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MARGIN SYSTEM FOR DERIVATIVES AS A LIQUIDITY MANAGEMENT TOOL

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Research relevance

Currently, all exchange markets of derivatives are margined. The margin system as a risk management tool has a number of positive features: its use increases market liquidity and reduces credit risk, and the unification of the applied risk assessment increases the transparency and availability of data. However, margin requirements are inherently a financial burden for traders: an excessive margin reduces the attractiveness of central counterparty and trading floor services and, consequently, reduces the trading volume of the derivatives section. This leads to an increase in liquidity risk and reduces the positive effect of the margin system implementation. Taking into account that increasing liquidity in the margined markets is a priority international task [BCBS CPMI IOSCO, 2021], analyzing the effectiveness of the margin system becomes an increasingly important task.

The use of a margin system carries several negative effects, as margin as a risk measure is inefficient [Artzner, 1999] and does not take into account the effects of diversification and hedging [Emmer et al. 2015]. Also, if the risk assessment of the central counterparty is overestimated compared to the risk assessment of the participants themselves, the positive effect is reduced. The margin system applied in the Russian market gives an overestimate, i.e. in the current situation there is a potential to reduce margin requirements, which will lead to an increase in market liquidity [Potapov, Kurbangaleev, 2023; Potapov, 2023].

It is also worth noting that all margin collateral is held by the central counterparty, and it has the right to dispose of it based on its own investment objectives. On the one hand, the central counterparty benefits from lower margins and higher market liquidity, as this will increase its revenues, and on the other hand, it is interested in increasing margin requirements, as this will reduce its costs to fulfil the obligations of defaulted participants. Based on the above, a reasonable question arises as to the need to develop a methodological solution that would allow to set the amount of margin requirements satisfying both the regulatory requirements in terms of the reliability of the central counterparty and the objectives of the central counterparty in terms of

investment attractiveness. In such a two-pronged approach, a downward shift of the margin will promote liquidity growth and the solution will be Pareto-optimal.

Theoretical and methodological basis of the study

The authors of the most significant works in this subject area considered the basics of the functioning of the margin system and the effectiveness of risk assessment [Cont et al, 2010; Artzner, 1999; Subrahmanyam, 1991; Acharya, 2009]: a comprehensive study of the accuracy and stability of the risk assessment used by the margin system, assessment of the difference in liquidity and efficiency of the cleared market compared to the non-cleared market. There have also been many studies related to proving the improved efficiency of centralised clearing compared to decentralized clearing [Acharya, Bisin, 2014; Danielsson et al., 2012]. It has been found that although margin, due to its theoretical properties, cannot be an accurate measure of the level of risk, it can be sufficiently reliable, and the margin system can be robust enough to improve market conditions through its use.

At the same time, systemic constraints and requirements for the functioning of financial infrastructure were studied for the first time [Danielsson et al., 2001], i.e. what can be achieved by using the margin system (increased liquidity, market transparency, pricing efficiency) and what must be sacrificed to achieve this (increased default risk, increased financial burden on market participants, possible decrease in liquidity).

The most relevant papers also study systemic risk [Pang et al., 2023], arising from the aggregation of the entire market exposure on the balance sheet of a single agent that does not take diversification into account. The problem of finding the optimal size of margin requirements is becoming increasingly acute [Berlinger et al., 2018], as the size of margin requirements overestimated compared to the risk assessment by the participants themselves reduces the positive effect of using the margin system, which is especially strong in times of instability in the global financial market. The properties of margin as a risk metric, such as the possibility of making

margin valuation countercyclical [Benos et al., 2022], the pricing of risk-adjusted assets, such as the different determinants of price differences between cleared and non-cleared markets [Jacobs, Li, 2022], and the possibility of more accurate risk forecasting [Bernales et al., 2017] continue to be studied.

