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The Agency Dilemma: Information Asymmetry in the "Principal-Agent" Problem

By possessing incomplete and imperfect information, market participants do not achieve the optimal allocation of resources that would be possible in the case of possessing complete information. On the other hand, timely and relevant information represents a product for which the appropriate market price must be paid. In modern corporations, the two sides engaged in a contract may have different goals and have different levels of information. This problem is called the "principal-agent" problem. Agents sometimes have personal goals that do not coincide with the goals of the principal, thus the principal must achieve its own, but also the needs of agents. One way is to motivate the agent using rewards, prohibitions and penalties. In this case, the qualitative needs assessment and evaluation of costs results in greater efficiency and faster problem solving. The paper points out the importance of economics of information for the operation and the result of market processes. To model market relations in a situation where two parties are asymmetrically informed, the methodology of game theory is used. The problem of " principal-agent " is modelled as the Bayesian game, where the solution is obtained using the concept of the Bayes-Nash equilibrium.

Keywords: "principal-agent" problem, asymmetric information, market signalling, market screening, game theory, Bayesian game, Bayes-Nash equilibrium.

1. Introduction

Economic science has been for decades developing concepts that relied, among other things, on the complete and uniform information of market participants. The starting point was a rather unrealistic assumption that all market participants have all relevant and necessary information about the variables that define their field of choice. Under such conditions, the market equilibrium and the optimal allocation of available resources is reached very simply. However, over time, it was concluded that such a restrictive assumption does not describe the real problem with sufficient precision, as well as that a better analysis requires different models to be developed [8]. Therefore, the game theory, as an economic science, has found its special application in the analysis of complex market situation characterized by imperfect and incomplete information.

Information asymmetry implies that one party in the transaction has all the relevant information, while the other does not. It applies to situations where checking the fulfillment of contract could not be performed in the contractual relationship. In order to overcome the problems resulting from information asymmetry, it is first necessary to define the causes of their emergence. As leading causes, problems of "moral hazard" and "adverse selection" are highlighted.

The problem of adverse selection occurs when one party acts opportunistically before contract. Akerlof [1] proposed, by analyzing the functioning of used cars market, a model that provides demonstration of a classic problem of adverse selection. On the other hand, moral hazard occurs when, after signing the contract, parties involved act opportunistically. For example, after signing an insurance contract, there is a tendency for company frauds. Therefore, in such cases it is not desirable to run a uniform insurance policy [9].

The literature identifies two possible ways to overcome problems of asymmetric information. The first is based on the assumption that it is necessary to establish such relationships that provide relevant incentives for the side which is in a possession of a "private" information, to inform the other side openly. This concept

is known as market signaling [10]. Another solution is based on the fact that the party which is less informed must take the initiative and try to obtain the lacking information, the so-called market screening [11].

One of the theories that follows the development of corporate management, and assumes the existence of asymmetric information is the agency theory. This theory, as well as conflicts between managers and owners, refers to the potential difficulties that arise when two sides engaged in a contract have different goals, and different levels of information [2, 5]. In this paper we focus on the problem of "principal-agent" as a special case of agency theory and problems of information asymmetry.

2. Agency theory and the problem of conflict of interests

The Agency theory views the company as a set of agreements between different parties. In modern corporations, owners or shareholders, that is principals, are hiring managers i.e. agents, and assigning them the task of managing the daily operations of the company. Managers, paid by salary, represent the interests of the principal in order to maximize the value of the company. On the other hand, the board elected by the owners regularly meets with managers to oversee their activities and try to ensure they truly act in the best interest of the principal.
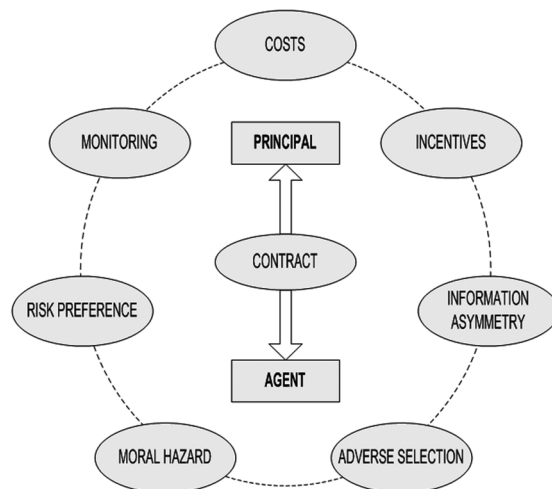

Figure 1: Basic elements of agency theory

It is clear that the market relations between principals and agents are very complex. The existence of information asymmetry is the source of the so-called agency conflicts, and many other features, including moral hazard and adverse selection. The basic elements of the agency theory are shown in Figure 1.

