Survival Analysis Methods for Assessing the Anti-Money Laundering System Effectiveness

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Abstract: - The article collects and systematizes statistical information to assess the anti-money laundering system effectiveness for 25 banks from 12 countries. The anti-money laundering system effectiveness was evaluated based on applying the survival analysis method by constructing tables of survival for banks subject to sanctions, determining the probability of deciding on the need to impose sanctions on banks, multiple assessments of Kaplan-Meyer, formalization of the Hazard rate instantaneous risk function. The anti-money laundering system effectiveness is compared based on the survival analysis in groups of banks around the world. Relevant factors influenced the assessment of the anti-money laundering system effectiveness based on the application of the principal components method by creating a scree plot and determining the factor loads of the statistical input base indicators in the study. A Cox proportional intensity regression model of dependence of the anti-money laundering system effectiveness on independent factors is constructed.

Key-Words: - Anti-money laundering, anti-terrorism financing, survival analysis methods, anti-money laundering system, effectiveness, anti-money laundering system effectiveness assessment

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1 Introduction

Money laundering is an attempt to conceal the proceeds of illegal activities by disguising them as legal earnings. The money laundering process involves the movement of illicit proceeds through official bank accounts, through the banking systems of several countries, to reach an unknown final beneficiary or mix them with legal money. Growing concerns about money laundering, terrorist financing, and the proliferation of mass destruction weapons contributed to the creation of the Financial Action Task Force (FATF) in 1989. It must analyse and monitor money laundering activities and evaluate the anti-money laundering measures in member countries. The FATF's recommendations are being updated and improved in light of new research and new challenges since international law considers money laundering a separate crime. Today, much attention is paid to the shortcomings of the financial system in the fight against money laundering, as the sector continues to grow and constantly faces new schemes and financial scandals. An important factor in further improving measures to combat money laundering is to assess the existing system's effectiveness for preventing such crimes.

2 Problem Formulation

Given the literature, one should note that the general theoretical and practical issues of combating money laundering are revealed in the works of a wide range

of scientists. Research in this area has different directions and reveals various aspects of the topic. For example, Noura Al-Suwaidi and Haitham Nobanee (2020), [1], analyse scientific theoretical study and practices, gaps in the safeguards adopted by countries regarding anti-money laundering (AML) and anti-terrorism financing (ATF). Marco Arnone and Leonardo S. Borlini (2011), [2], provide an empirical assessment and identify regulatory issues related to international anti-money laundering (AML) programs. Leonov S., Yarovenko H., Boiko A. & Dotsenko T. (2019), [3], investigate the information system for monitoring bank transactions related to money laundering.

The state of the anti-money laundering system affects the macroeconomic stability of the system, [4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21]. The relationship between macroeconomic stability and the effectiveness of state regulation has been studied in Lyeonov S., Vasylieva T. & Lyulyov O. (2018), [22], and Bilan Y., Tiutiunyk I., Lyeonov S. & Vasylieva T. (2020), [23]. Bouchetara M., Nassour A., Eyih S. (2020), [24], analyse the role and tools of macroprudential policy. The study of the shadow economy as a factor of macroeconomic instability conducted by Zolkover A., Georgiev M. (2020), [25], Zolkover A., Terziev V (2020), [26], Shpak et al., [27], Bilan et al., [28], Yoshimori M. (2019), [29], determine the impact of the shadow economy on public administration and financial and economic security. Vasylieva T., Jurgilewicz O., Poliakh S., Tvaronavičienė M., & Hydzik P. (2020), [30], studied the problems of measuring financial protection and its effect proceeds from crime. Buriak A., Lyeonov S., & Vasylieva T. (2015), [31], describe the fight against money laundering on the example of the banking system in Ukraine through the legal framework improvement. The activities of financial intermediaries and their impact on the anti-money laundering system are identified in the works of Brychko M., Savchenko T., Vasylieva T., & Piotrowski P. (2021), [32].

An important area of research is to assess the risk of money laundering through financial institutions, [33; 34; 35; 36; 37; 38; 39; 40; 41; 42; 43]. Dmytrov S., Medvid T. (2017), [44], suggest to assess the money laundering risks using indices-based analysis; Kuzmenko O., Šuleř P., Lyeonov S., Judrupa I., & Boiko A. (2020), [45], offer Data mining and bifurcation analysis of the money laundering risk with the involvement of financial institutions. The FATF evaluates the country's anti-money laundering system, but the FATF's effectiveness methodology does not reflect the focus on anti-money laundering outcomes. Pol R.F., [46], examines the FATF approach and notes the misapplication of outcome labels (output labels to outputs), making it impossible to assess the impact of anti-money laundering policies.

It is worth emphasizing that modelling the existing and projected systems and processes is widely used in today's conditions to analyse various issues of all sectors of the world and national economy, [47; 48; 49; 50; 51; 52; 53; 54; 55; 56; 57; 58; 59; 60; 61; 62]. For example, Subeh M. A., Boiko A. (2017), [63], conduct modelling of the public financial monitoring service effectiveness in terms of anti-money laundering and anti-terrorist financing; Kozmenko O. & Kuzmenko O. (2013), [64], carry out modelling of dynamics of banking system stability; Kuzmenko O. & Koibichuk V. (2018), [65], use econometric modelling of the influence of relevant gender policy indicators on the banking system efficiency. Among such models, a specific method of economic-mathematical modelling is modelling based on methods of survival analysis, which is covered in the works of the following specialists: Shoaee S. & Khorram E. (2020), [66] – general theoretical features are studied; Platero C. & Tobar M. (2020), [67], and Stevens N., Lydon M., Marshall A.H. & Taylor S. (2020), [68], describes the practical application in medicine and health care.

Although many scientists worldwide are working to study the effectiveness of the anti-money laundering system, anti-terrorist financing and the financing of the proliferation of mass destruction weapons, this question remains open and needs further development (Mavlutova et al. (2021), [69]; Malyarets et al. (2021), [70]; Perevozova et al. (2019), [71]; Vovk et al. (2020), [72]). We believe that special attention should be paid to modelling based on survival analysis methods, which allow us to assess and analyse the probability of appearance or occurrence of inevitable consequences over time.

This article aims to assess the anti-money laundering system effectiveness, terrorist financing and the proliferation of mass destruction weapons based on statistical modelling and comparison of the countermeasures effectiveness based on survival analysis in groups of banks around the world. Relevant factors influence the assessment of the anti-money laundering system effectiveness, terrorist financing and proliferation of mass destruction weapons based on the application of the main components method by scree plot creation and determining the factor loads of indicators.

3 Methodology and Data

To implement this stage, 25 banks from 12 countries were selected (Latvia, Denmark, Malta, Netherlands, Luxembourg, Portugal, Switzerland, Sweden, Korea, USA, China, Germany) for 2016-2019, for which decisions were made on the application of sanctions for violation by banks of the requirements of the legislation in the field of money laundering, terrorism financing. Data on violations and sanctions were obtained from published court decisions. Relevant dates in the format: month, date, year are given in columns 1 - 6 of table 1.

