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Micro-level description of the economic coordination

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Abstract

Economic agents (people) by information exchange can take into account each other's activities. This allows them to coordinate their individual actions. The current study identifies three basic forms of coordination, the content of which depends on the communication options between agents: 1) the contractual form, which is possible with direct communication between agents; 2) the stigmergy form, which is possible with indirect communication; and 3) the common rules-based action form, which is possible in the absence of communication. The proposed three basic forms of coordination reflect the diversity of natural abilities of humans to take into account the activities of other humans. The observable processes of economic coordination, e.g., the market, etc., can be represented as some manifestations of these three basic forms. It is proposed to consider these representations as the micro-level descriptions of coordination processes. Such micro-level descriptions can be treated as a fundamental one that allows us to make the assertion that all observable economic coordination processes can be represented as certain combinations of the proposed three basic forms. As a proof of this assertion, the known economic coordination processes like the market, hierarchy and network are considered as certain combinations of the basic forms of coordination. Based on this micro-level approach, the specific features of economic activity, which determine the structure and main characteristics of the system of economic coordination processes, are analyzed. The analysis showed that the processes of economic coordination at the micro-level are a complex hybrid of the three basic forms of coordination. The system of economic coordination processes consists of the one main process and two branches of additional processes. This approach can be used as a unified methodological basis for the analysis of diverse ways of economic coordination. The analysis results obtained by this way allow us to explore directions for the improvement of coordination processes in the economy.

Keywords: economic coordination, basic forms, micro-level, coordination processes

JEL: P0, O1, O3

1. Introduction

This study is based on the hypothesis that people while exchanging information with each other use the abilities given to them by nature to take into account the activities of other people. These abilities mean that people can take into account each other's activities in the following forms:

- to agree with others how to act in concert;
- to make decisions about one's own activities based on observations of other people's activities;
- to act based on the rules of conduct common to all.

These abilities are realized by people including economic agents, in the form of some specific efforts, which in relation to different types of socio-economic activity establish different coordination processes. It follows from this statement that well-known economic coordination processes, e.g., as the market, hierarchical management or hierarchy, and community or network (Adler, 2001; Powell, 1991; Provan and Kenis, 2008; Weigand et al., 2003; Reiter, 2003) are derived from the forms in which economic agents account for each other's activities.

To clarify the general context of this study, let us consider four examples of coordination processes.

Example 1. Coordination of family members' joint economic activities, or coordination between members of a work crew, or, in general case, members of a small group pursuing economic goals. This coordination arises as a result of reaching and maintaining agreements "who does what and in what sequence" in the process of direct exchange of information between all participants of joint activity. The process of direct communication, which Reiter (2003) called the "direct channels", allows the participants to maintain discussion of their joint activity contents in response to dynamic changes in its conditions, clarifying and adjusting their initial agreements about this activity.

In the literature this type of coordination processes (method) is often referred to as the network coordination (Powell, 1991), network management (Provan and Kenis, 2008) or mutual adjustment (Mintzberg, 1980; Weigand et al., 2003). Adler (2001) notes that this method occurs in communities and is based on trust. Trust, in this case, he defined as "the subjective probability with which an actor assesses that another actor or group of actors will perform a particular action" (Adler, 2001).

Example 2. Performers of some activity delegate the right to make decisions about the content of their activity to managers. Coordination occurs when a manager, through direct exchange of information with performers, ensures that all his performers' activities are coordinated among themselves. At the same time, the managers can execute commands of other managers higher up in the hierarchy. In this case, the same as in Example 1, there is a process of direct communication which supports reaching agreement between a performer and a manager, but the communication is limited to the configuration "manager-performers", rather than "all to all".

This coordination type is referred to as a hierarchical, administrative form of coordination (Malone and Crowston, 1994; Weigand, et al., 2003), and direct supervision (Mintzberg, 1980). In addition, Adler (2001) also define this type of coordination as "authority" (legitimate power).

