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Import Substitution in Electrical Engineering: Problems and First Results

Yaroslav O. Sedov[1], Irina V. Karzanova[1]

[1] RUDN University, Moscow, Russia

Author Note

Correspondence concerning this article should be addressed to
Yaroslav O. Sedov
RUDN University, 6, Miklukho-Maklaya str., Moscow, 117198, Russia
e-mail: 1032197929@rudn.ru
Irina V. Karzanova
RUDN University, 6, Miklukho-Maklaya str., Moscow, 117198, Russia
e-mail: karzanova-iv@rudn.ru

Abstract: The research aims to analyze the economic results of the functioning of manufacturers of electrical engineering in the Russian Federation under sanctions. To assess the consequences of economic restrictions in the short run, the authors use the case of the company "Izolyator," one of the world's leading companies in high-voltage bushings production. The authors use general scientific methods, such as empirical research, economic analysis, synthesis, and modeling, to assess the impact of large-scale restrictions on the supply of equipment, materials, and transaction costs of adjustment to the restrictions. Since 2022, electrical equipment manufacturers in the Russian Federation have faced massive restrictions on the supply of materials and equipment that are used in the main technological process and are of key importance. Manufacturers are trying to adjust their manufacturing process to limit their losses and find new approaches to maintain cost efficiency and scale. The analysis carried out has identified the most vulnerable bottlenecks in the production-supply chain in the industry. It will help find affordable, cost-effective options for import substitution.

Keywords: electrical engineering, import substitution, sanctions, power energy, high-voltage bushings

JEL codes: O19, O25, O38, O47

In today's world, the flows of goods, services, technology, capital, and labor create an economic interconnection between countries. The world market constantly reproduces the competitive struggle between its participants. As a result of political conflicts, periods of particular tension arise when well-established supply chains are torn, established forms of payment under contracts are complicated or even canceled, and restrictions and embargoes on the supply of goods and services are introduced. These restrictions entail additional economic costs to get out of this situation. These shocks for companies, individual industries, and national economies require the development of adequate adaptation measures to maintain economic stability.

Materials and Method

The paper examines the problem of economic costs in the field of material support during adaptation for enterprises in the electrical engineering industry of mechanical engineering in Russia based on the analysis of open-source data, internal company data, up-to-date data from counterparties, and manufacturers of various materials from China, India, Turkey, and Europe.

The processes of adaptation of electrical engineering companies to external shocks are considered in the work of Arutyunov (2015); Baer (1972); Kostin (2015); Kritskaya, Molchanova, and Klochkov (2013); Plotnikov and Vertakova (2014); Poliakov (2021); Sedov and Karzanova (2022); Shvets (2016); Volkova, Shuvalova, and Smirnov (2012); and Zhakevich (2015).

The authors use an empirical method and a system analysis. Companies producing electrical products are considered as a system that responds to external sanctions and performs a social function, producing equipment for generation and uninterrupted supply of electricity to the population on a commercial basis.

Results

Since 2014, the leadership of the Russian Federation has embarked on a policy of import substitution, seeking to ensure national security and the normal functioning of the Russian economy in the face of sanctions restrictions (Kostin, 2015). The essence of import substitution is to replace imports of foreign products with goods, services, and technologies produced domestically, which requires special efforts to develop and support domestic enterprises and industries (Shvets, 2016). The main goal of import substitution is to create conditions for the domestic economy and manufacturing companies to be able to function normally without being tied to the supply of foreign products, raw materials, materials, and technologies. For this purpose, it is necessary to replace the maximum possible share of foreign products from countries unfriendly to Russia with Russian-made products or, where this is not feasible, switch to other production and logistics chains (Plotnikov & Vertakova, 2014). After the first sanctions against Russia in 2014, the country launched several import substitution programs, including in the energy and electrical industries (Volkova et al., 2012). After February 24, 2022, the sanctions increased many times over; many foreign manufacturers and suppliers left Russia.

The Russian Union of Industrialists and Entrepreneurs identifies several categories of products with which industrial companies face difficulties, namely raw materials, materials, accessories, and equipment. In all categories, except for raw materials, the need for import substitution is assessed as high. In this context, one of the important tasks of the Russian economy is to establish the production of import-substituting products and spare parts for imported equipment. As part of the import substitution policy, programs were developed for the implementation of the policy by the Ministry of Industry and Trade of Russia, as well as target indicators for import substitution in electrical engineering and the fuel and energy complex. It is expected that imported equipment will not exceed 5% in a limited area of

procurement by 2030. Manufacturing enterprises will master more than 95% of the entire range of electrical equipment (Moiseev, 2020).

In the beginning, there were many problems in the implementation of import substitution:

1. Existing approved specifications required imported raw materials, materials, and equipment;
2. Lack of information about Russian analogs on the market or fragmented information;
3. There was no unified catalog of Russian-made goods, incompatibility of quality characteristics;
4. Russian analogs were more expensive than foreign products with comparable quality;
5. Russian analogs were inferior to imported products in terms of quality;
6. In several cases, there were no Russian analogs of imported products at all.

