MODELS OF WAGES AND INCENTIVES CONTRACTS IN THE CONDITIONS OF INFORMATION ASYMMETRY ON THE LABOR MARKET

Nada Trivic[1]* and Bojana Todic[2]

[1]*Faculty of Economics in Subotica, University of Novi Sad, Subotica, The Republic of Serbia*
[2]*University of Belgrade, Faculty of Mathematics, Belgrade, The Republic of Serbia*

The theoretical model of a perfectly competitive market leads to the efficient allocation of resources, and one of the assumptions of that model is complete information of market participants. In reality, however, market participants are usually asymmetrically informed. The goal of this analysis is to point out the fact that asymmetric information is almost ubiquitous, and also to point out the consequences of asymmetric information and the possibility of their elimination or mitigation. In addition, the research aim also reflects in achieving a theoretical confirmation of the presence of such asymmetric information and its consequences on the labor market as well, and in an attempt to mathematically formalize such markets, especially the labor market, by modeling the method of calculating wages and the employer's objective function as an opportunity to overcome the principal-agent problem. The precisely defined research goals determined the structure of the paper, as well as the methodological tools. In order to test and prove the defined research hypotheses in this study and to realize the defined research goals of the study, the methods of theoretical analysis, abstraction, comparison, concretization, generalization, and critical evaluation are used.

Keywords: asymmetric information, adverse selection, inefficiency, moral hazard, signaling

INTRODUCTION

The situation in which one party in an economic transaction has more information on a product or service than the other party does is called asymmetric information. The party possessing more information has an advantage and can make a more objective decision. As an assumption, all market participants in a competitive market have perfect information on the prices and quality of goods. Is this the case with the markets of medical or dental services, insurance, or the used car market? Hence, information is not equally available to all parties to a contract. Information is

---

* *Correspondence to*: N. Trivic, Ekonomsku fakultet u Subotici, Univerzitet u Novom Sadu, Segedinski put 9-11, 24000 Subotica, The Republic of Serbia;
e-mail: nada.trivic@ef.uns.ac.rs

asymmetric. What is the impact of such asymmetric information on how a market works?

The subject matter of the analysis carried out in this paper is the markets with asymmetric information. The results presented in this paper are result from many years of the author's engagement in researching this topic. Taking into account the generally known theoretical views of markets with asymmetric information, one of the goals set in this paper is the analysis of asymmetric information on the labor market, bearing in mind the specifics of this market. The primary goal of this part of the analysis is the theoretical confirmation of the presence of the consequences of asymmetric information on the labor market as well. The first research hypothesis arises from this goal:

H1: All negative consequences of asymmetric information are present on the labor market and on other markets, too, with certain specifics.

In addition to the theoretical analysis of the markets with asymmetric information, specifically the labor market with asymmetric information, another goal of this analysis is to try to mathematically formalize such markets. The ultimate goal is to formalize the labor market by modeling the method of calculating workers' wages and the employer's objective function as an opportunity to overcome the principal-agent problem. The second research hypothesis derives from the goal and is defined in the following manner:

H2: Different and precisely defined functional relations in the calculation of workers' wages can reduce the negative effects of the principal-agent problem on the labor market.

The set goals and hypotheses determine the methodological tools used in this research study, as well as the structure of this paper. The precise mathematical formulation of the functional interdependencies presupposes the precise theoretical findings of the problem of asymmetric information and market inefficiency as logical consequences. The understanding and analysis of the labor market with asymmetric information is therefore necessarily preceded by an analysis of the problems, causes,

and consequences of asymmetric information on the market in general.

It is essential to identify market defects, so that they could be either removed or continuously reduced. In this sense, the theory of asymmetric information can be perceived as the most significant new means of economic analysis.

ASYMMETRIC INFORMATION OF MARKET PARTICIPANTS

The foundations of asymmetric information theory were laid by the American economist G. A. Akerlof (1970), whereas M. Spence (1971) and J. Stiglitz (1975) gave an immense contribution to its foundation and further elaboration.

In the conditions of information asymmetry, the less informed side may face unfavorable consequences of its position, and certain models of such markets may serve a less informed side to diminish those consequences. At the same time, a more equal distribution of information may be useful even for the better-informed participant. Namely, equalizing the levels of information is sometimes in the interest of a better-informed participant, because only by conveying the information to a potential partner is it possible to establish economic relations that would otherwise be left out in the case of them not being informed. However, a better-informed party may direct its activities towards using the advantages of its position and achieving as great economic effects as possible. The problems of insufficient information of customers are becoming more apparent nowadays, with the emergence of technically complex products and services that require high qualification.

The examples of asymmetric information are numerous and typical of nearly all areas of life.

The production and turnover of products - A producer may introduce changes that reduce production costs, but also lower the quality of a product without lowering the sale price. Such changes cannot easily and timely be noticed by customers. This suits

neither the producers of a high-quality product nor customers. Many producers are faced with this problem - some consciously take hidden actions in order to gain benefits, while others make special efforts (and incur costs) to convince their customers that no hidden action is their business policy.

Moral hazard and insurance - Insurance is an institutional response to the circumstances in which there is a risk (Rothschild & Stiglitz, 1976). A person buys insurance from an insurance company and thus protects the value of his/her property from fire. When the insurance indemnity that the insured person expects is greater than the value of the insured property, his/her interest in prevention and risk mitigation may be lost. The owner of the insured property primarily reduces his/her caution to avoid the insured event. Such behavior already contributes to an increase in risk. Finally, he/she may become motivated to cause a "harmful" event him-/herself and claim a compensation afterwards. From the social aspect, insurance becomes harmful, because instead of contributing to a better protection of property, it may result in more property destruction.

