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Fighting counterfeit as a threat to the economic security of the state on the basis of criminology research

Abstract. The spread of counterfeit goods is an urgent problem of our time on a global scale with a multibillion-dollar physical circulation. The aim of the article is to monitor the influence of factors on the dynamics of changes in the size of counterfeit goods and to substantiate its predictive indicators. During the research, the following methods were used: theoretical, tabular, analytical, generalization, statistical, synthesis, abstraction, forecasting, modeling, experiment. The article examines the essence of the phenomenon of counterfeiting as an offense in the field of intellectual property, specifies its negative consequences. Global trends in trade for counterfeit and fake goods based on the European GTRIC methodology are demonstrated; the ranking of the countries of origin of counterfeit

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goods was analyzed, as well as the ranking of industries affected by counterfeiting was studied. The article outlines the scale of counterfeiting in Ukraine, substantiates the connection with the economic security of the state. It was emphasized that the ability to diagnose indicators of influence and counteract the spread of counterfeit products is a strategic task of the state in the direction of achieving security parameters. It is argued that the level of corruption, the ease of doing business and the protection of property rights in the country affect the volume of counterfeiting, and therefore it is proposed to investigate the nature of their influence using appropriate indicators (Corruption Perceptions Index, position in the Doing Business ranking, International Property Rights Index) and mathematical apparatus. On the basis of mathematical models, the basic functions of which are radial, a model of the dependence of effective indicators (volume of counterfeiting and budget losses) on justified indicators has been developed. As a result of the research, it was established that improving the state of the selected indicators has a positive effect on the resulting indicator. At the same time, the insufficient effectiveness of their influence determines the prospects for further exploration of levers for additional improvement of their individual components. The practical significance of the study is the substantiation of the system of indicators of influence on the volume of counterfeiting, and, based on them, the construction of an economic-mathematical apparatus that will allow forecasting its dynamics

Keywords: counterfeit goods; violation of intellectual property rights; shadow economy; indicators of influence on the volume of counterfeiting and budget losses; mathematical model with radial basis functions

INTRODUCTION

Sustainability of the state's economic development at the macro level requires a clear interaction of all system components, which are based on the quality of human capital. The intellectual resource is the foundation of the reliability and strength of the state's economy, therefore its protection is a primary security task. Violation of intellectual property rights in the form of the distribution of counterfeit products is a significant threat to the country's economy and to individual consumers of products, whose health and life may be at risk, therefore the ability to diagnose indicators of influence and counteract the spread of such products is a strategic task of the state in the direction of achieving the parameters security

Fighting counterfeiting, as the main consequence of violations of intellectual property rights, is an important direction of research into the economic security system, analysis of key indicators at both the micro- and macro-level, as well as the formation of methods and approaches to combat this phenomenon, which determines the relevance of the subject of this scientific research. The study of the circulation of counterfeit products in the world is the object of scientific works G. Gistri (2021), who studies the economic component of counterfeiting based on the interaction of supply and demand for goods manufactured in violation of intellectual property rights.

I. Jacob *et al.* (2018) investigate the influence of motivational factors of certain population groups on quantitative indicators of the purchase of counterfeit products in the world, and also form a list of motivational factors for the purchase of such products.

L. Song *et al.* (2021), L. Nash *et al.* (2014), as well as J. Wilson *et al.* (2016) carried out a thorough study of

the international aspect of the development of counterfeiting as a negative phenomenon, emphasizing that the production of products in violation of intellectual property rights is one of the biggest threats to the world economy in general. H. Valembos (2019) investigated the impact of infringement of intellectual property rights at different levels and made an attempt to forecast sales volumes taking into account the sale of counterfeit products. E. Auriol *et al.* (2022) based on taking into account the volume of international trade in items protected by intellectual property rights, developed a methodology for calculating the economic impact of the sale of counterfeit products.

In this scientific article, the authors will try to form their own approach to the choice of the method of mathematical modeling and the justification of the combination of the investigated factors of influence, based on the European GTRIC methodology (Global trade..., 2021), as well as taking into account the analyzed methodologies proposed by world scientists in their research.

As noted by N. Savka *et al.* (2012), in Ukraine, research on countering counterfeiting is carried out at the official level. Since the final goal of the study is to establish the influence of factors on counterfeiting in Ukraine and predict its level, emphasis was placed on the study of factors by world and Ukrainian scientists, namely: A.H. Chubenko *et al.* (2018), whose works are focused on the study of state security, V. Nyzhnykova (2018) on issues of international cooperation in the field of fighting counterfeit products, M. Koval (2020) on issues of intellectual property protection and countering counterfeiting, as well as in the previous works of the authors of this scientific article, as they investigate the realities of the

spread of counterfeit products in Ukraine and ways to strengthen economic security at all levels: Y. Muravska (Yakubivska) (2017) on the directions of combating industrial espionage, which is one of the prerequisites for the emergence of counterfeiting, O. Oliynychuk *et al.* (2021) regarding research issues of criminological aspects of combating the emergence of the phenomenon of counterfeiting implemented through cyberspace, as well as A. Kolesnikov (2019) on issues of strengthening the economic security of enterprises in the way of fighting counterfeiting.

