

Model Of Information Disclosure In A Multilevel Social-Economic System With Information Asymmetry By The Example Of A Regional Market Of Property Rights

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Abstract

The behavior of economic agents in an innovative process may be reduced to the problem of decision making under uncertainty in Knight's sense. The primary problem is that of cognitive limitations, characteristic for actual economic agents. It allows opportunism, i.e. inclination of individuals to deceive or to distort information for their own advantage, doing that in an indirect way. Bounded cognitive abilities and opportunism, taken together, result in the problem of knowledge asymmetry – namely, even if the information about essential aspects of a deal is available to all its participants, one of the parties lacks competences necessary to process that information.

Knowledge asymmetry in the system of innovative investment results in distortions of resources allocation efficiency and market failures related to the effects of disadvantageous selection and post-contract opportunism. An important factor determining the parameters (and the very existence) of market equilibrium in such a system is the character of distortions in the economic agents' preferences. These can be divided into two classes – individual deviation from risk-neutrality and deviations of the subjective probability assessment of distribution when forecasting future events from the true distribution. This division is important for studying the systems with uncertainty. The first class of distortions is observed both in systems with risk and in systems with uncertainty; it is usually considered to be an immanent characteristic of an agent, does not change with time and is described with the Arrow-Pratt measure in models. Its influence on equilibrium is well studied. The second class is observed only in systems with uncertainty and changes with time for each agent. Its influence on equilibrium under various mechanisms of market organization is rather poorly studied.

The paper presents the model of property rights market with an infrastructural institution disclosing non-personalized information under the situation when a regional economic system is a combination of market elements, administrative and shadow economy. In such a system agents make decisions under uncertainty, as for each object of property there is hidden, non-transferrable information essential for assessment. Under such conditions, the influence of subjective assessment deviations on the market equilibrium can be described as Bayesian probability model of adverse selection.

In the elaborated model, the equilibrium parameters are theoretically analyzed. Expressions for assessing ask and bid prices are obtained. It is shown that information asymmetry in the property rights

market, with the account of the specific features of economic systems of the Russian regions, leads to irrational allocation of investment resources.

It is shown that the infrastructural institutions disclosing non-personalized information are not only unable to efficiently counteract adverse selection, but facilitate it.

Keywords: *adverse selection, information disclosure, institutions, unobservable behavior, information asymmetry, Bayesian probability.*

Introduction

It has been over a quarter of a century since administrative economy was eliminated in the former Socialist countries, but institutional transformation of economic system of CIS countries is not finished yet. Apparently, institutions transplantation has its peculiarities, and the institutes effective within a certain environment may not always be successfully transferred and used for regulation of a different socio-economic environment (Polterovich, 2001). The problem of inconsistency between the institutional environment and the market practice is especially acute at regional level. Unlike at the federal level, regional authorities (especially in subsidized regions) do not possess such efficient levers as rates, budget investment, customs tariffs and quotas. Fiscal and taxation capabilities of regional authorities are also limited. On the other hand, unlike at the local level, it is hard for them to efficiently use the norms of customary law and informal regulation and to trace all significant investment opportunities. At the same time, researches show that regional officials may use the existing institutions to achieve their personal goals, which leads (as an externality) to dysfunctionality of these institutions (Ades & Di Tella, 1999; Becker et. al., 2009; Del Monte & Papagni, 2007; Gillanders & Parviainen, 2018; Neudorfer & Neudorfer, 2015; Pushkarev, 2007).

Economic systems of the regions of modern Russia are an interesting object for analysis – based on the market of administrative authorities, a peculiar institutional system has been formed, which is characterized by the amalgamation of a market, administrative, and shadow economies (Gimpelson & Kapeliushnikov, 2014; Kleiner, 1996; Makhmudov et al., 2018; Walewski, 2010). Naturally, it leads to difficulties in analyzing and forecasting the economic development, in particular – the investment process and the property rights market. It is especially apparent in depression regions, to which belong almost all Northern Caucasus republics and many Central Russian regions without a well expressed sector of specialization.