The production and turnover of medicines - In the process from the production of medicines to their consumption, several actors are involved, each having an important role: the producer of the medicine, the physician (they who prescribe the medicine), the pharmacist (they who issue the medicine), the patient (they who use the medicine), and the insurance fund (the party paying for the medicine). Therefore, there are numerous possibilities for the appearance of the phenomena related to asymmetric information. The possibilities for a moral hazard to occur on the medicine market are multiple (Adeyele, Ogungbenle & Isimoya, 2019). In this chain, the patient is in a special position. The initiative of the other participants implies production or turnover, but the patient is the consumer of medicines. The others bear a material and moral liability. Apart from financial consequences, however, the patient exposes his/her own life and health to risk. However, the patient's behavior may even take the form of moral hazard. If a third party (the insurance fund) pays for the medicines, the patient may needlessly increase

demand and cause damage. This sensitive market is faced with various forms of moral hazard, among which the occurrence of counterfeit medicines is the severest one. There are numerous examples of the occurrence of counterfeit medicines on the market. Placing counterfeit medicines on the market is sometimes a lucrative business with little chance of being detected and punished.

Health care and the principal-agent problem - The physician's behavior may take a form of moral hazard (Adeyele *et al*, 2019). The information asymmetry between the patient (the principal) and the physician (the agent) is huge, which implies that understanding this concrete problem is essential for understanding economic problems present in the healthcare system. The patient is forced to leave to the physician (the agent) to make a decision on diagnostic tests, the therapy, hospitalization, control examinations, etc. that are going to be applied. The only option the patient has is to believe the physician. The physician may (if motivated) induce demand for his/her services. When the treatment is paid by a third party (a fund), and when the physician is paid on the basis of the number of the services provided, he/she is motivated to invite the patient (the insufficiently informed party) to an increased number of examinations, keep them longer in the hospital, offer them diagnostic methods and treatments that are not necessary, and so on. Thus, the physician increases his/her income, causes no dissatisfaction with the patient, but contributes to incurring increased costs of healthcare protection. Monitoring medicine prescription is complicated and expensive, so hidden actions taken by physicians are possible to evidence. Therefore, a series of difficulties appear when trying to distribute healthcare services to users via the market mechanism. Finally, it may be concluded that asymmetric information generates immense problems in financing healthcare protection, and no satisfactory healthcare funding model has been made yet.

THE KEY CONSEQUENCES OF THE ASYMMETRIC INFORMATION OF PARTICIPANTS

The main consequences of asymmetrically distributed information are (Auster & Gottardi, 2019):

- adverse selection,

- moral hazard, and

- principal-agent problem.

Negative selection

Negative selection occurs when products of a different quality are sold at the same price because buyers or sellers do not have sufficient information on the real value of the product at the moment of its purchase. As a result, too many low-quality products and too few high-quality products are sold. The used car market served G. A. Akerlof (1970) as an example to explain the phenomena which became prominent in information asymmetry. For the purpose of this analysis, this particular example will be presented in short and in a simplified manner, with the same basic conclusions.

In the literature on microeconomics, an example of the used car market is often given, where the cars of low quality are called the "lemon" (the slang word for "low" quality). It is assumed that there are four types of cars: new ones and used ones, as well as the cars of a high quality and the cars of a low quality. New cars may be of a high quality and of a low quality, the same working for used cars as well. When a consumer purchases a new car, he/she does not know whether it is going to be of a high or of a low quality. That is, the probability that he/she will buy a car of a high quality is P, and the probability of his/her buying a low-quality car is (1-p), with the assumption that q is the share of high-quality cars, and (1-q) the share of low-quality cars.

The situation is somewhat different on the used car market. Used cars are assumed to be equal regarding everything except for the quality (the same brand, model, year of production, etc.). If both buyers and sellers can distinguish these two types of cars, there are two markets (Figure 1). In part (a), the curve Sv is the supply curve, and Dv is the demand curve for the cars of a high quality. On Figure (b), Sn is the supply curve, and Dn is the demand curve for the low-quality cars. For any price, the curve Sv is on the left from Sn, since high quality cars are sold rarely, and their owners want to achieve a higher price. Also, the curve Dv is higher than the curve Dn, since customers are ready to pay more for cars of a better quality. If both buyers and sellers have exchanged information fairly, the market price of the high-quality cars will be 10,000 currency units, and that of the low-quality cars will amount to 5,000 currency units, 50,000 cars of each type being sold. Free trade will bring an increase in welfare to each participant and the exchange will be efficient.

Due to the asymmetric information between buyers and sellers, buyers will consider that a car is of a medium quality when buying, and the demand curve for medium-quality cars is DM. The curve DM is below the curve Dv, but above the curve DN, and the cars are sold at the same price which is lower than 10,000 and higher than 5,000 currency units. In this case, the sellers of low-quality cars receive more than the actual value of the car, and the sellers of high-quality cars receive less than the actual value of the car. Since they cannot sell at a higher price, some sellers of high-quality cars will withdraw their cars from the market. Therefore, fewer high-quality cars (25,000) and more low-quality cars (75,000) will be sold.

Buyers will realize that the largest number of the sold cars are of a low quality, and their demand shifts and is represented by the curve DNM, meaning that the quality of the cars is perceived as low and medium. Buyers further perceive cars as mostly low-quality, and the demand curve shifts further to the left until only low-quality cars start selling. Then the market price is too low for the sale of high-quality cars. Any car they buy will be of a low quality and the only relevant demand curve is the curve DN. In the literature, this phenomenon is called adverse or reverse selection, because a low-quality product
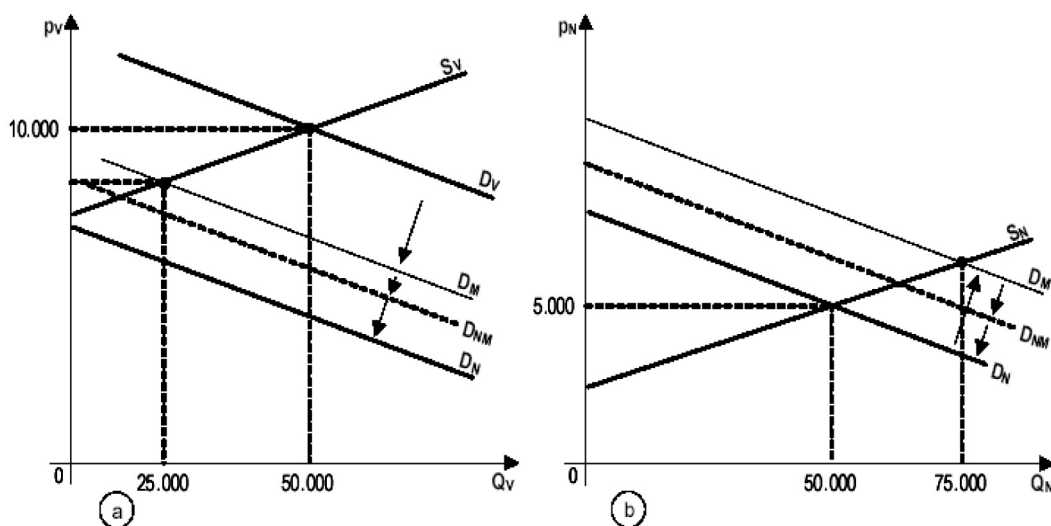
Figure 1 The used car market