The exceptional relevance of the research topic for Ukraine is that, according to the estimates of the State Customs Service of Ukraine, the amount of confiscated counterfeit products is 5.5 million UAH. from its estimated total volume of UAH 85-105 billion. was about 0.006% (Dubrovskiy *et al.*, 2021). That is, the share of confiscated products in the total volume of circulation of counterfeit products is very small, which indicates the need for significant changes in the implementation of the system for countering the spread of counterfeit products. This led to setting the goal of the article, which consists in researching the specifics of the influence of the factors substantiated by the authors on the state of distribution of counterfeit products in Ukraine and individual directions of management of these factors. The novelty of the research lies in the choice of the method of mathematical modeling and the justification of the combination of the researched influence factors.

MATERIALS AND METHODS

The main method of article architecture is deductive. In the conditions of the study, a gradual transition from the general problems of the circulation of counterfeit products to the macro level of Ukraine is made, then a study of the influence of individual factors (with a preliminary justification of their choice) and a forecast of their potential impact on the future development of the phenomenon under study are carried out.

The theoretical method is used in the study of the categorical apparatus. Materials for the application of this method are Customs Code of Ukraine¹, Terminological dictionary A.H.Chubenko *et al.* (2018), scientific paper V. Nyzhnykova (2018) and the online publication of M. Koval (2020).

Materials for research are also data from international organizations of the economic direction of the Organization for Economic Cooperation and Development

(Global trade..., 2021; Misuse..., 2021; Dangerous Fakes..., 2022), Intellectual Property Office of the European Union (Risks..., 2021; Intellectual property..., 2022) and the statistical organization of the European Commission (International trade, 2021). At the same time, a tabular method was used to rank the countries of origin of counterfeit goods and industries most affected by counterfeiting. An analytical method is used to work with statistical information. Statistics and methods of analysis, synthesis and generalization are used to establish the actual indicators of the phenomenon under study. The tabular method was used to group the main categories of goods that were most often seized by employees of the State Customs Service of Ukraine. For the representativeness of the material, official data of the State Customs Service of Ukraine (During..., 2020) and Special Report 301² (prepared annually by the Office of the US Trade Representative) related to copyright, patents and trademarks in other countries were used.

One of the research methods is statistical. When selecting the criteria that were used in the modeling, the method of abstraction was used, which made it possible to single out among a large number of criteria the three most significant, according to the authors. Data from the World Bank, the Doing rating, were used business (2019) and Corruption Perceptions Index (2021).

The observation method was used to monitor the predictive behavior of the resulting indicator under various development scenarios. Using the forecasting method allows you to predict the scenario of the development of the situation at a given level of influence of selected factors (corruption perception index, ease of doing business index, international property rights protection index). To achieve the goal of this block, within the limits of the modeling method, a model of the dependence of effective indicators (the volume of counterfeiting and budget losses) on influence indicators was used basing on mathematical models, the main functions of which are radial. The use of models of this type combines structural and parametric identification procedures. The approach to predicting the volume of counterfeiting and budget losses involves the use of an experimental method. The approach to the identification of centers is implemented using the method of cluster analysis (Dyvak *et al.*, 2021). Parametric identification was carried out using the method of backpropagation of the error (Nelles, 2001). The application of this method made it possible to carry out 6 iterations of structural identification and obtain an optimal

¹Customs Code of Ukraine No. 4495-VI. (2012, March). Retrieved from <https://zakon.rada.gov.ua/laws/show/4495-17#Text>.

²Law of Ukraine No. 202-IX "On Amendments to the Customs Code of Ukraine on the Protection of Intellectual Property Rights during the Movement of Goods Across the Customs Border of Ukraine". (2019, October). Retrieved from <https://zakon.rada.gov.ua/laws/show/202-IX#Text>.

mathematical model, which made it possible to predict indicators of the volume of counterfeiting and budget losses. Demonstration of modeling results is carried out using a graphical method. The method of scientific generalization was used to substantiate the conclusions.

RESULTS

The essence of counterfeiting as a crime

According to Customs Code of Ukraine No. 4495-VI the concept of “counterfeit goods” is quite extensive, because it includes goods that are the subject of infringement of intellectual property rights to a trademark and geographical indication in Ukraine, as well as “any packaging, label, sticker, brochure, operating instructions, guarantee or other document of this type, even if they are presented separately, which are the subjects of infringement of intellectual property rights to a trademark or geographical indication”¹. Thus, the approach of the legislator to the interpretation of counterfeit goods is quite complex to the designation of an offense in the field of intellectual property.

In turn, in the Terminological Dictionary on Prevention and Counteraction of Legalization (Laundering) of Proceeds of Crime, Financing of Terrorism, Financing of Proliferation of Weapons of Mass Destruction and Corruption, a counterfeit is defined as “a product that is an exact copy of a brand; the packaging is produced by persons who do not have the corresponding copyright for the production of products under the trademark” (Chubenko *et al.*, 2018). That is, comparing with the legal definition of counterfeit goods provided in the Customs Code of Ukraine, on a practical level, a significantly simplified approach to the interpretation of the concept of counterfeit can be noted.

Meanwhile, counterfeiting, causing damage to the owners of intellectual property rights, by its legal nature constitutes a substantial offense, which according to the Code of Ukraine No.8073- X “On Administrative Offenses”² is subject to administrative liability (imposition of a fine and confiscation of counterfeit products and materials and equipment that were used to manufacture counterfeit products). Violators may also be held criminally liable:

- ▶ for illegal use of a trademark – in the form of a fine;
- ▶ for the illegal use of inventions, utility models, industrial designs, copyright objects – in the form of a fine or corrective works or imprisonment for up to six years (Koval, 2020).

