

The Study of the Market Economy Problem by the Method of Econophysics

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The article considers the econophysical analysis of the relationship between monopoly and competition by using the methods, terms of physics. And it was investigated the philosophy of progress. It has been shown that in the transition from absolute monopoly to imperfect monopoly, the system becomes more complex, and its output characteristics depend on time, because monopoly is a natural, competitive is derivative process. Competition is created as a result of the interaction of at least two “monopoly firms” through the “market field” that they create to increase the production which is necessary of non-linear products over time. To do this, it is sufficient to have a multitude of firms interacting with each other under the influence force of “market field”. To create the necessary conditions, it is sufficient to have a high level of university education and a legal field for competition and unbreakable antitrust legislation. By acquiring technology and creating conditions for competition in the market, it is possible to achieve progress even without having a strong science. The term “progress” has received a new content and is defined as the value of a numerically equal increase in the rate of production per unit time or production per squared time. It has been shown that the relationship between monopoly and competition is very simple and there is no contradiction between them. Initially, the market is born as a monopoly, and then analogical firms were created, competition between firms begins.

Keywords: econophysics, market, monopoly, competition, duopoly, oligopoly, progress, sputtering, speeds of production

Introduction

In the modern world, competition is a driving force of the economy and an important factor in the development of the economy. Therefore, the relationship between competition and monopoly is widely investigated. The solution to this problem is beneficial in light of the science of econophysics. Econophysics as an interdisciplinary and independent research field has been set to form since 1995s. The term “econophysics” was coined by H. Stanley (Mantenga & Stanley, 2000). At present, econophysics is rapidly developing and physical models, methods, and approaches are used to address some of the economic problems.

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Literatura Review

A bright example of the application of physics to solve economic problems is “a gravitational pattern in foreign trade” (Chernavskii, Starkov, Malkov, Kosse, & Shcherbakov, 2011).

In physics, there are a number of phenomena where linear output characteristics become non-linear under the influence of various factors. Such phenomena include, for example, low-energy cathode sputtering (Askerov, 1970).

Research Methods

Cathode sputtering is a physical phenomenon that occurs when a surface of a solid is bombarded by ions. This phenomenon is characterized, basically, by two parameters: the sputtering yield Y (atom/ion) and the threshold energy E_0 (eV) of the sputtering. The first parameter shows the number of atoms knocked out from the surface by a single incident ion. The second parameter shows the minimum ion energy below which the sputtering process does not occur.

We have shown (Askerov, 1970) that the character of the dependence of the sputtering yield from ion energy in the near-threshold energy region is very different for single-crystal and polycrystalline samples. In Figure 1, it is shown that the dependence of Y (E_p) for different faces of a single crystal is linear (a, b, c line), and a face with a large angular coefficient has a large sputtering threshold (E_0). In the case where the bombarded surface consists of several single-crystal faces, the Y (E_p) dependence becomes a broken line (1-2-3). Unlike monocrystals, in the case of the polycrystalline surfaces, when the ionic energy increases, the number of crystallites added to the sputtering process increases. As a result, the energetic dependence Y (E_p) becomes non-linear, or rather cubic law for the polycrystals (Askerov & Sena, 1969):

$$Y = \kappa (E_p - E_{0a})^3$$

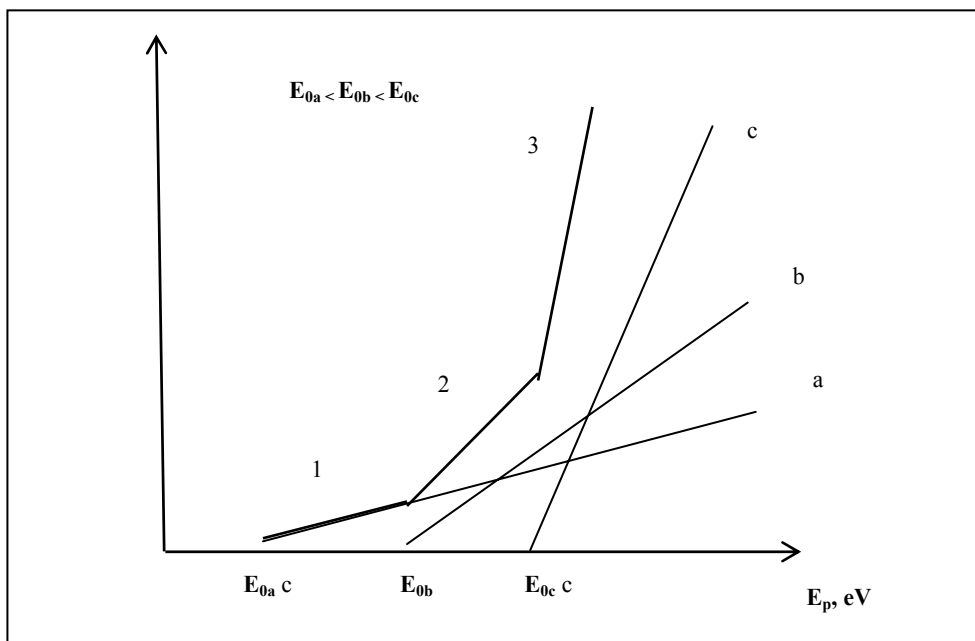


Figure 1. Energy dependence of the sputtering yield for single crystals (a, b, and c lines) and inhomogeneous surfaces (1-2-3 broken line).