Source: Trivić, 2009b, 113

remains on the market and drives a high-quality product out. Buyers cannot easily determine the quality of a product until they buy it. Therefore, prices are reduced, a high-quality product is driven out, and a low-quality product captures the market. Thus, a lack of the buyer's information leads to some mutually beneficial exchanges not occurring. This is due to the problem of adverse selection or market failure (inefficiency).

Adverse selection also occurs when products of different quality are sold at the same price, because buyers or sellers are not adequately informed to determine the actual value of the product at the moment of the purchase. As a result, too many low-quality products and too few high-quality products are sold on the market.

Moral hazard

Moral hazard can be defined as a hidden action of one party in a business or contract, because of which the other party, being unable to perceive or monitor these actions, suffers economic damage. However, there is usually nothing hazardous in the undertaken by the better-informed party. This is de facto rational

economic behavior in the circumstances where the other party lacks an important piece of information.

Moral hazard becomes apparent when the hidden action of one party is present in an economic relation. That is, one party undertakes an action that does not favor the other party, cannot be easily noticed or controlled by the other party, due to which action the other party suffers unfavorable economic consequences. Moral hazard may occur in particular forms in various types of economic relations (insurance, the capital market, the product market, etc.). The easiest way to explain moral hazard is by taking insurance as an example (Dembe & Boden, 2000), a property owner insured against fire does not remove flammable items, which he would do in case the property was not insured. This increases the probability of the occurrence of a harmful event, thus increasing the costs which the insurance company has to cover on the basis of the insurance contract. Moral hazard also occurs when the property owner him-/herself contributes to its destruction (a part of social wealth is lost).

The principal-agent problem

The principal refers to the person who places a request to the other party, i.e. the agent on the basis of the ownership or a certain given right. The agent has to perform certain tasks beneficial to the principal. A perfect agent decides how the principal would decide if he had the information the agent has. However, working for the principal, the agent may be guided by his/her own interest. Their activities are difficult to monitor and control. The principal-agent problem is a consequence of the asymmetric information which occurs when the agent (due to being better informed), performs the work beyond the agreement in the way that serves his/her own interest, but in a manner which does not coincide with the principal's interest.

The examples and situations where this kind of a relationship appears between two parties are numerous: a paid manager and the company owner, a patient and a doctor, a health insurance fund and a doctor, a public company director and the government, a student and a professor and so forth. Another example of the principal-agent problem is public enterprises. The managers of public enterprises may be interested in obtaining personal power and benefits outside the efficient limits. Since it is expensive to monitor the work of a manager in a public enterprise, there is no guarantee they will achieve efficient business results.

Possibilities of Modeling a Market with Asymmetric Information

The mathematical analysis of the used car market models: This example can mathematically be analyzed based upon utility theory (Pouyet, Salanie & Salanie, 2008). Suppose demand for used cars is mainly determined by the two variables: the price of a car p and the average quality of the used cars traded μ, or $QD = D(p, \mu)$. Both the supply of the used cars and the average quality μ depend on the price or $\mu = \mu(p)$ and $S = S(p)$. In equilibrium, supply must equal demand for the given average quality, or $S(p) = D(p, \mu(p))$. With a fall in prices, quality usually

decreases, and it is quite possible that products will not be exchanged at every price level.

Suppose there are two groups of buyers: the utility function of the group 1 is as follows:

$$U_1 = M + \sum_{i=1}^{n} x_i \tag{1}$$

where M is the consumption of other goods (apart from vehicles), x_i is the quality of the i-th car, n is the number of cars. In a similar fashion, the same applies to the second group:

$$U_2 = M + \sum_{i=1}^{n} 3/2x_i \tag{2}$$

Regarding these utility functions, the model starts from the three key assumptions:

- if a utility is not linear (e.g. a logarithmic utility), the algebra is needlessly complicated;
- assuming a linear utility enables focusing on the effects of asymmetric information;
- U_1 and U_2 have the property implying that, by adding both the second and the k-th car, the gain in the utility is the same as that with the first car.

This again sacrifices realism to avoid deviating from the primary focus of the analysis. It is further assumed that:

- both type-1 and type-2 buyers maximize the Neumann-Morgenstern expected utility;
- type-1 has N cars with an evenly distributed quality x, $0 \le x \le 2$, and type-2 has no cars at all;
- the uniform pricing of "other goods" M.

The income (including the revenue from car sales) for all type-1 buyers is marked as Y_1, and the income of all type-2 buyers is marked as Y_2. Demand for used cars will be the sum of the demands of both groups.

Demand for the cars of the type-1 buyers will be as follows:

$$D_1 = Y_1/p \qquad \mu/p > 1 \tag{3}$$

$$D_1 = 0 \qquad \mu/p < 1 \tag{4}$$

The supply of the type-1 cars is as follows:

$$S_2 = pN/2 \qquad\qquad p \le 2 \qquad\qquad (5)$$

for an average quality.

$$\mu = p/2 \qquad\qquad (6)$$

(for the deduction of the relations (5) and (6), an even distribution of cars regarding the quality is assumed).