The legislation assigns the duty to combat counterfeit products to the customs authorities of Ukraine,

which implement the protectionist policy of the national market. That is why the powers of customs authorities play a significant role in ensuring the protection of intellectual property rights, countering the spread of counterfeit products and international cooperation with customs authorities of foreign countries (Nyzhnykova, 2018).

The global scale of the phenomenon

The problem of counterfeiting is global and associated with multi-billion dollar physical circulation, and is characterized by powerful legal, economic and social consequences for the world community. Meanwhile, this is a very profitable business, which functions due to the fact that criminals master their capacities from the ever-growing demand for cheap goods at low costs for their production and sale, and at the same time, they are not afraid of severe punishment for their illegal activities. The production and sale of counterfeit goods has always existed in Ukraine and the world, and every year this problem becomes even more relevant, despite the efforts of both the world community and individual countries in the direction of combating this threat. International research company Euromonitor International predicted that the losses of the world economy in the near future were to amount to 3%, or 2.2 trillion US dollars (International..., 2021).

The global market for counterfeit goods is among the leaders of illegal businesses such as arms trade, drug trade and human trafficking. In addition to great losses to manufacturers of original goods and owners of intellectual property rights, counterfeiting often poses a threat to health and life. To demonstrate global trends in trade in counterfeit and counterfeit goods, we will turn to the European GTRIC methodology (General Trade-Related Index) used in the analytical work of the Organization for Economic Cooperation and Development (OECD) and the European Union Intellectual Property Office (EUIPO) and demonstrated in their report published in 2021 (Global trade..., 2021).

Analysts have chosen to calculate the GTRIC index, actually, for the period 2017-2019 to calculate the GTRIC index, taking into account the qualitative component of counterfeit indicators at the global level during the specified period (the period before the COVID-19 pandemic). This is also confirmed by a report published in 2022 entitled “Dangerous fakes: Trade in counterfeit goods that pose health, safety and environmental risks, illicit trade” (2022), which indicates that in 2019, trade in counterfeit goods accounted for 2.5% of world trade.

¹Customs Code of Ukraine No. 4495-VI. (2012, March). Retrieved from <https://zakon.rada.gov.ua/laws/show/4495-17#Text>.

²Code of Ukraine No. 8073-X “On Administrative Offenses”. (1984, December). Retrieved from <https://zakon.rada.gov.ua/laws/show/80731-10#Text>.

At the current stage of world development, the vast majority of leading economies are exporters of counterfeit goods. Meanwhile, it indicates that the majority of counterfeit goods originate from a small group of producing countries. During the reporting period, this country was China in the system of world trade indicators. During the specified period, the total number of global indicators of customs movement of counterfeit goods confidently exceeds the indicators of previous years (Commission..., 2022). Regardless of economic indicators and political aspects, any country in the world can become an active producer of counterfeit products.

Certain countries of the world tend to dominate the world trade in counterfeit and fake goods. The highest rates of manufacture on the trade of counterfeit goods withdrawn from circulation belong to the countries of East Asia (Table 1), with a pronounced dominance of China, Hong Kong (China), as well as the Syrian Arab Republic and Turkey, in which the GTRIC Index for 2017-2019 is the highest (Misuse..., 2021). In general context, about 90% of global counterfeiting originated from these countries during the indicated period. Note that the closer the GTRIC indicator is to one, the higher the level of counterfeiting of the country or industry.

Table 1. Rating of countries of origin of counterfeit goods, 2017-2019

Item No.	Country of origin of counterfeit goods	index, (average for 2017-2019)*
1.	Hong Kong (China)	1
2.	Syrian Arab Republic	0.998
3.	People's Republic of China	0.998
4.	Turkey	0.996
5.	Dominican Republic	0.984
6.	Pakistan	0.955
7.	Georgia	0.933
8.	Lebanon	0.872
9.	Senegal	0.831
10.	Afghanistan	0.761

Source: compiled by the authors based on data from the Organization for Economic Cooperation and Development (OECD) (Global trade, 2021)

Hong Kong (China), the Syrian Arab Republic and the People's Republic of China occupied the first positions of this ranking from 2014 to 2016, having the highest rate of export of counterfeit goods. The UAE and Morocco moved down in the 2017-2020 ranking to 13 and 14 positions with a GTRIC Index of 0.720 and 0.649 respectively, while the Dominican Republic and Singapore moved up 5 and 11 positions respectively.

An analysis of the ratings of the countries of origin of counterfeit goods destined for EU markets (according to the GTRIC index) showed that countries from all regions are represented in it. The indicators of the export of counterfeit products to the EU were the highest in the following countries: Benin, Hong Kong (China), the Syrian Arab Republic, and Afghanistan (Table 2). Senegal, China, Turkey

and the UAE are represented with a slight difference. The GTRIC index indicates that the total trade in counterfeit goods in EU countries amounted to about USD 134 billion in 2019. If you look at Balanced statistics International Trade in Services EBOPS (2020) and analyze the share of this indicator in the structure of the annual import indicator, we will get data that 5.8% of EU imports were fake and counterfeit goods. The total number of counterfeit goods detected by customs authorities at the EU border decreased after 2019: around 66 million items were detained and confiscated in 2020, compared to 76 million in 2019 (Intellectual..., 2022). We believe that the crisis caused by the COVID-19 pandemic also had a significant impact on such changes, which led to a decrease in trade volumes in the first months of the pandemic.