When speaking of depressiveness of a region in the aspect of reproduction, usually the financial aspect of the problem is distinguished and the following characteristic features are listed (Aimagambetov et al., 2017; Breinlich et al., 2014; Spiezia and Weiler, 2007):

- Average annual investments are less than average annual capital consumption;
- Average annual net profit of enterprises after deduction of reimbursement to the owners and managers and liquidity reserve for current activity financing is less than average annual investments necessary for simple reproduction;
- A large share of long-term unprofitable enterprises (over 30% of enterprises are unprofitable during 3 or more years).

Undoubtedly, the financial aspect is important for the assessment of a regional investment crisis; in particular, it allows objective comparison of different regional economies. At the same time, the institutional aspect of organization of the property rights market is no less important both for analysis and for elaborating efficient methods of investment process management in a region (Becker et. al., 2009; Gillanders & Parviainen, 2018).

Under institutional transformation characteristic for the economic systems of the Russian regions, new economic institutions are still rather weak, and the sphere of possible decisions of economic subjects cannot be rigidly regulated by the “rules of the game”. On the contrary, institutional frameworks expand under the influence of decisions of some market participants (Makhmudov et al., 2018). Deals formally signed between legal persons are actually signed between particular physical persons, while the mechanisms of transaction costs reduction (searching for a partner, insuring the deals, legal and documentary support, normative procedure) are based on personal responsibility, business reputation and customary law norms (Kleiner, 1996; Pushkarev, 2007). This leads, in different cases, both to saving transactional costs (for example, lack of formal insurance of the deals) and to losses (impossibility to sign relational contracts between unfamiliar partners).

The result is the high level of information asymmetry in the property rights market. In particular, one should note the non-transparency of financial reporting of enterprises and the diffuse legal field. The latter consists, among other things, in expanding the practice of tax evasion with both “grey” and openly illegal means, economic inefficiency of complete formal observance of legal norms and the determinative role of customary law in insuring transactions (Gimpelson & Kapeliushnikov, 2014; Radaev, 2003).

Under these conditions, traditional institutions of reproduction support are inefficient. Under information asymmetry, the adverse selection effect arises, when the “low quality” property rights (whose economic or administrative protection is not provided in certain cases) oust the “high quality” property rights (Akerlof, 1970; Duffie, 2012).

Although the existence and significance of the adverse selection effect are sometimes disputed in regard to certain markets (Handel et al., 2015; Hegde Shantaram & McDermott, 2004; Lewis, 2011), one may assert that the adverse selection effect is an objective feature of informationally asymmetrical markets, which reduces the market mechanism efficiency (Edmans et al., 2015; Hackmann et al., 2015 Kurlat, 2013; Morris & Shin, 2012).

In practice, one of the possible and rather obvious solutions to the problem of adverse selection in the property rights market in regional economy is creating special centralized institutions in the form of regional informational-investment centers in order to disclose the observed information and, as a result, increase the efficiency of a regional property rights market. Below we consider the methodological basis of regulating such market and analyze the efficiency of such mechanism of counteracting adverse selection under uncertainty.

Materials and methods

Numerous empirical data show that legal institutions influence the formation of business environment and, thereby, long-term economic growth. However, the specific mechanisms of such influence much less researched. Obviously, there are exceptions, like, for example, the correlation between organization of patent system and stimuli for innovative activity (Seitz & Watzinger, 2017). However, a number of other aspects, especially related to ensuring the contracts fulfillment, which is very important for the property rights market, are insufficiently studied.