Similarly, the demand of the type-2 buyers is as follows:

$$D_2 = Y_2/p \qquad 3\mu/2 > p \qquad\qquad (7)$$

$$D_2 = 0 \qquad 3\mu/2 < p \quad\text{and}\quad S2 = 0 \qquad (8)$$

Then, total demand is $D(p, \mu)$:

$$D(p, \mu) = (Y_1 + Y_2)/p \qquad\text{if}\quad p < \mu \qquad (9)$$

$$D(p, \mu) = Y_2/p \qquad\text{if}\quad \mu < p < 3\mu/2 \qquad (10)$$

$$D(p, \mu) = 0 \qquad\text{if}\quad p > 3\mu/2 \qquad (11)$$

For the price p, however, the average quality is $p/2$. Therefore, the determined price is the condition for a sale to even occur: despite the condition of for any price between 0 and 3 there are the type-1 sellers who are ready to sell their cars for the price which type-2 buyers are ready to pay.

The foregoing is the opposite of a symmetric information situation. Let us assume that the quality of all cars is evenly distributed $0 \le x \le 2$. Then the demand curve and the supply curve can be defined in the following manner:

Supply

$$S(p) = N \qquad\qquad p > 1 \qquad\qquad (12)$$

$$S(p) = 0 \qquad\qquad p < 1 \qquad\qquad (13)$$

and the demand curves are:

$$D(p) = (Y_1 + Y_2)/p \qquad p < 1 \qquad\qquad (14)$$

$$D(p) = Y_2/p \qquad 1 < p < 3/2 \qquad (15)$$

$$D(p) = 0 \qquad\qquad p > 3/2 \qquad\qquad (16)$$

In equilibrium:

$$P = 1 \qquad\qquad \text{if}\ \ Y_2 < N \qquad\qquad (17)$$

$$P = Y_2/N \qquad\qquad \text{if}\ \ 2\,Y_2/3 < N < Y_2 \qquad (18)$$

$$P = 3/2 \qquad\qquad \text{if}\ \ N < 2\,Y_2/3 \qquad (19)$$

If $Y_2 < N$, the additional utility gain exceeds the gain of $N/2$ in the conditions of information asymmetry. If $N > Y_2$, then the income of type-2 customers is insufficient for the purchase of all N cars, there is a gain in the utility of $Y_2/2$. Finally, it should be noted that type-1 and type-2 buyers have the same probability estimations on the quality of certain cars. Although these estimations may vary from car to car - the relations (17), (18), and (19) will still be describing the market equilibrium with one small change: p will then represent the expected price of one unit of quality.

POSSIBILITIES TO MITIGATE OR OVERCOME THE CONSEQUENCES OF ASYMMETRIC INFORMATION

Adverse selection is the cause of market inefficiency. The negative consequences caused by the use of defective products as a result of the inability of a consumer to assess their quality, the need to be prevented at least when food, drinks, medicine, living conditions, and other products of vital importance for people are concerned. The mitigation of such negative consequences (Citanna & Villanacci, 2000) is not simple although there is a number of different measures adopted to achieve it, such as:

• the measures relying on the market mechanism, and

• the measures involving state intervention.

The market mechanism and the activities carried out by market participants in the conditions of information asymmetry

When sellers intend to hide the information essential for a transaction, they want a less informed partner. They intend to hide the unfavorable characteristics

of their product. If they succeed in that endeavor, the product of a better quality is driven out of the market. However, the sellers of the product of a better quality are interested in raising or balancing the information of all participants. Thus a better-informed party often shows a considerable initiative on markets with asymmetric information. When it is in their interest to increase the information awareness of potential partners, they make the missing information available to them. The initiative of the informed party can be very strong (Samuelson, 1984). Also, buyers ready to pay more for a better quality want to obtain information about the quality of the product. There is a number of different market approaches whose application makes it possible to try to reduce the problems arising due to asymmetrically distributed information.

The producer of a high-quality product and the producer of a low-quality product have different attitudes towards the information they have about their own products. The party knowledgeable of the unknown to the other party will gladly provide the information to a potential partner only if that party itself also achieves a utility for itself by providing that piece of information. The producer of a high-quality product may try to maintain and strengthen its position on the market by giving certain signs (signals) based on which a potential buyer could be convinced of the quality of the product (Spence, 1974). Such signals cannot be sent by the producer of a low-quality product. The signal helps to differentiate a high-quality product from a low-quality product. Hence, the better-informed party may contribute to the balancing of the information level by using signals, because it is in its interest. Said signals are sent by the better-informed party when it is in its interest. Thus, the producer of a high-quality product distinguishes himself from the producers hiding their weaknesses. The high-quality product is sold for a higher price to the customer who is willing to pay more for higher quality. Then the seller of a low-quality product may only count on the customers to whom the products of higher quality became unavailable. The signal is only sent by the producer of a high-quality product, and the signal must be such that the producer of a low-

quality product is unable to also send it (Jovanović, 1982).

The less-informed party may try to obtain the information the better-informed party has. This is done via screening. Screening is the process opposite to signaling. A special type of screening is labor market screening (Spence, 1974), the analysis of which goes beyond the scope of this paper (Spence & Zeckhauser, 1971). It is an attempt of the less-informed party to "extract" a piece of information from the better-informed party or to lead the better-informed party to the behavior that will indirectly reveal the information that was hidden (certain types of tests, etc.). If it obtains the missing information, the less-informed party will adjust its previous intentions - to cancel the purchase or achieve a lower price. In this, it may encounter significant difficulties since the party having the interest of hiding certain facts will not easily renounce its superior position. The most common examples of signaling and screening are the following ones:

- warranty,
- prestige and reputation,
- standardization, and
- informed and non-informed customers.