Table 2. Rating of the countries of origin of counterfeit goods that entered the EU, 2017-2019

Item No.	Country of origin of counterfeit goods	Index for the EU, (average for 2017-2019)*
1.	Benin	1
2.	Hong Kong (China)	1
3.	Syrian Arab Republic	1
4.	Afghanistan	1
5.	Senegal	0.9997

Table 2. Continued

Item No.	Country of origin of counterfeit goods	Index for the EU, (average for 2017-2019)*
6.	China (People's Republic)	0.9986
7.	Turkey	0.9963
8.	UAE	0.9956
9.	Georgia	0.9745
10.	Lebanon	0.9355

Source: compiled by the authors based on data from the Organization for Economic Cooperation and Development (OECD) (Global trade, 2021)

The described statistics on the countries of origin of objects of pirated products illustrate the importance of counterfeiting in international trade. At the same time, most of the countries of origin of counterfeit goods are leaders in world trade in general. The GTRIC index takes this into account and provides a more accurate analysis. In particular, it considers both components: the share of seizures and trade flows of counterfeit products in individual countries of the world, and therefore, the indicated index takes into account the relative trend of

indicators of imports of counterfeit products from different countries of origin.

From 2017 to 2019, there are seven main industries that are objects of production and sale of counterfeit products (Table 3), and they remain practically unchanged compared to the corresponding data of 2014-2016. Perfumery and cosmetics, leather goods, clothing, shoes, toys and watches were characterized by the highest attractiveness for offenders in the field of intellectual property.

Table 3. Rating of industries affected by counterfeiting 2017-2019

Item no.	Harmonized system code of the industry (HS code)	index, (average for 2017-2019)*
1.	Perfumery and cosmetics (33)	1
2.	Leather products; Handbags (42)	1
3.	Knitted or crocheted clothing (61)	1
4.	Shoes (64)	1
5.	Watches (91)	1
6.	Toys and games (95)	1
7.	Jewelry (71)	1
8.	Tobacco (24)	0.997
9.	Other products from textile materials (63)	0.858
10.	Weapons and ammunition (93)	0.820

Source: compiled by the authors based on data from the Organization for Economic Cooperation and Development (OECD) (Global trade..., 2021)

The volumes of counterfeiting in industries sensitive to counterfeiting are extensive and tend to increase (88 out of 96 HS sections of the international Harmonized System of Classification were affected by piracy, i.e. 92% for the period 2017-2019 compared to 80% for the period 2011-2013 years) (Intellectual..., 2022). However, the intensity of counterfeiting differs significantly for individual types of goods and, therefore, for the corresponding HS categories of the Harmonized System of Classification.

Based on data from the Organization for Economic Co-operation and Development (OECD) and the European Union Intellectual Property Office (EUIPO) (Worrying..., 2021), as of 2019 the international trade in counterfeit goods was US\$ 464 billion, which in turn accounted for 2.5% of world trade. Thus, in terms of share in total trade, the volume of counterfeit trade remained significant during 2017-2019, affecting the GDP of advanced OECD economies such as Austria or Belgium (Worrying...,

2021). In 2019, the import of counterfeit goods to the EU amounted to 134 billion dollars USA, which accounted for 5.8% of EU imports (Dangerous..., 2022). These results are based on customs statistics and, accordingly, do not take into account such important indicators as domestic production and consumption of counterfeit products; in addition, they do not include online piracy of digital information.

The COVID-19 pandemic has affected the trade in counterfeit goods, although in terms of volume the impact has been less than initially expected. In most cases, the crisis strengthened the existing trends. The main trend was abuse in the online environment, as consumers turned mainly to online marketplace platforms to satisfy their needs, provoking a significant growth in the system of online offers of a wide range of counterfeit goods.

It is difficult for consumers to distinguish between genuine and counterfeit goods, especially when buying

them online. According to a study by the European Union Intellectual Property Office (EUIPO), 1 in 3 people (although in some countries 1 in 2) and on average almost 1 in 10 Europeans (9%) say they have been misled and bought counterfeits. They also emphasize that it is difficult to distinguish legitimate sources of digital content from illegitimate ones (Intellectual..., 2022).

As online shopping activity coincided with the pandemic, according to Eurostat, more than 70% of Europeans used the Internet to purchase goods in 2020 (International, 2021), and thus uncertainty about the trade in counterfeit products has become a growing concern in the context of rights protection consumers. According to the results of the analytical work of the Organization for Economic Cooperation and Development (OECD) and the Intellectual Property Office of the European Union (EUIPO), it was determined that counterfeit products make up 6.8% of imports of the European Union (EU) and amount to about 121 billion euros (Risks..., 2021), affecting every sector of the economy from cosmetics, toys and pharmaceuticals to the arms trade.