Traditionally, the role of contract fulfillment ensuring in a market with information asymmetry is considered with the help of game theory models, like “hold-up problem” (Hart and Moore, 1988; Tirole, 1999). In such a model, a company plans to finance research in order to develop a new product, and needs specific resources, while the supplier of such resources is able to revise the contract terms (because of the condition of the contract incompleteness). As the supplied resource is a key one, the supplier may revise the terms and appropriate a significant part of profit from the final product after beginning of investment,

which, in particular, decreases the stimuli for investment into innovations. Taking into account that formulating the contract terms and the measures for contract fulfillment ensuring is a nontrivial task for a product not yet developed, one may assume that in the countries with a better developed legal system it is solved more efficiently and the volume of innovative investment is larger.

Statistical data given in Seitz & Watzinger (2017) are concordant with this hypothesis. There is strong correlation between a series of indicators of contract fulfillment ensuring efficiency and a share of expenditures on R&D in GDP. This is, of course, insufficient to speak of causal relations — in countries with a better system of education there may be more competent jurists and researchers, which would lead to better indicators of contract fulfillment ensuring efficiency and a larger share of expenditures on R&D. There may be other characteristics of countries determining both of the studied indicators. To exclude the influence of those factors, intra-country researches are necessary. Seitz & Watzinger (2017) use the fact that standardized resources are characteristic for a number of sectors, hence independence of a particular supplier; while for another group of sectors, on the contrary, a change of the supplier entails significant additional costs. The latter strongly depend on the efficiency of the system of contract fulfillment ensuring. If contract are poorly ensured, the suppliers have strong stimuli for opportunistic behavior, and investments into R&D are often not made.

For OECD countries it is econometrically proved that the stronger dependence of a sector on contract fulfillment ensuring efficiency, the larger influence of the legal system quality on intensity of R&D in a sector. For example, if the legal system quality in Italy was the same as in Germany, then expenditures for R&D would grow by 23% (\$243 mln in 2005 prices) in automobile industry (specialized resources, strong dependence on contract fulfillment ensuring efficiency) and by 5% (\$5 mln) in food industry (standardized resources, weak dependence on contract fulfillment ensuring efficiency). Thus, there is a problem of under-investment. It is essentially similar to the problem of low liquidity of commercial property in a regional economy with uncertainty and information asymmetry – uncertainty about complete protection of property rights on an object leads to distortions in preferences of potential buyers, which not only reduces the number of potential buyers but also complicates allocating the property objects by types.

In the literature on contract theory, vertical integration is often viewed as a possible solution of the problem of under-investment. However, researches show that this solution is not very efficient in practice — otherwise there would have been no dependence obtained by Seitz & Watzinger (2017). Administrative barriers and differences in stimuli at various levels lead to the situation when for some sectors efficiency losses due to vertical integration exceed advantages. This hypothesis is confirmed by the results by Bresnahan & Levin (2012), Nunn (2007), and Seitz & Watzinger (2017), who showed that the influence of the legal system is larger for sectors with a large amount of resources used.

A number of works (Djankov et al., 2003; Glaeser et al., 2001) showed that countries with legislation based on customary law better ensure fulfillment of complex contracts than countries with legislation based on civilian law.

Achrya and Subramanian (2009) showed that a legal system supporting creditors in case of bankruptcy creates more failure-tolerant conditions, which stimulates innovations. Achrya, Baghai, and Subramanian (2013) showed that the efficiency of employees' protection against unlawful dismissal stimulates innovative activity of employees, limiting the opportunities for employers' pressure on the employees after innovation implementation.

There is vast literature on researching the problem of under-investment in various sectors, for example, cargo transportation (Baker & Hubbard, 2004), defense (Crocker & Reynolds, 1993), footwear

manufacturing (McMillan & Woodruff, 2002), residential construction (Field, 2005; Gebhardt et al., 2013), etc. However, these works investigate mainly well-established markets with certain goods and observed information; while in our case uncertainty significantly complicates defining the contract terms.

