EFFECTIVENESS OF CENTRALIZED MECHANISM OF LABOR RESOURCE ALLOCATION – EXPERIMENTAL TESTS

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ABSTRACT

In the article the issue of labor resources allocation in the context of the emerging field of economic sciences known as "market design" was discussed. The assumptions for the designed experimental environment were discussed. An experimental variable and variables dependent on it were defined. The main objective of the paper is to develop a matching mechanism for participants in the experiment as a basis for a broader, centralized resource allocation system in the labor market. The study confirmed the hypothesis that fulfilling the assumptions of stable allocations theory improves the matching efficiency in the labor market and thus reduces the frictional unemployment.

Key words: experimental economics, market design, labor market

INTRODUCTION

The issue of labor resource allocation is usually considered in several approaches. At the enterprise level it can be understood as the allocation of labor resources to different stages of the production process, and at the global level, it can be considered as a study of the relationship between labor demand and supply, as well as the study of the variables influencing such interactions. The matching of individual labor market participants divided into two disjoint sets, employers and job seekers, can also be examined [Parlińska and Pietrych 2016].

The literature analysis in the field of game theory also allows for specifying certain submarkets that have a specific character. This specificity is manifested, among others, in that the processes of matching employees and employers resemble marriage contracts [Stankiewicz 2013]. In this case, the salary is not the main factor conditioning the market balance. In game theory such a market structure is called a bilateral search market or a two-sided market. The theory of stable allocations applies to the adjustment of labor market mechanisms, while the process of intervening in free market mechanisms based on assumptions of this theory is referred to as the design of markets.

The aim of the paper is to develop a matching mechanism for the participants of the experiment as the basis for a broader centralized resource allocation system in the labor market. A hypothesis has been made that fulfilling the assumptions of stable allocations theory improves the efficiency of matching in the labor market and thus reduces the frictional unemployment.

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MATERIAL AND METHODS

The theory of stable allocations deals with finding stable relationships between individuals or groups in markets where simple market rules fail and prices are not a determinant of resource allocation [The Royal Swedish Academy of Sciences 2012]. The theory of stable allocations uses the tools of game theory, experimental economics and mathematical economics. It also has broad practical applications in modeling many economic phenomena, primarily in two-sided markets [Fleiner 2003].

The concept of stable association was introduced into the literature by Gale and Shapley. Stable allocation means such allocations of *n*-pairs in which none of partners will attempt to permanently split another pair in that set. The authors present the mathematical definition in their article from 1962 [Gale and Shapley 1962].

In the literature, the two-sided matching market is often used, which refers to the problem of associations of market participants. Markets with two-sided preferences consist of two disjoint groups of participants, e.g. job-seekers and employers. The word matching refers to the bilateral nature of exchanges in these markets [Roth and Sotomayor 1992]. An essential feature of such market structures is that not only the salary clears the market, i.e. it is not a primary criterion for resources allocation. The following objects, which are subject to research within the framework of stable allocations theory, such as schools, hospitals, laboratories, form the so-called marketplaces, and the institutions operating on them can play an important role in clearing the market (centralized markets) [Roth 2010].

The aim of the experimental study was to present the matchmaking processes between its participants taking into account competition, both among the participants representing the employees and the employers, and the congestion on the market. Of course, the presented experimental market is a generalization of complex processes taking place in the labor market. However, as Kagel and Roth state [2000], the advantage of this type of research is the generalization of some important elements common to many markets, while on the other hand, emphasizing the importance of variables desirable in the study.

The experimental market was composed of 16 participants. Half of them were randomly assigned the role of "employer", while the other half received the role of "job seekers". Each round of the experiment is understood as the matching market. For each participant the preferences for the participants from the opposite group were randomly generated.

In experimental research, it is important to understand the behaviour of the respondents and to determine precisely what premises influenced the decisions they made. In order to provide motivation for a fair presentation of their subjective preferences and their distributions, the payoffs in the shape of Experimental Monetary Units (EJM) were used [Pais et al. 2011].