2.1. Agency conflicts

Relations, and thus conflicts being considered by the agency theory, are between: (1) owners and managers and (2) owners and creditors.

Conflicts between managers and owners

Managers in some cases may have personal goals that do not coincide with the goals of owners, ie. maximizing the value of the company. The Agency theory argues that managers always seek to maximize their own benefit at the expense of the owner.

If the owner is at the same time the manager, then he takes actions that clearly lead to maximization of his wealth. The owner-manager attributes the value of the company to its own wealth, in exchange for the opportunity things in life, such as leisure time and part-time job. If the owner-manager decides to sell some of

its property to investors, an agency problem arises. Then, for example, a manager-owner could prefer free time and a secure life as opposed to hard work and further increasing the value of the company, because now the value does not belong entirely to him alone. In addition, the owner-manager could incur higher costs, because these are now paid by a number of parties.

Managers should be encouraged to work in the interest of the owner, by various awards, prohibitions and penalties. These methods are effective only when the owners can monitor the work of managers. Moral hazard occurs when managers risk to act in self-interest, because they know that owners can not monitor them constantly. To reduce moral hazard, owners need to look at *agency cost*.

There are three basic types of agency costs:
• costs of monitoring managerial activities, and audits;
• costs of restructuring the organization, elimination of certain units or adding new ones to reduce the undesirable actions of managers;
• opportunity cost that arises when the owner is required to decide on some important matters, which limits managers in their effects, and therefore in maximization of the owner's value.

It is necessary to choose the optimum level of these costs in order to achieve the maximization of company value.

The conflicts between creditors and owners

Creditors, as creditors of the company, have a priority in payment of interest and priority of payment in case of deterioration of the company. Creditors lend their free resources (money or capital) in relation to the risk of the company's business and economics in general, hoping they assessed situation well, and they will profit.

Giving creditors authority over managers, owners are running the contrary policy. They generally accept those projects that carry a higher risk over projects that are accepted by creditors when they entered the business. If these projects can make a profit, it goes only to owners, because the creditors receive a fixed interest rate. In the case when these projects are unsuccessful, all the involved share the loss.

2.2. Moral hazard and adverse selection

The emergence of the term *moral hazard* is related to the business of English insurance companies in the seventeenth century, according to the research conducted by Dembe and Boden [3]. Initially, the term was used to describe the negative effects, or fraud and unethical behavior of the insured. In the modern sense, the definition was given by Adam Smith in his book, which was released in 1776, although not in the context of insurance companies, but in the sense that someone who does not own the company has the ability to manage such capital, not bearing the same market *risk*. Specifically, in situations where the consequences of any decision cause negligence and decision maker is not responsible for them, there is moral hazard.

Moral hazard is a possibility that one party, if it does not comply with the terms of the contract, earns more than the amount contained in the contract. This problem occurs in almost all areas of business, or wherever there is information asymmetry. Specifically, the principal often does not know whether all parts of the contract with the agent are met, or whether the agent is properly motivated, and offered a compensation that satisfies him. Then the agent could take the moral hazard, in order to ensure himself a satisfactory value for the invested efforts. The Game theory provides space for the development of different strategies in order to connect the interests of the principal and the agent. Some of the strategies are *compensation and incentive mechanisms*, as well as *control and monitoring* [4].

The problem of moral hazard can be more closely explained in the example of insurance. The problem of insurance indicates that the probability of the insured event is less if there is no insurance. A most often described example is life insurance of spouse. If the husband insures his life with the clause that in case of his death the insurance money goes to his wife, then, if the insured amount is high enough, the wife might be tempted to "facilitate" the insured event i.e., the death of her husband. In this case the insurance company bears all the risk by itself. It is therefore important that such agreements are made so that the insured person bears one part of the risk. However, problems sometimes arise in the practical application of this principle.

On the other hand, the market often witnesses products and services of good and of poor quality. Due to the mechanism of *adverse selection*, products or services of poor quality remain, while products of good quality are not offered. Adverse selection can also be illustrated using the example of business insurance companies [9].

The insurance company, on the basis of available statistical data, can determine the expected probability of negative events which is the subject of insurance. Let it be auto insurance, and let us assume there are two categories of drivers identified based on the statistical data, careful drivers and risky drivers. What will happen if the insurance company offers insurance premium based on the average likelihood of a crash? Averages are determined based on the total sample of drivers, both careful and risky ones. Risky drivers will accept the offer because it is a rational decision for them. On the other hand, careful drivers will refuse this offer, considering it to be too expensive, knowing what type of drivers they belong to. As a result, risky drivers will dominate in the demand for insurance. The problem is that the insurance premium, which is determined based on the average, thus represents a false index. It will cause adverse selection of insurance buyers, and thus cause difficulties in the business of the insurance company.

