THE RESEARCH OF GLOBAL VALUE CHAINS - CONCEPTUAL, THEORETICAL AND PRACTICAL ASPECTS

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ИЗСЛЕДВАНЕ НА ГЛОБАЛНИТЕ ВЕРИГИ ЗА СЪЗДАВАНЕ НА ДОБАВЪЧНА СТОЙНОСТ - КОНЦЕПТУАЛНИ, ТЕОРЕТИЧНИ И ПРАКТИЧЕСКИ АСПЕКТИ

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Abstract: *The high-priority topics to be taken into consideration are the integration processes in the creation of global value chains, in particular - the concept of global value chains, value creation activities, the construction of global chains, the driving forces of integration in global value chains, types of governance in global value chains and some examples of value-added trade. The object of analysis is the possibilities of Germany as a European leader in digital cooperation with the Russian Federation. For this purpose, a brief overview of the state of the Russian digital economy, possible digital areas of cooperation between Russia and Germany, the Russian-German initiative for digitalization of the economy and the German-Russian concept of „Factory of the Future" in the context of accelerated digitalization of the Russian economy.*
Key words: *global value chains, digital economy, smiling curve, factory of the future, internal logistics, models of interaction, digital technologies, german-russian initiative, factory of the future, digital factory, intelligent factory, virtual factory.*
JEL Codes*: F01, F15, O14, O31.*

Резюме: *Високоприоритетните теми, които трябва да бъдат взети под внимание, са интеграционните процеси при създаването на глобални вериги на стойност, в частност – концепцията за глобалните вериги на стойността, дейностите по създаване на стойност, изграждането на глобалните вериги, движещите сили на интеграцията в глобални вериги на стойност, видове управление в глобалните вериги на стойност и някои примери за търговия с добавена стойност. Обект на анализ са възможностите на Германия като европейски лидер в цифровото сътрудничество с Руската федерация. За целта е направен кратък преглед на състоянието на руската цифрова икономика, възможните цифрови области на сътрудничество между Русия и Германия, руско-германската инициатива за дигитализация на икономиката и немско-руската концепция за „Фабрика на бъдещето" в контекста на ускорената дигитализация на руската икономика*
Ключови думи: *глобални вериги за стойност, цифрова икономика, усмихната крива, фабрика на бъдещето, вътрешна логистика, модели на взаимодействие, цифрови технологии, немско-руска инициатива, фабрика на бъдещето, дигитална фабрика, интелигентна фабрика, виртуална фабрика.*
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Part I. Conceptual, theoretical aspects
GLOBAL VALUE CHAINS AS A NEW PHENOMENON IN THE WORLD ECONOMY

Introduction

The term „global value chains“ (abbr. GVCs) is relatively recent in scientific thought. Its concept has become widespread in scientific and practical literature, first being used to identify the competitive advantages of a company and assess the effectiveness of their activity in the global market.

Under such a chain, understood „the totality of various types of company activities aimed at the development, production, marketing, delivery and service of its digital products“.

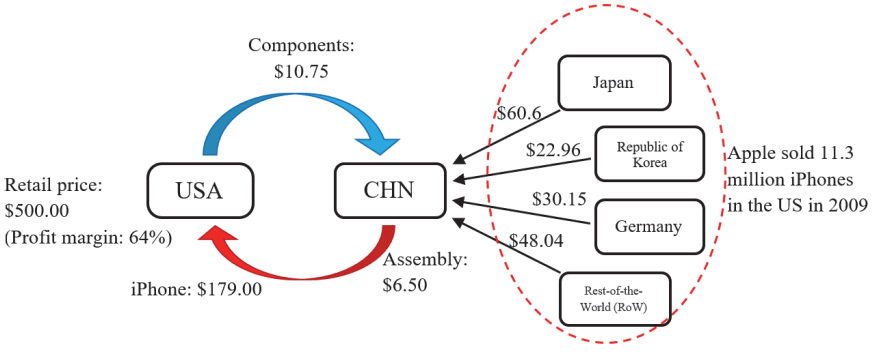
The value-added chain in Michael Eugene Porter theory consists of the main and auxiliary activities (infrastructure, personnel management, Information Technology, logistics). National value added contained in a country's exports: the value added in the export of intermediate and final products and services consumed by the importer; the value added that the importing country exports to another country and the value added that the importing country re-imports to the country of origin. (Porter M., 1998)

Referring to Lubskaya E.V. the term „value chain“ was first proposed in 1960-1970. (Lubskaya E.V., 2017) This issue is addressed by Michael Porter in his work „Competitive Advantage“. Under such a chain, the American economist understood „the totality of various types of company activities aimed at the development, production, marketing, delivery and service of its products“. (Porter M., 2016)

According to the World Trade Organization (abbr. WTO) „Trade in value-added and global value chains: statistical profiles“ the aforementioned profiles show the value-added content in an economy's exports, its participation in global value chains and the contribution of services to the value-added content of exports. They also cover trade in intermediate goods and services. (Trade in value-added and global value chains, 2021) [2]

1. About the concept of global value chains

Rafael Kaplinski's publication provides a conditional example of what „global value chains“ represent when creating the Apple iPhone.



Scheme 1. Global value chains in the mobile sectors - example with Apple iPhone
Source: constructed by Kaplinsky R., 2013.

[2] The statistical profiles show: - the content of value added in the export of the economy; - participation in global delivery and sales chains; - contribution of services to create added value of exports; and - trade in intermediate goods and services.

