

# Modern challenges in the electronics industry

## Desafíos modernos en la industria electrónica

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### Abstract

The paper analyzes the challenges and current trends in the global electronic industry, carries out a literature review and highlights the gaps in the study of the features of the development of world radio electronics. The article gives a brief historical review of the electronic industry development, provides a characteristic of the modern world electronics market and considers the most important challenges and current trends in the development of the electronic industry.

**key words:** Electronic industry, radio electronics, digital economy, microelectronics.

### Resumen

El documento analiza los desafíos y las tendencias actuales en la industria electrónica mundial. Lleva a cabo una revisión de la literatura y destaca las lagunas en el estudio de las características del desarrollo de la radio electrónica mundial. El artículo ofrece una breve reseña histórica del desarrollo de la industria electrónica, proporciona una característica del mercado electrónico mundial moderno y considera los desafíos más importantes y las tendencias actuales en el desarrollo de la industria electrónica.

**Palabras clave:** industria electrónica, electrónica de radio, economía digital, microelectrónica.

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## 1. Introduction

### 1.1. Relevance of the research

Electronic industry as a machine-building sector today is one of the state's competitiveness factors in the global market, an instrument for ensuring the economic development of the state in the conditions of an unstable environment and an engine of economic growth for other sectors of industry. Currently, the electronics market is one of the fastest growing and most capacious markets in the world that has great potential for its further development. However, there are a number of problems in the electronic industry that require careful study and

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development of optimal solutions. This causes interest in this industry from both the state and business representatives, as well as from the representatives of the scientific community.

## **1.2. Literature review**

To date, the features of the development of the global electronic industry are reflected in a number of theoretical works by researchers from around the world. Some aspects of the study of this issue are presented in publications indexed in the international Scopus database. Demenko O, Savina N. (2019) conduct a systematic analysis of the digitalization process, which directly affects the change in the usual models of industry markets, including the electronics market. In the works of Simoes W. and Wessolowski L. (2017) The analysis and development of directions to improve the sustainability of companies in the field of electronic industry. Fausiah Che Leh (2016) in his writings examines the role of R&D in the development of microelectronics as a segment of the electronics industry in Thailand. Skvortsova N.V., Koptyakova S.V., Balynskaya N.R. (2016) provide a rationale for the role of electronics in the innovative and technological development of the state on the example of the Russian Federation.

## **1.3. The goals and objectives of the study**

In accordance with the relevance of the research topic and the highlighted gaps in the study of the development of electronic industry in the world, the goal was set to study contemporary challenges in the global electronic industry. To achieve the goal, a number of tasks were defined: to consider the historical foundations of the development of the electronics industry in the world, to highlight models for the development of electronics, to give a brief description of the modern electronics industry, to identify key trends in the development of electronics, to present a number of forecasts in the field of electronics in the near future.

## **1.4. Research methods and sources**

Methods of system analysis and synthesis, a statistical method, a comparison method, graphical method, classification and generalization methods were used in article,

The sources of this publication were the scientific works of modern specialists, as well as the information presented on the official websites of organizations such as United Nations Educational, Scientific and Cultural Organization (UNESCO), Institute for Statistical Studies and Economics of Knowledge, HSE of Russia, international research and consulting Gartner, International Data Corporation, Frost & Sullivan, WSTS.

## **1.5. Scientific results**

As a result of the analysis performed by the authors, the most complete a list of modern challenges and development trends of the global electronic industry was formed: strengthening the processes of specialization and integration of companies from the industry; expansion of industry infrastructure; growth in contract production; China's role as a competitive developer of radio electronics products in the global market; increased demand for automotive electronics; increasing the number of developments for "smart" houses "; the shift of production and research bases to the regions; increasing demand for rare-earth, excised minerals, which carries with it a major environmental problem. As a result of a study of the current state of the electronic industry, as well as the main challenges and trends in this area, the authors presented a number of forecasts for the development of radio electronics until 2030: maintaining positive dynamics in the development of radio electronics; maintaining leadership in the production of component base for countries of East and Southeast Asia; an increase in the development and production of products from the segments of medical equipment,

automotive electronics, telecommunications, robotics, the Internet of things; annual increase in the number of remote workers in the field of electronics.

