SOME ECONOMIC IMPLICATIONS FOR THE NANOINDUSTRY

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Abstract: *This article discusses the economic implications of the use of nanotechnology in industry, services, and agriculture. Conclusions are made about the direction in which the modern economy will develop in the conditions of the nanoindustry.*

Keywords: *Nanotechnology, nanoscale processes, mechano-synthesis, Nano mechanisms, production costs, atomic-level materials, nano-industry.*

The end of the 20th century was marked by such scientific and technological developments, the economic and social consequences of which humanity is just beginning to realize. These consequences by their nature are objective, inevitable and unregulated. The nanoscale molecular analysis of nature has combined physics, chemistry and biology. As a result, science is on the verge of the emergence of a special complex of disciplines, which is often referred to as "NBIC" (nanotechnology + biology + informatics + cognition).

Nanotechnology is a new area of science and technology that has been actively developing in recent decades. Nanotechnology includes the creation and use of materials, devices and technical systems, the functioning of which is determined by a nanostructure, ranging in size from 1 to 100 nanometers. In the world literature, nanoscience is clearly distinguished from nanotechnology. The term nanoscale science is also used for nanoscience.

According to the recommendation of the international conference on nanotechnology (Wiesbaden, 2004), the following types of nanomaterials are distinguished: nanoporous structures, nanoparticles, nanotubes and nanofibers, nanodispersions (colloids), nanostructured surfaces and films, nanocrystals and nanoclusters. Some areas of application of nanotechnology: elements of nanoelectronics and nanophotonics; ultra-dense information recording devices; telecommunication, information and computing technologies; supercomputers; video equipment; molecular electronic devices; nanolithography and nanoimprinting; fuel cells and energy storage devices; micro and nanomechanical devices; nanorobots; nanochemistry and catalysis; coating; electrochemistry and pharmaceuticals; aviation, space and defense applications; environmental monitoring devices; targeted delivery of drugs and proteins, biopolymers and healing of biological tissues, clinical and medical diagnostics, creation of artificial muscles, bones, implantation of living organs; biomechanics; genomics; bioinformatics; bioinstrumentation; registration and identification of carcinogenic tissues, pathogens and biologically harmful agents; safety in agriculture and food production.

Modern science has reached a qualitative breakthrough in the study of nanoscale processes and allows the transition to nanotechnology. But nanotechnology should not be seen as a movement of production towards its miniaturization based on the convergence of quantum physics, molecular biology, chemistry, computer devices and technology. Nanotechnology is currently receiving great attention. The possible impact of this industry on economic growth and the economic picture of the world as a whole is being investigated. Among the main supposed achievements of nanotechnology are declared as the appearance of additional properties in a number of materials and the possibility of direct synthesis of objects from atoms and molecules (mechanosynthesis)[1].

Mechanosynthesis is an assembly process carried out simultaneously by a huge number of nanomechanisms assembled into a single device. A set of substances is fed to the input of the mechanosynthesis device, then, according to certain algorithms, the nanomechanisms assemble, and the finished product is obtained at the output.

The main economic aspect of mechanosynthesis is the absence of intermediate stages of material processing and a significant reduction in the amount of waste. Perhaps it will be a completely waste-free technology and production acceleration. In addition, the mechanosynthesis device can also reverse the process, disassembling the input materials down to the molecular or atomic level. This aspect of the technology allows the production of huge quantities of raw materials from the waste, removing the cost of separation and allowing the waste to be disposed of. Both of these aspects significantly reduce production costs. However, there is another important cost parameter - energy intensity. Since mechanosynthesis can significantly reduce the cost of raw materials and their processing, the energy intensity of the production process comes to the fore.