Gradually, the situation in the area of information availability began to improve. It became clear that a high share of imports in the electric power engineering industry is observed for the following equipment: gas turbines, hydraulic turbines, transformers, switches, voltage and current transformers (voltage 750 kV), power cables (voltage 30 kV, 500 kV, 750 kV), circuit breakers (voltage 330 kV, 500 kV, 750 kV), gas-insulated switchgear (voltage 330 kV and 500 kV), communication equipment, and digital information transmission systems (Moiseev, 2022).

In this regard, the Action Plan for import substitution in the energy, electrical, and cable industries of the Russian Federation was approved by the Ministry of Industry and Trade of Russia on July 2, 2021.

By 2023, a strong dependence on foreign partners has already formed in the electrical industry. The production of many types of products in Russia requires foreign raw materials, technologies, and components that have no analogs in the Russian Federation. Under sanctions, manufacturers are faced with the task of establishing production that is not dependent on foreign supplies in conditions of serious dependence on them. Companies producing high-tech electrical equipment often need imported materials, components, specific materials (e.g., synthetic fabrics, liquid silicones, specific resins, catalysts for chemical processes, crepe paper, etc.), and complex cast and turned metal products of foreign production. The adaptation process requires the search for new options for raw materials and components, the production of which must be established in Russia.

For deep localization of the production of electrical equipment, it is necessary to use domestic basic raw materials, often produced in related industries such as chemical, pulp and paper, and others. The list of basic materials and components used in electrical equipment includes chemical products (epoxy resins and liquid silicones), paper, including crepe paper, non-woven synthetic fabrics and materials, metal products, hollow composite insulators, etc. (Sedov & Karzanova, 2022).

The manufacturer of electrical equipment has several approaches to overcome sanctions restrictions:

1. Search for alternative material in Russia;
2. Search for alternative material in friendly countries;
3. Parallel import;
4. Stimulating the deployment of own production of materials in the near future.

Thus, the following options for overcoming sanctions restrictions can be distinguished:

- Step 1. Analysis of the pool of materials (raw materials) that are no longer available;
- Step 2. Search for alternative material in Russia;
- Step 3. Parallel import of needed material, if possible;
- Step 4. Estimation of the yearly spending of the unavailable pool as a percentage of the total materials budget;
- Step 5. Selection of the most consumed positions of materials.

The analysis of the production of high-voltage bushings with RIP and RIN solid internal insulation showed that possible options for import substitution have the following economic costs (Table 1):

Table 1

Actions and economic consequences of sanctions in the electrical engineering

Material used, supplier	Percentage of material composition	Alternative material or method of overcoming limitations	Difficulty in substitutions	Effect
Epoxy Resin				
CHS-EPOXY 530, Manufacturer Spolchemie (CZ)	18%	There is no analog of this material in Russia		Delivery through Turkey is 50% more expensive compared to direct delivery from the Czech Republic
		Supply of material through parallel import through Turkey	Longer and more labor-intensive delivery, the need to conclude an agreement with an intermediary in Turkey	5%–10% is the partner's commission in Turkey
		Search for alternative material in friendly countries: China, Sanmu SM-827, Tervan	The need for long-term testing of the material, long delivery time, complexity with financial transactions	Cost reduction by 45% relative to the base material, considering logistics

		DY-127		
Hardener MHTPA				
Lonza Spa	17%	TD “TAU”, Sterlitamak (uses imported material from the EU in production)	The need for approbation of the material	Cost reduction by 30% relative to the base material, satisfactory quality, prompt delivery, unified regulatory framework
		Han Epoxy	The need for approbation of the material	Cost reduction by 42% relative to the base material, considering logistics
Weidmann plant in Ukraine (Weidmann Electrical – Switzerland)	8-10%	Mari Pulp and Paper Mill, Volzhsk, Mari El	After testing – not satisfactory quality	
		Crepe Paper Cartire di Nebbiuno	The range of products supplied is limited	Availability of production with restrictions
		Zhengzhou Hengxing	Approbation of the material is required; the nomenclature is limited	The production cost is comparable to the reference material, logistics costs are 100% higher than the reference value
Composite Insulators				
Composite insulators MR, Germany	20%	Rosizol, Moscow Region	Lack of all nomenclature	Cost is 40% lower than the benchmark

		Direct deliveries from Germany with the permission of the government commission	Increase in delivery times	The risk associated with a total ban
GEL Unigel, UK				
Unigel, UK	6%–10%	Parallel import, Turkey	Increase in delivery times, price increase by 50%	Security of supply

Source: Developed and compiled by the authors

Discussion

The data show that the economic results of import substitution are quite uneven in the group of key components. For example, for such components as epoxy resin, there is a positive economic effect of import substitution in the amount of 40%, despite the restrictions. According to Daron Acemoglu and James Robinson, this effect can be called the "creative destruction" of previous supply chains, resulting in significant cost savings. The same effect can be observed with the import substitution of the MGTPA hardener, where the Russian analog, after a series of tests, showed full compliance with the technical requirements, the costs turned out to be insignificant, the risk was the same, and the overall economic effect was 30%.