The added value created by China is much lower than that of other countries. Even the US supplies China with more components in terms of value than China produces in the added value of assembling the final product. At the same time, the contribution of other countries (Japan, Korea, Germany, Roswell, NM, USA - Industrial Air Center) to the final added value is also significantly higher than that of China.

China's export statistics will include all previous value added. China's exports will be significantly higher than other countries. The United States derives the largest profit from this global chain of creation, adding a retail margin of 64%. The product enters the consumer market with a cost of $ 500, although the cost of the Apple iPhone is only $ 179. (Global Value Chain Development Report 2021)

Gereffi-Sturgeon approach „management in the value chain“: Having considered the evolution of the general concept of the chain, they came to the conclusion that there are many similar definitions that are used to describe the complex system of relationships in the global economy.

The concept of „global value chains“ reflects all stages of activity in the production chain of the final product, the management system of this chain and the amount of added value at each stage of production or service provided.

In that regard, Gary Gereffi identified two types of value chain management: producer-driven chains and buyer-driven chains. The manufacturer-driven chain is coordinated from top to bottom, representing vertical integration, mostly international manufacturing firms. The second type is coordinated by buyers, mainly the largest retailers like Walmart or branded manufacturers of certain brands (e.g., Nike) to manage global production and distribution depending on the market situation. Global buyers place orders and help create, shape and coordinate global value chains.

Timothy J. Sturgeon divided product chains according to the scale of activity into local (scale – municipality), local (one country), international (more than one country), regional (trade block from several countries) and global (region „triads“ – USA, Western Europe, Asia).

In addition, there are two ways to enter and move along the value chain: moving „from top to bottom“ and „from bottom to top“. The first approach describes the company's activities in the process of vertical integration of production, when the development of the lower, initial stages of production takes place.

The second way is an increase in the role within the global value chain. It consists of several stages: during the first stage the company carries out assembly, during the second it carries out turnkey production, during the third it participates in the research and design stage and lastly, the formation of its own brands. The process is demonstrated by the so-called „smile curve“ diagram, which characterizes the degree of profitability of various stages of the production process. (OECD, 2013 Interconnected Economies)

The new Global Value Chain Development Report 2021. Beyond Production. November 2021, emphasizes the following more important aspects:

First, The Global Value Chains are cross-border networks that deliver a product or service from concept to market;

Second, The activities that add the most value to these chains are usually performed before or after production, such as product design or marketing;

Third, Intangible Assets and Intellectual Property (brands, patented technologies and supply chain management know-how) are increasingly determining the ability of companies to manage and benefit from GVC. (Global Value Chain Development Report 2021)

For example, analyzing opportunities of Business Collaboration between Canada and Czech Republic, Hungary, Poland and Slovakia – or the so-called Visegrad Group or the V4, Muhammad Mohiuddin emphasizes the following points:

a. Technological development and opening of international market promoted the GVC where manufacturers slice up their value chain and disperse their activities to suppliers in a competitive way regardless of geographical borders.

b. According to the concept of global value chains, corporations decide what their core competency is and where its focus will be, and what activities can be outsourced to third parties making them more competitive.

The strategy of Global Value Chain can be observed in the following „Smiling Curve“ or „Smile/Smiling Curve“. (Mohiuddin M., 2018)

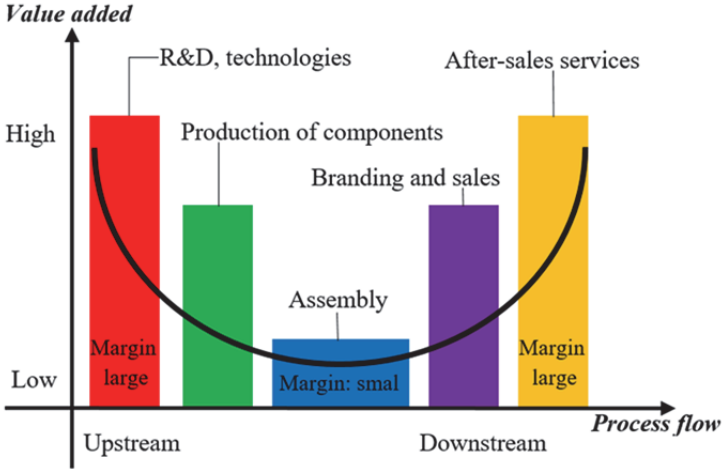


Diagram 1. „Smiling curve“ high and low added values
Source: Mohiuddin M., 2018.

The production chain starts from developing the idea of the product or service, research and development (R&D), going through the manufacturing process and then utilizing logistics and marketing to bring the product to the market.

Conslusion

First, International production, trade and investments are increasingly organised within so-called global value chains where the different stages of the production process are located across different countries. Globalisation motivates companies to restructure their operations internationally through outsourcing and offshoring activities.

Second, Corporations try to optimise their production process by locating various stages across different sites. In the past decades there has been a strong trend towards the international dispersion of value chain activities such as design, production, marketing, distribution, etc.

Third, The concept of global value chains is key to business digitalization, export orientation and competitiveness of economic units. This appears to be a modern foreshadowing for countries to engage in upward and downward linkages in world production. It shows the possible directions for the transformation of global chains after the pandemic and technological modernization to innovation-intensive industries.