The first dependent variable was the shared profit. The participants in each round received a payoff depending on the outcome of the game. Mismatched companies and job seekers received zero EJM in a given round. Entrepreneurs who were associated with employees received a payoff depending on ranking position of the associated employee. Therefore, the higher the ranking position, the higher the individual payoff. The same principle of the level of pay in relation to the position in the ranking was applicable to jobseekers matching the companies. All participants could be matched with at most one player from the opposing team.

The next dependent variable was the level of matching costs. It was determined mainly by lack of matching, i.e. the longer search for work. Each market (round) was divided into three periods, symbolically attributed to the numbers 1, 2 and 3, which served as the equivalent to the amount of costs attributed to the period (measured in EJM). This means that if the match did not occur in period 1, then the market generates a cost of 1 EJM for the employer. If the association did not occur in period 2, costs increased to 2 EJM, but if the association did not occur also in period 3, costs increased to 3 EJM. In addition, the level of costs was increased by 1 EJM in the case when the employer/employee was associated with an object positioned at the last three places on the preference list.

The third dependent variable was the number of optimal associations, which was summed at the level of each period for each round.

As an experimental variable, the deferred acceptance algorithm (DA) was defined, leading to stable matchings [Roth 2008]. To identify this variable, the markets (experimental environment) were divided into two types [Echenique et al. 2009]:

- decentralized market, i.e. the market on which the processes of matching employers and job seekers are random. Additionally, it is assumed that companies can offer one job offer in a given period if they are not matched yet. Similarly, employees may accept at most one job offer that is most preferred by them. Each participant learns only on the basis of his own offers and payoffs;
- centralized market (it is assumed that there is a top-down mechanism that coordinates the allocation of labor resources). This mechanism can be defined as such a function f that $f: P \to M$, i.e. one that assigns a match to each preference profile. In addition, the mechanism is stable if it meets the following assumption $f(P') \in S(P')$ for each $P' \in P$.

The experiment consisted of two parts. The first ten successive rounds formed decentralized markets. After ten rounds, there were ten rounds for the centralized markets (each consisting of three periods). This is a typical factorial plan in which several combinations of levels and types of experimental variable were repeated several times [Sanko 2001] – Table 1.

Table 1. The design of experimental study

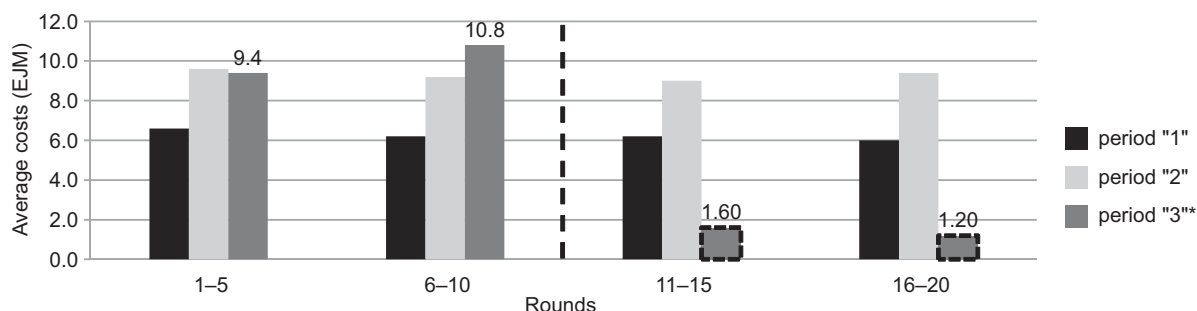| Market properties	Specification	
Type of market	market with two-sided preferences	
The size of the experimental group	16 people divided into two equal groups	
Number of rounds	20	
Preference profile	random, sharp	
Experimental variable	DA algorithm	
Dependent variables:	decentralized labor market	centralized labor market
Shared profit	yes	yes
Matching costs	yes	yes
Number of matches	yes	yes

Source: Pietrych [2017].