The main empirical results for most studies on the topic of central counterparty functioning are the same: the introduction of a margin system improves market efficiency and liquidity, but the risk assessment used is inefficient in the sense that it overstates the size of claims. No such large-scale studies have been conducted for Russia. Nevertheless, important results have been obtained. Firstly, it was confirmed that the margin system at Moscow Exchange is highly reliable [Utkin, 2010]. Also, the central counterparty acted as a currency market stabilizer during the 2007-2009 crisis, preventing its own default [Utkin, 2009]. And during the trading halt in February 2022, Moscow Exchange continued to carry out settlements in the derivatives section of the market and to supply participants with information on the amount of exposure to prevent mass defaults after the trading halt. Secondly, Moscow Exchange is developing not only in terms of liquidity, number of assets and infrastructure, but also in terms of legislation. For example, earlier the problem of liquidation netting — netting of liabilities with a legal entity that commits bankruptcy proceedings and has liabilities on the derivatives market [Ogorelkova, 2011] was highlighted. Thus, in 2019 the Federal Law No. 507 ‘On Amendments to Article 20 of the Federal Law “On Banks and Banking Activities” and the Federal Law “On Insolvency (Bankruptcy)” in terms of the development of financial market instruments’ initiated by Moscow Exchange was adopted, eliminating ambiguity in the interpretation of the concept of liquidation netting and fixing the mechanism of its implementation.

Research object and subject

The object of the study is the derivatives section of Moscow Exchange. The subject of the study is the derivatives margining system.

Purpose of the study

The aim of the work is to develop a new system of margining of standardized derivatives that takes into account the dependence of market liquidity and probability of default of trading participants on the size of margin requirements and regulatory restrictions.

In order to achieve the set goal, it is necessary to solve the following tasks:

1. Summarizing the results of academic research on the effectiveness of different margin systems for standardized derivatives, approaches to risk assessment and their advantages and disadvantages;
2. Determining the level of impact of the assigned margin on market liquidity. That is, finding the most detailed approximating estimate explaining how the change of margin affects the actions of market participants, and determining the functional relationship between them, taking into account the available market data;
3. Studying international and local regulations governing the activities of a central counterparty in order to determine the limitations of its activities, its objectives, capabilities and responsibilities;
4. Building a dynamic margin model that takes into account the impact of margin requirements on market liquidity, regulatory constraints, risk assessment of various assets and the benefits of the central counterparty;
5. Conducting empirical analysis aimed at comparative testing of the proposed model and the model used in practice, and meaningful interpretation of the results obtained regarding the features of the proposed model affecting the decisions of the central counterparty.

Main hypothesis

The study raises the question of the possibility of creating such a model of standardized derivatives margining that when it is used, market liquidity expressed in the volume of trading and the volume of open positions, as well as the profit of the central counterparty will be statistically significantly higher than when using the

current model. At the same time, the proposed model should meet international requirements for the reliability of the margin system.

The theoretical and methodological basis of the study

The methodological basis of the theoretical part of the thesis is the methods of system analysis, method of analogies, method of generalizations, classification. The methodological basis of the practical part of the thesis is the methods of econometric and statistical analysis.

To assess the relationship between market liquidity and the size of margin requirements for various positions, the methodology tested in an earlier study on this topic [Potapov, 2023] is used. This methodology involves bringing the initial parameters of contracts, liquidity parameters and market factors for derivatives for one underlying asset into a single time series by summing or weighting and their further selection for the construction of an autoregressive moving average model taking into account exogenous factors (ARMAX). The selection is carried out according to the results of the NG-Perron stationarity test, as it has higher accuracy on long time series [Arltova, Fedorova, 2016], Granger causality test to determine the unambiguous relationship excluding reverse causality, and correlation analysis. In addition to the liquidity indicators of assets (trading volume and volume of open positions), the illiquidity ratio of funding, which determines the probability of default of participants [Malkhozov et al., 2013].