Yet, there are mechanisms which resolve or at least alleviate the problems of adverse selection and moral hazard.

3. Strategies for overcoming the problem of asymmetric information

Two basic strategies for overcoming problems of asymmetric information as well as their consequences, as noted before, are market signaling and screening. Market signaling refers to a situation where the party who is better informed, takes an active role. Signaling in fact represents a two players game, one of which has a "private" information. The game is played in two moves, and is known as "leaders followers" game in the game theory [12]. In the first move, the better informed player (the leader) sends a message to the other, less-informed player (follower). In fact, the action of the leader is a "signal" to the other player, that is, by chosen action, the leader sends some sort of information to the other side. In the second move the less informed player, according to the message received, adjusts its behavior, and selects an appropriate action or actions.

There are numerous examples of signaling on the market: providing the guarantee, the share issue, taking loans, education level, the average rate of the studies, and the like. Signals can be good or bad, but also more or less credible. Signaling to player could be regarded as credible if there is no interest for deceiving. However, it often happens that even the most honest signals are not credible enough, thus, in order to solve the problem, a specific analysis of each problem is required.

Another solution to the situation of asymmetric information is based on the active role of the side that is less informed. When one party does not have enough information to take an active role, it is a so-called market screening. Market screening implies that the less-informed party motivates the better informed one to decide, declare, disclose, or take the risk. In this way it is possible to solve the problem of adverse selection. For example, in the case of insurance companies, the solution is implemented with such a model of insurance where a whole range of different contracts is offered, and buyers of insurance, i.e. drivers, could, according to their preferences and the real situation, choose a contract that suits them best. In this way, they show (reveal), through specific agreements, their secret information or one that is unknown to the insurance company. However, in practice, the process of establishing equilibrium is usually much more complex [11].

4. The „principal-agent" problem

The "principal-agent" problem, also known as agency dilemma, occurs while separating property from the management process. The agent works on behalf of the principal and receives remuneration for his/her work, while the principal gives the powers and controls him, but not completely. Problems related to risk are related to the risk of principals, because the control is never perfect and there is a lack or delay of information, and the agent can work in his/her own interest and not in the interests of principals (Figure 2). The agent risk is the possibility of losing a job, and making long term decisions that do not have immediate positive effect.
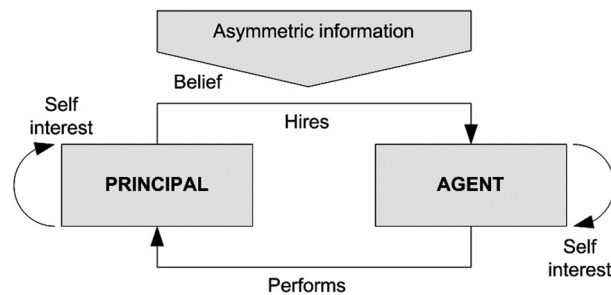
Figure 2: The "principal-agent" problem

An agent usually has better information than the principal, about his efforts and results, and the possibilities for expanding interests of the principal. On the other hand, the principal does not know what is the actual cost of the agent's work, nor his utility function. The main difference between the principal and the agent is in that the principal is a "superior party" (someone who owns or controls), while the agent is the company's staff. The principal bears the risk faced by the owner (a loss of invested capital), while the agent is insulated from risk by contractual obligations of principals.

Two fundamental problems that arise in agency relations indicate the possibility of divergence of goals and desires of principals and agents, so the principal is not sure whether the agent is acting in his best interest. In addition, the principal and the agent have different attitudes to risk, and therefore may prefer different actions. Thus, the principal cannot be sure that the action taken to reduce risk is correct, in order to protect his own interest.

If the „principal-agent" problem is viewed through contract law, then two cases can be distinguished:
• Model of agent's preferences to cost – The principal owns the company, and the agent is the manager. The owner has limited information and cannot fully consider all the actions of managers. Therefore, the owner requires the achievement of a satisfactory level of profit that is determined, for example, in comparison with the profit of rival companies. The manager, relative to such determined constraint, maximizes his/her preferences towards spending on him/herself, or on the agents of the company. The problem can be seen as ex-post opportunistic behavior of managers, when he/she believes that the relation is bad for him, and that some other behavior, different from the contracted, will fulfill his/her objectives.
• The model with moral hazard – It is the result of the *ex-post* opportunism of managers, only in this case the owner is not satisfied with the predetermined level of profit, but seeks to create appropriate incentives so the agent's behavior would come closer to the long-term profit maximization. The system of incentives is established by contract, which is formulated by the owner, and the manager can accept or decline it.