Warranty: By providing warranty, it is possible to gain customer trust. It is the apparent signal of the product quality (within the warranty period, possible deficiencies and defects are eliminated by the seller; sometimes, product return is accepted if the buyer is not satisfied). The producer of a low-quality product is not in the position to offer such sales conditions. Providing warranty is thus a powerful signal. The longer the warranty period, the greater the customer belief that the product is of a high quality.

Prestige and reputation: Repeat purchases (the buyer gains the experience of the quality of that product) allow the producer of a high-quality product to gain reputation and prestige. Such a producer must not exhibit the behavior typical of moral hazard. The product brand and the name of the producer become important. The buyer simplifies the purchase by

basing it on the trust in the product brand and the producer.

A reputation acquisition effort is aimed at differentiating that producer from the competitors whose offer is of a low quality. Then the impact of adverse selection is eliminated. When differentiation is achieved, the producer of a high-quality product may compensate for the costs of maintaining the quality at a high level by increasing prices. A lack of information is compensated for by the trust in the brand and the producer, and buying and selling are mutually beneficial. Reputation is a powerful tool in solving problems of asymmetric information and the impact of adverse selection. Once reputation has been gained, the producer must maintain its prestige. Anything that would damage the prestige must be quickly eliminated, even if this implies unplanned costs (Eckard, 1988).

Standardization: Sometimes buyers do not have the opportunity to gain their own experience, because there is no possibility of making repeat purchases. Then they can be assured of a high quality only with product standardization - standard food and lodgings for the people who frequently travel. For example, a network of restaurants in different places, and the food is prepared in the same manner and retains the same quality (for example, the McDonald's restaurant chain). The buyer is informed about the quality in advance, which simplifies the choice, compliance with the standards in these cases being of utmost importance.

Informed and non-informed customers: Not all customers are non-informed. Informed customers significantly contribute to the information awareness of other customers. Their choice and behavior may sufficiently serve to mitigate the consequences of adverse selection. "Expert consumers" have a special role in informing other customers. They convey information in a convenient manner to consumers and provide a useful piece of advice (on cars, stereo devices, computers, phones, etc.) via TV shows or special publications, magazines, and so on. Thus, they protect the interest of less-informed consumers and contribute to an increase in the quality of a product.

Furthermore, certain types of services demand a high level of expertise and skill (lawyers, doctors in private practice, dentists, service providers, instructors, coaches, etc.). They find new clients among those to whom they were recommended by their friends, cousins, and/or neighbors.

The unfavorable consequences of moral hazard are difficult to completely eliminate. Moral hazard will be present as long as the hidden action benefits a party in the given economic relation. If a sufficiently good market response was always present, the less-informed party could protect its own interests. However, there is the question of whether the market mechanism itself can resolve the market failures that occur due to an asymmetric distribution of information. The insufficient efficiency and powerlessness of the market may also cause socially unacceptable problems. This points to the necessity of state intervention, where the state takes on the role of the protector of the insufficiently informed.

The role of the state in the conditions of information asymmetry

On the markets with a noticeable information asymmetric distribution, state intervention may improve the condition to a certain level and prevent large failures and socially harmful consequences (Stiglitz, 2000). In this, the key assumption is that the state must also be well-informed.

In the areas of utmost social importance (citizen healthcare, food products, the production and turnover of medicines, etc.), the state necessarily appears playing the role of the protector of the less-informed party. The less-informed party is incapable of improving the level of its information awareness, and in the case of the absence of state intervention, the less-informed party suffers significant damage and other negative consequences may also occur (Trivić, 2009a). The market is inefficient and does not perform the expected role, and the interest of the less-informed party must be protected in order to avoid negative consequences. For example, the use of medicines cannot be left to the action of the

free market. The population's vital interest may be endangered by the hidden actions taken by certain participants in the production and distribution of medicines. Therefore, powerful measures for preventing, revealing, and punishing such a behavior are necessary to be introduced. One of the manners how this is to be achieved implies the control of the quality of production and trade. The control of the conditions under which certain products are created contributes to the protection of the general interest. The obligation regarding obtaining work permits (licenses, certificates, or diplomas), which can only be obtained when certain conditions are met, is imposed on producers. If this type of the protection of the public interest is weakened, society is exposed to a risk, and some mistakes may endanger human lives.

Beside this, the unfavorable consequences of asymmetric information can be mitigated by influencing information flows themselves. It is possible to set the requirements regarding the content of messages sent to customers. Regulations may prescribe the mandatory content of the information that a producer must make available to its customers, as well as the manner of conveying the information (from the chemical ingredients of a product to the minimum size of the letters on the packaging). The state has to regulate this area by applying law, so that the less-informed party does not suffer damage due to a lack of information (especially when a product of vital importance - food, water, medicines, etc. are concerned).

ASYMMETRIC INFORMATION ON THE LABOR MARKET

Asymmetric information is a characteristic of the labor market as well (Trivić, 2009b). Jobseekers know more about their own abilities than employers. The abilities, knowledge and skills that a worker has when concluding an employment contract are his hidden characteristic. Some characteristics of the worker can easily be identified by the employer: such as the worker's gender, age, origin, level of education, and previous work experience. In addition, the worker's

behavior may involve a hidden action. A typical example of a hidden action occurs in the worker-employer relationship. It is sometimes difficult for the employer to monitor the level of workers' commitment in the workplace. In some occupations and in some jobs, it is difficult to ensure the constant monitoring of the extent of the worker's commitment to performing work tasks. If control and supervision are simultaneously weak, the worker may almost stop performing work tasks and dedicate him-/herself to some other activity during the working hours (Siemens & Kosfeld, 2014).

On the labor market as well, the main consequences of asymmetric information are manifested in the form of the phenomena of adverse selection, moral hazard and the principal-agent problem.

Adverse selection on the labor market is a consequence of workers' hidden characteristics. The other party (i.e. the employer) does not have timely information about the existence of a worker's hidden characteristic (insufficient expertise, the worker's incompetence), and may be exposed to harmful consequences due to that fact (Kahn, 2013).