The technical side of the experiment was developed on the basis of the guidelines provided on the LEE website (Warsaw University). The study was conducted by the Internet on a group of 16 students. During the experiment the players played the labor market participants (employers and job seekers). Their job was to decide whether to choose a workplace or an employee based on a pre-generated list of preferences. According to Krawczyk [2012], most of the economic experiments is carried out with the participation of students and he simultaneously presents the advantages of using such research sample, but he also enumerates some counterarguments.

FINDINGS

Cost level

Figure 1 shows the average costs for each round, divided into rounds 1–5, 6–10, 11–15, 16–20, and taking into account different matching mechanisms. The columns represent the mean values calculated for each of the five rounds.

* The DA mechanism is marked with a dashed line.

Fig. 1. Average costs depending on rounds and periods

Source: Calculations and own study.

In the case of a decentralized labor market (rounds 1–10), the average costs of market functioning in the range of 6.2–10.8 EJM, depending on the period, can be observed. These costs increased in the next period (except rounds 1–5). The greatest increase occurred between the first and second period for which a test for the two populations mean showed that the null hypothesis of equality of average costs in the first and second period should be rejected at the significance level of 0.05. This hypothesis was rejected for average costs in both rounds 1–5 and 6–10. For the second and third period this test showed that the null hypothesis should be left unchanged since there is no statistically significant difference between the mean costs for the analyzed observations (Table 2).

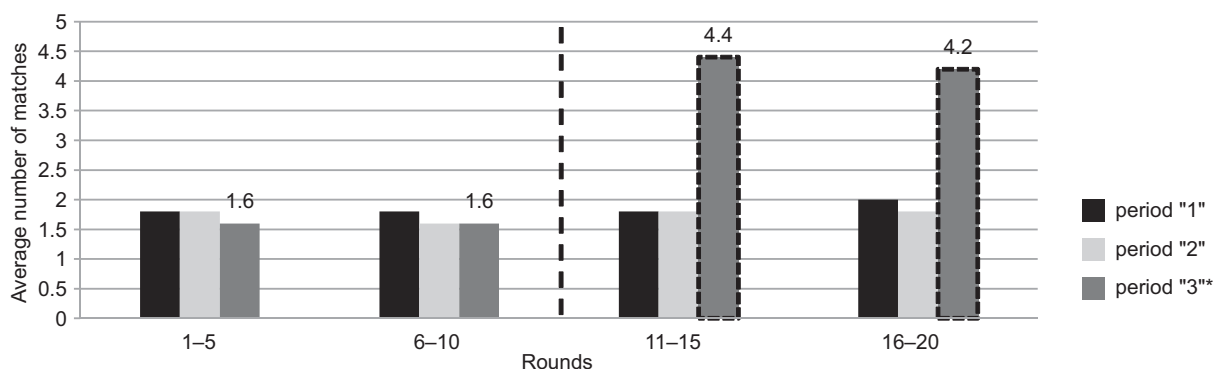**Table 2.** Test for two populations means – "cost level" variable

Period	Rounds 1–5		Rounds 6–10		Rounds 11–15		Rounds 16–20	
1	$t = -2.52$		$t = -2.76$		$t = -1.63$		$t = -4.19$	
2	$p = 0.04$	$t = 0.09$	$p = 0.02$	$t = -0.91$	$p = 0.14$	$t = 4.36$	$p = 0.00$	$t = 10.6$
3		$p = 0.93$		$p = 0.30$		$p = 0.00$		$p = 0.00$

Source: Calculations and own study.

In the case where on the designed labor market the DA matching mechanism was implemented, the average cost was reduced from 9.0 to 9.4 EJM in the second period to 1.6 and 1.2 EJM in the last period, in the 11–15 and 16–20 rounds. This decrease was statistically significant. The test for the two populations mean showed that the null hypothesis of equality of average costs in the second and third period should be rejected with the probability of 0.95 for both periods. There was also a significant drop in the p-value with respect to the results of the previous rounds.

