas of the agents of the other side, algorithms based on a modification of the Gale – Shapley algorithm are used (Gale & Shapley, 2013). For example, in the study of Bir et al. (2010) the algorithm used to match students among training courses was described. This algorithm involves sequentially running the Gale – Shapley algorithm and excluding courses where the minimum quota for the number of students was violated. The advantage of this algorithm is its speed, but the disadvantage is the possibility of obtaining a matching with blocking coalitions or the absence of a solution at all, even in cases where an acceptable matching exists.

Compared to the algorithm (Bir et al., 2010), the model proposed in this study always returns a weakly stable matching, if it exists, or a matching with a minimum number of blocking pairs and conflicting students, otherwise. At the same time, the integer programming problem is computationally complex, and therefore shows lower performance, but, nevertheless, allows to obtain a solution for full-scale data in a reasonable time.

## Conclusions

The study proposes an exact mathematical formulation and numerical solution to the problem of finding a stable matching (or, in case of its absence, a near-stable matching) of students of a certain education program according to the training academic trajectories of the university.

The mathematical formulation is a multi-criteria integer programming problem that uses the following optimization criteria: minimizing blocking pairs and the number of students participating in blocking coalitions for a weakly stable matching, maximizing the number of academic trajectories opened for this year, as well as maximizing student satisfaction from matching by academic trajectories.

A mathematical model can be considered not only as a tool that allows solving a given problem automatically, but also as a decision support tool that allows an expert to vary the order of optimization criteria, their weighting coefficients, use various methods for finding solutions to multi-criteria problems, and also choose the most effective solution from an expert's point of view. At the same time, due to the approach based on mathematical programming, additional optimization criteria and constraints can be added to (or excluded from) the model. Additional optimization criteria may include: minimizing the number of created groups where students are matching, since additional study groups create an additional financial burden for the university; maximizing the utility function of academic trajectories and others.

The ability to vary the model parameters provides flexibility in the approach and allows taking into account the resources and wishes of departments. Department resources are taken into account by entering information about the minimum and maximum size of groups for the academic trajectory, as well as the minimum and maximum number of groups for the academic trajectory. The wishes of each department can be taken into account by setting weighting coefficients for disciplines, on the basis of which the student’s weighted average score and, as a result, student academic trajectory preferences are calculated.

Further research includes studying the possibility of speeding up the calculation, in particular, by including additional cutting planes. In this study, only one type of stability was considered, the weakly stable matching. Other types of stability, such as strongly-stable and super-stable also should be studied. However, when constructing models with “stronger” types of stability, a significant increase in the search time for the optimal solution is predicted, which also requires additional study.

The result of the study is a mathematical model for solving the problem of matching students according to training academic trajectories as a problem of finding a stable matching for two-sided market. This model is part of the mathematical core of the “Smart University” information system, designed to automate problem solving as part of the educational process at the St. Petersburg State University of Economics.

## Conflict of Interest

The authors declare that there are no obvious and potential conflicts of interest related to the publication of this article.

### References

1. Bir, P., Fleiner, T., Irving, R. W., & Manlove, D. F. (2010). The College Admissions problem with lower and common quotas. *Theoretical Computer Science*, *411*(34–36), 3136–3153. https://doi.org/10.1016/j.tcs.2010.05.005

2. Boehmer, N., & Heeger, K. (2022). A fine-grained view on stable many-to-one matching problems with lower and upper quotas. *ACM Transactions on Economics and Computation*, *10*(2). https://doi.org/10.1145/3546605

3. Charnes, A., & Cooper, W. W. (1962). *Management Models and Industrial Applications of Linear Programming*. New York: John Wiley and Sons.

4. Diebold, F., & Bichler, M. (2017). Matching with indifferences: A comparison of algorithms in the context of course allocation. *European Journal of Operational Research*, *260*(1), 268–282. https://doi.org/10.1016/j.ejor.2016.12.011

5. Fleiner, T., & Kamiyama, N. (2016). A matroid approach to stable matchings with lower quotas. *Mathematics of Operations Research*, *41*(2), 734–744. https://doi.org/10.1287/moor.2015.0751

6. Fragiadakis, D., Iwasaki, A., Troyan, P., Ueda, S., & Yokoo, M. (2015). Strategyproof matching with minimum quotas. *ACM Transactions on Economics and Computation*, *4*(1). https://doi.org/10.1145/2841226

7. Gale, D., & Shapley, L. S. (2013). College admissions and the stability of marriage. *American Mathematical Monthly*, *120*(5), 386–391. https://doi.org/10.4169/amer.math.monthly.120.05.386

8. Hylland, A., & Zeckhauser, R. (1979). The Efficient Allocation of Individuals to Positions. *Journal of Political Economy*, *87*(2), 293–314. https://doi.org/10.1086/260757