It is found that in today's global economy, 70% of international trade involves global value chains. (According to estimates Global Value Chain Development Report 2021, The Organisation for Economic Co-operation and Development, 2021)

2. Value creation activities

The doyen of global value chains Michael Porter draws attention to the following categories of value creation activities: (Porter M., 2016)

- *Internal logistics* – includes activities related to the receipt, storage and distribution of everything that goes into the manufacture of a product: this includes loading and unloading operations, warehouses, inventory control, organizing transport scheduling, payments to suppliers;
- *Manufacturing process* – includes activities related to the transformation of raw materials into an end product. These are, for example, the operation of technical equipment, packaging, assembly, maintenance of equipment, testing, the operation of factories and production centers;
- *External logistics* – includes activities related to the collection, storage and actual delivery of products to customers. This is the storage of finished goods in warehouses, loading and unloading operations, the work of transport delivering products to customers, processing orders and determining the time of their execution;
- *Marketing and retail* – includes activities aimed at ensuring that customers can purchase a product and, moreover, want to purchase it. This includes advertising, promotion of products on the market, the work of sales personnel, quotas, the choice of a sales channel, any relations to it, pricing policy;
- *Service* – activities in this category are related to the provision of services to maintain or even increase the value of the product: installation, repair, training in the utilization of the product, supplying of spare parts and customization of the product in accordance with the needs of a particular consumer.

The author concludes that no country can be competitive in all production areas. Michael Porter's strategy suggests that the common expansion of exports will be facilitated by the transfer of products abroad. In some industries, positions will undoubtedly be lost, but in others they will become stronger.

3. Construction of building global value chains

According to Smorodinskaya and Katukov, international companies can build value chains by: (Smorodinskaya N. and Katukov D., 2017)

- the initial connection, where a product idea is formed (the practice of General Motors, Sony, Apple);
- the final connection with the organizer being a distributor company (such as Walmart) or a company with a world-famous brand (such as Nike).

To illustrate the benefits of creating global value chains, several illustrative examples are given, namely:

The first example is the Walmart chains, which cover more than 60.000 suppliers, 80% of which are located in China. (Gereffi G. & Christian M., 2009)

A second example, Nike chains, with 38.000 employees in the United States, form a network of 930 companies in 50 countries with a total of over 1 million employees. (Locke R. M., 2013)

A third example is Boeing, which in 2005 reorganized the production scheme of the Boeing-737 and created a new global value chain. In it, foreign contractors from Japan,

Italy and the United Kingdom assemble full-fledged aircraft modules. The modular system reduced the line assembly time by almost 6 times. More efficient supply chain coordination has brought the company additional cost savings.

Fourth example, a new global value chain for the production of Boeing-787 Dreamliner parts. It includes dozens of suppliers around the world (from Australia, India, Spain and other countries), which reduces assembly time and time for research and development. (Huwart J.-Y. & Verdier L., 2013)

Fifth example, thanks to the outsourcing service of the Swedish Ericsson, Estonia became a manufacturer of telecommunications equipment by the 2000s, and 10 years later - an exporter of services for the creation and support of data transmission systems. (Tiits M. & Kalvet T., 2012)

The global semiconductor value-creating model for consumer electronics, which includes:

i. The cluster structure for global value chains:

- cluster in Japan: production of flint plates;
- cluster in the USA: plate processing;
- cluster in the USA Alaska – division of plates into crystals;
- cluster in Malaysia – assembly, testing and packaging of chips;
- cluster in Singapore – storage and distribution of chips;
- cluster in China – integration of chips into consumer goods;
- cluster in the USA New York – sale of electronics to the final consumer.

ii. The global trade flow generated by the key links of global value chains

- from Japan to the USA;
- from the USA to Malaysia;
- from Malaysia to Singapore;
- from Singapore to China;
- from China to the USA.

iii. Countries are members of the respective links

- Stages of processing and manufacturing of microcircuits: trade flow of 1.340 trillion dollars (15 countries - China, Hong Kong, Singapore, Taiwan, USA, Malaysia, Japan, Germany, Philippines, Mexico, Thailand, France, Vietnam and Netherlands);
- Suppliers of raw materials and semi-finished products - flow from $ 36.8 billion (China, USA, Japan, Germany, Korea, Taiwan, UAE, Singapore, UK, Italy, Norway, Mexico, Netherlands, France and Brazil);
- Suppliers of the 2nd level for the link of assembly and testing of microcircuits - a flow of 23.7 billion dollars. (China, Germany, USA, Japan, Taiwan, France, Korea, Hong Kong, Italy, UK, Mexico, Netherlands, Poland, Canada and Belgium).

The following important aspects can be distinguished from the commented interpretation:

a. Business network, which is built by global companies as a collective project with its own time frame and sequence of actions;

b. The new value is created jointly by a network of legally independent but functionally related firm suppliers;

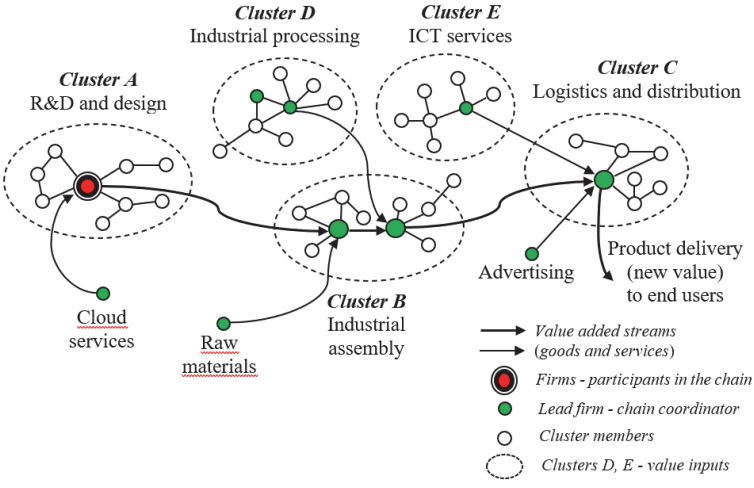
c. Most of the suppliers belong to one or another highly specialized regional cluster;

d. The company, the organizer of the chain, is not present in most of the links, does not seek to control key links, it acts as the coordinator of the project;

e. By coordinating the chain, the leading company increases its income by maximizing the total income of all participants;

f. An additional increase in added value is brought by synergistic feedback effects, that is, skillful coordination of the actions of network partners.