Number of matches

Figure 2 shows the average number of matches for each round, divided into rounds 1–5, 6–10, 11–15, 16–20, and taking into account different match mechanisms. The columns represent the mean values calculated for each of the five rounds.

*The DA mechanism is marked with a dashed line.

Fig. 2. Average number of matches depending on rounds and periods

Source: Calculations and own study.

On the decentralized labor market, which operated in the case of rounds 1–10, the average number of employee and employer associations in the range of 1.6–1.8 was observed, depending on the period. Thereupon, these values were not subject to large deviations. It is also difficult to observe any regularity between consecutive periods and the average number of matches. Therefore, it can be assumed that the period's number does not affect the number of associations. Confirmation of this conclusion are the test results for the two populations means presented in Table 3. The probability values allow to apply the null hypothesis of mean equality in successive periods.

Table 3. Test for two populations means – "number of matches" variable
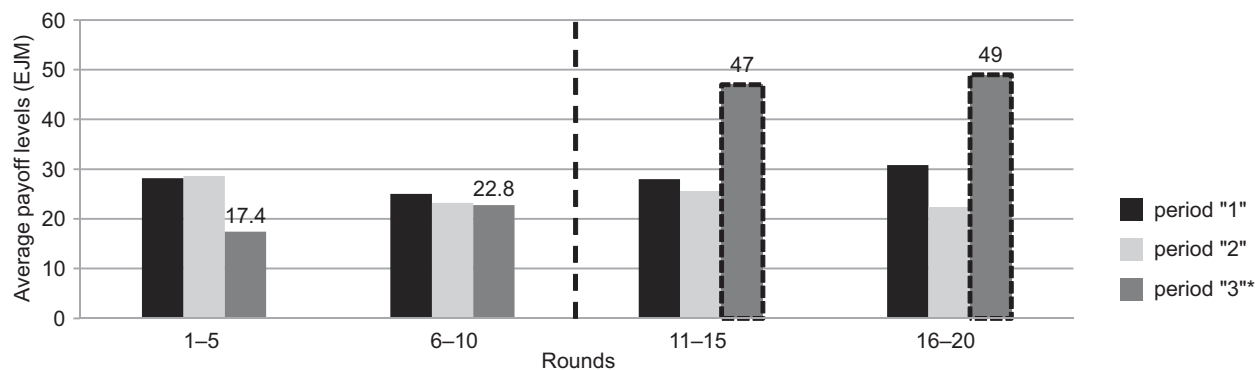
Period	Rounds 1–5		Rounds 6–10		Rounds 11–15		Rounds 16–20	
1	$t = 0.00$ $p = 1.00$		$t = 0.45$ $p = 0.67$		$t = 0.00$ $p = 1.00$		$t = 0.34$ $p = 0.74$	
2		$t = 0.45$ $p = 0.67$		$t = 0.00$ $p = 1.00$		$t = -2.74$ $p = 0.03$		$t = -3.89$ $p = 0.00$
3								

Source: Calculations and own study.

In successive rounds, when the DA mechanism was introduced to the designed market, the average number of matches increased to 4.4 and 4.2, respectively in rounds 11–15 and 16–20. This increase was statistically significant. The test for the two populations mean showed that the null hypothesis of equality of average costs in the second and third period should be rejected with the probability of 0.95 in both cases.

Shared profit – payoffs

Figure 3 shows the average level of payoffs for each period divided into rounds 1–5, 6–10, 11–15, 16–20, and taking into account different matching mechanisms. The columns represent the mean values calculated for each of the five rounds.

*The DA mechanism is marked with a dashed line.

Fig. 3. Average payoff levels depending on rounds and periods

Source: Calculations and own study.

In the case of rounds 1–10, during which the decentralized market was active, the average profit sharing between employees and employers was in the range of 17.4–28.6 EJM depending on the observed period. It should be noted however, that in the sample these observations clearly differed from the mean value calculated for the shared payoff, i.e. they were subject to a large standard deviation. For the first ten rounds there was no statistically significant difference between the total average payoffs for the respective periods (the confirmation are the results of two populations means test presented in Table 4). The probability values allow to apply the null hypothesis of mean equality in successive periods.