A model to estimate the sensitivity of futures trading volume:

$$ln\left(\frac{TA_t}{TA_{t-1}}\right) = \alpha_{1,0} + \beta_{1,1}\, ln\left(\frac{OI_{t-1}}{OI_{t-2}}\right) + \beta_{1,2}\, ln\left(\frac{Deals_{t-1}}{Deals_{t-2}}\right) + \beta_{1,3} r_{t-1} + \beta_{1,4}\, ln\left(\frac{TTM_t}{TTM_{t-1}}\right) + \beta_{1,5}\, ln\left(\frac{PV_{t-1}}{PV_{t-2}}\right) + \beta_{1,6}\, ln\left(\frac{rf_{t-1}}{rf_{t-2}}\right) + \beta_{1,7}\, ln\left(\frac{rf_{foreign}{}_{t-1}}{rf_{foreign}{}_{t-2}}\right) + \beta_{1,8}\, ln\left(\frac{TM_t}{TM_{t-1}}\right) + \sum_{i=1}^{p} \gamma_{1,i}\, ln\left(\frac{TA_{t-i}}{TA_{t-1-i}}\right) + \sum_{j=1}^{q} \theta_{1,j}\, \varepsilon_{t-j} + \varepsilon_t \quad (1)$$

,

TA – trading volume of the contract in roubles;

OI – open interest;

$Deals$ – the number of contract transactions per day;

r – logarithmic return on the contract;

TTM – time to contract maturity in days;

PV – daily volatility of contract price;

rf – risk-free rate in roubles for the period until the date of contract maturity;

$rf_{foreign}$ – risk-free rate in dollars for the period until the date of maturity of the contract;

TM – the amount of contract margin in roubles.

Model for estimating the sensitivity of the volume of open positions on futures:

$$ln\left(\frac{OI_t}{OI_{t-1}}\right) = \alpha_{2,0} + \beta_{2,1}\, ln\left(\frac{TA_{t-1}}{TA_{t-2}}\right) + \beta_{2,2}\, ln\left(\frac{Deals_{t-1}}{Deals_{t-2}}\right) + \beta_{2,3} ln\left(\frac{PV_{t-1}}{PV_{t-2}}\right) + \beta_{2,4}\, ln\left(\frac{rf_{t-1}}{rf_{t-2}}\right) + \beta_{2,5}\, ln\left(\frac{rf_{foreign_{t-1}}}{rf_{foreign_{t-2}}}\right) + \beta_{2,6}\, ln\left(\frac{TM_t}{TM_{t-1}}\right) + \sum_{i=1}^{p} \gamma_{2,i}\, ln\left(\frac{OI_{t-i}}{OI_{t-1-i}}\right) + \sum_{j=1}^{q} \theta_{2,j}\, \varepsilon_{t-j} + \varepsilon_t \quad (2)$$

Model for estimating the sensitivity of options trading volume:

$$ln\left(\frac{TA_t}{TA_{t-1}}\right) = \alpha_{3,0} + \beta_{3,1}\, ln\left(\frac{OI_{t-1}}{OI_{t-2}}\right) + \beta_{3,2}\, ln\left(\frac{Deals_{t-1}}{Deals_{t-2}}\right) + \beta_{3,3} r_{t-1} + \beta_{3,4}\, ln\left(\frac{TTM_t}{TTM_{t-1}}\right) + \beta_{3,5}\, ln\left(\frac{TM_t}{TM_{t-1}}\right) + \beta_{3,6} d_{t-1} + \beta_{3,7} \Delta h_{t-1} + \sum_{i=1}^{p} \gamma_{3,i}\, ln\left(\frac{TA_{t-i}}{TA_{t-1-i}}\right) + \sum_{j=1}^{q} \theta_{3,j}\, \varepsilon_{t-j} + \varepsilon_t \quad (3)$$

,

d – the relative size of the implied volatility bias:

(4) $$d = \frac{centralIV - minIV}{minIV}$$

,

centralIV – implied volatility at the centre strike;

minIV – minimum implied volatility.

Δh – strike distance:

(5) $$h = \frac{K(minIV) - K(central)}{K_{dist}}$$

,

K(minIV) – the strike at which the minimum implied volatility value is located;

$K(central)$ – centre strike;

K_{dist} – step between two neighbouring strikes - a parameter set by the exchange in the course of trading.