As for the markets with imperfect information, a significant part of modern researches of economic agents' behavior in such markets can be divided into two main classes of tasks – the tasks with unobservable characteristics and unobservable actions. Distortions of efficient resources distribution under information asymmetry is proved in literature (Akerlof, 1970; Hackmann et al, 2015; Morris & Shin, 2012; Netzer & Scheuer, 2012; Spence, 1973). The examples are usually credit and insurance markets (Fama, 1980; Finkelstein & McGarry, 2006), secondary markets of goods with unobservable characteristics (Garcia-Flores et al., 2000; Greenwald et al., 1984), and labor market (Cho & Kreps, 1987; Denzau & Munger, 1986; Docquier & Marfouk, 2004). The main object of analysis is the possible market response to asymmetrical information, as well as prerequisites for state intervention into economy with a view to correct the information failures of the market (Fuchs & Skrzypacz, 2015).

If characteristics are unobservable, the possibility of partial or overall collapse of the market is usually researched (adverse selection models). A lot works, including Russian ones, study the labor market equilibrium under unobservable types of employees, including the possibility of several equilibriums and the problem of coordination. These researches resulted in creating the information theory of discrimination in the labor market (Cho & Kreps, 1987; Denzau & Munger, 1986; Hart & Moore, 1988). Also, a lot of works are devoted to discussing the problem of unobservable characteristics in credit and insurance markets, and the possibility of non-equilibrium and rationing as a market response to information asymmetry (Fama, 1980; Finkelstein & McGarry, 2006; Garcia-Flores et al., 2000; Greenwald et al., 1984; Guiso & Parigi, 1999).

Another large group of works is devoted to the study of market agents' actions under information asymmetry aimed at overcoming its undesirable effects. The notion of signaling is broadly used to describe one of the classes of filtration mechanisms in the market with unobservable characteristics (Spence, 1973). Situations of signaling in economy include labor markets, commodities markets, and signaling in economic policy. Principles of reliable signaling are elaborated, classification of equilibriums in signaling tasks is provided. A number of works present normative analysis of signaling. Concept and methods of screening under asymmetric information are developed, including monopoly and competitive screening.

Another modern direction of research focuses on the problem of unobservable actions and market failures due to them. In this case the task is usually interpreted in terms of incomplete contracts, when the task “principal-agent” is formulated and the optimal contract is constructed under unobservable actions of the agent. The literature devoted to analysis of “principal-agent” situations is very vast, beginning from the pioneer work by S. Ross (1973). A classical review of the state of affairs as of the beginning of the 21st century is given in (Laffont & Martimort, 2002). In the recent ten years, a lot of interesting results were obtained for particular markets and specific systems with information asymmetry (Arve & Martimort, 2016; Battigalli et al., 2015; Ehrlinger et al., 2016; Gurtuev et al., 2018).

Under the circumstances, of particular interest is market functioning under uncertainty, when objective assessment of the object of a deal both on the part of a buyer and a seller is impossible due to the uncertainty of the future. So far, the main works in this sphere focused on researching the process of individual decision-making and modeling particular markets. One of the main areas of applying imitation models in economy is studying the process of individual decision-making under risk and uncertainty. Modern research of the problems associated with risk and uncertainty relies mainly on the approach from

the viewpoint of expected utility theory (Jurado et al., 2015; Saito, 2015; Shmaya & Yariv, 2016). This approach is based on several postulates, which separately and jointly provide, as it seems, a sufficient basis for making a rational decision. Universality and normative attraction of this method have facilitated its establishment as a “commonly accepted theory”. The expected utility theory is in many aspects an ideal object of experimental research. This theory provides several clear predictions about individual decision-making. These predictions may be easily checked. If the facts and the theory apparently contradict each other, one may check if these contradictions are a result of accidental errors or they should be viewed as a manifestation of some definite and steady behavior patterns differing from the predicted ones. In the latter case, theoreticians should modify the expected utility theory or create new models correlating with the obtained results. If these new models are able to yield clear and potentially refutable predictions, they should also undergo testing. Recent research followed this scheme. They stimulated elaboration of alternative models, which, in turn, undergo further testing.