Suppose that the worker population consists of the two relatively homogeneous groups of workers: group A - low-productive workers and group B - highly productive workers. When concluding a contract, the employer does not know which group the worker belongs to. However, the employment of the workers from either the group A or the group B results in a different marginal product of labor MPL and a different marginal revenue MR. Thus, if group A worker is employed, he/she will generate a marginal revenue of 10,000 currency units per year; otherwise, if a worker belongs to the group B, a marginal revenue will be 20,000 currency units. Since the employer cannot predetermine which group the worker belongs to, he/she calculates with a marginal revenue of 15,000 currency units. Then workers from the group A earn more (15,000 instead of 10,000), and workers from the group B earn less (15,000 instead of 20,000), i.e. the negative consequences of asymmetric information are to the detriment of the workers whose abilities are

greater, and the allocation of workers then deviates from the optimal.

Moral hazard on the labor market manifests itself when a hidden action of the better-informed party in the economic relationship is taken (the worker consciously and intentionally slacks). The employer cannot notice the action in time, so he/she is exposed to economic damage. Slack in the workplace has always brought the executor of work orders a reduction in the psychophysical effort. For the employer, this means a breach of work discipline and reduced performance. In practice, they try to avoid or at least reduce these damages in various ways (Altonji & Pierret, 2001), primarily by the control and application of different payment methods.

The principal-agent problem on the labor market is a phenomenon accompanying the worker-employer relationship. The worker may take a hidden action in various ways, which reduces the level of the commitment compared to the expected one. The worker-employer relationship is burdened by this opposing interest. The employer is often unable to control the worker's level of commitment in the workplace (Saibal & Debabrata, 2015). By a mutually defined contract (agreement), it is possible to envisage the various measures by which the effort made by the worker is rewarded, whereas slackness is punished. These are attempts to boost the worker's motivation to increase his/her personal productivity and discourage slackness. Their application reduces the need for constant supervision and reduces the costs that control and supervision entail (Altonji & Pierret, 2001).

The previous analysis showed that all the consequences of asymmetric information were present on the labor market, as well as on other markets, yet with certain specifics. This has confirmed the hypothesis H1.

Measures to reduce asymmetric information on the labor market

If an employee invests a smaller effort than usual for the job he/she is performing, lower productivity will negatively affect the business result. The supervision, control, and punishment of such a behavior usually implicate additional costs. Therefore, such a behavior may partially be prevented by applying different methods of wage payment to employees. Different payment methods have different effects on workers' commitment (Bowlus, 1995).

If the worker is paid by the time he/she spends at work, slacking allows him/her a smaller effort and fatigue at work, while not affecting his/her earnings at the same time. Since the wage he/she receives does not depend on the results of the work they have done, they are motivated to invest a smaller effort. When applying this payment method, employers usually try to find a satisfactory way to control the execution of work tasks.

The per-piece payrate means the payment in favor of the worker according to a measurable indicator (according to the number of the units produced, for example). Greater commitment brings higher earnings. Such a payment method is often an effective measure to keep work intensity at a satisfactory level and contribute to a reduction in some costs (such as the costs of supervision, scrap, etc.), and more capable workers earn higher wages. Payment per piece, however, is not always applicable; there are many jobs whose result is not easy to measure, and when more workers work on a team, the result of the work done is shared.

Paying workers by time and per piece are the traditional payment methods the importance of which has not diminished in modern business. Practice and various experiences, however, have developed a number of the payment forms and methods that affect the worker's motivation and diminish his/her interest in slacking in the workplace.

The mathematical model of the labor market with asymmetric information

The worker-employer relationship is also an example of the principal-agent problem (Spence & Zeckhauser, 1971). The worker is hired by the principal (the employer) to perform certain work. Only the

worker is he/she who is aware of the effort he/she invests (asymmetric information), and the worker's invested effort influences the principal's earning. The principal's problem is how to make a contract containing the incentive that will lead the worker to make such an effort that will maximize the principal's earning.

Allow us to assume that e is the worker's (agent's) effort (Bowlus, 1995). The principal's earning is $y = f(e)$. The contract that contains the incentives is the function $s(y)$, which defines the worker's earnings when the principal's earning is y.

The principal's profit then equals as follows:

$$\Pi_p = y - s(y) = f(e) - s(f(e)) \qquad (20)$$

Let $\tilde{u}$ be the worker's (reservation) utility when not working. In order to secure that the worker will participate, the contract must offer the worker a utility of at least $\tilde{u}$ (i.e. greater than $\tilde{u}$). The cost of work for the worker in the utility equations when the investing effort level of e is equal to $c(e)$. Hence, the principal's problem is to choose such e, so that:

$$\max \Pi_p = f(e) - s(f(e)) \qquad (21)$$

with the limitation $s(f(e)) - c(e) \geq \tilde{u}$ (the participation constraint).

In order to maximize the profit, the principal draws up a contract that will provide the worker with at least his/her reservation utility.

The replacement of $s(f(e))$ leads to:

$$\max \Pi_p = f(e) - c(e) \ - \tilde{u} \qquad (22)$$

The principal's profit is maximized when:

$$f'(e) = c'(e) \qquad (23)$$

$$f'(e) = c'(e) \rightarrow e = e^* \qquad (24)$$

The contract that maximizes the principal's profit insists on the worker's effort level e^*, which equates the worker's marginal cost of the effort with the principal's marginal profit from the worker's effort.

How can the principal make the worker choose $e = e^*$? Actually, $e = e^*$ must be preferred by the worker. That is, the contract $s(y)$ must satisfy the compatibility of the incentives constraint:

$$s(f(e^*)) - c(e^*) \geq s(f(e)) - c(e) \qquad (25)$$

Below are some examples of the contracts containing the incentives (Zavadskas, Turskis & Antucheviciene, 2019):

Rent: Then the principal keeps the lump sum R for him-/herself, and the worker appropriates the entire profit above R, ie:

$$s(f(e)) = f(e) - R. \qquad (26)$$

Does such a contract maximize the principal's profit?