Modern technological development at the global level is characterized by a high level of digital piracy, which, in turn, represents a highly profitable platform for violations in the field of intellectual property. For example, in the field of Internet television (IPTV), 1 billion euros is generated illegally every year through the supply and consumption of digital content in the EU in violation of copyright (Commission, 2022). Encroachments on the intellectual property rights of individuals and

legal entities whose activities are related to Internet television were revealed by law enforcement agencies and amounted to about 13.7 million people in the EU in 2019 (which is 3.6% of the EU population) (Risks..., 2021). For bona fide copyright owners, counterfeiting means loss of funds and, above all, reputation. At the state level, the damage to the economy is determined by the annual failure to receive significant amounts of tax revenue in the budget, the country's loss of investment attractiveness, and a decrease in the volume of direct investments. That is why every citizen of any country should be aware that by offering for sale or buying a counterfeit, he supports crime and, above all, endangers his safety.

The scale of the phenomenon in Ukraine, the connection with the economic security of the state

A new stage in the development of the system for combating the spread of counterfeit products in Ukraine began in 2019 with the adoption by the Ministry of Finance of by-laws No. 281 and No. 282 dated 06.09.2020, which approved two new procedures – Procedure for applying measures to promote the protection of intellectual property rights and cooperation between customs authorities, right holders and declarants and the Procedure for registering objects of intellectual property rights in the customs register. The main goods appearing in the latest reports of the State Customs Service of Ukraine are well-known global brands, but the number of seized units and their total value is insignificant in terms of the shadow economy in the country (Table 4).

Table 4. Main categories of goods most often seized by employees of the State Customs Service of Ukraine in 2020

No	Product category	Quantity, units	Trademarks	Declared value, thousand UAH
1	2	3	4	5
1	portable electronics	about 13 thousand	NGK, Apple	2000
2	toys	more than 107 thousand	Hot Wheels, LOL Surprise, Lego, UEFA	1000
3	clothes and hats outfits	more than 25 thousand	Puma, Nike, Adidas	904
4	footwear	more than 10 thousand	Nike, Puma, Adidas	654
5	bags and belts	about 15 thousand	Dior, Puma, Nike	202
6	perfumery and cosmetics	about 29 thousand	Chanel, Lacoste	109
7	clocks bracelets	16	Michael Kors	32

Source: compiled by the authors based on the data State customs services of Ukraine (During..., 2020)

Adoption of changes to Law of Ukraine No. 202-IX “On Amendments to the Customs Code of Ukraine on the Protection of Intellectual Property Rights during the Movement of Goods Across the customs Border of Ukraine”

in October 2019¹ led to an increase in the effectiveness of the measures of the State Customs Service. For example, in 12 months of 2019, the customs authorities suspended about 7,000 operations of customs clearance of goods due

¹Law of Ukraine No. 202-IX “On Amendments to the Customs Code of Ukraine on the Protection of Intellectual Property Rights during the Movement of Goods Across the Customs Border of Ukraine”. (2019, October). Retrieved from <https://zakon.rada.gov.ua/laws/show/202-IX#Text>.

to suspicion of violation of intellectual property rights, but only in 1.3% (91 cases) of this number, it ended with the destruction of goods and drawing up protocols on violations of customs rules. In 2020, with 1,900 cases of product detention, the rate of drawing up protocols was 10% (190 cases). If we normalize the indicators, we will have that in 2019, one protocol accounted for 77 suspensions of customs clearance. In 2020, there were 10 suspensions per arrest. Such results made it possible not only to save considerable time of customs officials, but also to avoid delays in product deliveries, which facilitated the functioning of business in Ukraine in general.

Positive developments were also noted by foreign experts. In particular, the Office of the US Trade Representative in the annual report 2021 Special 301 Report (n.d.) noted important developments in the development of the legal field against the circulation of counterfeit products, which resulted in the partial restoration of the system of GSP benefits. At the same time, the slowness of progress is indicated by the fact that in the same report Ukraine is included in the list of nine countries that will receive priority attention. The above proves that overcoming this problem is not possible only through the adoption of separate legislative acts or sanctioning actions of foreign partners.

Collection of statistical data for the model, their justification

The negative impact of counterfeit products is very diversified. It harms not only the life and health of consumers and owners of intellectual property rights to the brand, but also the economic security of the state in general. It follows that solving the problem of the circulation of counterfeit products involves solving the problem of the influence of a number of components of Ukraine's economic security. In the instructions for calculating the level of economic security of Ukraine (On approval..., 2013) a separate criterion for counterfeiting is not defined, however, in separate groups of indicators there are separate indices directly related to the circulation of counterfeit products. In particular, when calculating the integral index of investment favorability of the business environment, business conditions subindex is used due to the Doing Business (2019), published by International Finance Corporation and the World Bank. Actually, the more favorable the business environment in the country, the greater the share of entrepreneurs with a higher probability of "coming out of the shadows".

Corruption is not the main concomitant phenomenon that creates the basis for the shadowing of the economy and, in particular, the sector of counterfeit products. The high level of materialization of corruption risks makes the task of counteracting the significant

circulation of counterfeit products almost impossible. A favorable regulatory and legal climate in the country and the high efficiency of the property rights protection system are important conditions for the exit of business "from the shadows", and therefore their diagnosis is important for the development of measures to counter shadow operations, the spread of violations of property rights, including intellectual property, and, respectively, reducing the circulation of counterfeit products.