Eleven indicators of Effectiveness in a Country of Parents (using the 2013 FATF Methodology) were selected in terms of 25 banks in the world (columns 7-17 of Table 1) to characterize the anti-money laundering system: IO1- IO11. It uses an approach focused on determining the achievement of specific results in implementing measures to combat money laundering and terrorist financing to assess the Effectiveness of the FATF. Each of them is one of the critical goals of effective Anti-Money Laundering and Countering Terrorism Financing (AML / CFT):

- "IO1 - Money laundering and terrorist financing risks are understood and, where appropriate, actions co-ordinated domestically to combat money laundering and the financing of terrorism and proliferation;
- IO2 International co-operation delivers appropriate information, financial intelligence, and evidence, and facilitates action against criminals and their assets;
- IO3 Supervisors appropriately supervise, monitor and regulate financial institutions and DNFBPs for compliance with AML/CFT requirements commensurate with their risks;
- IO4 Financial institutions and DNFBPs adequately apply AML/CFT preventive measures commensurate with their risks, and report suspicious transactions;
- IO5 Legal persons and arrangements are prevented from misuse for money laundering or terrorist financing, and information on their beneficial ownership is available to competent authorities without impediments;
- IO6 Financial intelligence and all other relevant information are appropriately used by competent authorities for money laundering and terrorist financing investigations;
- IO7 Money laundering offences and activities are investigated and offenders are prosecuted and subject to effective, proportionate and dissuasive sanctions;
- IO8 Proceeds and instrumentalities of crime are confiscated;

Table 1. Input statistical base of the study

№	Bank	Country of Parent	The date of the last event that preceded the sanctions			Date of sanctions application		
A	B	C	1	2	3	4	5	6
1	ABLV Bank	Latvia	13	2	2018	12	6	2018
2	Danske bank Estonia	Denmark	8	5	2018	1	10	2019
3	Pilatus Bank	Malta	19	3	2018	4	11	2018
4	ING	Netherlands	3	4	2016	4	9	2018
5	CA Indosuez Wealth (Europe)	France	3	4	2016	15	12	2017
6	DNB Luxembourg S.A.	Luxembourg	3	4	2016	15	12	2017
7	Nordea Bank S.A.	Luxembourg	15	12	2017	14	11	2019
8	Novo Banco S.A.	Portugal	3	4	2016	15	12	2017
9	LPB Bank	Latvia	25	7	2016	16	10	2018
10	Bank Julius Baer & Co. Ltd.	Switzerland	1	11	2015	27	5	2021
11	Bank Hapoalim B.M.	Switzerland	12	11	2015	30	4	2020
12	Rietumu Banka	Latvia	17	7	2017	15	6	2021
13	PNB banka (NORVIK BANKA)	Latvia	19	7	2017	15	8	2019
14	Swedbank	Sweden	1	2	2019	5	5	2021
15	Industrial Bank Of Korea	Korea	14	12	2016	20	4	2020
16	Apple Bank for Savings	USA	1	9	2018	21	12	2020
17	Mega International Commercial Bank Co., Ltd.	USA	31	12	2016	17	1	2018
18	Citibank N.A.	USA	5	4	2012	4	1	2018
19	Capital One Bank	USA	7	10	2015	23	10	2018
20	Industrial and Commercial Bank of China Financial Services LLC	China	1	6	2014	16	5	2018
21	Deutsche Bank AG	Germany	31	12	2016	30	5	2017
22	Lone Star National Bank	USA	30	11	2014	1	11	2017
23	Habib Bank	USA	15	12	2015	7	9	2017
24	Gibraltar Private Bank & Trust Co.	USA	16	10	2014	23	2	2016
25	Agricultural Bank of China	China	31	7	2015	4	11	2016

Continuation of Table 1

№	Bank	IO1	IO2	IO3	IO4	IO5	IO6	IO7	IO8	IO9	IO10	IO11	Censored
A	B	7	8	9	10	11	12	13	14	15	16	17	18
1	ABLV Bank	ME	SE	ME	ME	LE	ME	ME	ME	ME	ME	LE	completed
2	Danske bank Estonia	ME	SE	LE	LE	ME	ME	ME	ME	SE	ME	SE	completed
3	Pilatus Bank	ME	SE	LE	ME	ME	ME	LE	LE	ME	ME	SE	completed
4	ING	-	-	-	-	-	-	-	-	-	-	-	censored
5	CA Indosuez Wealth (Europe)	-	-	-	-	-	-	-	-	-	-	-	censored
6	DNB Luxembourg S.A.	-	-	-	-	-	-	-	-	-	-	-	censored
7	Nordea Bank S.A.	-	-	-	-	-	-	-	-	-	-	-	censored
8	Novo Banco S.A.	SE	SE	ME	ME	ME	ME	SE	ME	SE	SE	SE	completed
9	LPB Bank	ME	SE	ME	ME	LE	ME	ME	ME	ME	ME	LE	completed
10	Bank Julius Baer & Co. Ltd.	SE	ME	ME	ME	ME	SE	SE	SE	SE	SE	SE	completed
11	Bank Hapoalim B.M.	SE	ME	ME	ME	ME	SE	SE	SE	SE	SE	SE	completed
12	Rietumu Banka	ME	SE	ME	ME	LE	ME	ME	ME	ME	ME	LE	completed
13	PNB banka (NORVIK BANKA)	ME	SE	ME	ME	LE	ME	ME	ME	ME	ME	LE	completed
14	Swedbank	ME	HE	ME	ME	ME	ME	SE	SE	SE	ME	SE	completed
15	Industrial Bank Of Korea	SE	SE	ME	ME	ME	SE	ME	SE	SE	ME	ME	completed
16	Apple Bank for Savings	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
17	Mega International Commercial Bank Co., Ltd.	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
18	Citibank N.A.	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
19	Capital One Bank	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
20	Industrial and Commercial Bank of China Financial Services LLC	SE	ME	ME	LE	LE	ME	ME	SE	SE	LE	LE	completed
21	Deutsche Bank AG	-	-	-	-	-	-	-	-	-	-	-	censored
22	Lone Star National Bank	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
23	Habib Bank	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
24	Gibraltar Private Bank & Trust Co.	SE	SE	ME	ME	LE	SE	SE	HE	HE	HE	HE	completed
25	Agricultural Bank of China	SE	ME	ME	LE	LE	ME	ME	SE	SE	LE	LE	completed

Notes:
IO1- IO11 - immediate outcomes, which represent key goals that an effective AML/CFT system should;
HE - High level of effectiveness;
SE - Substantial level of effectiveness;
ME - Moderate level of effectiveness;
LE - Low level of effectiveness.

- IO9 Terrorist financing offences and activities are investigated and persons who finance terrorism are prosecuted and subject to effective, proportionate and dissuasive sanctions;

- IO10 Terrorists, terrorist organisations and terrorist financiers are prevented from raising, moving and using funds, and from abusing the NPO sector;

- IO11 Persons and entities involved in the proliferation of weapons of mass destruction are prevented from raising, moving and using funds, consistent with the relevant UNSCRs" [73].

In addition, the availability of complete information about the considered set of banks is essential to assess the effectiveness of the national anti-money laundering system and anti-terrorist financing based on survival analysis methods.

Thus, the column "Censored" defines two possible values: "completed" in the presence of complete information and "censored" in the absence of data on the occurrence of the event of interest. In particular, according to the methodology, for some countries (Netherlands, France, Luxembourg, Germany) evaluation adopted by the FATF since 2013 has not been conducted.