For the given contract, the following is valid: $s(f(e)) = f(e) - R$.

Then the worker's earning is:

$$s(f(e)) - c(e) = f(e) - R - c(e) \qquad (27)$$

and in order to maximize it, the worker should choose the effort level for which:

$$f'(e) = c'(e) \quad e = e^*. \qquad (28)$$

What should the principal's rent R be? The principal should extract as high a rent as possible, whereas the worker accepts the job, so R should meet the condition:

$$s(f(e^*)) - c(e^*) - R = \tilde{u}, \qquad (29)$$

$$R = s(f(e^*)) - c(e^*) - \tilde{u}. \qquad (30)$$

Wages: such a contract envisages the payment of a worker in accordance with the following formula:

$$s(e) = we + K \qquad (31)$$

where w is the wage proportionate to the quantity of the invested effort; K is the lump sum payment. Then, $w = f'(e^*)$, while K makes the worker directly indifferent between participating on the job or not participating at all.

Take it or leave it. If he chooses that $e = e^*$, the lump sum amount L will be paid, and if he chooses

$e \neq e^*$, he will be paid a zero. The utility of the worker when choosing $e \neq e^*$ is $c(e)$, so he will choose $e = e^*$. It is assumed that L is chosen so that the worker is indifferent towards either accepting or rejecting the job.

The mutual characteristic of all efficient contracts containing incentives is that they make all the residual rights to the profit attributed to the worker, i.e. each part of the remaining profit must fully be attributed to the worker.

However, starting from the assumption that the employer (principal) motivates the employee (agent) with a certain fee to perform a task, in the end the employer only knows the actions taken by the employee, not how he/she would act in the event of being differently rewarded. If the employer had such a piece of information, he would be able to offer him/her the wage that would be suitable for his/her efficiency level and the problem would so be solved. Thus, efficient market equilibrium would be achieved. The employer, however, tends to define as low as possible, although yet a sufficient reward that would incite the employee to efficiently work. This further complicates the given problem since the employer does not know the worker's utility function. Several approaches may be comprehended for solving the given problem (Contreras-Reyes & Arellano-Valle, 2018).

Allow us to assume that the employee may choose one of the actions from the available set of actions A, where this set is made of the strategies a_0, a_1 and a_2 ($A=\{a_0, a_1, a_2\}$). The action a_0 signifies that the employee does not perform the given work; action a_1 signifies that the employee performs his work, but does not conscientiously do the job, while action a_2 signifies that the employee works conscientiously. Allow us to assume that each action bears a certain cost of work for the employee, $w_i = w(a_i)$, $i = 0, 1, 2$, where $w_0 = 0$. This cost may be described as the sacrifice the employee has made in order to perform the given job.

Take $r_i = r(a_i)$, $I = 0, 1, 2$, as the function that represents the employee's wage (reward) for the work performed, and which is defined by the employer depending on whether and how much the employee does work. Therefore: $r_0 = r(a_0) = 0$.

Utility for the employee $V(t, a_i, r_i)$ depends on how much aversion he/she has to the action required of him/her to take (t), the employee's strategy applied in performing the work (a_i) and the wage (r_i), i.e. the compensation he/she receives for the work he/she does. Aversion to execution is expressed by the function of t, which represents the employee's effort and is known to the employee, but not to the employer. Assuming that the employee is rational and that he/she will always choose the action by which he/she maximizes his/her own utility, the utility for the employee can be expressed as follows:

$$V(t, a_i, r_i) = v(t, a_i) + r(a_i) = r(a_i) - tw(a_i) \tag{32}$$

for $i = 0,1,2$, where $v(t, a_0) = 0$, for each t. Namely, $v(t, a_i)$ is the employee's cost for the effort t and the strategy a_i, ie. $c(e)$. Finally, the utility for the employee is the difference between the employee's wage $r(a_i)$ as the utility, and the cost of work for the employee, which is represented by $tw(a_i)$.

Utility for the principal depends on the wage, i.e. the reward that he/she must pay to the employee, as well as on how important the action that the employee needs to perform is to him. Therefore, the utility function for the employer can be expressed as follows:

$$U(a_i, r_i) = u(a_i) - r(a_i), za \ i = 0, 1, 2 \tag{33}$$

where $U(a_i, r_i)$ represents the profit the employer makes depending on the action chosen by the employee, where $u(a_0) = 0$. A profit $U(a_i)$ represents the difference between the employer's earning $u(a_i)$ or $f(e)$ and the wages paid out to the employee $r(a_i)$ or $s(f(e))$. That is, the obtained relation 33 is in accordance with the relation 20.

The presented mathematical model for calculating the worker's (agent's) wages and the principal's profits shows that, based on the simple functional relations in the calculation of the worker's wages, it is possible to reduce the negative effects of the principal-agent problem on the labor market, which proves the hypothesis H2.

CONCLUSION

Asymmetric information theory is one of the most powerful analytic approaches in contemporary economic science. Asymmetric information of the participants in economic transactions leads to market inefficiency. The number of the beneficial trades performed is smaller than the number which would be performed if buyers and sellers were equally informed about the quality of a product, the product durability, and so on. There are numerous examples of asymmetric information markets. It is precisely this fact that may serve as the basis of the thesis that (to a greater or lesser extent) information asymmetry is the characteristic of almost all markets. If such a thesis is accepted, this further means that the consequences of asymmetric information are ubiquitous. Moreover, this means that the results of the way the market works must be corrected by certain market mechanisms and the activities of the market participants themselves, and even state intervention (implying the protection of the less-informed party by introducing certain state measures) is required on some markets. Sometimes, however, the influence of asymmetric information is such that not even state intervention can successfully resolve the entirety of the problem.