Taking into account the above arguments, we come to the conclusion that the level of corruption, the ease of doing business and the protection of property rights in the country are factors in the volume of counterfeiting, and therefore it is proposed to investigate the nature of their influence using appropriate indicators (Corruption Perceptions Index, position in the Doing Business ranking, International Property Rights Index) and mathematical apparatus. Corruption Perceptions Index (2021) is determined by the international organization Transparency International. The result of using the rating method is the determination of the number of points, and not the ranking of the country. The lowest score (0 points) indicates that corruption is a widespread phenomenon, the highest (100 points) means the actual absence of corruption. The index reflects the results of the assessment of corruption only in the public sector and is based on the points of view of business representatives, investors, market researchers, etc. Thus, this indicator reflects the point of view of the private sector and its perception of corruption in the public sector.

Using the Doing Business ranking (2019) from the World Bank, it is possible to evaluate the ease of doing business according to ten main indicators and compare countries with each other. This expert study is quite realistic and has practical significance. When forming the rank of countries, not only the legal acts adopted by the country during the year are taken into account, but also the conclusions of entrepreneurs about the reality of their actions.

International Property Rights Index is calculated by the International Alliance of Property Rights and is an integrated indicator that characterizes the general regulatory and legal climate in the country and the effectiveness of the property rights protection system. From a methodological point of view, the calculation of this index is carried out by analyzing 10 indicators calculated on the basis of statistical data of the Organization for Economic Cooperation and Development, the World Bank, the World Trade Organization, other research institutions and are grouped into 3 groups: (political and legal environment; law physical property; intellectual property right) (Ukraine, 2023).

These indicators are determined by authoritative international organizations, independent agencies,

research centers and have scientific value and applied nature, acting as a kind of marker for international investors, business partners, financial organizations, etc. Table 5 shows a generalization of indicators, based

on which a model of the dependence of effective indicators (the volume of counterfeiting and corresponding budget losses) on substantiated impact indicators was built.

Table 5. Indicators of influence on the resulting indicators

Indicator	2017	2018	2019	2020
1	2	3	4	5
Corruption Perceptions Index – CPI (points) Index of perception of corruption (points)	30	32	30	33
Doing business (rank)	80	76	71	64
International index of protection of property rights (International Property Rights Index (IPRI)) position (rank)	123	110	109	105
Effective indicators				
Volume of counterfeiting, UAH billion.		35-55	40-60	45-70
Corresponding budget losses, billion hryvnias	10	10-12	11.5-16	12-20

Source: compiled from (Doing, 2020; Corruption, 2021)

Model dependence of performance indicators on indicators impact

The model of dependence of effective indicators (volume of counterfeiting and budget losses) on influence indicators was developed on the basis of mathematical models, the basic functions of which are radial. Such models are quite effective in modeling problems where there is a nonlinear relationship between input and output characteristics, and have sufficient prognostic properties (Oliynychuk *et al.*, 2021). The development of the structure of such models takes place by analogy with artificial neural networks with radial basis functions (RBF) (Nelles, 2001; Bodyanskiy *et al.*, 2020).

$$\hat{y} = \sum_{i=1}^N w_i f_i(\|x - c_i\| \sigma^{-2}) \quad (1)$$

where $\vec{w}_i = (w_0, w_1, \dots, w_h)^T$ – parameters that must be determined in the process of parametric identification; $f_i(x) = (f_1(x), f_2(x), \dots, f_N(x))$ is a radial n – base vector functions; $\vec{x} = (x_1, x_2, \dots, x_n)$ – vector of input data; $\vec{c}_i = (c_1, c_2, \dots, c_h)$ – vector of centers; σ – window width parameter of the basic function; $\hat{y}$ – initial characteristic; $i = 1, \dots, h$, where h is the number of basis functions.

$$\hat{y} = w_1 f_1(\|x - c_1\| \sigma^{-2}) + w_2 f_2(\|x - c_2\| \sigma^{-2}) + \dots + w_{16} f_{16}(\|x - c_{16}\| \sigma^{-2}) \quad (2)$$

Such a structure of the model is quite complex, requires significant computing resources and, as the results of the experiments show, does not have predictive

properties. Thus, the procedure for structural identification of such models is significantly simplified and consists in calculating the number of basis functions. Since the basis functions are of the radial type, they are based on two parameters: the centers of the receptor field of the basis functions and the standard deviation, which determines the width of the RBF. It is worth noting that the method of identifying models of this type combines the procedures of structural and parametric identification (Savka *et al.*, 2012).

We calculate the BBF width parameter experimentally (Nelles, 2001). To identify the centers, we use the method of cluster analysis, which is described in detail in (Dyvak *et al.*, 2021). Parametric identification is carried out on the basis of the method of backpropagation of the error (Nelles, 2001). Considering the table of experimental data, denote by $\vec{x} = (x_1, x_2, x_3)$ – factors affecting performance indicators as input data for model development, and effective indicator and – volume of counterfeiting and budget losses. At the first iteration of the implementation of the clustering method, we obtain the structure of the model based on the radial basis:

properties. At the 6th iteration of structural identification, we get the optimal radial-type mathematical model for modeling and forecasting performance indicators:

$$\hat{y} = w_1 f_1(\|x - c_1\| \sigma^{-2}) + w_2 f_2(\|x - c_2\| \sigma^{-2}) + w_3 f_3(\|x - c_3\| \sigma^{-2}) \quad (3)$$

Based on the developed structure of the mathematical model (3), we obtain the results of modeling indicators of

the volume of counterfeiting and budget losses based on the influencing factors shown in Figures 1 and 2.