### **1.5. Application area**

The results of the presented study can be applied in theoretical studies examining this segment of mechanical engineering in the context of the digitalization of the economy and a number of negative socio-economic trends, as well as in the practice of companies operating in the electronics market.

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## **2. History and development of the electronics industry**

### **2.1. The historical foundations of the development of electronic industry in the world.**

The beginning of the development of the electronics industry can be considered the first years of the last century, when there was an expansion in the use of telephone communications (primarily for the needs of wartime in the conditions of the First World War). By the middle of the XX century, the impetus for the development of the electronics industry was given by the invention of the transistor, and then by computer technology. However, this industry has made the most powerful leap since the beginning of the 1980s. and stood out separately in the engineering industry. It was from this time that the rapid development of radio electronics around the world began, but mainly in the USA, Germany and Japan. It should be noted that even then in these countries there was a tendency to monopolize (large companies take over smaller players). Thus, the well-known market representatives such as Intel, Siemens, Toshiba, Motorola and others began to take strong positions in this industry. Small companies appeared on the market and, soon, either left it or integrated into larger corporations, receiving technologies, a working strength, management decisions.

By the beginning of the 2000s. more active development of the electronic industry market has been outlined in the countries of the East Asian region. So, in China, the first attempts to form its own electronic industry were made in the middle of the last century, when various research centers began to appear in the country, long-term programs for the development of the electric power industry were developed, the first computer designs appeared (Chinese national firms Legend Group, Great Wall, Start, Founder). By the 2000s, about 50 large companies producing computers and smartphones were already operating in the electronic industry in China, among which the most famous in the world market are Lenovo, Huawei, Meizu, Xiaomi. Nevertheless, both China and the countries of Southeast Asia gained a foothold in the market to a greater extent as the largest production sites for world leaders in radio electronics.

Thus, the electronic industry has developed rapidly in recent decades, and today its potential is far from exhausted. Similar rates of growth (up to 15-17% in the 1990s) were not found in any industry all over the world. Since the 1980s, the pace of development of the electronic industry has outstripped oil production, the automotive and chemical industries, and machine tools.

Today, for some countries, the electronics industry has become a leading sector of the economy (particularly for Singapore and South Korea). The share of electronics in total industrial production is also large in the USA, Japan, and Germany (Kulikova, 2016).

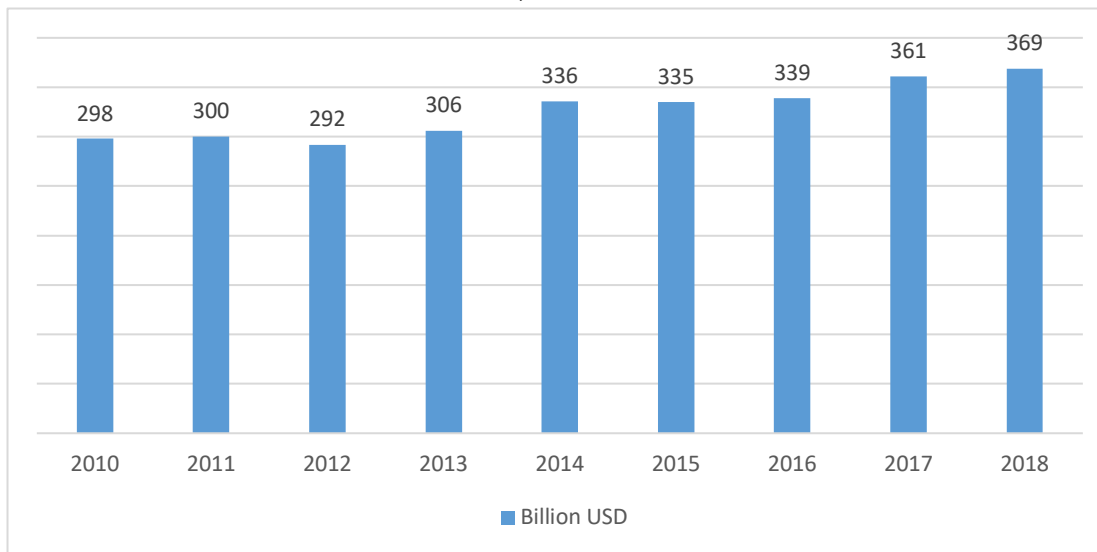
### **2.2. The current state of the global electronic industry**