The following example illustrates the coordination that occurs between agents who do not have or do not use the ability to directly exchange information with each other. Agents can use indirect communication to coordinate, arising from their observations of each other's activities in the common environment. Agents can leave traces of their activities in the common environment, including specially prepared labels that may contain sufficiently detailed information for other agents to define the proper content of their activities (Heylighen, 2016). By analyzing such information, agents make decisions about their own activities and thus take into account, to some extent, what other agents are doing. This form of coordination has been called "stigmergy" (Elliott, 2006; Marsh and Onof, 2008; Elliott, 2016; Heylighen, 2016).

Example 3. Market coordination, in which market participants meet their supply and demand by matching prices and exchanging goods, is an example of coordination, part of which is realized through indirect communication. As noted by Heylighen (2016): "Probably the best-known example of stigmergic self-organization is the 'invisible hand' of the market: the actions of buying and selling leave a trace by affecting the price of the transacted commodities. This price in turn stimulates further transactions".

Agents can also act coherently in the absence of communication. In these cases, agents use the rules of behavior and explicit or implicit norms, existing as cultural and behaviorally accepted attitudes. "The members of a society build the same cognitive structures and adopt respective behavioral regularities during a long evolutionary socialization process" (Mantzavinos, et al., 2004). Philippe and Suavee (1999) also called them the "tacit rules".

Example 4. Rules of use of public goods, which allow people even in the absence of direct or indirect communication to consume public goods, taking into account the interests of each other. Routinized and normative coordination, which includes standardization (Mintzberg, 1980), refers to this coordination method.

The proposed study considers the claim that listed examples of coordination processes, and many other methods created by people to coordinate their various socio-economic activities, are based on the following three basic forms of coordination:

- the contractual form, which uses people's abilities to negotiate in direct communication with each other;
- the stigmergy form, which provides coordination in indirect communication;
- the common rules, which allow people's activities to be coordinated in the absence of communication.

As a preliminary test and justification of the practical applicability of the proposed assumptions, it is supposed to build descriptions of the most well-known in the literature methods of economic coordination "network", "hierarchy" and "market" (see examples above) as combinations of the three basic forms of coordination. The resulting representations of the coordination methods are proposed to be considered as a description of the coordination processes at the micro-level. Such approach makes it possible to organically combine micro-level descriptions of coordination processes with already existing in economics concepts of the methods and mechanisms of coordination (Weigand et al., 2003; Scheerer, et al., 2014).

To build realistic micro-level representations of existing methods of coordination, it is necessary to take into account that human economic activity, in comparison with its non-economic types, is determined by special motivations and has a rather complex nature. For example, the coordination of economic activity involves coordination of the joint production of goods (production activities), as well as the coordination of the collective distribution, exchange, and consumption of the produced goods. The study showed that, at the micro-level, the processes of economic coordination are a complex hybrid of the three basic forms of coordination. The system of economic coordination processes consists of one core process, which is observable as the market coordination, and two levels of additional processes which are visible as the network and hierarchy methods.

The conducted analysis showed that micro-level description of the processes of coordination makes it possible to obtain more detailed picture of how economic coordination works. Moreover, this approach creates a unified methodological basis for the analysis of different methods of coordination, and the results obtained on its basis allow us to explore the directions for improving coordination processes in the economy. This unified methodological basis can complete the limitation of the current coordination theory described as “Challenges for future research include developing testable hypotheses (e.g., about the generality of coordination mechanisms) and more structured approaches to evaluate and choose between alternate coordination processes” (Crowston, et al., 2015).

Section 2 discusses the basic forms of coordination and presents micro-level representation of the "network" and "hierarchy" as universal methods of coordination. Section 3 provides a discussion of the features of the economic activity which are important for building economic coordination processes description at micro-level. Section 4 presents a description of the system of economic coordination processes at micro-level, including the market way of coordination. The conclusion briefly summarizes the main results of the study and identifies possible areas of implementation of the results obtained.

2. Basic forms and designed methods of coordination

The underlying assumption of this study is that humans naturally have the following abilities to consider the activities of others:

- In direct communication with each other, people can negotiate who does what and in what sequence (Weigand, et al., 2003). This is how family members and members of other small groups coordinate activities. In hierarchical organizations, performers and managers negotiate in the same way.