Since the surface of the polycrystalline consists of numerous chaotically oriented faces, it can be assumed that both the angular coefficients κ of the $Y(E_p)$ dependences and the threshold energies vary chaotically and continuously. As can be seen from the figure, the character of the output characteristics of the sputtering depends on the structure of the bombarded surface and changing the structure; it is possible to change the angular coefficients of the $Y(E_p)$ dependence.

To achieve progress in the field of market economy, one can borrow the scientific results obtained in the field of cathode sputtering at low ion energies.

Research and Results

Suppose that the volume of production (\dot{I}) depends linearly on the time t (Sh. G. Askerov & A. Sh. Askerov, 2017):

$$\dot{I} = b t \quad (1)$$

Here b is the proportionality coefficient, which shows the volume of production produced per unit time. It can be called *production speed*. At $b = 0$ there is no production, i.e., commodity is not produced. We can assume that in the case of a pure monopoly, b remains constant ($b = b_m = \text{const}$) and does not change with time. In this case, there is production, although there is no progress. For progress, it is necessary that the quantity of production speed (products produced per unit of time) increases with time. In other words, for progress, the linear $\dot{I}(t)$ dependence should become nonlinear or change nonlinearly. This means that the proportionality coefficient b in equation (1) should increase with time. We believe that this is a necessary condition for progress.

Figure 2 shows the dependence of the volume of products (or services) on time in conditions of perfect (mm straight line) and imperfect monopoly (1-2 broken lines), more precisely in the case of duopoly (Econophysics, 2007). As it is easy to see, the presence of a second independent producer of identical goods (dd direct) in the market causes competition and the dependence $\dot{I}(t)$ is transformed from a straight line into a broken line. As new independent producers of products (oo lines) appear on the market, competition will increase, and the number of broken lines will also increase (1-2-3). In economic theory, this case is called oligopoly. In the case of oligopoly, the angular coefficient b , respectively, will increase as the number of firms increase.

The parallelity of the lines mm, dd, and oo in Figure 2 means that the technologies used in the production of goods by competing firms are at the same level and, as can be seen from the graph, as the number of firms increase, the volume of output produced per unit time also grows: $b_o > b_n > b_m$. As the oligopoly is created, the angular coefficient b_o also increases, as a result of which $\dot{I}(t)$ dependence takes the form of a broken line (1-2-3). Thus, in the transition from an absolute monopoly to an imperfect monopoly (duopoly, oligopoly), the system becomes more complex, and its output characteristics are nonlinearly time-dependent. The transition from a linear characteristic to a nonlinear one means that the system obeys the theory of complex systems (Loskutov & Mikhailov, 2007), and its output characteristics differ significantly from the output characteristics of individual independent producers on the market.

Discussion

The increase in the quantity of production per unit time (b) (speed of production) with duopoly can be represented by the following equation:

$$b_{\pi} = b_M + \alpha t \tag{2}$$

Here, b_{π} , b_M , respectively, rate production of a duopoly and pure monopolistic firm; α is a constant characterizing *progress*. According to the equation (2), progress can be defined as a quantity numerically equal to the change in b per unit time or the amount of product produced per squared of time.