4 Results

4.1 The Study of the Anti-Money Laundering System Effectiveness based on Survival Tables

The technique of constructing survival tables is one of the data analysis methods of survival, based on the table of frequencies of the possible occurrence of critical events following a certain number of intervals. In terms of the anti-money laundering system effectiveness, the approach based on survival tables enables to build frequency tables of possible decisions on the application of sanctions (fines, revocation of licenses) for violations by banks of anti-money laundering and terrorist financing legislation.

We use the software package Statistica to implement this stage. Then we execute the following command: Statistics / Linear / Nonlinear Models / Survival Analysis / Life labels and Distributions, i.e. by selecting the command table of lifetime and distribution (Figure 1).

Based on the data in Figure 1, it is possible to conclude that for the selected set of banks, their activities are constantly monitored in terms of anti-money laundering and on average, in cases of violations within 2100 days (i.e. 5.75 years), the relevant banks are allowed to eliminate them, or an appropriate managerial decision is made to declare banks insolvent or liquidate banks, which is a quantitative feature of the national system efficiency.

Thus, during the first 191 days after the revealed factors regarding the use of banks for money laundering (after the last event preceding the sanctions) among the 25 banks considered in the sample (Count Entering column), the number of banks subject to inspection and not liquidated is 100%, i.e. 25 (column Number Exposed). During this period, the share of banks that intensified their activities in anti-money laundering was 95.943% (Proportion Surviving column).

In contrast, the percentage of liquidated banks (or banks subject to fines) within 191 days after deciding to declare the bank insolvent is 4.1%. Moving to the next time interval – the next 191 days after discovering the facts of legalization of criminal proceeds (after the last event preceding the sanctions), the share of liquidated banks (or banks subject to fines) increases to 4.3%.

Life Table (Spreadsheet2.sta)
Log-Likelihood for data: -47,5847

Interval	Interval Start	Mid Point	Interval Width	Number Entering	Number Withdrwn	Number Exposed	Number Dying	Proportn Dead	Propo rtn Surviv ng	Cum. Prop Survi vng	Problty Density	Hazard Rate	Std.Err. Cum.Surv	Std.Err. Prob.Den	Std.Err. Haz.Rate	Median Life Exp	Std. Err. Life Exp
Intno.1	0	95	191	25	1	25	1	0,041	0,959	1,000	0,0002	0,0002	0,000	0,0002	0,0002	900	120
Intno.2	191	286	191	23	0	23	1	0,043	0,957	0,959	0,0002	0,0002	0,040	0,0002	0,0002	733	119
Intno.3	382	477	191	22	0	22	4	0,182	0,818	0,917	0,0008	0,0010	0,056	0,0004	0,0005	567	117
Intno.4	573	668	191	18	3	17	3	0,182	0,818	0,751	0,0007	0,0010	0,088	0,0003	0,0006	514	155
Intno.5	764	859	191	12	1	12	3	0,261	0,739	0,614	0,0008	0,0015	0,101	0,0004	0,0009	494	305
Intno.6	955	1050	191	8	0	8	2	0,250	0,750	0,454	0,0005	0,0015	0,109	0,0003	0,0010	477	135
Intno.7	1145	1241	191	6	0	6	1	0,167	0,833	0,340	0,0003	0,0009	0,107	0,0002	0,0009	382	234
Intno.8	1336	1432	191	5	0	5	2	0,400	0,600	0,284	0,0005	0,0026	0,103	0,0003	0,0017	286	213
Intno.9	1527	1623	191	3	0	3	1	0,333	0,667	0,170	0,0003	0,0021	0,088	0,0002	0,0020	382	220
Intno.10	1718	1814	191	2	0	2	0	0,250	0,750	0,113	0,0001	0,0015	0,075	0,0002	0,0020	318	180
Intno.11	1909	2005	191	2	0	2	1	0,500	0,500	0,085	0,0002	0,0034	0,066	0,0002	0,0032	95	135
Intno.12	2100			1	0	1	1	0,500	0,500	0,043			0,045				

Fig. 1: Table of decision-making frequencies on the application of sanctions (fines, revocation of licenses) for violation by banks of the legislation requirements in the field of anti-money laundering and terrorist financing

The percentage of banks that took measures to counter the existing facts of violations is reduced to 95.7%. It is the indicator of the survival share (column Proportion Surviving) indicates the effectiveness of the anti-money laundering system, which constantly decreases during the first six-time intervals (764 days - 2 years) after the detection of violations or insolvency of banks from 0.959 shares to 0.739 units.

During the following two periods (from 765 to 1145 days, i.e. up to 3.1 years), the effectiveness of the anti-money laundering system increases to the level of 0.833 units and in the following 3-time intervals on day 191, we observe a decrease with a gradual increase to level 0, 75 as of 1527 (4.2 years) the day after the last event preceding the sanctions. Further, in the previous two-time intervals, the anti-money laundering system effectiveness decreases to the level of 0.5 shares of the unit and remains at this level. Thus, in terms of imposing sanctions, the periods of 1145 and 1527 days (3.1 and 4.2 years, respectively) after the last event preceding the sanctions are important from the point of view of the anti-money laundering system effectiveness.

The probability density indicator (column Probability Density) is interesting from the point of view of the analysis, i.e., the assessment of the decision probability to liquidate the bank (the need to apply sanctions to the bank) in the appropriate time interval:

$$p_{li} = \frac{K_i - K_{i+1}}{w_i} \quad (1)$$

where p_{li} – assessment of the bank's liquidation density (application of sanctions) in terms of the *i*-th interval;

K_i , K_{i+1} – cumulative shares (survival functions) of banks that were not liquidated (to

which sanctions were not applied) before the beginning of the *i*-th and *i* + 1 intervals;

w_i – the width of the *i*-th interval.

Based on the data obtained in Figure 1 in terms of probability density, one can conclude that the probability of banks' liquidation declared insolvent (sanctions) during the first 387 days (about one year) is the highest and is 0.00087 units. In the following period, this figure decreased sharply to 0.00022 units.

The analysis of the indicator of the failure rate function or instantaneous risk function (graph Hazard rate of Figure 1) is critical in the context of this stage, which for the normal type of distribution takes the form:

$$\lambda_{norm}(t) = \frac{\frac{1}{\sigma\sqrt{2\pi}}\exp(-\frac{t^2}{2\sigma^2})}{1 - \frac{1}{\sigma\sqrt{2\pi}}\int_{-\infty}^{t}\exp(-\frac{t^2}{2\sigma^2})dt} \quad (2)$$

where $\lambda_{norm}(t)$ - failure rate functions or instantaneous risk functions for the normal type of distribution;

t – time indicator;

σ – standard deviation.

The hazard rate function is defined as an estimate of the probability that a surviving bank (not liquidated, sanctioned) before the relevant time interval will be liquidated (sanctions will be applied) during this interval. (Next 191 days for this case). The analysis of this indicator shows the instantaneous risk function at the level of 0.00022 units for the first time interval. It means that the instantaneous risk of the decision on their elimination (application of sanctions) is 0.00022 units among 25 banks that were not liquidated after the decision on their insolvency (to which no sanctions were applied). This risk increases gradually to 0.00157 units over 2, 3, 4 and 5 intervals (i.e., from 192 to 764 days) and then decreases to 0.00095 units at the end of the next interval. During the following intervals until the end of the study period, the immediate risk of deciding on their elimination (application of sanctions) increases to 0.00349 units, i.e., is the largest during the two periods: from 1336 to 1432 days (0.00262 units) and from 1909 to 2005 days (0.00349 units).