Model for estimating the sensitivity of the volume of open options positions:

(6) $$ln\left(\frac{OI_t}{OI_{t-1}}\right) = \alpha_{4,0} + \beta_{4,1}\, ln\left(\frac{TA_{t-1}}{TA_{t-2}}\right) + \beta_{4,2}\, ln\left(\frac{Deals_{t-1}}{Deals_{t-2}}\right) + \beta_{4,3} r_{t-1} + \beta_{4,4}\, ln\left(\frac{TTM_t}{TTM_{t-1}}\right) + \beta_{4,5}\, ln\left(\frac{TM_t}{TM_{t-1}}\right) + \sum_{i=1}^{p} \gamma_{4,i}\, ln\left(\frac{OI_{t-i}}{OI_{t-1-i}}\right) + \sum_{j=1}^{q} \theta_{4,j}\, \varepsilon_{t-j} + \varepsilon_t$$

The model used to estimate the sensitivity of the funding illiquidity coefficient is as follows:

(7) $$ln\left(\frac{FI_t}{FI_{t-1}}\right) = \alpha_{5,0} + \beta_{5,1}\, ln\left(\frac{OI_{t-1}}{OI_{t-2}}\right) + \beta_{5,2}\, ln\left(\frac{TA_{t-1}}{TA_{t-2}}\right) + \beta_{5,3}\, ln\left(\frac{rf_{t-1}}{rf_{t-2}}\right) + \beta_{5,4} ln\left(\frac{rf_{foreign_{t-1}}}{rf_{foreign_{t-2}}}\right) + \beta_{5,5} R_{t-1} + \beta_{5,6}\, ln\left(\frac{TM_t}{TM_{t-1}}\right) + \sum_{i=1}^{p} \gamma_{5,\mathrm{i}}\, ln\left(\frac{FI_{t-i}}{FI_{t-1-i}}\right) + \sum_{j=1}^{q} \theta_{5,\mathrm{j}}\, \varepsilon_{t-j} + \varepsilon_t$$

,

FI – funding illiquidity coefficient;

R – logarithmic return on the RTS index.

Due to the presence of statistically significant dependence of risk on the time to exercise, the amount of margin collateral for options is estimated with this in mind [Potapov, 2024]. For correct risk assessment, instead of the usual empirical quantile of option value changes (Value-at-Risk), the time series of value changes is first detrended using maximum likelihood estimation of the risk trend. To estimate the residual risk of an option, despite the widespread use of volatility risk premium [Jacobs, Li, 2022], values of implied volatility and their bias relative to the center strike of options are used.

The obtained values are approximated through the trend for the mean (μ) and standard deviation (σ), respectively:

(8) $$\mu_t = a_\mu \cdot exp^{b_\mu \cdot t} + \varepsilon_t$$

(9) $$\sigma_t = a_\sigma \cdot exp^{b_\sigma \cdot t} + \varepsilon_t$$

,

t – time to contract maturity as a percentage of the year.

Based on the distribution obtained at each point in time, the parameters of the option risk distribution can be estimated using the maximum likelihood method:

(10) $$\theta = (a_\mu, b_\mu, a_\sigma, b_\sigma) = max\, f(\theta) = max \sum_{t=1}^{T} \frac{(VaR_{x\%}(P\&L) - \mu_t)^2}{\sigma_t} + ln\,(\sigma_t)$$

,

$P\&L$ – contract value change;

VaR – Value-at-risk at a significance level $x\%$.

Potapov and Kurbangaleev (2023) use a two-stage approach to assess the efficiency of the margining system. First, the reliability of the model is assessed - the main test is the binomial test [BCBS, 2005]. There are many different tests from the one proposed by the Basel Committee, but this one is used in this paper, since compliance with international requirements is checked with its help and the use of

many additional tests over a large time interval may give contradictory results [Shaik, Padmakumari, 2022]. Next, we compare the parameters of margining systems, such as default rates, using Wilcoxon signed-rank test, Mann-Whitney U test and estimation of the intersection of bootstrapped distributions of values.