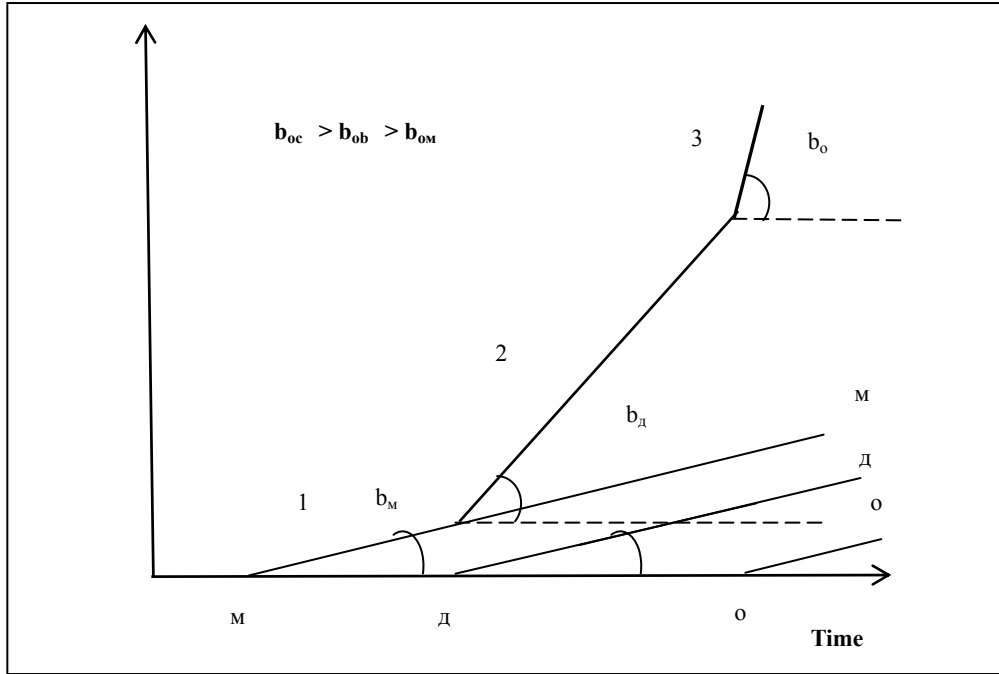


Figure 2. Dependence of the volume of goods/services on time in duopolistic environment (aa and bb lines).

It is known from school physics that, the speed of uniform acceleration motion determined by the equation:

$$v_t = v_0 + at \tag{3}$$

where v_t is the speed at any moment of time, and v_0 is the velocity at the time of the reference, and a is the acceleration.

If we take equation (2) into account in equation (1), we can get that \dot{I} is nonlinearly time-dependent. Even with perfect competition (many firms) and an identical technology, the amount of output per unit time proportionally increases the square of time, which leads to the emergence of progress:

$$\dot{I} = b_M t + \alpha t^2 \tag{4}$$

In such conditions there is no need for strong of science, it is sufficient to have a high level of university education and a legal field for competition.

Another factor that strongly influences progress is technology. It is well known that technology depends on the level of science. The need for technological development leads to a greater need for science. For this reason, developed countries for science spend a lot of money.

The relationship between the change in the level of technology (ΔT) and science (S) in a certain time interval Δt can be represented in the following form:

$$\Delta T = \kappa_1 S \Delta t \tag{5}$$

where k_1 is the coefficient of proportionality.

Figure 3 shows the time dependence of the growth of production of goods by competing firms using different technologies. The graph shows the case where each newly created company uses more advanced technology for economic growth.