4.2. A Study of the Anti-Money Laundering National System Effectiveness

A study of the anti-money laundering national system effectiveness is based on the Kaplan-Meier method, which involves assessing the survival and risk functions. The advantage of using the Kaplan-Meier method compared to the method of life tables described in the second stage is that in this approach, performance evaluations do not depend on the grouping of the observation interval into intervals.

The Kaplan-Meier method involves estimating the survival function as follows:

$$KM(t) = \prod_{i=1}^{t}\left[\frac{n-i}{n-i+1}\right]^{\beta i} \quad (3)$$

where $KM(t)$ – the assessment of survival function;

n – the total number of observation objects (banks) in the studied sample;

$\prod_{i=1}^{t}$ – product (geometric sum) in the context of all observation objects (banks), the study of which is completed by the time t;

βi – takes a single value if the observation in terms of the studied bank is not censored (completed), and zero value if the observation in terms of the studied bank is censored (incomplete, lost communication);

i – the observation number is not in terms of the studied bank in the source file, and the observation number in the new file, ordered by the number of days of banks' life.

We use the software package Statistica for this stage. The following commands were executed: Statistics / Linear / Nonlinear Models / Survival Analysis / Kaplan and Meier product-limit method, i.e., selecting the command Method of product restriction Kaplan and Meyer (Fig. 2).

	Kaplan-Meier (Product-limit) analysis (Spreadsheet2 Note: Censored cases are marked with +		
Case Number	Time	Cumulatv Survival	Standard Error
1	119,00(	0,96000(	0,03919:
21+	150,00(		
3	230,00(	0,91826.	0,05542:
17	382,00(	0,87652:	0,06679'
25	462,00(	0,83478:	0,07553'
24	495,00(	0,79304.	0,08249:
2	511,00(	0,75130.	0,08807'
8	621,00(	0,70956'	0,09254:
6+	621,00(		
5+	621,00(		
23	632,00(	0,66226.	0,09772:
7+	699,00(		
13	757,00(	0,61131:	0,10262'
9	813,00(	0,56037'	0,10596:
14	824,00(	0,50943.	0,10788'
16	842,00(	0,45848:	0,10846.
4+	884,00(		
22	1067,00(	0,40117'	0,10899'
19	1112,00(	0,34386(	0,10744:
15	1223,00(	0,28655'	0,10370.
12	1429,00(	0,22924.	0,09752(
20	1445,00(	0,17193:	0,08839(
11	1631,00(	0,11462:	0,07524'
10	2034,00(	0,05731.	0,05529'
18	2100,00(	0,00000(	0,00000(

Fig. 2: The results of the effectiveness analysis of anti-money laundering system based on the Kaplan-Meier method

Analysing the anti-money laundering system effectiveness based on the Kaplan-Meier method using the data in Figure 2, we note that the censored banks are marked with a + sign. This table groups all surveyed banks by the number of days (column Time), when the bank will intensify activities in combating money laundering after the revealed violations, and take insolvency decisions (the need for sanctions). The column Cumulative Survival in Figure 2 shows the probability that the bank in question will "live" (will not be liquidated for violations in terms of money laundering) and take countermeasures.

Thus, the national anti-money laundering effectiveness is the highest at the level of at least 95% in the first 119 days after violation detection. This figure is reduced to 90% in the interval up to 230 days (about eight months); up to 80% in the range of up to 462 days (1.3 years), up to 50% in the range of up to 824 days (2.3 years). It means that the effectiveness of anti-money laundering measures and anti-terrorist financing will decline rapidly with

increasing time passed since the detection of the offence (decision-making on the need for sanctions). We represent Figure 3 to visualize the identified dependence.

ABLV Bank of Latvia, which decided to be liquidated based on a FinCEN report on suspicion of the bank in money laundering, currency control avoidance, belongs to the group of banks for which the anti-money laundering system effectiveness is the highest at 95% in the first 119 days after the facts of violations detection. High counteraction efficiency (at least 75%) in the first 514 days after detecting the offence is also peculiar for the USA, China, Malta, Danish systems. A specific feature is that this response interval includes banks that have violated the law in anti-money laundering, anti-terrorist financing, and proliferation of mass destruction weapons. In particular, there are cases of liquidated Danske bank Estonia, ABLV Bank. Most cases of banks, using which it is decided to apply sanctions (fine or re-fine) due to imperfect monitoring and prevention of violations in the money laundering combating, terrorist financing and financing the proliferation of mass destruction weapons, belong to the quartile with an efficiency of at least 50% and a response interval of up to 827 days. A quartile with an efficiency of at least 25% and a response interval of up to 1354 days includes cases of banks that have been sanctioned (fined) for their inability to create an effective system for combating money laundering, terrorist financing and proliferation of mass destruction weapons.

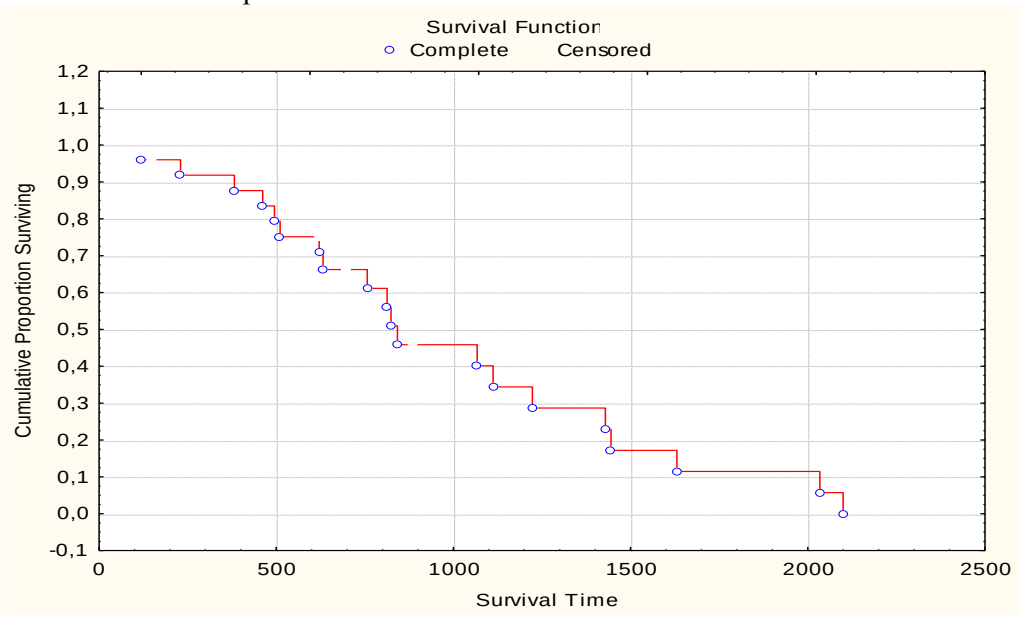

Fig. 3: Dependence of the anti-money laundering system effectiveness (based on the Kaplan-Meier method) on the time interval after the violation detection

We construct Figure 4 to reflect the distribution of the anti-money laundering system effectiveness, presented in Figure 3. We give the percentage there: 25% (lower quartile) - banks that make decisions on liquidation (sanctions), i.e., take appropriate measures in terms of countering the offence, during the first 514 days (1.4 years) after the detection of these facts; 50% (median) - reflect the banks that activate countermeasures within at least 827 days (2.3 years). The decision on the largest number of banks (75%) on anti-money laundering measures is made within 1354 days after the detection of violation, i.e., within 3.7 years.