Offering a *typical scheme* for the organization of global value chains, Smorodinskaya N., Malygin V. and Katukov D. point out three important points:



Scheme 2. Cluster organization of a global value chain
Source: Constructed by Smorodinskaya N., Malygin V. and Katukov D., 2017.

First aspect. Firms that provide various types of business services (information, intellectual, etc.) always participate in the chains of a particular profile. For example, in the US and the UK, firms like Apple or Dyson are involved in global chains through the development of new products, but do not have their own production facilities – *„factoryless goods producing firms"*;

Second aspect. The nodes of global value chains are usually not any cluster agglomerations, but the most successful clusters of the innovation type (innovation clusters) – constantly deepen their specialization on the basis of innovations that create new products on a collective basis and in a continuous mode, form an open and relatively stable ecosystem;

Third aspect. In order to enter local clusters and build global chains, the global value chains host company itself must have maximum organizational mobility.

4. Driving forces of integration in global value chains

The decomposition and restructuring of the value chains means the discovery of all elements of the chain, as well as the possible ways to integrate information technology by structures and units. The emerging e-market is differentiated as open - any number of sellers and buyers, or semi open - one buyer and many sellers.

Value-added chains are characterized by the following components, namely:

First, the decomposition and identification of the elements as:

- ✓ basic, including marketing and sales, internal and external logistics, processing, maintenance;

- ✓ additional - human resources management, technological development, corporate infrastructure and supply.

Second, models of interaction that are built based on the following schemes:
- „one to one";
- „many to one";
- „one to many";
- „many to many".

Third, restructuring and integration of information processes in different units and stages.

The result of combining the models of interaction and integration of value chains are the possible structures of business models: (Bonev, P., 2014)
- E-shop;
- Electronic delivery (E-procurement);
- Electronic auction (E-auction);
- Electronic halls (*email* or e-mail);
- Third party marketplace;
- Virtual community;
- Value chain service provider;
- Value chain integrators;
- Collaboration platforms;
- Information brokerage, trust, etc. services (Information brokerage, trust and other services).

In the interpretation of LI Yong and Zhao Zhongxiu the opinion that a striking feature of the twenty-first century global economy is the fragmentation of the production process along global value chains (GVCs). Despite being called „global", the chains are often regional, with three main centres in North America, Europe and East Asia, of which the latter has witnessed the most dramatic GVC development, giving rise to the *concept* „*Factory Asia*". (Timmer, Marcel P. et at, 2014; Li Y., Kong, X. X. & Zhang, M., 2015)

In the research project GLOBAL VALUE CHAINS AND INDUSTRIAL DEVELOPMENT. Lessons from China, South-East and South Asia are launching the following *five key messages* on global value chains:
- The global value chains are a major component of the global economy and their importance is increasing;
- GVC participation hinges on low trade barriers and trade costs, but also on domestic conditions;
- The global value chains have been regional rather than global, and Factory Asia is the prime example of this;
- GVC integration increases incomes and employment, and is a driver of structural change;
- GVC integration may have adverse environmental effects if participation entails laxer environmental protection laws.

The integration processes in the global value chains are driven by:

i. *Trade Liberalization Helps*

GVCs operate across borders and therefore rely on trade as a tool for integrating dispersed activities. It is emphasized that „the global value chains phenomenon has been

strongly associated with trade and investment liberalization, and a reduction in the costs of international trade.“ Trade liberalization makes the international movement of goods easier, less costly and faster by relaxing tariff and non-tariff barriers to trade.

ii. *Big Geography Matters*

Proximity to an economic hub increases the prospects of integration into a global value chain that operates around that hub. The story of Asia’s integration into GVCs, captured by the *„flying geese“* model, is one of export-oriented industrial activities flowing from more advanced countries in the region to less economically developed countries in geographic proximity.

Examples of such processes are:

- The Republic of Korea and Taiwan Province of China were integrated into Japanese GVCs;
- China relied on its connection to Hong Kong Special administrative regions of China;
- Singapore was initially a hub for Malaysia and Indonesia. Value chains are often organized regionally rather than globally;
- India and Vietnam increased GVC participation within chains that end in Southeast Asia and China.

Consequently, value chains are often organized regionally rather than globally.

iii. *Small Geography Matters Too*

Special industrial zones can attract GVCs by providing a local environment with a more liberalized regime than the rest of the country, and thereby providing benefits associated with clustering.

iv. *Investment Incentives Should Not be Overestimated*

The emergence and expansion of global value chains has been linked to offshoring of industrial activities by lead firms in the United States, Japan, Europe and recently from emerging countries like China.

v. *Building Up Manufacturing Competitiveness Comes First*

Global value chain integration may improve industrial competitiveness through technology transfers and other types of learning. *So that* developing a competitive industry may be a prerequisite for successful GVC integration.

vi. *Integration Requires Investment, Investment Requires Financing*

Integration into GVCs requires the establishment of manufacturing facilities, and upgrading implies investments in tangible (capital equipment, technology licenses) and intangible (better educated employees, training, learning-by-doing) assets. (Global Value Chains and Development, 2015)

Conclusions

First, Global Value Chains are defined as a „phenomenon“ where the making of a product is spread across countries, regions and continents benefiting from comparative local cost advantages to become globally competitive. GVCs are value chains, which are activities that companies engage in to bring a product from development all the way to the final consumer.