Table 4. Test for two populations means – "payoffs" variable

	Rounds 1–5		Rounds 6–10		Rounds 11–15		Rounds 16–20	
Period 1	$t = -0.03$ $p = 0.98$		$t = 0.25$ $p = 0.81$		$t = 0.23$ $p = 0.82$		$t = 0.91$ $p = 0.39$	
Period 2		$t = 0.94$ $p = 0.37$		$t = 0.06$ $p = 0.95$		$t = -1.74$ $p = 0.12$		$t = -3.51$ $p = 0.01$
Period 3								

Source: Calculations and own study.

In the successive rounds, when a DA-based matching mechanism was introduced, the average payoffs amount increased to 47 and 49 EJM in rounds 11–15 and 16–20, respectively. This increase was statistically significant only in the second period. Taking into account the above and the high standard deviations for the observations obtained also in these rounds, the results should be interpreted with some caution.

SUMMARY

The problem of imbalance in the labor market does not only exist on the supply side but also on demand side. Results of empirical research conducted so far indicate that employers also have problems with filling the vacancies offered [Sadowska-Snarska 2006]. Consequently, the issue of solid and satisfying match for jobseekers and potential employers is of growing importance. Stable matching of these two groups will increase the sustainability of employment. The research conducted so far emphasize the significance of the effective matching problem in the labor market, indicating that longer time spent as unemployment resource reduces the likelihood of employment [Jackman and Layard 1991].

The results of the comparison of decentralized and centralized labor allocation mechanisms justify the conclusion that in decentralized markets the rate of labor allocation depends on the size of the market. With the increase in the size of the labor market, there is a need for greater interaction between market participants, i.e. greater mobility and activity of market participants in order to achieve a stable allocation. However, this task is related to the prolongation of the searching period and the increase of costs.

In the case of a centralized mechanism of labor allocation based on the deferred acceptance algorithm, three variables were applied, ie the costs of matching employees and job seekers, the number of matches and the shared payoff amount. The implementation of the DA algorithm on the designed labor market showed that average costs were reduced and that change was statistically significant. The number of matches in the experimental study increased what should also be considered statistically significant. The results for the third variable, i.e. shared profit, were less clear due to the large deviations of the variable in the test. However, it should be noted that the statistically significant increase in the average value of the shared profit was noted.

It should be stated that it is possible to develop a centralized recruitment system for jobseekers based on, for example, the algorithm of deferred acceptance and meeting the assumptions made under the theory of stable allocations. However, it is necessary to deepen the understanding of this problem and to broaden the consideration of the organization and management theory.

Due to the low level of interest in the design of labor markets in Poland, empirical research presented in this article may provide a starting point for further studies of the analyzed phenomenon. In times of structural mismatch of labor supply and demand, the labor allocation system would be a significant facilitator, both for job seekers and employers.

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EFEKTYWNOŚĆ SCENTRALIZOWANEGO MECHANIZMU ALOKACJI ZASOBÓW PRACY – BADANIA EKSPERYMENTALNE

STRESZCZENIE

W artykule podjęto problematykę alokacji zasobów pracy w kontekście rozwijającej się dziedziny nauk ekonomicznych, jaką jest projektowanie rynków. Omówiono założenia dla zaprojektowanego środowiska eksperymentalnego. Zdefiniowano zmienną eksperymentalną i zmienne zależne od niej. Głównym celem artykułu jest opracowanie mechanizmu dopasowującego uczestników eksperymentu, jako podstawy dla szerszego, scentralizowanego systemu alokacji zasobów na rynku pracy. Wyniki badań potwierdziły hipotezę, według której spełnienie założeń teorii stabilnych alokacji przyczynia się do poprawy efektywności dopasowania na rynku pracy, a tym samym do zmniejszenia bezrobocia frykcyjnego.

Słowa kluczowe: ekonomia eksperymentalna, projektowanie rynków, rynek pracy