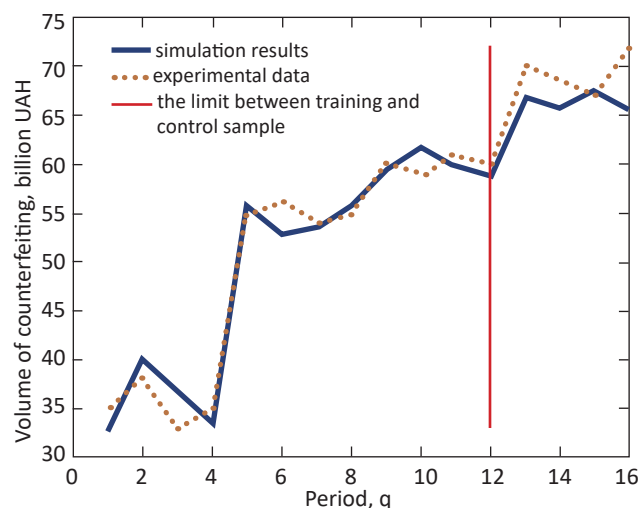


Figure 1. Forecasting the volume of counterfeiting

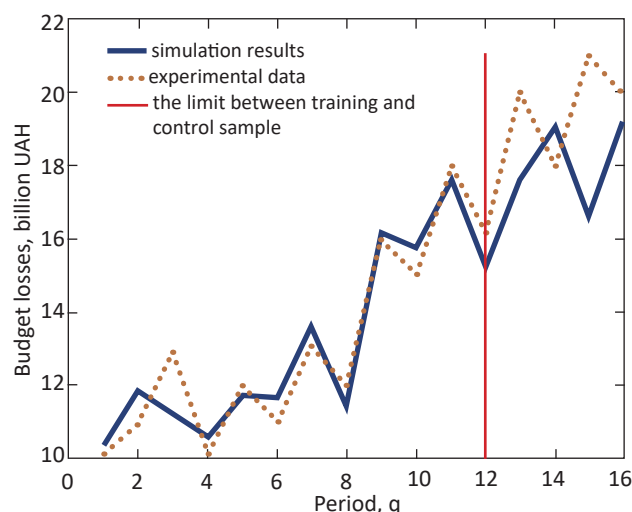


Figure 2. Forecasting budget losses

DISCUSSION

The conducted data analysis allows us to see confirmation of the correctness of the choice of impact indicators, since the potential dynamics for their improvement leads to a decrease in the projected amount of counterfeiting (Fig. 1) and projected budget losses (Fig. 2). In particular, with regard to Ukraine, the influence of the Corruption indicator is decisive Perceptions Index, as it largely determines not only the possibilities of increasing the volume of counterfeiting, but also has a significant impact on filling the budget in general. The choice of factors and the tools for determining their influence determine the peculiarity of this study and may be the subject of further discussion. Factors that have a decisive influence on the spread of counterfeit products in different countries may be different, and they may change over time (including in Ukraine). In particular, after Ukraine's accession to the EU, and the increase in the influence of European regulators of the legal system and the market (and the

application of EU fines in the system of countering violations of intellectual property rights, which are much tougher and more effective than Ukrainian ones), we predict that the size and quantity will be added to the list of determining factors application of penalties. Meanwhile, the mathematical toolkit used in the study will be preserved, as it provides for the possibility of changing the influencing factors. The difference in the approaches of foreign authors to the study of the problem of counterfeiting is different, because the influence of the factors of corruption and the ease of doing business is much smaller (which determines the much smaller volume of distribution of counterfeit products compared to Ukraine), so the psychological factors of buying counterfeit products come to the fore (Jacob *et al.*, 2018), and the impact of its volumes on the market equilibrium (Gistri, 2021). In the conditions of Ukraine, the low education of citizens in the field of intellectual property leads to the actual absence of a psychological reaction of society to

counterfeiting, and its conscious consumption. L. Nash *et al.* (2014) identified the following as indicators of influence: quantitative characteristics of target markets, type of products subject to counterfeiting, as well as production and logistics data on counterfeit products (place of production, distribution channels, etc.). At the same time, their protection program was focused on the protection of the business sector.

H. Valembois (2019) in his work emphasizes that the fight against infringement of intellectual property rights must be strengthened. The author attempted to develop a new approach to assessing the impact of violations of intellectual property rights on economic indicators at both the macro and micro levels, as well as to measure the impact of such violations on the domestic market. For this purpose, the following indicators were analyzed: the total contribution of integrated intellectual property industries to the economy, indicators of export and import of products manufactured in violation of intellectual property rights. H. Valembois (2019) made an attempt to forecast sales and their direct impact on the economic result, taking into account the indicator of counterfeit products on the market. The author emphasizes that it is quite difficult to calculate such an economic result, given the lack of a complete picture of counterfeiting in the world, and only the data of customs authorities are taken into account.