According to calculations, energy costs for production using mechanosynthesis can be about 200 kW·h per 1 kg of product. For calculations, production from carbon or alumina was used, the final product of production could be diamonds or sapphires. These calculations were made for a simple assembly process when the material to be processed is homogeneous. The end product is also homogeneous. The application of the resulting product is quite wide - from construction materials for construction to heavy-duty tools. Such products can be seen as the first step towards the economy of the future. If we assume that the mechanosynthesis device is created and available, then it turns out that the production cost will be $ 4 per 1 kg of crystals of a certain size.

Since nanomechanisms are practically indifferent to which objects to collect, it turns out that almost any item will cost exactly as much as the energy spent on the assembly. In the case of assembling complex devices, an increase in energy consumption will occur due to additional modules for separating the substance at the inlet and feeding it to the assembly front. It seems that a tenfold increase in energy consumption is more than enough to organize any complex objects. Thus, the marginal cost of producing 1 kg of the final product by mechanosynthesis will be $ 40. It is worth noting that the production of complex objects may require substances that cannot be obtained directly from the environment. This applies, for example, to rare earth metals used in electronics [2,3]. Accordingly, the delivery of such substances or the processing of existing ones will be required, which will increase the cost of synthesizing complex objects.

The average density of solar radiation near the planet's surface is about 250 W/m^2. Based on this figure, it is possible to calculate the area of the solar battery, which must be deployed in order to supply the mechanosynthesis device with free energy. Since the maximum known efficiency of solar cells is 40%, calculations can be based on this efficiency. It turns out that the required area of the battery is approximately 2500 m^2. - for devices of simple synthesis and 25 000 m^2 - for devices of complex synthesis.

Summarizing all of the above, we can see that the main consequence of the use of mechanosynthesis in economics will be:

• reduction of costs for production and delivery of a large number of material objects;

• increasing information exchange;

• significant increase in the life cycle of resources;

In the scientific literature of recent years, it is customary to distinguish five industrial revolutions in world economic history [4]:

1. The first industrial revolution (1780-1840) - the content of the steam engine, the textile industry and mechanical engineering.

2. The second industrial revolution (1840-1900) - the maintenance of the railways and the metallurgical industry.

3. The third industrial revolution (1900-1950) - maintenance of the electric motor, heavy chemicals, automobiles and consumer durables.

4. The fourth industrial revolution (1950 - present) - the content of synthetic organic chemicals and computers.

5. The fifth industrial revolution - the content of nanotechnology.

A distinctive feature of the fifth industrial revolution is seen in the ability to build anything that can be designed by manipulating molecules under the direct control of a computer. Nanoindustrialization will lead to a change in society, transforming medicine, biotechnology, agriculture, manufacturing, materials, aerospace, information technology and telecommunications. It is important to realize that today it is nanotechnology that gives impetus to the development of competitive innovations, the emergence of new types of business and the prospects for economic progress for those countries striving to become leaders in the era of globalization of knowledge. The positive side of mastering nanotechnology:

1. Nanotechnology does not require a significant mass of skilled labor and a developed supporting infrastructure. The main reason is that only robots can work at the molecular level.

2. Disappearance of the basis of the market organization of social production and competition. Because nanotechnology makes it possible to produce a wide range of different goods from the same source material.

3. The withdrawal of competition will make it senseless to search for optimal financial institutions and monetary instruments.

4. Many industries will be replaced by nanoindustrialized production.

5. The rapid development of modern technologies has accelerated the innovation dynamics of the economies of developed countries.

6. Nanotechnology transforms inorganic and organic substances at the atomic level and is capable of exploding the modern structure of organization and economy.

7. Nanotechnology frees countries from oil dependence. Nano-manufactured goods can generally replace natural substances.

The negative side of the development of nanotechnology:

1. The disappearance of numerous non-nanotechnological production lines and job losses.

2. Expansion of the monopolistic structure.

3. Obsolescence of many elements of the non-economic infrastructure.

Thus, the main question that will arise before mankind in the era of ubiquitous molecular production is the issue of obtaining and transporting large amounts of energy. For modern infrastructure, transmission losses are too high. In this regard, there are promising developments, but there is still no systematic approach to building the economy of the future.

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