Today, in modeling the innovative investment tasks (and more broadly – the tasks of trading taking into account the uncertainty of the future) it is assumed that there is a combination of limited and complete rationality due to limitedness of knowledge, but unlimited ability of an economic agent for processing information (Jurado et al., 2015; Shmaya & Yariv, 2016). Limitedness of knowledge generates the problem of its asymmetry, while unlimited ability for processing information makes it possible to develop an optimal contract. This is an unduly strong assumption, leading to the impossibility to distinguish between the situations with knowledge asymmetry and those with information asymmetry.

The opportunism, which an informationally weak participant attempts to counteract at the stage of searching a participant with information advantage, is denoted as pre-contract one. It is manifested in concealing the knowledge about their type by the participant with information advantage. The type of the participant with information advantage may consist, for example, in hidden knowledge about the object they sell, or their expectations about the object they buy. A consequence of pre-contract opportunism is adverse selection which leads to the market shrinkage.

The problem of pre-contract opportunism arises when solving the task of filtration the offers in the market in order to eliminate the deals knowingly disadvantageous for the buyer. The situation of pre-contract opportunism is most often described with the model of adverse selection (Akerlof, 1970; Handel et al., 2015; Kurlat, 2013; Lewis, 2011).

In the classical model of adverse selection, the conditions of one-time intersection of costs and utility must be fulfilled (concavity of the utility function and linearity of the cost function, or linearity of the utility function and convexity of the cost function). Thus, the condition of decrease of marginal utility of costs is fulfilled. Accordingly, in terms of attitude to risk, the only admissible variants are either risk aversion of the participant with informational advantage under risk-neutrality of the informationally weak participant (concave utility function and linear cost function), or risk-neutrality of the participant with informational advantage and risk seeking of the informationally weak participant (linear utility function and convex cost function). In case of asymmetrical knowledge, such a market will face mixing equilibrium, and the worst agents will have an advantage.

In this case, the task of an uninformed participant is to differentiate the agents, which is done by forming a menu of contracts from different variants by the number of agents' types. The menu is formed so that for each participant with informational advantage it is profitable to choose the contract intended for them. Thus, the uninformed participant has an opportunity to maximize their utility by offering a suboptimal menu of contracts to differentiate the agents. For such a menu, special type conditions must be fulfilled, which are called participation restrictions and self-selection restrictions. The former comprise

the conditions under which an agent would accept the contract, and the latter – the conditions ensuring that each participant with informational advantage would select the contract intended for their type.

Under the conditions of that type, the highest type (in the sense of the product/project quality) obtains the optimal volume of deals, corresponding to the equality of marginal costs and marginal utility. The more remote agent type is from the highest type, the larger the distance is between marginal costs and marginal utility. As a result, the highest type participant obtains the largest value of informational rent, and so forth — each worse type obtains less rent up to zero for the lowest type.

In the literature, there are models with an opposite assumption concerning the bargaining power of a participant with informational advantage. In them, it is not the participant with informational advantage but their uninformed counteragent has no bargaining power, hence the participant with informational advantage can, in case of symmetrical knowledge, redistribute all rent to their own advantage. Such distribution of bargaining power is observed, in particular, in case of Bertrand competition between uninformed participants. In this case it implies establishing of such reimbursement for a participant with informational advantage by an uninformed participant, at which he obtains zero utility (Gurtuev et al., 2016).

In this situation, unlike in the models with zero bargaining power of a participant with informational advantage, either a single separating equilibrium or no equilibrium is possible. At that, the existence of a separating equilibrium depends on the distribution of participants with informational advantage by types. The existence of such equilibrium requires exceeding a certain critical share of participants with informational advantage of the lowest type, so that in the game of uninformed participants (representing Bertrand competition) Bayesian equilibrium is achieved.