Second, global value chains were developed as priorities initially in Japan, whose production base is in several East Asian countries. These processes later involved Chinese industry to gain access to the benefits of location. This is reflected in the development of

national export platforms in order to avoid adverse exchange rate developments. Subsequently, China's industry has become a „global trading platform for digitalization".

Third, The „Trade in value-added and global value chains" statistical profiles provide insights on the actual contribution of foreign trade to an economy, the interconnection of national economies within global value chains and the impact of the services industry on trade.

Participation in global value chains and the international fragmentation of production, will inevitably lead to increased job opportunities and economic growth. The COVID-19 pandemic has highlighted the urgent need to understand the dependence of many countries on suppliers across the world. It is no coincidence that the new global paradigm of the World Bank for the participation of countries in value chains added focuses on the revolutionary approach to participating in global value chains. (Koishibekov, K., 2020)

In that regard, some developing countries have fully embarked on these processes. Others believe that GVC recreates the periphery model – „good" jobs concentrated in the north and „bad" jobs in the south. The competitiveness of the economy can be achieved by combining the competitive production costs of value chains plus the application of high technology. A clear example of this is China, India and Singapore, which achieve significant economic growth through value chains. The right strategies can help developing countries maximize their participation in global value chains.

Part II. Practical and applied aspects

GERMANY AS A EUROPEAN LEADER IN DIGITAL COOPERATION WITH THE RUSSIAN FEDERATION

Introduction

The term Industry 4.0, also known as I4.0 or simply i4, first appeared in the Federal Republic of Germany in 2011. It is part of the German federal government's new high-tech strategy to accelerate the computerization of production. The term described a set of technological changes in production. The term sets out priorities for a coherent policy framework in order to maintain the global competitiveness of German industry. (See for details: Smit, J. & St. Kreutzer, 2016)

The Industry 4.0 concept was presented to the public for the first time in the same year at the Hanover Fair on 4-8 April 2011. At its initiative, a working group composed of academic and university staff, managers and businessmen, led by Siegfried Dyce of Robert Bosch GmbH and Henning Kagermann of the German Academy of Sciences and Engineering, who launched the main aspects of the strategy. Industry Working Group 4.0 proposed a set of recommendations from the German federal government for the introduction of a new digital industry.

The digital economy refers to a wide range of economic activities in which digitized information and intellectual knowledge are used as key factors in production. The wide scope of the application of digitalization processes requires sustainable cooperation between the parties. In this context, the possibilities for cooperation between the Russian Federation and Germany in the field of digital processes are considered.

In this commented aspect, Jann Raveling defines the main challenges for companies focused on: (Raveling, J., 2020)

- Standardization of interfaces. In Industry 4.0, however, every system must be able to communicate with every other system;

- IT Security Infrastructure. The Internet of Things only makes sense if data can be securely stored and exchanged online;
- Fast and accurate human-robot communication;
- Individual production requires individual marketing, sales and business processes;
- Self-regulating processes in flexible factories;
- Big data and artificial intelligence – optimization of processes through data evaluation;
- Work and training in digitization;
- Customer-oriented thinking. The customer should always be at the center of attention of any enterprise.

1. Status and assessment of Russia's digital economy

In recent years, the government of the Russian Federation has shown an open interest in cooperation with all developing countries. The state of digitalization in the country shows that the digital economy of Russia is actively developing. This is a serious prerequisite for its participation in mutually beneficial digital projects. In this context of reflections and as a basis for fruitful cooperation, let us note some important aspects of the state of digitalization in Russia, namely:

(a) According to Digital/McKinsey, in five years the digital economy of the Russian Federation has grown by 59% and all sectors of the economy by 7%. It is noteworthy that Russia is ahead of the European Union, including Germany, on the availability of broadband and the best positions in terms of human capital. In terms of the number of Internet users - first in Europe and sixth in the world, users of the portal for public services - about 80 million people, about 10% of online banking customers use only mobile applications, 60% of Muscovites register as a doctor online. (Digital/McKinsey, 2018)

(b) The contribution of the digital economy to Russia's GDP and its components compared to other countries: USA – 10.9%, China – 10 %, European Union - 8.2%, Poland, Czech Republic – 6.35 %, Brazil – 6.2%, India – 5.5%, Russia – 3.9%.

(c) The potential effect on GDP from the digitalization of the economy by 2025 is estimated to reach between 4.1 and 8.9 trillion rubles, which will amount to 19-34% of the total increase in GDP. (World Trade Organization, 2019)

If one takes into account the important indicators for a country's participation in global value chains: value-added shopping centers in different aggregate networks (ICT sector), respectively traditional trade networks, simple trade networks of GVCs, integrated trade networks of GVCs (all goods and services), a different, but *real and specific picture* is to be distinguished:

First, For the period 2000-2017, nothing significant has changed. In 2000 and 2017, Russia corresponded with the same digital counterparties: most often with Kyrgyzstan, Kazakhstan, Belarus, Mongolia and less frequently with Estonia, Cyprus, Lithuania and Latvia.

Second, Russia is too far from participating in global value chains with major digital leaders – such as the US, China and Germany. Moreover, the aforementioned countries have not been associated with one another in the context of GVCs for a very long time - about 18 years.