The theoretical part of the analysis carried out in this paper has shown that information asymmetry is present on the labor market with all the effects that are characteristic of information asymmetry in general, which has confirmed the hypothesis H1. It was identified that the key problem of the labor market was the principal-agent problem, which represented a new research goal and task - the possibility of the mathematical formalization of the method of calculating wages in the conditions of information asymmetry. The possibility of mathematical modeling is a specific challenge in the analysis of markets with asymmetric information. The paper presents the models of both the used car market and the labor market with asymmetric information of the participants. The specifics of the labor market have resulted in an alternatively defined method of calculating workers' wages in order to mitigate or overcome the principal-agent problem. Some models of the functional connection between employee engagement and the employer's objective function are presented in the paper. The possibility of their formulation and application confirms the defined hypothesis H2. The results of the analysis showed that their application significantly mitigated the principal-agent problem on the labor market, which is the most important contribution made by this paper.

The key limitation of a research study of this type is the limited possibility of its empirical quantification and verification. Research in markets with asymmetric information is a challenge for future theoretical and empirical research in general, and for individual specific markets as well. A particularly important area of future research is the markets in which asymmetric information may endanger participants' health.

REFERENCES

Adeyele, J. S., Ogungbenle, G. M., & Isimoya, O. A. (2019). Asymmetric information and health risk behaviour in national health insurance scheme in Jos Metropolis, Nigeria. *Economic Horizons*, *21*(2), 143-156. doi:10.5937/ekonhor1902145A

Altonji, J. G., & Pierret, C. R. (2001). Employer learning and statistical discrimination. *Quarterly Journal of Economics*, *116*(1), 313-350. doi.org/10.1162/003355301556329

Auster, S., & Gottardi, P. (2019). Competing mechanisms in markets for lemons. *Theoretical Economics*, *14*(3), 927-970. doi.org/10.3982/TE2921

Akerlof, G. A. (1970). The market for „lemons": Quality uncertainty and the market Mechanism. *Quarterly Journal of Economics*, *84*(3), 488-500. doi.org/10.2307/1879431

Bowlus, A. (1995). Matching workers and jobs: Cyclical fluctuations in match quality. *Journal of Labor Economics*, *13*(2), 335-350. doi.org/10.1086/298377

Citanna, A. & Villanacci, A. (2000). Competitive equilibrium with moral hazard in economies with multiple commodities. *Journal of Mathematical Economics*, *38*(1-2), 117-147, doi:10.1016/S0304-4068(02)00070-8

Contreras-Reyes, E. J., & Arellano-Valle, B. R. (2018). *Asymmetric Distributions and Information Theory: Information Measures for Symmetric and Asymmetric Distributions, with Applications*. LAP Lambert Academic Publishing.

Dembe, A. E., & Boden, L. I. (2000). Moral hazard: A question of morality? New solutions. *A Journal of Environmental and Occupational Health Policy*, *10*(3), 257-279. doi: 10.2190/1GU8-EQN8-02J6-2RXK

Eckard, W. E. (1988). Advertising, concentration changes, and consumer welfare. *Review of Economics and Statistics*, 70(2), 340-343. doi.org/10.2307/1928320

Jovanovic, B. (1982). Favorable selection with asymmetric information. *The Quarterly Journal of Economics*, *97*(3), 535-539. doi.org/10.2307/1885876

Kahn, L. B. (2013). Asymmetric information between employers. *American Economic Journal: Applied Economics*, *5*(4), 165-205. doi:10.1257/app.5.4.165

Pouyet, J., Salanie, B., & Salanie, F. (2008). On competitive equilibria with asymmetric information. *Journal of Theoretical Economics*, *8*(1), 1-16. doi:10.2202/1935-1704.1385

Rothschild, M., & Stiglitz, J. (1976). Equilibrium in competitive insurance markets: An essay on the economics of imperfect information. *The Quarterly Journal of Economics*, *90*(4), 629-649. doi.org/10.2307/1885326

Saibal, K., & Debabrata, D. (2015). Asymmetric information in the labor market. In K. Saibal, & D. Debabrata (Eds.). *Industrial and Labor Economics - Issues in Developing and Transition Countries* (pp. 39-86). Springer, India. doi:10.1007/978-81-322-2017-6_3

Samuelson, W. (1984). Bargaining under asymmetric information. *Econometrica*, *52*(4), 995-1006. doi. org/10.2307/1911195

Siemens, F. A., & Kosfeld, M. (2014). Team production in competitive labor markets with adverse selection. *European Economic Review*, *68*(C), 181-198. doi:10.1016/j.euroecorev.2014.03.003

Spence, M. (1974). Job market signaling. *The Quarterly Journal of Economics*, *87*(3), 355-374. doi:10.2307/1882010

Spence, M., & Zeckhauser, R. (1971). Insurance, information and individual action. *American Economic Review*, *61*(2), 380-387.

Stiglitz, J. (2000). The contributions of the economics of information to the twentieth century economics. *The Quarterly Journal of Economics*, *115*(4), 1441-1478. doi.org/10.1162/003355300555015

Trivić, N. (2009a). Model of market with asymmetric information. In L. Fang (Ed.). *CORS-INFORMS Joint International Meeting of the Canadian Operational Research Society and Institute for Operations Research and Management Sciences* (p. 102). Toronto, CA: Ryerson University.

Trivić, N. (2009b). Asimetrična informisanost - Ekonomski i/ili etički problem. *Anali Ekonomskog fakulteta u Subotici*, *45*(22), 111-121.

Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2019). Solution models based on symmetric and asymmetric information. In E. K. Zavadskas, & Z. Turskis (Eds.). *Solution Models Based on Symmetric and Asymmetric Information* (p.p. 1-10). doi.org/10.3390/books978-3-03921-007-7

Nada Trivic is a full professor of Political Economy, Microeconomics, Principles of Microeconomics and Microeconomic Models, at the Faculty of Economics in Subotica, in the field of General Economic Theory.

Bojana Todic is an assistant and doctoral student at the Faculty of Mathematics in Belgrade. She is engaged in the following subjects: Probability and Statistics, Elements of Financial Mathematics, Random Processes, Probability Theory, Time Series and Applications in Finance, Statistical Software. Her key areas of interest are the coupon-collector problem, random processes, financial mathematics, probability and statistics.