Another mechanism of improving the market equilibrium under information asymmetry is signaling. It has been shown that signaling as a means of solving the problem of pre-contract opportunism can be viewed only under assuming the positive bargaining power of a participant with informational advantage. Signaling occurs as a result of the participant with informational advantage bearing the costs characteristic for the “highest” type in order to reveal their type to the potential uninformed agents, which means that they are interested in overcoming the asymmetry of knowledge about the type of the participant with informational advantage. However, when participants with informational advantage have a zero bargaining power, as shown in filtration models, for the highest type participants the only possibility to obtain a non-zero rent is connected with the existence of asymmetrical knowledge, as in that case they may select “somebody else’s” contract and shift to the more advantageous indifference curve.

Thus, the participants with informational advantage may obtain advantage from their higher type only under the condition that they retain a part of their rent, i. e. under the existence of positive bargaining power. In that case, the participant with informational advantage of the highest type may use a signal to announce their type. The key moment here is the difference in costs for participants with informational advantage of various types – the negative dependence between the signal generation costs and the type of the participant with informational advantage means that the higher is the type of the participant with informational advantage, the easier it is for them to send a signal. Besides, the condition is introduced of decreasing marginal costs of signaling by type, i. e. an additional unit of signaling is cheaper for the higher type than for the lower one.

Although there are a lot of mixing and separating equilibriums in signaling, it has been shown that as a result of a mechanism named Cho-Kreps criterion (Cho & Kreps, 1987) a unique stable equilibriums can be achieved; the mechanism consists in selecting the least value of the signal level at which separating equilibrium for the given configuration of agents is possible.

At the stage of market research knowledge asymmetry acquires the form of hidden information, when the uninformed participant does not know the type of a participant with informational advantage, and at the stage of contract signing — the form of hidden actions, which occur when the uninformed participant does not know the preliminary costs of the participant with informational advantage, with whom the contract is signed. At the same time, it stems from the above definitions that these forms of knowledge asymmetry are also the forms of pre- and post-contract opportunism.

It should be noted that there is a great difference as to at which stage the problem is solved. If it is solved at the stage before signing the contract (Greenwald et al., 1984; Gurtuev, 2018), then it is an *ex ante* contract procedure. If it is solved at the stage of contract implementation, it is an *ex post* problem.

The existence of hidden knowledge is the most significant criterion for distinguishing between an uninformed agent and an agent with informational advantage, as it is knowledge asymmetry that is the source of problems occurring in their relations. In compliance with this criterion, the participant without knowledge is the party without with informational advantage, while the participant with advantage in knowledge is the party with informational advantage. This distinction bears a different meaning depending on the type of the models under consideration. In the adverse selection models, awareness refers to the type of the participant with informational advantage, in the sense that an uninformed participant does not know the type of a participant with informational advantage, while the participant with informational advantage knows both their own type and the type of their counteragent.

Model and Results

Thus, let us consider a regional market of property rights with information asymmetry.

Let the value of investment object v (expressed via NPV) be H or L , while $H > L$.

Let H be a high-quality goods, and L – a low-quality one (for example, high crediting risks, inefficient management, lack of links – for the object of investment; risk of unfriendly actions of a creditor, financial instability – for the investor), similar to the “market for lemons” (Akerlof, 1970; Laffont & Martimort, 2002).

A potential participant of the property rights market is either informed (knowing the value of v) or uninformed.

The uninformed participant believes that $v=H$ with probability $p < 1$, and $v=L$ with probability $1-p$.

Let the Regional Investment Informational Center (further – RIIC) accumulate information about applications for selling and buying property rights (applications for credits and capital allocation, selling and buying enterprises and their shares) and does not influence the prices for applications (is financed from the state budget and acts so as its own profit is zero).

Here, RIIC can be considered as a market рыночного посредника с нулевой прибылью.

RIIC does not know the value of v and has the same expectations as an uninformed participant.

Let us assume that all actual applications can be represented as a product of a minimal standard application (MSA) and some coefficient. This is done for convenience.