Third, This means that profitable global value chains bypass Russia and it cannot „intertwine“ in their favorable financial and technological parameters.

2. Views on possible digital areas of cooperation between Germany as a European leader and the Russian Federation

At the end of 2013, the Digital Agenda 2014-2017 became part of the coalition agreement between the Christian Democratic Union of Germany/Christian Social Union in Bavaria and the Social Democratic Party of Germany, which set out the principles of interaction between government departments, entrepreneurs, and trade unions, as well as science and society in the digital economy.

The Agenda is based on the Industry 4.0 strategy, which is designed to provide answers to the challenges of the forthcoming Fourth Industrial Revolution – back in 2011.

The Federal Republic of Germany was the first to justify the reasons, formulate the content, and then put forward the concept of timely adaptation of the German industry to the upcoming innovative and technological challenges, developed a set of state measures to support businesses, primarily small and medium-sized ones. A special network communication platform „Platform Industrie 4.0“ was created – bringing together representatives of the state, business, science and education.

The Industry 4.0 map provides an overview of over 350 practical examples from the industry, highlighting Germany's role as a leader in Industry 4.0.

Key digital business models have been identified, enabling new digital technologies, including areas of mutually beneficial cooperation, namely:

- Cyber-physical systems (CPS);
- Cloud computing;
- Edge computing;
- IIoT/industrial internet platforms;
- Industrial Internet of Things (IIoT);
- Digital twin;
- Software-defined and service-oriented manufacturing;
- Great information;
- Artificial Intelligence. (Plattform INDUSTRIE 4.0., 2020)

Russia adopted the program "Digital Economy of the Russian Federation" in mid-2017. The document developed by the Government of the Russian Federation provides a set of measures in the field of markets and industries (smart cities, public administration, digital healthcare, education), platforms and technologies (research and technological development), framework conditions (legislative and regulatory environment, personnel), as well as management systems (information infrastructure and security).

Five basic directions of development of the digital economy in Russia for the period up to 2024 are defined:

- ✓ Regulatory regulation;
- ✓ Personnel and education;
- ✓ Formation of research competencies and technological reserves;
- ✓ Information Infrastructure;
- ✓ Information Security.

The software tools of the two countries are the basis of their cooperation in the field of digital technology. Although there are a few projects to digitalize the economies of the two countries, the Russian Federation cooperates thoroughly with Germany within the framework of the European Union.

In the aforementioned aspect, the focus is on the current forms of cooperation in the field of digital transformation of the two economies:

• In June 2016, at the St. Petersburg International Economic Forum (abbr. SPIEF), Russian Railways and Siemens concluded a Strategic Memorandum of cooperation for a period of five years – in the field of digital technologies, railway automation and telemechanics;

• The end of April 2017 in the framework of the traditional industrial fair in Hannover „Russia-Germany: digital economy and industry 4.0. Business opportunities "set the stage for identifying Russian and German markets of the digital economy and searching for interaction models between entrepreneurs in this field;

• In early June 2017, a joint platform was created for the exchange of know-how and the discussion of projects of German-Russian cooperation in the field of digitalization, as well as a demonstration center for the German digital economy;

• Implementation of the concept of „Digital Enterprise“ at Russian enterprises and the creation of digital energy systems, including Smart Grid technologies;

• The equipment of the Russian car manufacturer KamAZ will be upgraded within the framework of the „Digital Production“ and „Smart Factory“ programs from „Siemens AG“. In addition to the two divisions of its parent subsidiary in Russia, Siemens LLC (digital production division and continuous production and propulsion division) and another Russian subsidiary, Siemens PLM Software, are also involved in digitalization. It is no coincidence that Siemens AG is defined as a leader in the digital cooperation with Russia;

• In February 2017, together with Russian Railways on the basis of the „Podmoskovnaya“ multiple-unit depot, where diagnostics and servicing of „Lastochka“ electric trains are carried out, the concern created a center for processing and analysis of data obtained during the operation of rolling stock and railway infrastructure. The new structure became part of the Digital Railroad project being implemented by Russian Railways;

• „Kaspersky Lab“ and „Siemens“ conducted joint testing of the domestic platform Kaspersky Industrial Cyber Security (KICS) and system SIMATIC WinCC Open Architecture (WinCC OA) on the SCADA Companies in Germany.

The SCADA system SIMATIC WinCC Open Architecture (WinCC OA) is part of the SIMATIC HMI product family and is designed for use in applications requiring a flexible and adaptive platform for solving individual customer tasks, as well as in large and/or complex projects with specific requirements to the functionality and architecture of the system. German-speaking countries (describe Germany (D), Austria (A), and Switzerland (CH) - DACH), which include Germany, Switzerland and Austria, account for about 15% of Kaspersky Lab's turnover.

As the export leader of Russian software abroad, Kaspersky Lab is an important link in the Russian-German dialogue in the field of digitalization:

⬧ Siemens AG, together with the Ministry of Industry and Trade of the Russian Federation, began the practical implementation of a program for creating a single digital space for Russian industry, aimed at the integrated implementation of digital technologies at all stages and levels of industrial production. It should also be noted that the Siemens company actively cooperates in the field of digitalization with the St. Petersburg State University, the Ural Federal University, the German-Russian Institute of Modern Technologies in Kazan and the Peter the Great St. Petersburg State Polytechnic University, in which a joint laboratory „Industrial artificial intelligence systems“ has been created.

