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# Model of Collective Behavior of Investors and Producers in Decentralized Economic System

Vladimir G. Red'ko<sup>1,2\*</sup> and Zarema B. Sokhova<sup>1</sup>

<sup>1</sup>Scientific Research Institute for System Analysis, Russian Academy of Sciences, Moscow, Russia

<sup>2</sup>National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Moscow, Russia

[vgredko@gmail.com](mailto:vgredko@gmail.com), [zarema\\_s@mail.ru](mailto:zarema_s@mail.ru)

## Abstract

The paper presents the interaction mechanism between investors and producers in a decentralized economic system. The main element of the interaction is the iterative process. In this process, each investor takes into account the contributions of other investors into producers. The model is investigated by means of the computer simulation, which demonstrates the effectiveness of the considered mechanism.

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## 1 Introduction

Competition is an important element of the economic systems. Is cooperation possible in competitive societies? Based on game theory and computer simulation, Robert Axelrod demonstrated the advantages of cooperation for two players [1]. Forms of aggressive and constructive competition between individuals within an agent-oriented approach were also analyzed in [2]. In the current paper, we design and investigate the model of the economic system with a soft constructive competition. The prototype of our model is the work of Belgian researchers [3, 4]; their systems have used agents-messengers to optimize a production hall's work and routing car traffic in a city.

In our model, the economic system is the community of producers and investors. The producers and investors compete with each others. Nevertheless, the information about capitals, profits, and intentions of community members is open within the community. In particular, investors inform producers about their intention to invest the certain values of capital into the separate producers. The information exchange ensures the possibility to create a decentralized system of interaction within the community of investors and producers. The iterative process is an important element of the model,

\* Corresponding author: Tel.: +7 915 1673584  
E-mail address: [vgredko@gmail.com](mailto:vgredko@gmail.com)

which helps each investor to take into account the intentions of other investors. The model describes an effective interaction of investors and producers in the economic community. This effective interaction was demonstrated by means of computer simulation.

## 2 Description of the Model

### 2.1 General Scheme of the Model

We consider a community of  $N$  investors and  $M$  producers; each of them has a certain capital  $K_{inv}$  and  $K_{pro}$ . The investors and producers operate in the transparent economic system, i.e. they provide the information about their current capital and profit to the entire community. There are periods of operation of the community. For example, a period can be equal to one year. Further,  $T$  is a time period number.

At the beginning of each  $T$  period, a particular investor makes the investments into  $m$  producers. At the end of the period, every investor has to decide: how much capital should be invested into one or another producer in the next period. In order to take into account intentions of all investors, there is an iterative process, which is described in details below.

The  $i$ -th producer has its own initial capital  $C_{i0}$  before the period  $T$ . The producer obtains some additional capital from investors. The whole capital of the  $i$ -th producer is:

$$C_i = C_{i0} + \sum_{j=1}^N C_{ij}, \quad (1)$$

where  $C_{ij}$  is the capital invested into the  $i$ -th producer by the  $j$ -th investor at the beginning of the period  $T$ .

We believe that the dependence of the producer profit  $R_i$  on its current capital  $C_i$  is nonlinear:  $R_i(C_i) = k_i F(C_i)$ , the coefficient  $k_i$  characterizes the efficiency of the  $i$ -th producer, the function  $F$  is the same for all producers. In computer simulations, it was supposed that the function  $F(x)$  has the form  $F(x) = x^2/(x^2+a^2)$ , where  $a$  is a positive parameter. The values  $k_i$  vary randomly at the end of each period.

At the end of the period  $T$ , the producer returns the invested capital to its investors. In addition, the producer pays off a part of its profit to the investors. The  $j$ -th investor receives the profit part that is proportional to the investment made into this producer:

$$R_{ij} = k_{replay} R_i(C_i) \frac{C_{ij}}{\sum_{l=1}^N C_{il}}, \quad (2)$$

where  $C_i$  is the current capital of the  $i$ -th producer,  $k_{replay}$  is the parameter determining the part of the profit that is transferred to investors,  $0 < k_{replay} < 1$ . The producer itself gets the remaining part of the profit:

$$R_i^* = (1 - k_{replay}) R_i(C_i). \quad (3)$$

Each investor has the following agents-messengers: the searching agents and the intention agents; these agents are used for information exchange within the community.

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