Let B be the price of demand

Let A be the price of supply

Let $E(v|I)$ be the expected value of v according to information I .

$$E(v|I) = Hp(v = H|I) + Lp(v = L|I) \quad (1)$$

where

$p(v = H|I)$ is probability that $v = H$ according to information I

$p(v = L|I)$ is probability that $v = L$ according to information I

If a participant wants to sell a share of an enterprise, constituting Q minimal standard applications, then RIIC “buys” them at a price B. RIIC’s income is:

$$Y_c = QE(v|I_{RIIC}) - QB$$

where $E(v|I_{RIIC})$ is the expected value of v according to information RIIC.

In this case, the condition of RIIC’s zero profit can be written as:

$$[B = E(v|I_{sell})] \wedge [A = E(v|I_{buy})]$$

RIIC possesses information about deals but does not know if particular participants are informed or uninformed.

It can be assumed that RIIC believes that a participant is informed with probability $q < 1$ and uninformed with probability $1 - q$.

Then it can be assumed that q is the share of informed participants among all participant of the property rights market.

According to Bayes law, from (1) we obtain:

$$p(v = H|I) = \frac{p(v = H)p(I|v = H)}{p(v = H)p(I|v = H) + p(v = L)p(I|v = L)}$$

$$p(v = L|I) = \frac{p(v = L)p(I|v = L)}{p(v = H)p(I|v = H) + p(v = L)p(I|v = L)}$$

We determine the price of supply A when an application for buying appears

$$A = E(v|I_{buy})$$

$$A = Hp(v = H|buy) + Lp(v = L|buy)$$

According to Bayes law:

$$p(v = H|buy) = \frac{p(v=H)p(buy|v=H)}{p(v=H)p(buy|v = H)+p(v=L)p(buy|v=L)} \quad (2)$$

$$p(v = L|buy) = \frac{p(v=L)p(buy|v=L)}{p(v=H)p(buy|v = H)+p(v=L)p(buy|v=L)} \quad (3)$$

Now we define what is the probability of appearing an application for buying $p(buy|v = H)$. We denote an informed participant as i^K , and uninformed as i^N . Then

$$p(buy|v = H) = p(i^K)p(i^K buys|v = H) + p(i^N)p(i^N buys|v = H)$$

We denote as α the probability that the uninformed participant applies for buying, regardless of the value of v (as the uninformed participant does not know it).

Now we may write:

$$p(\text{buy}|v = H) = 1q + \alpha(1 - q) = q + \alpha(1 - q) \quad (4)$$

Similarly for $p(\text{buy}|v = L)$:

$$p(\text{buy}|v = L) = p(i^K)p(i^K \text{ buys}|v = L) + p(i^N)p(i^N \text{ buys}|v = L)$$

Hence we may write:

$$p(\text{buy}|v = L) = 0q + \alpha(1 - q) = \alpha(1 - q) \quad (5)$$

We simplify the expressions, denoting $p(v = H)$ through p , and $p(v = L)$ through $1-p$, as there are only two types in the model. Putting the value obtained in (4) into (2), we get:

$$p(v = H|\text{buy}) = \frac{p(q + \alpha(1 - q))}{p(q + \alpha(1 - q)) + \alpha(1 - p)(1 - q)}$$

hence

$$p(v = H|\text{buy}) = \frac{\alpha p + (1 - \alpha)pq}{\alpha(1 - q) + pq}$$

Similarly, putting (5) into (3), we get:

$$p(v = L|\text{buy}) = \frac{(1 - p)\alpha(1 - q)}{p(q + \alpha(1 - q)) + \alpha(1 - p)(1 - q)}$$

hence

$$p(v = L|\text{buy}) = \frac{\alpha(1 - p)(1 - q)}{\alpha(1 - q) + pq}$$

Consequently,

$$A = E(v|\text{buy}) = H \left(\frac{\alpha p + (1 - \alpha)pq}{\alpha(1 - q) + pq} \right) + L \left(\frac{\alpha(1 - p)(1 - q)}{\alpha(1 - q) + pq} \right)$$

As $q > pq$ (because $p, q < 1$), it follows:

$$\frac{\alpha p + (1 - \alpha)pq}{\alpha(1 - q) + pq} = p \left(\frac{(q + (1 - q)\alpha)}{pq + (1 - q)\alpha} \right) > p,$$

as $\frac{(q+(1-q)\alpha)}{pq+(1-q)\alpha} > 1$

Hence the optimal price for buying is

$$A = E(v|buy) > (pH + (1 - p)L)$$

Hence it follows that, as the expected value of v for the risk-neutral uninformed participants $E(v) = (pH + (1 - p)L)$ is less than the optimal price of buying, they will not buy at all ($\alpha=0$).