Scientific novelty of the research

Scientific novelty of the dissertation research consists in the following:

1. The paper presents a classification of both specific exchange margining models and the generalized approaches underlying them. The analysis reveals advantages and disadvantages of these approaches, theoretical properties of margin as a risk metric and positive and negative factors of margin impact on various market efficiency indicators;
2. The paper provides estimates of the impact of changes in the volume of margin requirements on various market liquidity indicators for different assets, types of positions and types of participants, clarifying the results of previously published studies;
3. For the first time the task of margin requirements estimation is formulated from the point of view of a central counterparty taking into account its benefits and costs. At the same time, the benefits, costs and opportunities of the central counterparty, which determine its behavior, are defined from international and local regulations;
4. For the first time in the solution of the problem of margin requirements estimation the influence of changes in the volume of margin requirements on various market liquidity indicators is explicitly taken into account. The task of margin requirements estimation is solved under actual regulatory restrictions, not within the framework of theoretical requirements to risk-metrics, which proves the applicability of the proposed approach. The method of taking into account the trend in their risk is proposed for risk assessment of exchange traded options. Decomposition of risk taking into account the time component allows to obtain a more accurate risk assessment compared to the use of empirical quantile;

5. In addition to the developed method of margin requirements estimation taking into account the impact of changes in the volume of margin requirements on various market liquidity indicators, the paper also proposes an approach to comparing margin models. The presented approach is based on the comparison, firstly, of the reliability criteria of the margin model, secondly, of the risk indicators of the margin system: frequency and strength of participants' defaults, thirdly, of the market liquidity indicators: trading volume and volume of open positions, fourthly, of the central profit indicators. This approach can be applied to both practical and theoretical models.

Key point for the thesis presentation

The following points are put forward for defence:

1. The existing approaches to risk assessment of standardized derivatives have been classified, and their main properties have been identified: all assessment methods are based on the construction of scenarios of changes in the risk factors underlying the assessment of derivatives in various ways ranging from the use of sensitivity coefficients to distribution simulations. All of these systems can be characterized in terms of the accuracy and stability of the resulting valuation or the flexibility and transparency of the methodology. While they all meet regulatory requirements, they also result in adverse selection, statistically significant price differences between cleared and non-cleared markets and reduced hedge effectiveness, additional risk increase due to procyclicality of valuation and reduced liquidity compared to the optimal size of margin requirements;

2. For futures and options, an estimate of the impact of changes in margin requirements on trading volume and open positions was obtained. The obtained estimation was detailed for long/short positions of individuals/legal entities, and for options also at different ratio of strike and value of the underlying asset. It was found that the impact on long and short positions of individuals and legal entities is different in strength, but strictly negative regardless of the size of the sliding window for estimation. The impact of the size of margin requirements on illiquidity of funding is also strictly negative;

3. Contradictions in international and local regulations and legislation have been identified: according to them, the central counterparty is obliged to ensure a sufficient level of reliability of the margin system and, at the same time, to increase liquidity in the market. The problem arises from the fact that the central counterparty is a goal-oriented organization. Consequently, its activities are aimed at maximizing its own profit and/or value. It has been found that liquidity is negatively related to the amount of collateral [Potapov, 2023], so the central counterparty has to choose between making a profit: by reducing margin requirements, which will increase revenue through trading commissions and a possible increase in the total amount of collateral (the number of contracts held may increase more than the reduction in margin) or by increasing margin requirements, which will reduce default losses and potentially increase the value of the collateral;

4. The task of the central counterparty characterizing its profit is constructed. This approach to solving the problem of determining optimal margin requirements is chosen because, firstly, the central counterparty is a commercial legal entity, and secondly, it assesses its own risks and benefits when independently switching to a margin system different from the one used. The task reflects the profit of the central counterparty, consisting of commissions from trading and income from invested free funds, and the costs associated with the need to fulfil the obligations of participants in case of their default. This problem is dynamic, i.e. every day the optimal volume of margin requirements is recalculated, as the information accumulated by the current moment is taken into account when optimizing the model. Optimization is performed every day for each asset for short and long positions. The solution to this problem is such values of margin requirements for short and long positions that maximize the expected income of the central counterparty taking into account changes in the trading volume (income from commissions), the volume of open positions (income from investing free funds), illiquidity of funding (probability of participants‘ default) and the minimum amount of collateral (amount at risk in case of participants’ default). When assessing the risk of options, in contrast to the risk of futures, the risk decomposition with a time component is used to estimate the minimum permissible

amount of margin requirements, which implies detrending the yield with the remaining time to contract fulfillment. This two-step method of calculating Value-at-Risk allows us to obtain an estimate of risk that meets regulatory requirements, while the simple calculation of empirical quantile does not meet these requirements [Potapov, Kurbangaleev, 2023];