9. Irving, R. W. (1994). Stable marriage and indifference. *Discrete Applied Mathematics*, *48*(3), 261–272. https://doi.org/10.1016/0166-218X(92)00179-P

10. Ivakhnenko, D. A. (2021). Application of Two-Sided Market Models in the Problem of Distributing the teaching load between teachers of the department. *Modern Economics: Problems and Solutions*, *9*, 16–28. (In Russian). https://doi.org/10.17308/meps.2021.9/2667

11. Kamada, Y., & Kojima, F. (2015). Efficient matching under distributional constraints: Theory and applications. *American Economic Review*, *105*(1), 67–99. https://doi.org/10.1257/aer.20101552

12. Manlove, D. (2013). *Algorithmics of Matching Under Preferences*. World Scientific. https://doi.org/https://doi.org/10.1142/8591

13. Manlove, D. F., Irving, R. W., Iwama, K., Miyazaki, S., & Morita, Y. (2002). Hard variants of stable marriage. *Theoretical Computer Science*, *276*(1–2), 261–279. https://doi.org/10.1016/S0304-3975(01)00206-7

14. Minu, M. (1990). *Mathematical programming. Theory and algorithms*. Moscow: Nauka Publisher. (In Russian).

15. Monte, D., & Tumennasan, N. (2013). Matching with quorums. *Economics Letters*, *120*(1), 14–17. https://doi.org/10.1016/j.econlet.2013.03.007

16.Roth, A. E. (1986). On the Allocation of Residents to Rural Hospitals: A General Property of Two-Sided Matching Markets. *Econometrica*, *54*(2), 425–427. https://doi.org/10.2307/1913160

17. Roth, A. E. (2008). Deferred acceptance algorithms: History, theory, practice, and open questions. *International Journal of Game Theory*, *36*(3–4), 537–569. https://doi.org/10.1007/s00182-008-0117-6

18. Rothblum, U. G. (1992). Characterization of stable matchings as extreme points of a polytope. *Mathematical Programming*, *54*(1–3), 57–67. https://doi.org/10.1007/BF01586041



**Yuriy M. Vasiliev**, Assist. Prof., Saint Petersburg State University of Economics, Saint Petersburg, Russian Federation

E-mail: vas_yu_m@mail.ru

ORCID ID: 0000-0002-1189-7138

**Ekaterina V. Glazunova**, Postgraduate Student, Saint Petersburg State University of Economics, Saint Petersburg, Russian Federation

E-mail: katarina.glazunova97@inbox.ru

ORCID ID: 0000-0001-9936-8961

**Gregory M. Fridman**, Dr. Sci. (Eng.), Full Prof., Saint Petersburg State University of Economics, Saint Petersburg, Russian Federation

E-mail: grifri@finec.ru

ORCID ID: 0000-0001-9876-4276



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# «Умный университет»: справедливое распределение студентов по учебным профилям

**Ю. М. Васильев[1], Е. В. Глазунова[2], Г. М. Фридман[3]✉**

[1, 2, 3] Санкт-Петербургский государственный экономический университет, ул. Садовая, 21, 191023, Санкт-Петербург, Российская Федерация

**Предмет.** Одним из этапов реализации информационной системы «Умный университет» в Санкт-Петербургском государственном экономическом университете, цель которой – повышение эффективности и качества обучения в университете посредством автоматизации различных процессов, является разработка математической модели, позволяющей оптимизировать процесс распределения студентов по учебным профилям.
**Цель.** Статья посвящена математической постановке задачи поиска справедливого распределения студентов по учебным профилям с учетом их предпочтений и успеваемости.
**Метод.** Модель разработана на базе двусторонних рынков вида один на много, вводится понятие стабильности, а также конфликтов для рассматриваемого типа рынка.
**Результаты.** Апробация произведена на полномасштабных данных СПбГЭУ при распределении студентов на профили направления «Экономика». Числовые результаты демонстрируют возможность использования модели для решения поставленной задачи, наличие минимального количества конфликтов.

**Ключевые слова:** распределение студентов по учебным профилям, двусторонние рынки, сочетания, стабильное распределение, нижняя граница, математическое программирование.

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## Конфликт интересов

Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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**Васильев Юрий Михайлович**, старший преподаватель, Санкт-Петербургский государственный экономический университет, Санкт-Петербург, Российская Федерация

E-mail: vas_yu_m@mail.ru

ORCID ID: 0000-0002-1189-7138

**Глазунова Екатерина Валерьевна**, аспирант, Санкт-Петербургский государственный экономический университет, Санкт-Петербург, Российская Федерация

E-mail: katarina.glazunova97@inbox.ru

ORCID ID: 0000-0001-9936-8961

**Фридман Григорий Морицович**, д-р техн. наук, профессор, Санкт-Петербургский государственный экономический университет, Санкт-Петербург, Российская Федерация

E-mail: grifri@finec.ru

ORCID ID: 0000-0001-9876-4276

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