- In indirect communication, people use stigmergy (Heylighen, 2016; Crowston, et al., 2017), which refers to a person's ability to observe other people's activities and/or traces of their activities in a common environment, analyze this information, and make decisions about the content of their own activities. Market participants in the economy, authors of scientific publications, participants in pedestrian and vehicular traffic, etc. coordinate their activities in this way;
- In the absence of all communication, people can follow common rules, which allows them to act in concert (Mantzavinos, et al., 2004). Thus, members of society, following the cultural norms and/or laws of the country, coordinate their social activities. In the same way, car drivers, following traffic rules, coordinate their activities in the absence of visibility of other road users.

The form of manifestation of a person's ability to take into account the activities of other people varies depending on the possibilities of exchange of information between people. The change in communication characteristics can have many gradations and be quite smooth. For simplicity we will consider only the following main options of the information exchange: 1) direct communication, which provides a direct exchange of information of the "all to all" type; 2) mediated communication, in which direct information exchange is not possible, but indirect information exchange through a common environment is possible; 3) absence of both direct and indirect communication.

Let us define the basic forms of socio-economic coordination as specific efforts of people, through which they take into account each other's activities. The three options for communication listed above define the following three basic forms of coordination for socio-economic agents:

- 1) the contractual form that works as coordination tool if economic agents have opportunities for direct communication of the "all to all" type;
- 2) the stigmergy form, if only indirect communications are possible between agents;
- 3) the common rules form if there is no communication between agents.

The desire of people to maximize the benefits of their joint activity, known in the theory of rational choice as the maximizing behavior of agents, motivates them to search for combinations of the basic forms of coordination, which, other things being equal, allow them to get a higher benefit from their activities or to coordinate at a lower cost. By trials and errors, the agents are selecting some combinations of the basic forms of coordination, which give them the greatest benefit from their activities. Such successful combination, if agents use it on a continuous basis, is called the method of coordination. The methods of coordination created this way differ for various types of activity, because they are adapted to the specifics of the corresponding types of socio-economic activity. Examples of some coordination methods were given in the previous section.

The description of a coordination method as a combination of the three basic forms, for example, for the market coordination, allows us to analyze the functioning of the corresponding coordination process at micro-level. Such micro-level descriptions can be a response to the questions raised almost 30 years ago: "Are there fundamental coordination processes that occur in all coordinated systems? If so, how can we represent and analyze these processes?" (Malone and Crowston, 1994). The micro-level description applied to diverse coordination processes makes it possible to analyze them from unified methodological basis. This approach allows us to set and solve many new research tasks, some of which are discussed below.

By this approach, socio-economic coordination in general can be represented as a two-level methodological construction. The lower level of this construction, or microcosm of coordination, consists of fundamental coordination processes based on the three forms of human abilities to take into account the activities of other people. The upper level of this construction, macrocosm of coordination, is made up of a multitude of human-created methods of coordination, which are adapted to the specifics of different types of their activity. For certain types of activity, in which a large part of society members takes part (as, for example, the economic activity), agents create

institutional structures to standardize the using of the coordination methods. It gives some reduction in the coordination costs and creates conditions for the constant and uniform use of methods of coordination. Such institutionalized coordination methods can be referred to the coordination mechanisms.

Similar idea was discussed in (Adler, 2001) for the context of the knowledge economy and the future of capitalism trends. Adler proposed “three ideal–typical forms of organization and their corresponding coordination mechanisms: market/price, hierarchy/authority, and community/trust. Different institutions combine the three forms/mechanisms in different proportions” (Adler, 2001). If we compare only views on coordination, our approach has a more rigorous methodological basis, because the content of the three proposed basic coordination forms, compare with Adler’s three ideal typical forms, logically follows from objective factors, which are the communication options existing for economic agents.

Let us consider a micro-level description of the network and hierarchical methods of coordination. In this section these coordination methods are considered as universal, i.e., without taking into account specifics of their application to economic activity. Peculiarities of application of these methods for coordination of economic activity, and the micro-level analysis of the market coordination method are considered in sections 3 and 4.

2.1 Micro-level of the network coordination method

The considered above example 1 noted that the network coordination method is based on reaching and maintaining agreements between the participants of joint activity, i.e., the foundation of network method is the basic contractual coordination form.