Thousands of companies producing electronic materials and electronic engineering products, as well as research and development organizations, are represented on the modern radio electronics market. By the 2000s, the

radio electronics market included three segments: consumer, professional and special. The first includes household appliances, cellular communications. The professional segment includes computer technology, telecommunications and medical equipment. In addition, finally, component base production often referred to a special segment of the industry.

According to a number of studies, the global market for microelectronics alone is today about \$ 370 billion. Over the past ten years, the global market for microelectronics has grown by at least \$ 70 billion (Fig. 1):

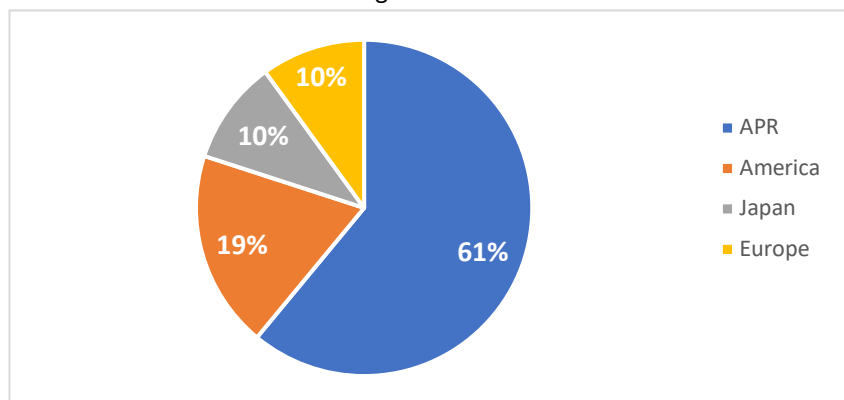
**Figure 1**  
The volume of the global microelectronics market, in 2010-2018



The globalization processes that the world faced at the turn of the century particularly affected the electronics industry, in which the specialization level of individual companies began to rapidly increase. The global market of electronic industry in recent decades was as follows: the most important achievements of electronics were concentrated in the USA, Japan, and a number of countries in Western Europe. China and a number of Southeast Asian countries provided advanced manufacturing.

So, the main market share of microcomponents (more than 60%) today is in the countries of the Asia-Pacific region. This is followed by the United States and other countries of the Americas (19%), Japan (10%), Europe (10%) and others (Fig. 2)

**Figure 2**  
The structure of the global microelectronics market



However, in recent years, enterprises in the Asian region have become increasingly competitive in the field of electronic development. With serious competitive advantages (cheap labor, proprietary technological developments, the presence of large reserves of rare-earth metals used in the manufacture of household appliances, smartphones, electric vehicles, etc.), Asia-Pacific companies are trying to take a strong position in the global electronics market.

The electronics industry also has a clear specialization of companies operating in the electronics market. This was facilitated by high competition in the industry and the need to attract large investments to maintain its market position, which led to the narrowing of the company to certain areas of the electronic industry. For example, specialization is clearly visible in the market of electronic components (element base), where companies specializing in the production of silicon crystals, companies for testing electronic components, and companies for packaging of microcircuits are distinguished. Among the largest manufacturers of microelectronic components, one can distinguish such companies as Samsung Electronics, Intel, SK hynix and some others (Table 1).