Thus, RIIC will have to set the buying price at

$$A = E(v|buy) = H$$

The same is true for selling:

$$E(v|sell) = Hp(v = H|sell) + Lp(v = L|sell)$$

According to Bayes law, we have:

$$p(v = H|sell) = \frac{p(v = H)p(sell|v = H)}{p(v = H)p(sell|v = H) + p(v = L)p(sell|v = L)}$$

$$p(v = L|sell) = \frac{p(v = L)p(sell|v = L)}{p(v = H)p(sell|v = H) + p(v = L)p(sell|v = L)}$$

We denote as γ the probability that the uninformed participant applies for selling, regardless of the value of v (not knowing it).

Hence we may write:

$$B = E(v|sell) = H \left(\frac{p\gamma(1 - q)}{\gamma(1 - q) + q(1 - p)} \right) + L \left(\frac{(1 - p)(q + \gamma(1 - q))}{\gamma(1 - q) + q(1 - p)} \right)$$

As

$$\frac{p\gamma(1 - q)}{\gamma(1 - q) + q(1 - p)} < p$$

then

$$B = E(v|sell) < (pH + (1 - p)L)$$

Here we see that the expected value of v for uninformed participants $E(v) = (pH + (1 - p)L) > B$, which makes selling irrational ($\gamma=0$).

Thus, RIIC will have to set the selling price at L .

Equilibrium in the market institutionalized in this way will be set under the following conditions:

The selling price = L (all property rights applied for selling are considered to be low quality).

The buying price = H (all property rights for which there are applications for buying are considered to be high quality).

There are no uninformed participants in the market (adverse selection).

Conclusion and Discussion

Uncertainty and information asymmetry in the property rights market, taking into account the specificity of economic systems of regions with shadow economy, lead to irrational allocation of investment resources.

Most of the decisions in such markets are based on assessment and uncertain reasoning. When assessing the future profit from the property rights object, a buyer has to take into account such uncertain parameters as informal restrictions in the market, transferability of informal relational contracts with key persons, and the probability of significant changes in the future. An essential feature of such markets is that the conditions under which participants make decisions are unique. This leads to the situation that the mechanisms used to regulate traditional competitive markets are often inapplicable here.

The proposed model demonstrates that centralization is a poor solution for the problem of adverse selection under uncertainty, when information asymmetry occurs not due to the expensive means of observing the significant information, but due to the absence of such means. In such markets, be it a property rights market in a region with shadow economy, or investing into innovative projects, or interaction of agents in a multilevel system with hidden information, or something else, the main reason for inefficiency of the interaction mechanisms is distortions of subjective assessments of the market participants. The model shows how deviations of the subjective probability assessment of distribution when forecasting the future events from the actual distribution may lead to the market collapse.

At that, introduction of a centralized infrastructural institution like RIIC to solve the problem of information provision and increase the efficiency of a regional property rights market does not counteract the adverse effects of information asymmetry. On the contrary, leading to the consolidation of the local markets into a single information space, it facilitates adverse selection and leads to equilibrium when property rights market does not exist.

The obtained result shows that the character of knowledge, in regard of which asymmetry exists, is determinative when elaborating the mechanisms of interaction organization between heterogeneous agents in social-economic systems with information asymmetry. The mechanisms effective under risk, when elimination of information incompleteness leads to forming an effective market, cannot be transferred to the conditions of uncertainty.

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