4.1. Mathematical formulation of „principal-agent" problem

The objective of the problem is that the principal determines a smallest but sufficient reward that will encourage an agent to work effectively. This problem may seem complicated from such a perspective, because the principal does not know the agent's utility function. If he had that information, he could offer him a salary corresponding to his degree of efficiency and the problem would be solved. Thus, an efficient market equilibrium would be achieved.

If we assume that the principal motivates the agent with a certain amount of fee to do some job, in the end, all that the principal knows is what actions the agent has taken, but not what the result in the case of different reward would be. It is possible to consider several approaches to solving the problem. Some of them are [2]: Bandit algorithm; Ascending gradient algorithm for the case when the distribution of awards is fixed, but unknown, Bayesian approach, if the distribution of awards is fixed, and the principal has some predictions about the distributions.

Let us assume that an agent may choose one of the actions from the available set of actions $\{A\}$, where the set are made of actions a_0, a_1 i a_2 ($A=\{a_0, a_1, a_2\}$). Action a_0 indicates that the agent is not performing the given job; action a_1 that the agent does his hob, but not efficiently, while action a_2 means that the agent works efficiently.

Suppose also that each of the actions is carrying some cost of labor, $w_i = w(a_i)$, $i = 0,1,2$, where $w_0 = 0$. This cost can be described as a sacrifice that the agent bears to perform a certain job. Let $r_i = r(a_i)$, $i = 0,1,2$, which is a function of wages (reward) to an agent for the job done, and which the principal defines depending on whether and how the agent really works. Therefore, $r_0 = r(a_0) = 0$.

The utility of the agent depends on the salary and rewards he receives for work done, and how much he resents the action that is required of him. This aversion to executing is given by function t, and is known to the agent, but not to the principal.

Assuming that the agent is a rational person, and will always choose the action that maximizes his own utility, the utility of the agent can be expressed as follows:

$$V(t,a_i,r_i) = v(t,a_i) + r(a_i) = -tw(a_i) + r(a_i), \qquad (1)$$

for $i = 0,1,2$, where $v(t, a_0) = 0$, for every t.

The usefulness for the principal depends on the salary, or reward he must pay to the agent, and on how much the action is important to him. Therefore, the utility function for the principal can be expressed as:

$$U(a_i, r_i) = u(a_i) - r(a_i), \text{ for } i = 0,1,2, \qquad (2)$$

where $u(a_i)$ represents the profit the principal is achieving, depending on the selected action of the agent, where $u(a_0) = 0$.

4.2. Ilustrative example

Let us start with the problem presented with a game in an extensive form (Figure 3). The game involves three players: "nature", company and worker. The company is to decide whether to hire worker (Z) or not to hire him (N). The worker may be "lazy" or "hard working", where the worker, of course, knows what type he belongsto. The problem, however, lies in the fact that the company does not know which type of workers it is hiring at the moment when the contract is signed, or how the worker with whom a contract is signed will perform his/her work.

Suppose that the game is opened by the "nature", which attributes certain probabilities to each type of workers. Since this is the game with imperfect information, the company, which is next to play, must decide whether to hire the worker or not, not knowing with certainty whether he/she is hard working or lazy, but taking into account the probability assigned in the "nature" turn. If the company hires him/her, the worker can choose whether to work in good faith (action a_2) or not (action a_1).
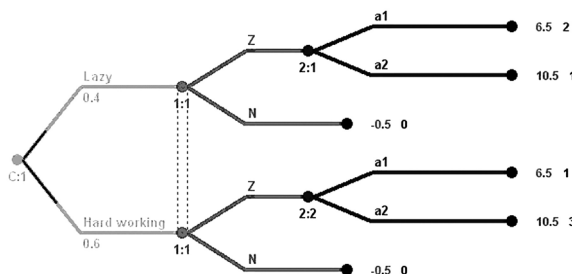

Figure 3: Decision tree for the example of „principal-agent" problem

Suppose that a worker has a total cost or sacrifice: $v(a_1|\text{"lazy"}) = 1$ if he/she is lazy and does not work in good faith; $v(a_1|\text{"hard working"}) = 2$ if he/she is hard working, but does not work in good faith; $v(a_2|\text{"lazy"}) = 3$ if he/she is lazy, but works in good faith; $v(a_1|\text{"hard working"}) = 1$ if he/she is hard working and works in good faith. Suppose further that the salary the company gives to the worker who performs the work in good faith is $r(a_2) = 4$, and to the worker who does not perform his/her work in good faith is $r(a_1) = 3$.