E. Auriol *et al.* (2022) in their study conducted an empirical analysis of the determinants of the perception of intellectual property rights and their impact on innovation and developed a methodology for calculating the economic impact of the protection of intellectual property rights in order to combat counterfeiting, using the approach of assessing the quality of a key indicator – the volume of international trade of protected goods intellectual property rights. Meanwhile, the authors emphasize the need for the formation of a new modern methodology for calculating the size of the world counterfeit in order to compare these indicators.

J. Wilson *et al.* (2016) conducted a study based on data from ten large global firms, trying to understand how they protect their intellectual property rights, as well as calculate the benefits of applying this kind of will in the way of protection against counterfeiting. Scientists focus their research on the following main parameters: management efficiency, the level of funding for the protection of intellectual property rights, the focus on counterfeiting as a negative phenomenon in general.

L. Nash *et al.* (2014) investigated not only the marketing aspects of the promotion of global brands to the market, but also focused their attention on the development of a single unified approach to combating counterfeiting, taking into account the following indicators: quantitative

characteristics of target markets, the type of products subject to counterfeiting, as well as production logistical data regarding counterfeit products (place of production, distribution channels, etc.). With the availability of this information, companies will be able to develop a plan for protection against violations of intellectual property rights, the formation of a logistics management system, as well as customs control over the movement of goods across borders.

CONCLUSIONS

Therefore, today the international market for the production and sale of counterfeit products is among the leaders of illegal business, and can compete with such negative phenomena as human and organ trafficking as well as drug and arms trafficking. In addition to significant losses incurred by producers of original goods and owners of intellectual property rights as a result of such activity, counterfeiting is also a threat to people's health and life, violating a significant number of their fundamental rights. A comparative analysis of ratings based on the criteria of the country of origin of counterfeited goods (the share of seizures and trade flows of counterfeited products in individual countries of the world), which were implemented on European markets, demonstrated their wide coverage, regardless of the level of economic development of the country. However, we should note that the vast majority of the countries of origin of counterfeit goods are world leaders in trade in general.

As a result, the annual shortfall of tax revenues to the budget, a decrease in the level of investment attractiveness of the country, and a decrease in the volume of direct investments are characteristic.

In this scientific article, the authors investigated the dependence of the performance indicators (the amount of counterfeiting and budget losses) on the corresponding influence indicators and made an attempt to develop an optimal mathematical model of the radial type for modeling and forecasting performance indicators. On the basis of the developed structure of the mathematical model, the results of modeling indicators of the volume of counterfeiting and budget losses based on influencing factors were formed.

Analytical substantiation of the choice of intermediate indicators and the study of the strength of their influence on the resulting indicators of the volume of budget losses and the volume of counterfeit products based on the use of mathematical modeling methods made it possible to substantiate the conclusion about the insufficient effectiveness of state policy in this direction. The forecast shows a further increase in the volume of counterfeiting and budget losses, but the slowdown in growth rates is positive. Thus, it can be claimed that

the influence of the identified indicators is positive, but the insufficient effectiveness of its power makes it necessary to find levers of greater influence on the partial components of these indicators. This may be the subject of further exploration in this direction.

None.

None.

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CONFLICT OF INTEREST

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Протидія контрафакту як загрозі економічної безпеки держави на основі кримінологічного дослідження

Анотація. Поширення контрафактних товарів – це актуальна проблема сучасності глобального масштабу із багатомільярдным фізичним обігом. Мета статті полягає у відслідковуванні впливу чинників на динаміку зміни розміру контрафакту та обґрунтування його прогностичних показників. Під час проведення дослідження використано методи: теоретичний, табличний, аналітичний, узагальнення, статистичний, синтезу, абстрагування, прогнозування, моделювання, експерименту. У статті розглянуто суть явища контрафакту як правопорушення у сфері інтелектуальної власності, конкретизовано його негативні наслідки. Продемонстровано світові тенденції торгівлі підробленими та контрафактними товарами на основі європейської методології GTRIC; проаналізовано рейтинг країн походження контрафактних товарів, а також досліджено рейтинг галузей промисловості, що постраждали від контрафакції. У статті окреслено масштаби контрафакту в Україні, обґрунтовано зв'язок з економічною безпекою держави. Наголошено, що здатність діагностувати індикатори впливу та протидіяти поширенню контрафактної продукції є стратегічним завданням держави у напрямі досягнення параметрів безпеки. Аргументовано, що рівень корупції, легкість ведення бізнесу та захисту прав власності в країні впливають на обсяг контрафакту, а тому запропоновано дослідити характер їхнього впливу, використовуючи відповідні індикатори (Corruption Perceptions Index, позиція в рейтингу Doing business, International Property Rights Index) та математичний апарат. На основі математичних моделей, базисні функції яких є радіальними, розроблено модель залежності результативних

показників (обсягу контрафакту та втрат бюджету) від обґрунтованих індикаторів. У результаті проведення дослідження встановлено, що покращення стану обраних індикаторів позитивно впливає на результуючий показник. Разом з тим недостатня ефективність сили їх впливу визначає перспективи подальших розвідок важелів додаткового покращення окремих їх складників. Практичне значення дослідження полягає в обґрунтуванні системи показників впливу на обсяги контрафакту, та, на їх основі, побудови економіко-математичного апарату, що дозволить спрогнозувати його динаміку

Ключові слова: підроблені товари; порушення прав інтелектуальної власності; тіньова економіка; індикатори впливу на обсяг контрафакту та втрати бюджету; математична модель з радіально-базисними функціями