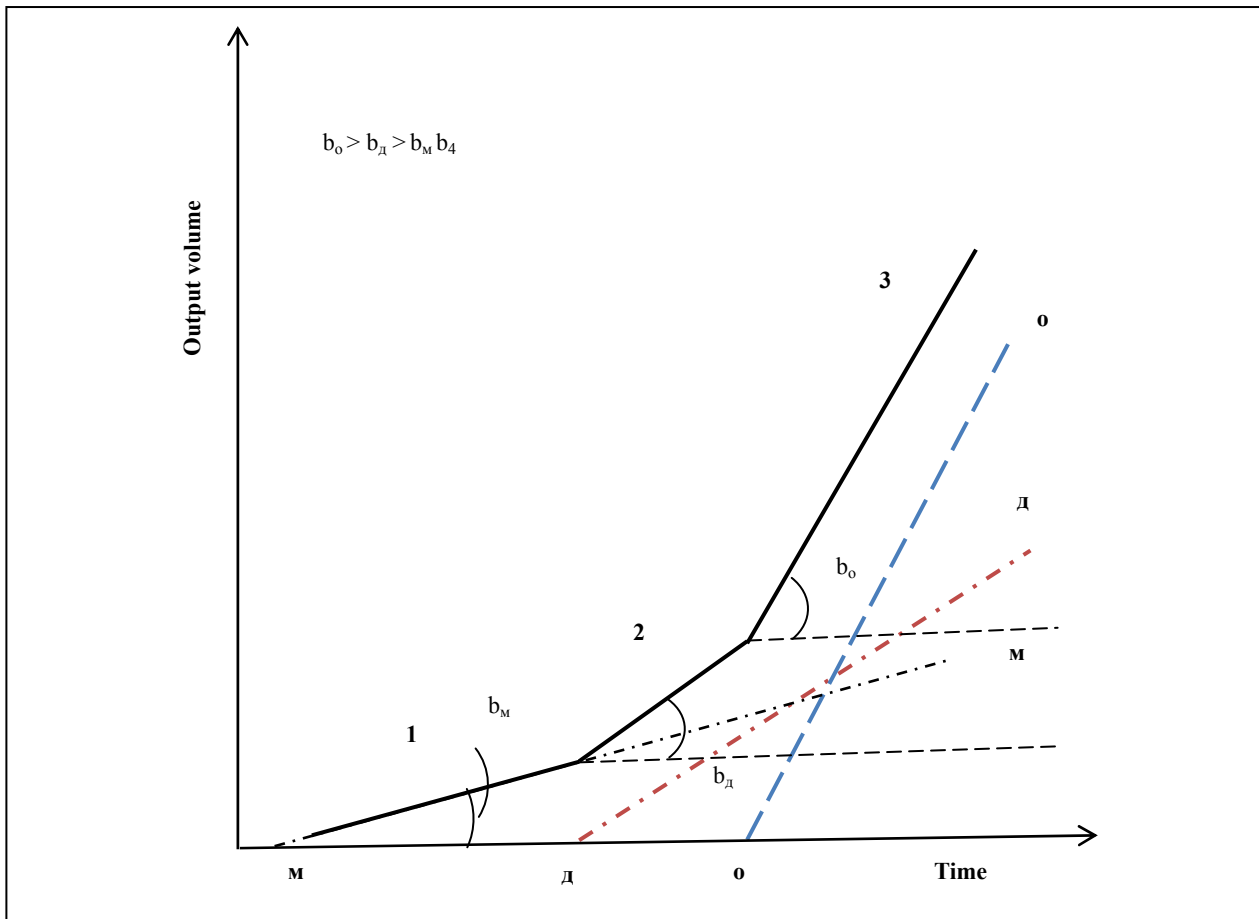


Figure 3. Time-dependence of output characteristics of production in the environment of various technologies: mm—old technology, ДД—technology of the day, оо—high technology.

The structure of the market depends on the number of firms that make up it, and the market performance characteristics depend on its structure. If a firm operates in the market, it is a monopoly and the volume of the product linearly depends on time. When the second monopoly firm enters the market, the structure of the market changes and the volume of production grows, and progress is made. The market, which has such a structure, is called duopoly. When the third firm enters the market, the market is called oligopoly and so on... Thus, as the number of structural elements grows, the market properties change and competition is intensified.

Thus, the relationship between monopoly and competition is very simple and there is no contradiction between them. Initially, the market is born as a monopoly, and then analogous firms were created, competition between them begins.

As the structure of the market changes, the dependence of the output behavior on time also varies. This is a dependency line during pure monopoly, while imperfect competition is non-linear.

Proceeding from the foregoing, we can conclude that to achieve economic progress, a nonlinear increase

in the production of output over time is necessary. To do this, it is sufficient to have a multitude of firms (more than two) interacting with each other under the influence of competition. It is noted that as the number of firms grows, the market is subject to the law of complex systems. Secondly, acquiring technology and creating conditions for competition in the market, one can achieve progress even without having a strong science. Another factor that strongly influences progress is technology. For the development of technology, there is a great need for science. Science is a very strong factor that influences the nonlinearly changing of the economy. And, finally, free competition and unbreakable *antitrust laws* are very important for the economic growth of states.

Thus, the monopoly-competition problem was studied by the econophysical method and showed that the relationship between monopoly and competition is very simple.

There was no contradiction between monopoly and competition, but rather a logical connection, and they complement one another. Initially, the market is born as a monopoly, and then analogical firms were created, competition between firms begins.

Conclusion

The following results were obtained in this study:

It is obtained that with the growth of the number of competing firms, the types of market structures is changed. Transition from pure monopoly to perfect competition can be represented by the following chain: pure monopoly, duopoly, oligopoly, imperfect competition, perfect competition. As the structure of the market changes, the dependence of the output behavior on time also varies. This is a dependency line during pure monopoly, while imperfect competition is non-linear.

Shown, that for progress, it is necessary the quantity of production speed increases with time nonlinearly. In other words, the linear $\dot{I}(t)$ dependence should become nonlinear or change nonlinearly. This means that the proportionality coefficient b in equation (1) should increase with time. It is a necessary condition for progress.

To achieve the progress is necessary to bring together several (more than two) monopoly firms producing the same product (service). This makes contracting companies a complex system and creates an essential competitive environment for mutual influence.

A factor that strongly influences economic progress is technology. It is possible to achieve progress by buying technologies if they create a healthy competitive environment. There is no need for serious science, but there is a great deal in university education.

For the development of technology there is a great need for science. Science is a very strong factor that influences the nonlinearly changing of the economy.

Another important prerequisite for progress is the protection of entrepreneurs from monopoly, i.e., the need for tough anti-monopoly law.

As a result of the research, the term “progress” has a new meaning, indicating an increase in speed of production in a unit time, and has measure by the product/squared time.

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