	Percentiles of (Spreadshee the Survival Function
Percentiles	Survival Time
25'th percentile (lower quartile)	514,43
50'th percentile (median)	827,33
75'th percentile (upper quartile)	1354,39

Fig. 4: Percentile of the survival function

4.3 Comparison of the Effective Anti-Money Laundering System: Modelling based on the Analysis of Survival in Groups of Banks around the World

We use the software package Statistica to implement this stage. Therefore, we perform the following command: Statistics / Linear / Nonlinear Models /

Survival Analysis / Comparing multiple samples, i.e., by choosing the command to compare survival in more than two groups (Fig. 5). We analyse the results obtained under the cumulative share of banks that "survived" (were not liquidated or to which sanctions were not applied) by groups. This procedure helps to plot the cumulative survival function for banks in each group of countries separately.

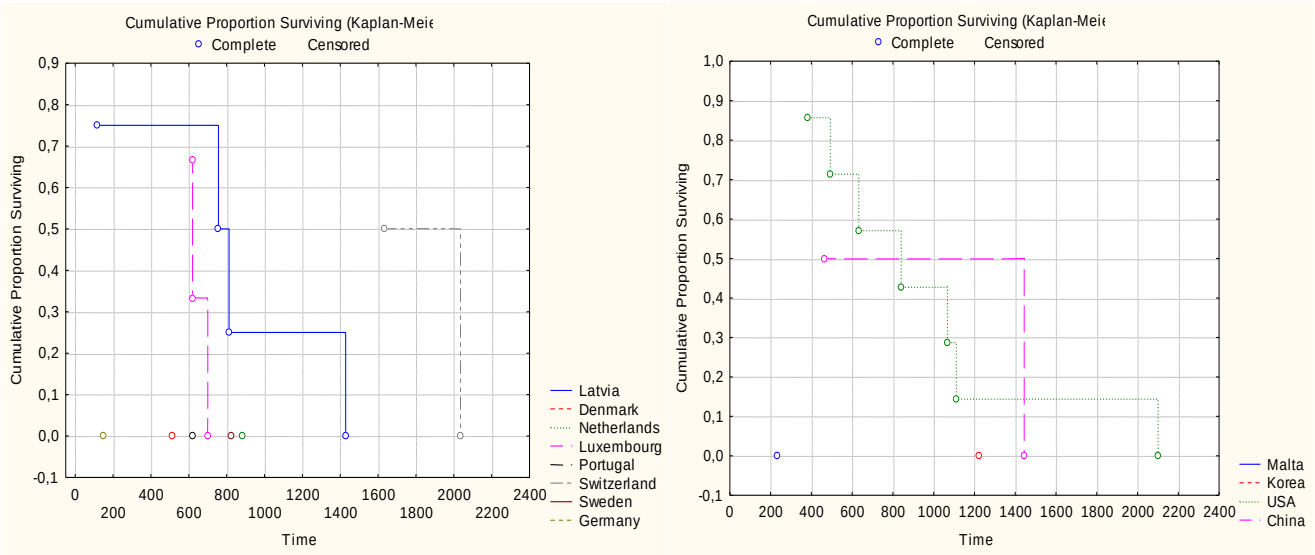

Fig. 5: Comparison of the observed banks in anti-money laundering (based on the Kaplan-Meier method) from the time interval after the detection of violations for the sample of countries

Table 2. Life Table for Group: Latvia, Denmark, Netherlands, Luxembourg, Portugal, Switzerland, Sweden, Germany

Lower Limit	Latvia		Denmark		Netherlands		Luxembourg		Portugal		Switzerland		Sweden		Germany	
	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr
119	75	100	100	100	100	100	100	100	100	100	100	100	100	100	0	100
332	100	75	0	100	100	100	100	100	100	100	100	100	100	100	0	0
545	67	75	0	0	100	100	0	100	0	100	100	100	100	100	0	0
757	50	50	0	0	0	100	0	0	0	0	100	100	0	100	0	0
970	100	25	0	0	0	0	0	0	0	0	100	100	0	0	0	0
1183	100	25	0	0	0	0	0	0	0	0	100	100	0	0	0	0
1396	0	25	0	0	0	0	0	0	0	0	100	100	0	0	0	0
1608	0	0	0	0	0	0	0	0	0	0	50	100	0	0	0	0
1821	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Life Table for Group: Malta, Korea, USA, China

Lower Limit	Malta		Korea		USA		China	
	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr	% Srvvng	Cum.%.Sr
230,0000	0	100	100	100	86	100	100	100
437,7778	0	0	100	100	67	86	50	100
645,5555	0	0	100	100	75	57	100	50
853,3333	0	0	100	100	100	43	100	50
1061,111	0	0	0	100	33	43	100	50
1268,889	0	0	0	0	100	14	0	50
1476,667	0	0	0	0	100	14	0	0
1684,445	0	0	0	0	100	14	0	0
1892,222	0	0	0	0	0	14	0	0
2100,000	0	0	0	0	0	0	0	0

A similar step system is typical for Latvia.

There are tough and more aggressive systems in Germany, Denmark, Portugal, Sweden, Malta.

However, the distinctive feature for these countries is the presence of only one bank in the sample.

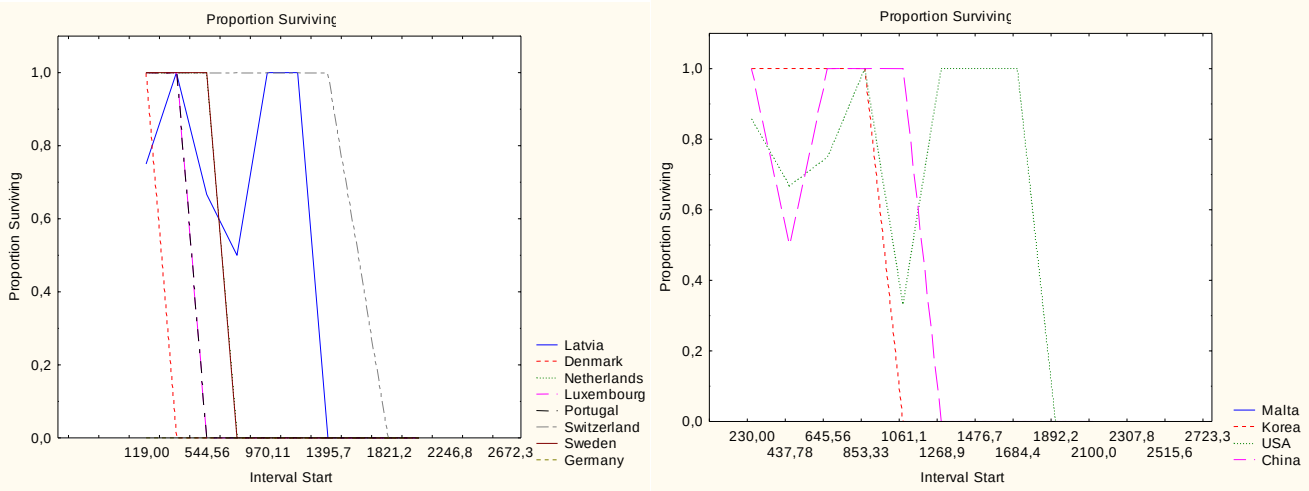

Fig. 6: Comparison of the number of observed banks that have been inspected and not liquidated (they have not been sanctioned) depending on the time interval after the violation detection for the sample of countries