5. It is shown that the central counterparty's income depends non-monotonically on the amount of collateral, while liquidity depends on monotonically. The dependence of liquidity on the amount of collateral is monotonic because the financial burden on market participants decreases when the amount of collateral decreases, while counterparty risk does not increase, as it is all on the balance sheet of the central counterparty. The dependence of the central counterparty's income on the amount of collateral is non-monotonic, because at the minimum acceptable amount of margin requirements it is less than at the optimal one. This is due to the fact that there is volatility of open positions in the market. Consequently, the amount of funds available for investment by the central counterparty depends not only on the amount of margin at each point in time, but also on the consequences of the realized dynamics of the value of the asset. Also, the income of the central counterparty may decrease when margin requirements are reduced because the costs of participant default increase more than the profits from trading volume and open positions. If we take into account all the facts obtained in the course of the dissertation research when building the margin system, then the given system will increase liquidity in the market and profit of the central counterparty, provided that the regulatory requirements are met.

Empirical base of research

The theoretical basis of the research is the works of foreign and domestic authors devoted to the assessment of risks and liquidity of derivatives, as well as the assessment of the central counterparty's activity. The theoretical basis of the dissertation is the works of Russian and foreign scientists who substantiate the importance of the margin system [Acharya, 2009; Acharya, Bisin, 2014; Benos et al, 2022; Loon, Zhong, 2014; Mayordomo, Posch, 2016], as well as considering the

problem of the relationship between liquidity and margin requirements [Chou et al, 2014; Daskalaki, Skiadopoulos, 2016; Brunnermeier, Pedersen, 2009], and confirming the inefficiency of the existing system [Cont et al, 2010; Artzner, 1999; Berlinger et al, 2018].

The empirical part of the dissertation research used a database compiled on the basis of data from the Moscow Exchange portal, containing information on trading in derivatives. The final sample includes options and futures on 21 underlying assets in the period from 26.03.2014 to 29.12.2021. The beginning of this period refers to the date from which the risk parameters for calculating the amount of Moscow Exchange's collateral are published. The end date of this period is due to the fact that since February 2022 there has been no trading for a long time, and after the resumption of trading there was increased volatility in the market with reduced liquidity.

Theoretical significance

The thesis reveals the central counterparty's problem of setting the optimal level of margin requirements taking into account regulatory constraints, and it is presented in the form of a formal optimization problem. The approach using mathematical and statistical-econometric tools makes it possible to justify the proposed estimates of margin requirements and make the obtained estimate favorable for all market participants.

Practical significance

The practical significance of the work consists in the substantiation of a method that allows estimating the amount of margin that is favourable to both the central counterparty and all trading participants. The fact that the central counterparty will receive increased profit from the use of the proposed method motivates it to increase the benefits of participants.

The developed toolkit will be useful for infrastructural participants of the exchange market, international regulators and communities of central counterparties.

It can be used both for assigning collateral and for solving other global tasks other than increasing market liquidity. An important plus of the method is the use of only publicly available information, transparent and understandable modelling methodology.

Also, the materials of the dissertation research can be used in the framework of scientific and teaching activities in the direction of ‘Derivatives’.

Publications reflecting the main results of the research

1. Potapov A.I. (2023) Assessing the Margin Requirements Impact on the Russian Futures Market Liquidity. *Financial Journal,* 15, 5, pp. 94–116. HSE list D.
2. Potapov A.I. (2024) Options Time Risk-Profile. *HSE Economic Journal*, 27, 1, pp. 108–132. HSE list B. Scopus Q3.
3. Potapov A.I., Kurbangaleev M.Z. (2023) Comparison of Central Counterparty Risk Assessment Approaches. *HSE Economic Journal*, 27, 2, pp. 196–219. HSE list B. Scopus Q3.