⬧ In the beginning of February 2018 in Moscow within the framework of the International Forum „Week of Russian Business“ organized by the Russian Union of

Industrialists and Entrepreneurs, the German-Russian Initiative for Digitalization of the Economy (GRID) was launched. (Belov V., 2018)

Given that the concept of „cybersecurity“ will soon become obsolete and will be replaced by the concept of „cyberimmunity“, both Russian and German IT business could work together on „cyberimmunity“ as an important and promising area of digitalization.

♦ While the traditional economy is experiencing a lockdown due to the COVID-19 pandemic, the importance of its digital sector, like digital technologies in general, has grown exponentially. In this sense, in Russia, as well as in Germany, tech companies have proposed effective solutions, including but not limited to monitoring the spread of the virus. At the same time, digitalization is not only an opportunity, but also a risk. The webinar „Opportunities and Challenges: Russian-German Cooperation in Digitalization after the Coronavirus“, held on July 9, 2020, was dedicated to those issues.

3. German-Russian Initiative for Digitalization of the Economy

The German-Russian Initiative for the Digitalization of the Economy brings together the potential of Russian and German businesses in the digital economy.

The German-Russian Initiative for Digitization initiative was officially launched at the St. Petersburg International Economic Forum in early June 2017. The main mission of the Initiative is to intensify the Russian-German dialogue in the field of the digital economy and Industry 4.0.

On the German side, members of the GRID initiative are Siemens, SAP, Bosch, Volkswagen and Phoenix Contact, as well as the Eastern Committee of the German Economy and the Russian-German Chamber of Commerce.

On the Russian side, GRID includes: the Russian Union of Industrialists and Entrepreneurs, Rostelecom, the Skolkovo Foundation, Tsifra, TMK, Sinara Group, Rostec Corporation, Kaspersky Lab and Russian Railways.

The objectives of the German-Russian Initiative for Digitization can be specified: (GRID, 2017)

- Intensification of the Russian-German dialogue on the application of world-renowned practices in the field of digitalization and industry 4.0;
- Accelerating the digital transformation of the Russian economy and increasing the competitive advantages of German and Russian high-tech products through the exchange of experience and the creation of strategic models of cooperation;
- Expanding the presence of GRID members in both markets of its partner countries;
- Strengthening and developing Russian-German synergy in the digital economy;
- Public demonstration and promotion of this synergy.

4. The German-Russian concept of the „Factory of the Future“ in the conditions of digitalization of the Russian economy

The „factories of the future“ are production systems based on comprehensive technological solutions (integrated technology chains), which make it possible to develop and produce internationally competitive new generation products at short notice. The design is usually based on so-called „Testbeds“ 13. The term „factory of the future“ stands for digitized, intelligent and virtual factories, which make it possible to manufacture technology-intensive products better and faster than the current case in the Russian economy.

Figure 1. Components of a factory of the future

	I. Digital factory	**II. Smart factory**	**III. Virtual factory**
	Digital product development Modeling	*Agile production and mass production Development of tailor-made solutions like a digital factory +*	*Spatially distributed, networked production like a digital factory + like an intelligent factory +*
I. Technologies	Digital development and Modeling; New materials and designs including certification; Additive and hybrid technologies; CNC technologies; Smart Big Data=.	Industrial robots; MES and ICS systems; Sensor technology; Industrial Internet; Big data.	Digital operations management systems (ERP, CRM, SCM ...)
II. Results	Less errors in development; Little need for revision, less production waste; Get to market faster for new products.	Less production waste, low energy consumption; Higher productivity; Less before production starts or end of production.	More value creation; More employment; More transparent supply chains; Protection of intellectual property.
III. Product	Digital model; Digital twin; Samples or small series.	Series product;	Supply chain; Pattern or Small series; Series product.
IV. Technological maturity	TRL1 - TRL 9; MRL 1 - MRL 10.	TRL 4 - TRL 9; MRL 4 - MRL 10.	TRL 1 - TRL 9; MRL 1 - MRL 10.
Defining the concept	The „*factories of the future*“ are production systems based on comprehensive technological solutions (integrated technology chains), which make it possible to develop and produce internationally competitive new generation products at short notice.		
	The concept is based „TestBeds“ 13 – digitized, intelligent and virtual factories, which make it possible to manufacture technology-intensive products better and faster.		

Author's construction by: Geschäftsanbahnung. Industrie 4.0 mit Fokus auf die Kfz - und Maschinenbauindustrie. September 2020, s. 14

Symbols used:

Computer Numerical Control, abbreviation (CNC);
MES – Manufacturing Execution System;
ICS – Incident Command System;
ERP – Enterprise Resource Planning;
CRM – Customer Relationship Management;
SCM – Supply Chain Management (SCM);
TRL – Technology Readiness Levels: TRL 1. Basic principles observed; TRL 9. Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space);
MRL – Manufacturing Readiness Levels: MRL 1. Basic manufacturing implications identified; MRL 10. Full rate production demonstrated and lean production practices in place.

The factories of the factories of the future are presented in the following table.

Table 1
Markets for the „factories of the future“ in numbers

Indicators	Market for consulting and engineering services		Market for services and accelerated certifications		Market for training and further education services	
Years	2020	2035	2020	2035	2020	2035
Worldwide (thousand US dollars)	896 118 859	1 396 000 000	5 000 000	33 600 000	-	-
Russia (thousand US dollars)	2 509 133	10 900 000 – 21 200 000	25 000	160 000	13 861	50 000 – 94 000
Share of Russia (%)	0.3	08-1.5	0,5	0,5	-	-

Constructed by: Industrie 4.0 mit Fokus auf die Kfz – und Maschinenbauindustrie. 2020, s. 15.