Agents' use of the basic coordination forms is influenced by their maximizing behavior. Agents are interested in reducing the time spent on the processes of keeping agreements, because less time for coordination give them more time for their primary activity and thus can increase their benefits.

The network coordination method can also include the common rules and/or stigmergy coordination forms, in addition to the contractual form. This is possible in certain situations or stretches of time when the conditions for joint activities are stable. If there are no changes and nothing to adjust, participants in the contractual coordination process can save time/effort if they use predetermined rules of behavior (e.g., following established responsibilities) or a signaling system (e.g., leaving messages in a common environment). Temporarily replacing the contractual form with stigmergy and/or common rules in such cases does not disrupt the maintenance of coordination but reduces time and thus increases the benefit of joint activities.

This, the basic contractual form as the core of the network coordination method can be temporarily used in combination with other basic forms (stigmergy and/or common rules), as it allows agents to reduce the total cost of coordination.

2.2 Micro-level of the hierarchical coordination method

To create hierarchical coordination, individual participants (performers) delegate the rights to decide on the content of their activities to other participants (managers). In this way, the performers take on the obligation to execute the commands of the manager. Typically, the hierarchical coordination is based on the direct exchange of information between the manager and the performer. The manager, having initially agreed with the performers and sending them commands, ensures the coordination of all performers' activities among themselves. At the same time, the manager may execute the commands of other managers higher in the hierarchy. In this case, the basic contractual coordination form, modified by limitation of some rights of performers, is implemented on the basis of a set of paired "manager-performer" type of communications.

Coordination based on pairs of direct communications "manager-performer" will certainly be less complete in comparison with the case of direct communications "all with all". Completeness of coordination means the degree of consideration of the intentions and capabilities of the agents in the process of their joint determination of the content of the collective activity. The higher the completeness of coordination, the higher the probability of obtaining the maximum benefit from agents' joint activity, since the agents have better chance for self-realization.

In the hierarchical coordination method there is no consideration, for example, to the performers' intentions and capabilities that could be used in "horizontal" coordination directly between them. On the other hand, the limited "performer-manager" communications of hierarchical coordination make it possible to coordinate activities for a much larger number of agents than the network coordination based on the "pure" contractual basic form. Thus, the hierarchical coordination, if applied to activities in which the development of specialization and division of labor is beneficial, provides participants with more benefit from their activities than the network coordination method.

Similarly, as it works for the network coordination method, agents seek to reduce the costs of hierarchical coordination. The costs of using the basic contractual form in a hierarchy can be reduced by replacing it, in situations where it does not disrupt coordination, on using the other basic forms (stigmergy and/or common rules).

As a result of agents' maximizing behavior, the hierarchical coordination method exists as a complex hybrid of all basic forms of coordination. Building the hierarchical method, agents partially sacrifice the completeness of coordination and fragmentarily replace, where possible, the basic contractual form with less costly basic forms of coordination. The known from practice mass use of hierarchy as a universal method of coordination of various types of socio-economic activities confirms that in this case some losses from the reduction of completeness of coordination are offset by growth of benefits through increasing the number of participants of coordinated activity.

3. Coordination-wise features of economic activity

Unlike the "network" and "hierarchy" coordination methods, which are applicable to various kinds of human activity, the market coordination method refers to economic activity. Its description at micro-level requires a preliminary consideration of some features of economic activity.

This study assumes that the purpose of economic activity, in its most general form, is to provide people with the life support resources (LSR) they need for physical and social reproduction in a stochastic environment. By economic activity people strive to provide themselves and those who depend on them with a certain quantity and quality of SLR now and in the future.

For this study, the key features of economic activity, which distinguish it from other types of human activity, is the need to create two types of relations between its participants. On the one hand, it is required to create relations for collective production of LSR, and on the other - to collectively agree on how created LSR should be distributed among economic agents. The collective nature of production is explained by the fact that the development of specialization and division of labor between participants in economic activity makes it possible to increase the benefits of this activity. The necessity of collective distribution is explained by the fact that, under conditions of the free will, agents must agree on what share of collectively produced LSR each of them will receive to ensure their individual survival. The collective distribution should give agents the expected benefits of their participation in collective production. Otherwise, agents lose their motivation to participate in economic activity.