Approbation of the study

1. XXIV Yasinskaya (April) International Scientific Conference on Problems of Development of Economy and Society. Date of the event: 04.04.2023-14.04.2023. Date of presentation: 11.04.2023. Session Финансовые институты, рынки и платежные системы. Presentation: Effect of margin on trading volume of derivatives;
2. IX International Conference 'Modern Econometric Tools and Applications – META2022'. Date of the event: 15.09.2022-17.09.2022. Date of presentation: 17.09.2022. Session Time-Series Modelling. Presentation: Derivatives margin: its quality aspects and influence on trading volume.

Intermediate results of the paper were also discussed at seminars organised by the Postgraduate School of Economics of the Higher School of Economics. Date of presentation: 24.05.2023.

Dissertation structure

The thesis is set out on 169 pages of typed text. It includes 14 tables, 28 figures and consists of an introduction, three chapters, conclusion and 17 appendices.

The main contents

The introduction substantiates the relevance of the chosen topic, defines the purpose, objectives, object and subject of the dissertation research, reveals the scientific novelty, theoretical and practical significance of the results obtained.

The first chapter of the dissertation research reflects theoretical aspects of the problem posed. A review study of the issue of assigning margin for standardized derivatives is carried out. It was found that the existence of a margin system in the market is a positive factor: it increases the liquidity of trading, increases the efficiency of pricing, reduces transaction costs, and nullifies counterparty risk compared to the over-the-counter market. Despite this, all positive manifestations of the margin system are maintained only if the size of margin requirements is not too large compared to the risk assessment of the participants themselves. In such a case, the positive effect is reduced as participants switch to OTC trading.

It was also found that margin as a risk metric is inefficient, i.e. the estimation of the size of potential risk at a given confidence interval is not accurate. This means that for a central counterparty to comply with international requirements for the reliability of the margin system, the amount of collateral must be overstated. The consequence of overestimating margin requirements compared to an accurate assessment of potential risk is an increased financial burden on traders and thus a reduction in the positive effect of the existence of the margin system. If the margin as a risk metric was effective and the amount of collateral was equal to its estimate, the effect of the margin system would be effective.

Further we have considered the main methods of marginal claims estimation: Quasi-Monte Carlo method, Monte Carlo method, method based on sensitivity coefficients. Each of them has its own advantages and disadvantages. Due to its relative

simplicity and speed of implementation, Moscow Exchange uses the Quasi-Monte Carlo method, which consists in applying a set of fixed scenarios to estimate the potential change in the value of an asset, which is used as a margin call.

As a result, the existing data on the relationship between liquidity and the size of margin requirements, on methods of guarantee collateral valuation, their advantages and disadvantages were systematized regarding the purpose of the study.

The second chapter is devoted to the consideration of the requirements for the central counterparty as a market participant and an independent legal entity set out in international and local regulations and legislative acts. The main criteria to be met by the margin system were identified: the margin requirement must cover potential losses on a position over a 1 trading day horizon or over the entire position liquidation period, if any, with a 99% probability. The main objective required of a central counterparty by regulators is to increase liquidity in the market. This objective is actually driven by the fact that in times of financial crisis, when the macroeconomic situation changes and political relations change at the moment, there is an excess of liquidity in certain markets or in certain assets due to risk-aversion by investors. Since all margining systems assess risk retrospectively, on average, risk will be underestimated in markets with reduced liquidity and overestimated in markets with high liquidity. This structural shift causes a further overall decline in trading volumes in all markets and clustering of open positions in some markets, with risks remaining elevated in the long term as liquidity will ‘flow’ in the opposite direction when the situation stabilizes.

In addition to global objectives, the central counterparty as a separate legal entity aims to increase its own profit and/or value. The central counterparty's profit is made up of three components: trading revenue, i.e. the amount of commissions that the central counterparty will receive, investment revenue from available funds, i.e. the collateral available to participants to invest at a risk-free rate, and the central counterparty's costs associated with the need to cover the costs of participants in the event of default. The central counterparty's income arises from the fact that it is the organizer of trading and holds all the collateral on its balance sheet, the expenses are a

direct consequence of the principles of functioning of the margin system. The only instrument by which the central counterparty can influence both the probability and size of defaults and the liquidity of the market is the amount of margin requirements to be set.