In conclusion, the table shows that the indicators „Market for consulting and engineering services“ and „Market for services and accelerated certifications“ report very low relative weights in percentagewise.

German companies are pioneers in the field of digitization, while Russia is only just beginning its transition. Its economy shows good growth rates. In the period from 2016 to 2017, the first bilateral pilot projects in the field of digitization at company level were launched. Companies such as Siemens AG, SAP, Bosch Rexrodt play a leading role on the German side and KAMAZ, JSC „Russian Railways“, „Atommash“ and „Gazprom Neft“ on the Russian side.

In the chronological aspect, the cooperation between Germany and the Russian Federation on the creation of Industry 4.0 is presented as:

(i) ***Siemens AG*** [3]

KAMAZ, the largest automobile manufacturer in Russia, is renewing its model range, implementing new technologies and adapting its production processes using Siemens PLM software. The project was launched in 2006 and is supported by a comprehensive approach to implementing product lifecycle management (PLM) technologies. KAMAZ uses a number of Siemens PLM Software products including NX, Teamcenter and Tecnomatix.

In 2018, Kaspersky, ITELMA NPP and Siemens agreed a partnership as part of the project to create a unified digital space for Russian industry „4.0 RU". The core idea of the 4.0 RU project consists in the consistent implementation of digital technologies at all levels of industrial production and in all phases of the product life cycle.

In 2019, the compatibility of the current versions of the Kaspersky Industrial Cyber Security product and the SIMATIC WinCC Open Architecture platform from Siemens was confirmed. The shared use of KICS and WinCC OA provides the customers of different industrial sectors the opportunity to meet comprehensive requirements in the area of cybersecurity of the deployed and implementing industrial automation, operational monitoring and control systems.

Siemens and DMG Mori are also cooperating with the „Digital Mechanical Engineering" center at the Tambov State Technical University - the first of 15 planed centers. The German-Japanese machine tool manufacturer DMG Mori has networked the CNC machines in its plant in Ulyanovsk with the Celos interface, thus collecting operating data and storing it in the cloud.

For the Russian rail transport company OTEKO, Siemens is developing solutions for the digitization and automation of a mound for freight trains at the „Panagija" train station (Taman port) in the Krasnodar region. The shunting of the wagons is computer-controlled without the use of locomotives.

Siemens opened a data service center in Moscow in 2017 in cooperation with Russian Railways. In the future, smart data will ensure the optimized operation and predictive maintenance of trains. It is the third data center of its kind after Munich-Allach and Atlanta. Data streams from trains from 15 countries converge in all three centers. (Geschäftsanbahnung, 2020)

(ii) ***SAP SE (Systems, Applications and Products in Data Processing)***

The international NLMK Group (steel production) is the first company in the CIS market to switch to SAP SE / 4HANA [4], a new generation IT platform. SAP SE / 4HANA is now integrated with two dozen IT and production systems of the NLMK Group in Russia in the EU – with a total of more than 6,500 users.

One of the largest projects in the field of digital transformation is the development of an operational management system based on the SAP ERP for the Nornickel Group, one of the world's largest producers of palladium, nickel, platinum and copper. The uniform IT system covers more than 6,000 employees, around 50 locations and business units. The

[3] Siemens AG is a German conglomerate operating in the fields of electrical engineering, electronics, power equipment, transportation, medical equipment and lighting, as well as specialized services in various areas of industry, transport and communications.

[4] SAP SE - German multinational software corporation based in Walldorf, Baden-Württemberg, that develops enterprise software to manage business operations and customer relations.

largest companies in the Norilsk industrial region were included in the uniform information space of the Nornickel Group, the Production processes have been included in the group's continuous production chain. It is planned to have one by 2022.

Complete basic automation with SAP ERP, and at the same time, the conception of a future-oriented SAP architecture based on the latest SAP products including SAP SE / 4HANA and SAP Leonardo. Severstal PAO, one of the world's largest metal manufacturers and mining companies, started to switch from the currently used SAP ERP platform to the new generation SAP SE / 4HANA platform in the first quarter of 2020.

(iii) ***KUKA AG*** [5]

In 2017, the agreement on a strategic partnership between KAMAZ PAO and KUKA Robotics RUS OOO was signed. The object of the agreement is to set up industrial robots in the production facilities of the automobile manufacturer. As part of the strategic partnership, projects for comprehensive automation and modernization of the production capacities of the automotive group are to be implemented. Accordingly, KUKA Robotics RUS was added to the list of strategic suppliers of Russia's leading truck manufacturers for the period up to the end of 2022.

Germany also supports Russia in training specialists for automation and robotics technology at the German-Russian Institute of Advanced Technologies of the Technical University of Kazan „A. N. Tupolev“ in Tatarstan. The St. Petersburg Polytechnic University is also involved in this cooperation.

Under the auspices of the project, the German-Russian Initiative for the digitalization of the Yekaterinburg economy is the subject of cooperation in the field of artificial intelligence and innovative technologies. The Sverdlovsk region, and in particular the Middle Urals, are very interesting for German business.

In the context of cooperation in the field of digital economy between the two countries, we could draw the following ***conclusion***: The Russian Federation and the Federal Republic of Germany have a different understanding of Industry 4.0. In Germany, this is, first of all, the digitalization of the entire industry, and Russia has gone very far ahead in terms of digital services. The digital economy is an economy of partnership, it opens up a wide field for cooperation. German companies are ready to offer solutions for the modernization of Russian industry, including the implementation of the Smart Region project which provides the solution of a wide variety of problems, from infrastructural to legislative.

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