Considering the noted features of the economic activity, the process of its coordination consists of the production coordination, in which agents decide who does what; and the distribution coordination, which determines how much LSR agents receive for their contribution

to the joint productive activity. However, distribution coordination is complicated by the well-known scientific problem of the inseparability of the collective activity results to the contributions of its participants (Alchian and Demsetz, 1972).

If both parts of the economic activity coordination use the basic contractual coordination form, then the problem of inseparability of the collective activity results is overcome by agents based on their observations of each other's activities (Alchian and Demsetz, 1972 p. 780). In the process of observation, agents develop their subjective assessments of the quality of other participants' performance. The agents collectively discuss these evaluations and agree on a common view. As a result, they produce some collective decision. Even if this solution is not the best, by trial and error they find a way to distribute LSR that encourages the participants of the joint activity not to shirk their duties properly.

In economic activity there is an opportunity to gain more benefit through development of specialization and labor division among its participants. This fact creates strong economic motivations to increase the number of labor division (LD) participants. When the number of participants exceeds the limit of the basic contractual form and/or hierarchical coordination, people must use coordination in the form of stigmergy.

Using stigmergy to coordinate economic activity is a necessary condition for the development of agents' specialization and their LD through inclusion of new participants. This, in turn, allows agents to benefit from the expansion of the scale of production and the development of LD.

However, stigmergy is based on indirect communications, in which it is practically impossible to coordinate production and distribution as is. One reason is that indirect communications in their classical form (i.e., without Internet technologies) limit the ability of agents to "observe behavior of individual inputs" (Alchian and Demsetz, 1972). In addition, reaching agreements between agents, by definition, requires the consent of all parties involved in these processes of agreement. In conditions of free will, i.e., when agents cannot impose their opinion on other agents, reaching an agreement cannot be achieved if one of the parties does not agree with the terms of the agreement processes. With indirect communications, reaching an agreement is costly. Thus, the problem of using stigmergy to coordinate economic activities is the high cost of reaching agreements in indirect communications.

One source of this problem is the inseparability of the results of joint production activities on the contributions of the participants. However, necessary separability production results into agents' contributions naturally arises if agents independently perform production operations without direct agreement with each other. To do this, it is necessary to divide the collective production activity of agents into separate individual acts but keeping a certain coordination of these individual acts between all agents.

Another source of the problem is the need to reach an agreement on the distribution of LSR among all agents participating in LD. The results of this agreement on the distribution of LSR should motivate the agents to perform their duties well.

To address the problems that prevent the use of stigmergy for economic coordination, agents have created an organizational mechanism that ensures the circulation of rights to LSR instead of the actual LSR. Today this organizational mechanism acts as a global monetary system. Such a mechanism, on one hand, allows agents to use stigmergy to involve all existing agents in joint activity and thus maximize the benefits of their joint activity. On the other hand, it allows one to break down the task of coordinating economic activity into separate partly independent stages, which significantly reduces the cost of reaching agreements on the distribution of LSR.

As a result of the transition to the turnover of the rights to LSR, economic activity is divided into four stages of economic activity well-known in the economic theory: production, distribution, exchange, and consumption, in which each agent acts both as a producer and a consumer. In the context of this study, these four stages have the following specific use of the basic coordination forms:

- Stage 1. The process of production in the form of separate individual acts of agents. These acts result in obtaining by each agent a certain product created to exchange it for a certain amount of rights to LSR. At this stage, the agent, based on indirect communications with other agents, decides what to produce with the expectation that the created product will be used by other agents (stigmergy). The agent makes this decision independently, and, therefore, the results of his activity belong only to him. In this case there is no problem of the inseparability of results by contributions of participants. For cases where the process of production cannot be realized by an individual agent, an economic agent is created as a group of individuals who coordinate activities within the group based on the network and/or hierarchical methods.
- Stage 2. The process of exchanging the agent's produced products for a certain amount of rights to LSR. In the classical definition of economic activity this stage corresponds to "distribution". Acting as a producer, the agent agrees (contractual form) with agents, potential consumers of his product, to receive from them in exchange for his product the largest possible amount of rights to LSR. If such an exchange takes place, the agent's usefulness for LD is confirmed. At this stage, the agent-producer should be able to receive offers to exchange the created product for the rights to LSR from all participants of LD. This is a consequence of the development of specialization in the production activity of agents, and a necessary condition for the use of the benefits arising from their joint activity by all participants of LD.
- Stage 3. The process of exchange of the agent's rights to LSR for the actual LSR. In the classical definition of economic activity this stage corresponds to "exchange". The consumer agent agrees (contractual form) with other agents, who are potential suppliers of LSR, to exchange his existing rights for the maximum possible volume and quality of the actual LSR. At this stage, the consumer agent should be able to receive LSR from all participants of LD, which ensures that any agent uses the benefits arising from the action of LD.
- Stage 4. The process of consumption of LSR, which can be shared by multiple agents, if it is the public goods. At this stage, the agent-consumer agrees (contractual form) with other participants of LD on the parameters of joint use of public goods. Agent-consumers may also collectively consume the public goods just by following common rules without any communication among them.

By creating a monetary system, which ensures the circulation of rights to LSR instead of the circulation of actual LSR, agents have created conditions for using stigmergy to coordinate economic activity of a large number of participants. This allows them to build the market coordination method that, in its present form, serves the global economy.

4. Economic coordination at micro-level

Because of maximizing behavior, agents strive to get the maximum benefit from economic activity, including by improving its coordination. To improve economic coordination processes, agents use the three basic coordination forms for each of the four stages of economic activity and create the following coordination processes:

1. Coordination of collective production based on indirect communication and stigmergy;
2. Collective distribution coordination, which is the process of reaching agreements and allows agents to find consumers for the products of their production activities and to receive in exchange for their product a certain amount of LSR rights;
3. Collective exchange coordination, which is also a process of reaching agreements between agents that allow them to receive LSR created by other agents in exchange for their existing LSR rights;

4. Coordination of joint consumption, which is the process of coordinating the agents' collective use of the public goods of LSR.

Let us consider these four economic coordination processes at micro-level in more details.

As noted above, the coordination of the production process on the scale of LD (item 1 in the list above) must be realized in the form of stigmergy, since it is needed to benefit from economic activity by developing the agents' specialization.

To simplify the analysis, we assume that the process of coordination of collective consumption (item 4) is realized using the basic coordination form "common rules".

For the item 2 and 3 listed above, which are about to build the coordination of "exchange" stages of economic activity, there are two important requirements that partly have been discussed above:

- a) the coordination of the "exchange" requires agreements between the participants, which, in theory, means the use of the basic contractual form of coordination;
- b) getting benefits from LD requires participation of all agents in reaching agreements on the content of the "exchange" stages.

Thus, requirement "a" means using the basic contractual coordination form, but it cannot be used at the exchange stages because this form does not work for all LD participants as it is needed in "b". Therefore, the requirements "a" and "b" cannot be met simultaneously. Agents, however, have found it possible to design the exchange coordination processes (items 2-3) that satisfy these requirements. They created a hybrid of stigmergy and the contractual form which meets both the requirements "a" and "b".

The agents, as they do in stigmergy, put information into the common environment of LD participants about their intentions and capabilities in relation to the exchanges like "LSR" <-> "LSR rights". This information contains the conditions and, in particular, the rate, with which the agents want to perform the act of exchange. In the economy, the prices provide such information. Based on this information, potential participants of the exchange are found from all participants of LD. When the potential exchange participants are found, the process of exchange itself is negotiated with them by the agents in the contractual form. As a result, coordination, on one hand, includes all participants in LD, and, on the other hand, makes it possible to take into account by negotiations the dynamically changing conditions and parameters of coordination.

Thus, the typical way of coordination of economic activity in relation to LD is the use of:

- the stigmergy to coordinate the production for all LSR participants (stage 1);
- the hybrid of stigmergy and a contractual form for coordinating the exchanges like "LSR" <-> "LSR rights" (stages 2-3);
- the common rules form for coordinating the consumption of the public goods (stage 4).

When considering at micro-level the processes of coordination of economic activity on the scale of LD, we can conclude that it is a complex hybrid of all basic forms of coordination. The practical representation in the economy of this hybrid coordination process is the market coordination.