**Table 1**  
The largest global manufacturers of microelectronic components

Nº	Company	Revenue, \$ billion (2018)	Market share, % (2018)
1	Samsung Electronics	75,854	15,9
2	Intel	65,862	13,8
3	SK hynix	36,433	7,6
4	Micron Technology	30,641	6,4
5	Broadcom	16,544	3,5
6	Qualcomm	15,380	3,2
7	Texas Instruments	14,767	3,1
8	Western Digital	9,321	2,0
9	NXP Semiconductors	9,010	1,9
	Others	98,648	20,7
	Summary:	476,693	100,0

There was a situation of horizontal and vertical types of integration. So, horizontally integrated organizations involved in the production of element base use their own technological developments and transfer part of the production to other companies, which are usually called contractual. These companies produce electronic products, which are sold on the market by the parent company (the development company). Vertical integration enterprises include a number of the largest companies in the USA, Japan, and Southeast Asia.

### **2.3. The main models of the formation of the electronic industry**

Today, three defined models of the electronic industry can be distinguished: US-Japanese-Korean, European, and Chinese. It is important to note that the main scientific groundwork in electronics today is concentrated in the USA, Japan and Korea. Serious research bases have been created in these countries, and production sites have been sufficiently developed. All this was created over many years and contributed to the fact that to date, complete production chains have been formed in the above countries, which characterizes the first of three models of functioning of companies in the electronics industry.

A number of countries in Western Europe also conduct their own developments in the field of electronics (mostly in the field of telecommunications and automotive electronics), but they do not have large production capabilities, which forces them to send their developments to the production capacities of other countries, as a rule, China and countries of the South East Asia. The European model for the formation of the electronic industry is also characterized by the development of those areas of the electronic industry that are closely related to priority areas of the economy.

The Chinese model is characterized by the fact that contract production has been actively developing in the country for many years. At industrial sites in China, products are manufactured according to the developments of European, North American and other countries of the world. In particular, the vast majority of all components of the global electronic industry (namely, radio components, computer components, etc.) are made in China. Developments of such world-famous brands as HP, Apple, Dell are sent to Chinese manufactures. However, it should be noted that in recent years the country has clearly seen a tendency to increase the number of its own national developments, which are able in some segments of the electronics to compete with American or Japanese products. In China, design centers have been actively developing in recent years, which carry out the design of scientific developments in the field of radio electronics. In the past decade, China has been a leader in the export of office and telecommunications equipment (Tsvetkova N.N., 2016)

### **2.4. Key challenges and trends in the global electronics market**

One of the most important challenges global electronic industry face nowadays is a global slowdown in the pace of innovation. This contain more challenges such as reduction of economic effects in existing electronic industry markets and the need to search for new directions - drivers of growth in the electronic industry. Other group of modern problems is an active increase in competitiveness and gaining leadership in the global market by China and other countries in the Asian region; limited reserves of a number of rare-earth metals that are actively used today in the production of radio electronics (for example, already today the reserves of cobalt and nickel, according to experts, will end in 15-20 years). Major volume of these resources are located in Asian Region. A number of distinctly emerging other trends in the industry also characterize the electronics industry as a growing but changing sphere of mechanical engineering.

So, as a tendentious direction in the development of world electronics, we can name the rapid expansion of the industry's infrastructure, including the creation of various design centers, fabless companies, electronic

development test centers, and factory foundations. So, in design centers the design of scientific developments is carried out. Foundry factories - contract manufacturing factories - specialize in the manufacture of microelectronic components according to the development of the customer company (these structures can also provide services for patenting products of the developing company). It is important to note the trend of the gradual destruction of the system, in which China was the largest, and in some cases the only production base for the whole world. Currently, production is shifting to other countries of the world, as well as to the direct markets of customers and end users. China, in turn, from the production site is gradually turning into the largest competitive electronics developer in the world.

Fabless companies, by contrast, carry out product development without further production. In addition, such structures offer services for the promotion of finished products, as well as after-sales services. Accordingly, development testing centers are engaged in testing products manufactured in factory foundries. It should be noted that such industry infrastructure has developed over several decades, under the influence of trends and a number of factors (economic, political, social, legal, etc.) (Karpukhina N.N., 2013).