However, import substitution turns out to be difficult and costly for certain positions. For example, according to the class of material paper, it was not possible to replace the reference product in full; only a part of the paper of the required width is available, which entails reengineering the production technology, which will entail material overruns and additional delivery costs by 100%. A similar situation is observed with glass-organic silicon tires: the local supplier has provided part of the required products, and the reference supplier continues to supply from Germany despite the restrictions. In this case, we can talk about a hybrid approach to improve economic efficiency.

Separately, it is worth mentioning components that are difficult to replace in the near future, such as foil with a special PMMA coating based on epoxy resins, which is used to equalize the electric fields in the core of high-voltage bushings and other electrical products. The main consumer of products made of ordinary foil is the packaging industry. Foil with a specific coating is a small batch production. Thus, the production of such foil was engaged by a limited number of manufacturers of food products. The above-mentioned manufacturers provided their cutting of products, which was expressed in certain thicknesses and widths, as well as the thicknesses of the PMMA coating. These characteristics have been used as the basis for producing high-voltage cores since the start of mass production of products with solid insulation in 2006. The absence of a component can stop production; the component is critical in terms of the ability to produce equipment and cannot be replaced by a technologically simplified counterpart. This problem is solved by reverse engineering, namely, the decoding of all technical characteristics of the component by competing

manufacturers to produce an analog that meets the necessary requirements as closely as possible. According to the results, it was possible to achieve a component (foil) that meets the requirements by the manufacturer of the company Vonke (China). However, the result of small batch production resulted in a 70% increase in the cost of the component compared to the previously used component.

With the restrictions imposed on some industries, difficulties arise in other industries. According to the Federal State Statistics Service of the Russian Federation (Rosstat), for some items of metallurgical production, in particular the production of aluminum products, there was an increase in the production of finished products. Despite this, there was a redistribution of consumption within the country. As a result, the average production period of aluminum pipes increased, according to Izolyator's internal data, to 180–210 days, which is more than two times longer than the production time before the introduction of various restrictions. An effective restructuring of supply chains based on the data above is not feasible. In this case, import substitution based on the search for analogs in the Asian region is the best solution from an economic point of view. While maintaining the required quality and cost, it is possible to reduce the production time to 30 days.

The experience of the continuous process of import substitution in companies allows us to more closely assess the risk, even by classes of components and materials produced by domestic manufacturers. Thus, when introducing a new type of domestic hardener, samples from different countries of the Asian region undergo a comprehensive assessment to diversify and protect the supply chains of the main components despite the decrease in economic efficiency.

Strategic security and the ability to continuously produce equipment take precedence over economic efficiency goals.

There may also be a situation when there is a class of materials produced exclusively in one country, and there are also a number of patents that protect the exclusive right to manufacture. In this case, all costs for parallel imports are fully borne by the company.

In addition to costs in the short term, the cost of retraining or re-staffing should be included – trained personnel with special experience, as well as additional specialists who speak foreign languages, are required. In the long term, this will be an investment in human capital that will increase production efficiency.

Conclusion

Thus, based on the analysis of the economic consequences of the introduction of restrictions in the electrical industry, we can conclude that the results vary in different categories. In some cases, the positive effect of "creative destruction" in supply chains is expected to exceed the negative effect of introducing restrictions. When calculating the economic effect, it makes sense to use a hybrid version of adaptation to the introduced restrictions, that is, a project approach to each individual material. The project approach makes it possible to consider the weight of a particular category of material in the cost structure and the cost of new supply chains or materials.

It is especially necessary to consider that in the field of electrical engineering, the safety of manufactured equipment is the main strategic criterion for the manufacturer and the user. In this sense, the process of transition to new materials is not as dynamic as the situation requires, multi-stage testing of materials and components is necessary, and decisions can be approved in an environment of uncertainty with the acceptance of a certain degree of risk of technical non-compliance when introducing materials into mass rather than piece production. In connection with the foregoing, it seems possible to conclude that the continuous production of products is one of the most important tasks in the current conditions of sanctions pressure on the industry. In order to achieve continuous production of products, including social obligations, management has to abandon evolutionary, uniform development, with gradual improvements, as well as breakthrough and disruptive technological leaps in production and technologies, replaced by simpler materials, equipment, and entire technologies. Many materials and components are subject to special tests in specialized laboratories. Competence is also required in interpreting the results obtained and their impact on product safety.

The economic and technological effect of the decisions made has yet to be assessed in the future.

There is no single approach to making managerial decisions to achieve economic efficiency under the influence of sanctions restrictions. It is necessary to make flexible decisions in the existing system of restrictions.

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