4.1. The system of economic coordination processes at micro-level

Coordination of the production activities within LD based on stigmergy is possible with a significant reduction in the details about the intentions and capabilities of the agents in relation to these activities. This is a consequence of the use of indirect communications through the traditional (without Internet technologies) common environment. This incomplete consideration of agents' intentions and capabilities manifests itself as a missed opportunity to gain a higher benefit from their activities. Agents can use these reserves and receive higher benefits by organizing additional joint production activities, which turned out not to be demanded when agents were coordinating their participation in LD. In this case, the condition for obtaining additional benefits is the use of a basic form of coordination, which provides a fuller account of

the intentions and capabilities of the agents. Regarding stigmergy, such form is the contractual one represented by the network or hierarchical coordination methods.

By creating such additional processes of the production economic activity coordinated by the network or hierarchical methods, agents can obtain additional benefits. All these interrelated processes of coordination of economic activities can be represented as a coordination system containing the core process and a set of additional processes consisting of two levels. Based on the above, the system of economic coordination processes at micro-level has the following structure:

- The core coordination process for LD which use: a) the stigmergy to coordinate the production of LSR; b) the hybrid of stigmergy and contractual forms to coordinate the exchange of LSR; and c) the common rules form to coordinate the consumption of public goods.
- Additional first-level coordination processes created by agents to use their intentions and capabilities, which were left not used by the core coordination process at the production stage of the economic activity. These additional processes can be implemented as the hierarchical or network coordination methods. Their participants, to take advantages of LD, must coordinate their exchange and consumption activities using the components “b” and “c” of the core coordination process. Thus, the first-level additional coordination processes cover only the production activity.
- Additional second-level coordination processes created by agents to use their intentions and capabilities, which were left unaccounted in the first-level additional coordination processes. The first-level coordination processes can contain these reserves if agents use the hierarchical method to coordinate their production activity at the first level. To get additional benefits the agent must use the network method to coordinate the second-level production activity. The same as at the first-level, agents use the core coordination process to coordinate exchanges and consumption of LSR.

In micro-level representation, the system of economic coordination processes is a complex hybrid of all three basic forms of coordination. Its core coordination process corresponds to the market coordination method, and two levels of additional processes correspond to the economic application of universal methods of the network and hierarchical coordination.

4.2. Market coordination method at micro-level

Market coordination of the economic activity, including the regulation of supply and demand by the “invisible hand”, can be described at micro-level (in some simplified form) by the sequence of the following actions of the market participants:

- Based on the information received from indirect communications, they decide what product to produce. This is the first action of the “invisible hand” of the market which is the part of stigmergy.;
- Producers put in the common environment the information about their products and the desirable rates of its exchange for the rights to LSR. It is the second action of the “invisible hand”, when according the stigmergy routine the producers are offering the products to other market participants and announcing prices for it.;
- Producers agree on the actual terms of exchange of the product for the rights to LSR with the interested consumers of the products, taking into account other offers in the common environment. It is the third action of the “invisible hand” when the producers and consumers are using the basic contractual form to agree on a transaction. By the same way consumers exchange the rights to LSR obtained from the sale of the product on the actual LSR they need for consumption.

This micro-level description presents more precisely when and what basic forms of coordination are used, as well as what information exchange and processing underlie the corresponding coordination processes. This knowledge is needed to develop methods for

improving economic coordination processes, e.g., by digitizing them, and is also necessary to analyze the consequences of such changes.

5. Conclusions

The analysis performed in this study shows that the well-known observable methods of economic coordination like "network", "hierarchy" and "market" can be reliably represented as combinations of the proposed three basic forms of coordination. Such representations can be considered as micro-level description of observable coordination processes where these three basic forms of coordination present the fundamental units for building different economic coordination processes. This fundamental approach also creates a unified methodological basis for the analysis of various coordination processes existing in the economy.

Such approach has many applications. On one hand, it allows developing methodological concepts of the nature and processes of coordination for various types of joint human activities. On the other hand, it makes possible to present socio-economic coordination as processes of information exchange and processing, which allow solving practical problems of developing methods for improving coordination using modern communication technologies and computer data processing methods.

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