Analysis of Figure 5 suggests that the United States has the most flexible anti-money laundering system, because during the first three years after the detection of violations, one can observe the most intensive system of gradual control weakening (column Cum.%. Sr table 3, Fig. 5), when the number of banks gradually decreases from the level of 86% during the first 438 days from the revealing the violations (application of sanctions) to 57% - 646 days (1.8 years), to 43% - 1061 days (2.9 years), 14% - 1892 days (5.2 years), and level 0 by the end of the study period. At the same time, the number of banks that successfully passed the inspection and were not subject to sanctions (column% Srvvng table 3, Fig. 6) has a variable nature: the period of greatest control over the application of sanctions which is critical for banks, from 33% of banks in 1061 days (2.9 years) after monitoring until the easing periods, when no sanctions were applied to any of the observed banks - ie 100% in the periods of 853 days (2.3 years) and from 1269 to 1684 days (3.5 - 4.6 year) after the inspection.

4.4. Determination of Relevant Factors Influencing the Assessment of the Anti-Money Laundering System Effectiveness based on the Application of the Principal Components Method

Several intermediate calculations were performed to implement this stage.

The quantitative evaluation by the quality indicators of Effectiveness in a Country of Parent (using the 2013 FATF Methodology) introducing the following scale:

$$\widetilde{IO}_{ij} = \begin{bmatrix} 1, if\ IO_{ij} = HE \\ 0.75, if\ IO_{ij} = SE \\ 0.50, if\ IO_{ij} = ME \\ 0.25, if\ IO_{ij} = LE \end{bmatrix} \quad (4)$$

where IO_{ij} – quality evaluation of j-index Effectiveness in a Country of Parent for i-bank;

$\widetilde{IO}_{ij}$ – quantitative evaluation of j-index Effectiveness in a Country of Parent for i-bank;

HE - High level of effectiveness;

SE – Substantial level of effectiveness;

ME – Moderate level of effectiveness;

LE - Low level of effectiveness.

According to formula (4), the calculations are presented in tabular form (Table 4).

Table 4. Quantitative assessment of indicators of Effectiveness in a Country of Parent

№	Банк	IO1	IO2	IO3	IO4	IO5	IO6	IO7	IO8	IO9	IO10	IO11
1	ABLV Bank	0.5	0.75	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5	0.25
2	Danske bank Estonia	0.5	0.75	0.25	0.25	0.5	0.5	0.5	0.5	0.75	0.5	0.75
3	Pilatus Bank	0.5	0.75	0.25	0.5	0.5	0.5	0.25	0.25	0.5	0.5	0.75
4	ING	0	0	0	0	0	0	0	0	0	0	0
5	CA Indosuez Wealth (Europe)	0	0	0	0	0	0	0	0	0	0	0
6	DNB Luxembourg S.A.	0	0	0	0	0	0	0	0	0	0	0
7	Nordea Bank S.A.	0	0	0	0	0	0	0	0	0	0	0
8	Novo Banco S.A.	0.75	0.75	0.5	0.5	0.5	0.5	0.75	0.5	0.75	0.75	0.75
9	LPB Bank	0.5	0.75	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5	0.25
10	Bank Julius Baer & Co. Ltd.	0.75	0.5	0.5	0.5	0.5	0.75	0.75	0.75	0.75	0.75	0.75
11	Bank Hapoalim B.M.	0.75	0.5	0.5	0.5	0.5	0.75	0.75	0.75	0.75	0.75	0.75
12	Rietumu Banka	0.5	0.75	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5	0.25
13	PNB banka (NORVIK BANKA)	0.5	0.75	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5	0.25
14	Swedbank	0.5	1	0.5	0.5	0.5	0.5	0.75	0.75	0.75	0.5	0.75
15	Industrial Bank Of Korea	0.75	0.75	0.5	0.5	0.5	0.75	0.5	0.75	0.75	0.5	0.5
16	Apple Bank for Savings	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
17	Mega International Commercial Bank Co., Ltd.	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
18	Citibank N.A.	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
19	Capital One Bank	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
20	Industrial and Commercial Bank of China Financial Services LLC	0.75	0.5	0.5	0.25	0.25	0.5	0.5	0.75	0.75	0.25	0.25
21	Deutsche Bank AG	0	0	0	0	0	0	0	0	0	0	0
22	Lone Star National Bank	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
23	Habib Bank	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
24	Gibraltar Private Bank & Trust Co.	0.75	0.75	0.5	0.5	0.25	0.75	0.75	1	1	1	1
25	Agricultural Bank of China	0.75	0.5	0.5	0.25	0.25	0.5	0.5	0.75	0.75	0.25	0.25

5.2. Identification of relevant indicators of Effectiveness in a Country of Parent by constructing a scree plot and determining the factor loads of the input statistical base indicators in the study. We will use the Statistica software package with the Statistics / Multivariate Expljratory Techniques / Principal Components and Classification Analysis toolkit to implement this step. The scree plot (Fig. 7) enables us to determine that the variation of the effective Kaplan-Meier feature by 84.67% is due to the first main component variation (i.e., the first factor), proposed to consider when determining the priority indicators Effectiveness in a Country of Parent.

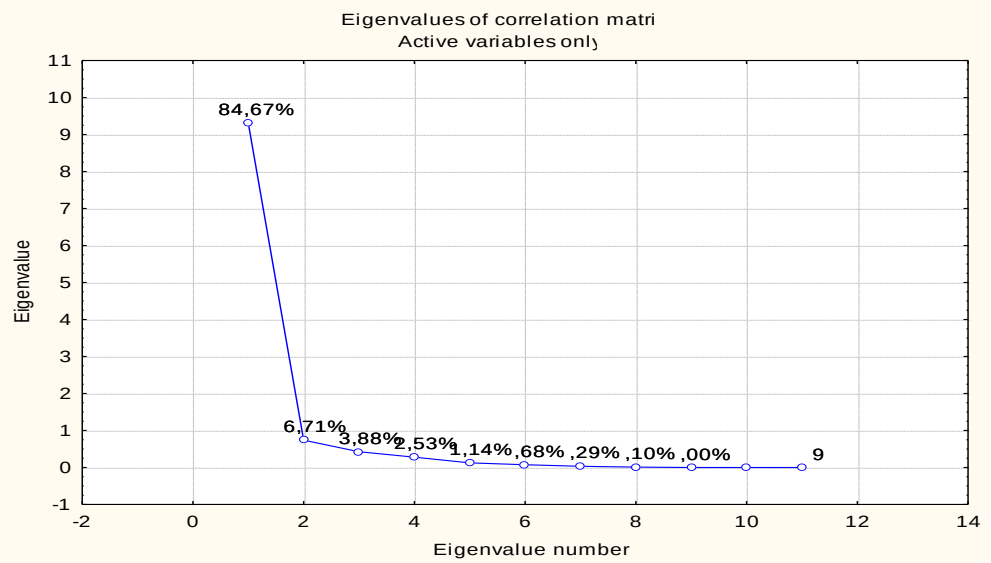

Fig. 7: Scree plot of evaluation factors relevance regarding Effectiveness in a Country of Parent

The obtained results of using reasonability to determine the priority of indicators regarding Effectiveness in a Country of Parent regarding the first main component are confirmed by the data of the eigenvalues of the correlation matrix presented in Figure 8, column% Total variance.