All over the world today, there is a tendency to expand electronics facilities in small cities, where entire clusters are formed with the necessary infrastructure, with the participation of both manufacturing companies and research centers, research and development bureaus, as well as commercial companies interested in promoting advanced developments electronics. Placing electronic industry facilities in small towns allows companies to reduce rental costs, pay wages, minimize negative trends of high levels of competition, and others. Today, electronics clusters are widely known in California (Silicon Valley, USA), cluster of the «Auvergne-Rhône-Alpes» (France) region, telecommunication cluster NorCom (Denmark) are widely known today). In Italy, in order to increase the level of development of depressed regions (Sardinia and Sicily), was created an electronic cluster of the type "Silicon Valley". The main development of the cluster was ST Microelectronics. Stanford University and HP (Hewlett Packard) were involved. In Germany, 3 of the 7 global high-tech clusters (in the cities of Hamburg, Munich and Dresden) are the well-known research clusters within which high-tech production is developing.

In recent years, worldwide segments of the electronic industry associated with the management of "smart home", as well as in the field of automotive electronics, have been actively developing. "Smart home" - organized spaces for people to live with the help of automation and high-tech devices. This concept includes control of lighting, heating, video surveillance systems, control of household appliances, air purification and air conditioning systems, security systems, monitoring systems for children, the elderly, animals, etc. Companies in North America, Japan and Western are working on the development of these areas Europe and the Asian region (for example, the Chinese company Xiaomi). The technology market for the "smart home" grew in 2018 in the countries of the Latin American region (+ 6%), Europe (+ 3%), and the Asia-Pacific region (+ 2%). Until the end of 2019, it is expected that, in general, this market will show growth of 6%, and in the next decade it will be more actively developing.

The uneven pace of innovation characterizes the global electronics industry today. So, for example, in a number of developing countries, the amount of R&D financing in industry is insufficient, there is a lack of the latest equipment and technology, there is no state industrial policy, there is a weak economic efficiency of innovations with a small scale of implementation in the commercial sector, etc.

Research and development (R&D) includes three groups of activities: basic research; applied research; experimental design and technological developments. These groups, as well as R&D as a whole, are one of the indicators of the country's scientific and technological development. Thus, according to the rating of the

countries of the world in terms of R&D expenditures (the level of R&D expenditures is expressed as a percentage of the gross domestic product (GDP), Ireland, Kenya, Italy, Sweden and Australia allocate most of all for R&D) (Table 2)

**Table 2**  
The level of expenditure on R&D (Research and Development Expenditure) of the countries of the world, 2017

State	R&D expenditures as a percentage of (GDP)
Ireland	4,3
Kenya	4,2
Italy	3,3
Sweden	3,3
Australia	3,1
Czech Republic	3,0
Georgia	2,9
Ethiopia	2,9
USA	2,8
Belarus	2,5
Russia	1,1

However, not always high R&D expenses lead to a large number of high-level and competitive developments in the world markets (we are talking about countries such as Ethiopia and Kenya). Thus, this indicator is indicative, but does not provide a complete picture, including the quality of research and development. A share of GDP does not demonstrate the absolute scale of R&D funding. Thus, in 2018, the absolute largest R&D expenditures were in the USA (502.9 billion dollars), China (408.8 billion dollars), Japan (170 billion dollars) (Table 3)

**Table 3**  
TOP 10 countries in terms of R&D funding

Rating	Country	R&D financing, in billions of dollars
1	USA	502,9
2	China	408,8
3	Japan	170,0
4	Germany	114,8
5	The Republic of Korea	74,1
6	France	60,8
7	India	50,3
8	United Kingdom	46,3
9	Brazil	38,4
10	Russia	37,3

Today, it should be noted that increase in research costs in more promising areas, as current technologies have almost reached their limit of development. Therefore, the technology of transistors has almost exhausted its ability to improve performance, so huge amounts of money are now invested in quantum technologies (including the development of a quantum computer, quantum communications and sensors). In the field of quantum technology research to date, countries such as the United States, Canada, and China have stood out. Among the first developers of quantum computers, experts name three companies - Google, IBM, Alibaba Group.