Let us introduce the assumption that the company, if it employs the worker who performs his/her job in good faith, regardless of his/her personality type, makes a profit $u(a_2) = 15$. But if it employs the worker who is negligent in his work, the assumption is the company will profit in the amount of $u(a_1) = 10$.

Regardless of whether the company has entered into agreement with an agent or not, it will have additional costs related to the procedure of selection $t(a_0) = t(a_1) = t(a_2) = 0,5$.

In problem given, the company aims to determine the optimal action that maximizes the total *expected utility*, for a conviction on the type of worker. On the other hand, the worker seeks to decide whether to work in good faith or not, in order to maximize his/her own *expected utility*, in accordance with the type of person. We should determine the optimal action of the company, as well as the expected benefits for the company and agents, provided that the estimated probability of the worker being lazy is 0.4.

Table 1 provides the utility of the company (*U*) and the worker (*V*), for all possible outcomes of the game described in Figure 3, and calculated from equations (1) and (2).

Table 1. Utilities of the company and worker

Strategy	U	V
„lazy", Z, a_1	10 – 3 – 0,5 = 6,5	3 – 1 =2
„lazy", Z, a_2	15 – 4 – 0,5 = 10,5	4 – 3 =1
„lazy", N	0 – 0 – 0,5 = –0,5	0
„hard working", Z, a_1	10 – 3 – 0,5 = 6,5	3 – 2 =1
„hard working", Z, a_2	15 – 4 – 0,5 = 10,5	4 – 1 =3
„hard working", N	0 – 0 – 0,5 = –0,5	0

The game described above is well known as the Bayes game in extensive form, and the solution can be determined by applying the concept of perfect Bayesian subgame equilibrium. Given that this is a game with imperfect information, it cannot be solved using backward induction. The solution to the game, for which benefits are given in Table 1, was obtained using the Gambit software and is shown in Figure 4.

For a given probability distribution, the expected benefit to the company at equilibrium is 8.9; while for worker it is 2.6. For a company, the best strategy is to employ the worker, regardless of whether he/she is hard working or not. On the other hand, if the worker is hard working, the best strategy for him is to work in good faith, which would bring him the utility of 3. In the case the worker is lazy, choosing his best strategy, not to work in good faith, would bring him the utility of 2.
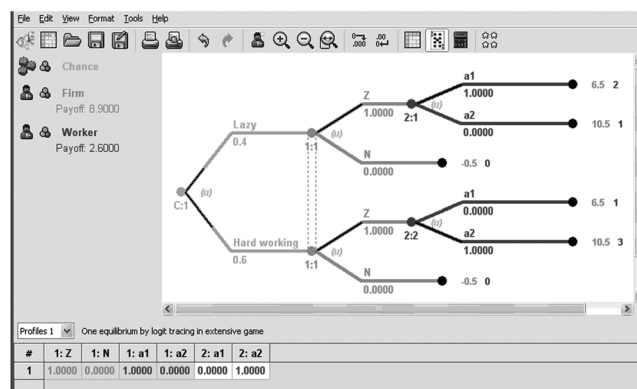

Figure 4: Solution in the example of „principal-agent" game

The question is whether the solution is changed in case of different probability distribution related to subjective beliefs about the type of the company agent. The answer could be obtained by conducting a „what-if" analysis, if the analysis is repeated for different probability distribution related to personality types.

As mentioned in previous chapters, the problem of asymmetric information can be partly solved. Given that the company is the less informed partly in the contract, it should apply a strategy of screening. In the present case, this strategy may be related to a system of incentives through compensation for the work performed. If the principal offers low pay (below average) for the job, only bad candidates will apply. However, the principal can overcome this „problem" if he lets the agent choose whether to work for a fixed pay, or by performance.

On the other hand, the agent, who is the better informed party in such a situation, should use a signalling strategy. As a measure of how valuable the agent is to the company, signals could be the level of education, the choice of a more difficult to master department at Faculty, training, scholarships and more. It should be noted also that the lack of good signals can be a bad signal in itself.

Conslusion

The paper shows the importance of information economics to the operation and the result of market processes which are characterized by asymmetric information. To model these market conditions, we used the methodology of the game theory. Possible strategies for overcoming the problem of existence of imperfect and asymmetric information are presented, especially the strategy of signalling and screening.

One of the most distinctive problems, the problem of "principal-agent", found its place in the interpretation of economic and financial phenomena. In this paper, the problem is modelled as a Bayesian extensive game, where the solution is obtained by applying the concept of the Bayes-Nash equilibrium. Possible ways to overcome the problem are suggested.

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