We consider the variable contribution (indicators) of Effectiveness in a Country of Parent in terms of the first main component (first factor), presented in Figure 9. Thus, the relevant indicators are defined as IO1, IO3, IO4, IO6, IO7, IO8, IO9, IO10.

	Eigenvalues of correlation matrix, and related st Active variables only			
Value numbe	Eigenvalue	% Total variance	Cumulative Eigenvalue	Cumulative %
1	9,31358:	84,6689.	9,3135	84,668
2	0,73828:	6,7116	10,0518	91,380
3	0,42631	3,8756	10,4781	95,256
4	0,27812:	2,5283	10,7563	97,784
5	0,12519	1,1381	10,8815	98,922
6	0,07476.	0,6796	10,9562	99,602.
7	0,03215	0,2923	10,9884	99,894
8	0,01107:	0,1006	10,9995	99,995.
9	0,00050:	0,0045	11,0000	100,000

Fig. 8: Eigen values of the correlation matrix of indicators regarding Effectiveness in a Country of Parent

Therefore, Immediate Outcomes related to each of the three Intermediate Outcomes of the International Standards of Anti-Money Laundering, Anti-Terrorist Financing and Proliferation of Mass Destruction Weapons were considered relevant:

- "policy, coordination and cooperation reduce the risks of money laundering and terrorist financing" *IO*1 is relevant, characterizing the awareness of the money laundering and terrorist financing risks and the need for appropriate action to combat them;
- "criminal money and funds for terrorism support in the financial and other sectors have been prevented or detected and reported in these sectors", $IO3, IO4$ are relevant. At the same time, $IO5$ which characterizes the possibility of legal entities and institutions for money laundering or terrorism

financing, with low or average importance for the sampled countries, is irrelevant;

- "threats to terrorist financing have been identified and eliminated, terrorists have been deprived of resources, and those who financed terrorists have been punished, thus contributing to the prevention of terrorist acts" - $IO6, IO7, IO8, IO9, IO10$ are relevant. Indicator $IO11$ is irrelevant, characterizing the disqualification of individuals and legal entities involved in the proliferation of mass destruction weapons, to collect, move and use funds.

	Variable contributions, based on correlations (Spreadsheet2.sta)								
Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9
IO1	0,09874	0,00019	0,03173	0,16766	0,01464	0,07510	0,38576	0,01186	0,00737
IO2	0,08673	0,09478	0,00429	0,22317	0,45023	0,01708	0,00462	0,04477	0,00017
IO3	0,09216	0,02386	0,28021	0,00026	0,00781	0,03997	0,00695	0,02573	0,02777
IO4	0,09225	0,05853	0,00923	0,25150	0,16090	0,01710	0,00428	0,19256	0,00508
IO5	0,05557	0,48149	0,20746	0,13141	0,00450	0,00869	0,01965	0,00429	0,06462
IO6	0,10332	0,00180	0,00097	0,01062	0,08006	0,20005	0,18843	0,16649	0,23321
IO7	0,10165	0,00402	0,00432	0,00467	0,00143	0,62154	0,00397	0,02460	0,05543
IO8	0,09442	0,10103	0,03789	0,04678	0,04762	0,00229	0,30294	0,06861	0,27248
IO9	0,10087	0,04002	0,00033	0,05049	0,11729	0,01311	0,03087	0,01250	0,00550
IO10	0,09147	0,10813	0,04845	0,10806	0,10464	0,00483	0,04810	0,21667	0,20959
IO11	0,08277	0,08610	0,37507	0,00531	0,01083	0,00020	0,00437	0,23187	0,11875

Fig. 9: The main component contribution (factors) in terms of indicators of Effectiveness in a Country of Parent

4.5 Construction of the Cox Proportional Intensity Regression Model Regarding the Dependence of Anti-Money Laundering System on Independent Factors

Then we use the Statistica software package with the command Statistics / Advanced Linear / Nonlinear Models / Survival Analysis / Regression Models. The Cox proportional intensity model is based on the idea that the survival intensity function has a certain level, which acts as a function of independent variables (covariant):

$$EFSAML_i = \sum_{j=1,3,4,6,7,8,9,10} b_i \cdot \widetilde{IO}_{ij} \qquad (5)$$

where $EFSAML_i$ – Kaplan-Meier assessment of the anti-money laundering system effectiveness for the i-bank;

b_i- i-parameter of influence

$\widetilde{IO}_{ij}$ - quantitative assessment of the j-indicator of Effectiveness in a Country of Parent for the i-bank.

A necessary condition for building a Cox proportional intensity regression model of the dependence of the anti-money laundering effectiveness on independent factors is the standardization of the statistical input data, proposed using the tools of Data / Standardize (table 5).

Thus, choosing columns 1-6 in Table 1 as the input array to describe the effective feature (effectiveness of the anti-money laundering system), and the data in Table 5 - as factor features, we obtain estimates of Cox model parameters and standard deviations of parameter estimates (Fig. 10).

Table 5. Standardized values of indicators of Effectiveness in a Country of Parent