## 2.5. Global electronics market development forecasts

The trends and challenges of recent years allow us to make a number of forecasts in the development of the electronics industry for the near future. In the near future, the growth of this industry sector will maintain its momentum in recent years. It is expected that in the coming years the growth rate of the global electronics market will amount to an average of 2.2% per year. The leaders in the production of semiconductor components will remain the countries of East and Southeast Asia: Malaysia, China, Taiwan, South Korea and Singapore.

In the near future, according to forecasts of the International Data Corporation (IDC), a sharp drop in demand for electronic micro-components is expected by the end of 2019 (up to \$ 440 billion, which is 7.2% less than in 2018). However, in subsequent years, growth will be observed, although not significant. According to IDC, by 2023 the volume of sales of the element base will reach \$ 524 billion.

In the near future, among the dominant areas of the electronic industry, the most promising are the following: electronic information processing systems; communications and telecommunications; household electronics; industrial electronics; medical, scientific, automotive.

The main drivers of the electronic industry, according to experts from the international consulting company Frost & Sullivan, will be the automotive and telecommunications industries, robotics, and the Internet of things. It is expected that it is in these areas that research and development efforts will intensify. The market for virtual and augmented realities will increase. Telemedicine will receive special development in the near future (for example, remote monitoring of the patient's condition, etc.).

The infrastructure of the industry will continue to expand. For example, in some design centers, work can be carried out simultaneously on hundreds, and sometimes thousands, of projects, which makes such radio-electronic infrastructure facilities a promising direction of development. Moreover, employees of these factories often work remotely and live in various cities of the world. It is expected that the growth in the proportion of distance workers employed in the electronics industry will increase annually.

It should also be noted that the main driving force behind the development of the global electronics market in recent decades has been semiconductor technology, which remains the current development driver. The miniaturization and lower cost of semiconductor devices caused the appearance of the so-called "killer application", which provided a multiple increase in demand for electronic components and the growth of the electronics market as a whole. Such "applications" were television (since the 1970s), computer (since the 1980s), the Internet and mobile communications (since the 1990s). In the early 2000s, a new application did not appear, and the radio electronics market continues its, although not so active growth. This happens, among other things, due to the improvement of new technologies and the development of joints, for example, "consumer electronics-computer", as is the case with smart home technology. It is assumed that when a new application, the killer application, is found, the electronics industry again expects a round of rapid growth. However, while the question of the emergence of a new "application" remains open.

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## 3. Conclusions

The electronic industry is one of the phenomena of economic sectors in most countries of the world, as in recent decades it has developed at an unprecedented pace, outstripping the growth rates of industries such as oil production, the chemical, machine-tool and automotive industries. The potential for further development of radio electronics remains high today. Nevertheless, there are a number of limiting trends and features that can

impede further development of the industry: the lack of modern application (“killer application”), which has been the driver of the rapid development of radio electronics in the last fifty years; inadequate R&D funding in a number of developing countries; monopolization of the market, which impedes the development of small firms in the electronics market, etc. Among the positive trends can be noted the active expansion of industry infrastructure; Opportunities for the development of other areas of the electronics industry (automotive electronics, medical equipment, equipment for smart homes, robotics, etc.); the shift of radio electronics objects to small cities and others.

Based on the data of international organizations and reputable research consulting companies, as well as the results obtained in the course of studying the features of the global electronic industry, it can be assumed that the industry will maintain positive growth dynamics over the next decade; opportunities for development of telemedicine, robotics, automotive electronics, telecommunications equipment will increase; labor resources employed in this sector of industry will increasingly shift towards remote employment. An important issue will be the regulation of the production of rare-earth natural resources used in the electronic industry, and minimizing their impact on the environment. The search for promising segments of electronics, which serve as a further development driver, will become increasingly relevant.

The key provisions of this work, recommendations and conclusions can be used in further theoretical developments in the field of development of the global electronic industry, as well as in the practical activities of radio electronics companies.

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