№	Bank	IO1	IO3	IO4	IO6	IO8	IO9	IO10
1	ABLV Bank	-0.10	0.58	0.63	0.00	-0.25	-0.33	-0.14
2	Danske bank Estonia	-0.10	-0.63	-0.58	0.00	-0.25	0.36	-0.14
3	Pilatus Bank	-0.10	-0.63	0.63	0.00	-0.93	-0.33	-0.14
4	ING	-1.82	-1.85	-1.80	-1.79	-1.61	-1.71	-1.49
5	CA Indosuez Wealth (Europe)	-1.82	-1.85	-1.80	-1.79	-1.61	-1.71	-1.49
6	DNB Luxembourg S.A.	-1.82	-1.85	-1.80	-1.79	-1.61	-1.71	-1.49
7	Nordea Bank S.A.	-1.82	-1.85	-1.80	-1.79	-1.61	-1.71	-1.49
8	Novo Banco S.A.	0.75	0.58	0.63	0.00	-0.25	0.36	0.54
9	LPB Bank	-0.10	0.58	0.63	0.00	-0.25	-0.33	-0.14
10	Bank Julius Baer & Co. Ltd.	0.75	0.58	0.63	0.89	0.44	0.36	0.54
11	Bank Hapoalim B.M.	0.75	0.58	0.63	0.89	0.44	0.36	0.54
12	Rietumu Banka	-0.10	0.58	0.63	0.00	-0.25	-0.33	-0.14
13	PNB banka (NORVIK BANKA)	-0.10	0.58	0.63	0.00	-0.25	-0.33	-0.14
14	Swedbank	-0.10	0.58	0.63	0.00	0.44	0.36	-0.14
15	Industrial Bank Of Korea	0.75	0.58	0.63	0.89	0.44	0.36	-0.14
16	Apple Bank for Savings	0.75	0.58	0.63	0.89	1.12	1.05	1.22
17	Mega International Commercial Bank Co., Ltd.	0.75	0.58	0.63	0.89	1.12	1.05	1.22
18	Citibank N.A.	0.75	0.58	0.63	0.89	1.12	1.05	1.22
19	Capital One Bank	0.75	0.58	0.63	0.89	1.12	1.05	1.22
20	Industrial and Commercial Bank of China Financial Services LLC	0.75	0.58	-0.58	0.00	0.44	0.36	-0.82
21	Deutsche Bank AG	-1.82	-1.85	-1.80	-1.79	-1.61	-1.71	-1.49
22	Lone Star National Bank	0.75	0.58	0.63	0.89	1.12	1.05	1.22
23	Habib Bank	0.75	0.58	0.63	0.89	1.12	1.05	1.22
24	Gibraltar Private Bank & Trust Co.	0.75	0.58	0.63	0.89	1.12	1.05	1.22
25	Agricultural Bank of China	0.75	0.58	-0.58	0.00	0.44	0.36	-0.82

Based on the data of the column “Beta” of Figure 10, we construct a Cox proportional intensity regression model regarding the dependence of the anti-money laundering system effectiveness on independent factors (5) for the selected data set in terms of 25 banks from 12 countries:

$$EFSAML_i = -0.8811 \cdot \widetilde{IO_1} + 0.1978 \cdot \widetilde{IO_3} + 1.1586 \cdot \widetilde{IO_4} - 0.3852 \cdot \widetilde{IO_6} - 3.0344 \cdot \widetilde{IO_8} + 4.4421 \cdot \widetilde{IO_9} - 0.9399 \cdot \widetilde{IO_{10}} \quad (6)$$

The most priority indicator of the impact on the effectiveness of the money laundering combating system is IO9. For this indicator, the p level (probability of rejecting the statistical insignificance hypothesis of this parameter) does not exceed 0.05, the Student's criterion of statistical significance at 2.10. exceeding the critical value. Indicator IO9 is a stimulator of the anti-money laundering system effectiveness, namely when the level of IO9 increases by 1%, the value of the effective feature will increase by 4.44%.

Analysing the next statistically significant indicator IO8 (according to the t-statistics criteria, Wald's criterion, p-level), we note that it is a disincentive in terms of the anti-money laundering system effectiveness, namely when the level of IO8 by 1% decrease by 3.03%.

The other six indices of Effectiveness in a Country of Parent have worse indicators and significance, which indicates their indirect impact on the anti-money laundering system effectiveness: when indicators IO3 and IO4 increase by 1%, the value of $EFSAML_i$will increase by 0.20% and 1.16%, respectively, due to the focus of these indicators on assessing the ability to apply preventive measures for anti-money laundering and anti-terrorist financing. IO3 and IO4 are correlated with the prevention of criminal money and funds for terrorism support in the financial sector. In the context of the studied issues, indicators IO1, IO6, IO8, IO10 are disincentives and their increase will lead to a decrease in the effective feature by 0.88%, 0.39%, 3.03% and 0.94%, respectively. All indicators identified as disincentives focus on assessing the ability to recognize risks, record and block threats of money laundering and terrorist financing, using relevant information from the competent authorities.

Dependent Variable: Survival times in days (Spreadsheet2 stand
Censoring var.:Censored
Chi? = 9,30920 df = 7 p = ,23125

N=25	Beta	Standard Error	t-value	exponent beta	Wald Statist.	p
IO1	-0,8810(	1,92477·	-0,4577[	0,4143·	0,20953[	0,64713[
IO3	0,1978(	2,09326[	0,0944[	1,2187:	0,00892[	0,92472(
IO4	1,1585[	1,65131[	0,7016:	3,1854:	0,49225[	0,48292:
IO6	-0,3852:	1,84757·	-0,2085(	0,6803(	0,04347[	0,83483[
IO8	-3,0343[	2,20112[	-1,3785(	0,0481(	1,90042:	0,16804(
IO9	4,4420[	2,10750(	2,1077[	84,9511[	4,44259[	0,03506.
IO10	-0,9399:	0,86407:	-1,0877[	0,3906(	1,18326[	0,27670.

Fig. 10: Parameter estimates and standard deviations of parameter estimates

Thus, the system's effectiveness is determined by its ability to act in a biased manner and to prevent violations in the field of money laundering and terrorist financing.

5 Conclusion

Evaluation of the effectiveness of the anti-money laundering system, based on the survival analysis method by constructing tables of "survival" for banks to which sanctions have been applied, allowed to determine the response intervals of the system. It is possible to conclude that, on average, if there are violations within 2100 days (i.e., 5.75 years), the relevant banks are allowed to liquidate them or make a managerial decision to declare banks insolvent or liquidate banks, which is a quantitative feature of the national system. In this case, the probability density (column Probability Density) enables us to assess the probability of a decision to liquidate the bank (the need to apply sanctions to the bank) in the appropriate time interval. Analysis of this indicator shows the value of the instantaneous risk function at 0.00022 units per unit for the first time interval (up to 191 days), then a gradual increase in risk to 0.00157 units per unit for 2, 3, 4 and 5 intervals (i.e., from 192 to 764 days), and then reduce it to 0.00095 parts per unit at the end of the next time interval.

Comparing the anti-money laundering system effectiveness through modelling based on survival analysis in groups of banks around the world suggests that the United States has the most flexible anti-money laundering system.

Based on the application of the principal components method, the relevant factors influencing the assessment of the anti-money laundering system effectiveness are defined. Moreover, a Cox intensity proportional regression model regarding the dependence of the anti-money laundering system effectiveness on independent factors is formed. It is found that the system effectiveness is determined by its ability to pro-act and prevent violations in money laundering and terrorist financing.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Olha Kuzmenko carried out development and design of methodology, creation of models.
- Olena Krukhmal was responsible for determination of relevant factors influencing the assessment of the anti-money laundering system effectiveness based on the application of the principal components method and preparation of the published work, specifically critical review.
- Vitaliia Koibichuk was responsible for the Statistics.
- Vita Hordiienko has implemented the modelling based on the analysis of survival in groups of banks around the world.
- Galyna Pasemko was responsible for Construction of the Cox proportional intensity regression model regarding the dependence of anti-money laundering system on independent factors.
- Kostiantyn Hrytsenko applied computational analysis using of the Statistica software complex.
- Oleksandr Kushneryov was responsible for application of statistical, mathematical, computational to analyse and synthesize study data.
- Oksana Taran carried out preparation, creation of a published work.
- Olena Smihunova carried out preparation of a published work, including meaningful translation.

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Conflict of Interest

The authors have no conflict of interest to declare.