Based on these objectives and the capabilities of the central counterparty, its profit function was described as a function of the amount of collateral at any time t for any asset i:

$$
\begin{aligned}
&\begin{cases} CM^i_{t-1;l} + dP^i_t - TR, & \text{если } CM^i_{t-1;l} - SM^i_{t;l} + dP^i_t < 0 \\ 0, & \text{иначе} \end{cases} \\
&\cdot Q(default; l) \cdot min\left(OI^i_{t-1;l}; OI^i_{t;l}\right) \\
&\begin{cases} CM^i_{t-1;s} - dP^i_t - TR, & \text{если } CM^i_{t-1;s} - SM^i_{t;s} - dP^i_t < 0 \\ 0, & \text{иначе} \end{cases} \\
&\cdot Q(default; s) \cdot min\left(OI^i_{t-1;s}; OI^i_{t;s}\right) + \left(TA^i_{t;l} + TA^i_{t;s}\right) \cdot fees_t \\
&+rf_{t-1} \cdot \left(CM^i_{t-1;l} \cdot min\left(OI^i_{t-1;l}; OI^i_{t;l}\right) + CM^i_{t-1;s} \cdot min\left(OI^i_{t-1;s}; OI^i_{t;s}\right)\right)
\end{aligned}
\tag{11}
$$

,

CM – margin account balance;

SM– support margin;

TM – the amount of contract margin in roubles;

P – market value of the asset;

dP – changes in the market value of the asset;

TA – trading volume of the contract in roubles;

$fees$ – commission that the exchange receives from trading;

OI – open interest;

l, s – a sign of a long or short position, respectively;

TR – transaction costs;

rf – risk-free overnight rate in roubles;

$Q(default)$ – probability of the Trading Member's failure to fulfil its obligations to replenish the margin account.

This formula consists of three main elements: trading income $\left(\left(TA^i_{t;l} + TA^i_{t;s}\right) \cdot fees_t\right)$, return on investment of available funds $\left(rf_{t-1} \cdot \left(CM^i_{t-1;l} \cdot min\left(OI^i_{t-1;l}; OI^i_{t;l}\right) + CM^i_{t-1;s} \cdot min\left(OI^i_{t-1;s}; OI^i_{t;s}\right)\right)\right)$, and everything else represents the central counterparty's costs associated with the need to cover the costs of participants $\left(CM^i_{t-1} \pm dP^i_t - TR^i_t\right) \cdot min\left(OI^i_{t-1}; OI^i_t\right)$ in the event of default with a probability of $Q(default)$.

Obviously, the formula above cannot be optimised as presented, as it requires knowledge of the $dP^i_t, dP^i_{ask;t}, dP^i_{bid;t}$. The problem of the relationship between the profit at time t and the amount of collateral at the moments of t and $t-1$. In other words, the situation may be such that it will be favourable to overestimate claims at one moment and underestimate them at another. Since the default probability ratio, the volume of open positions and trading volume depend on changes in margin $(TM_{t-1}; TM_t)$, then the central counterparty can maximise its profit by the value of margin requirements TM_t, because TM_t is set for the moment t, asset i and positions l and s at the moment $t-1$. Therefore, according to the parameters $(\mathrm{TM}^{\mathrm{i}}_{\mathrm{t;l}}; \mathrm{TM}^{\mathrm{i}}_{\mathrm{t;s}})$ maximises the value of profit, where actual losses are replaced by the quantile of the distribution of gains and losses ($\mathrm{VaR}^{\mathrm{i}}_{\mathrm{t;1\%}}$ и $\mathrm{VaR}^{\mathrm{i}}_{\mathrm{t;99\%}}$), and the costs of position liquidation - estimated transaction costs ($\mathrm{TR}^{\mathrm{i}}_{\mathrm{t;l}}$ и $\mathrm{TR}^{\mathrm{i}}_{\mathrm{t;s}}$). As a starting point for all parameters with index $t-1$ real values are used, for all further observations - as a $\mathrm{TM}^{\mathrm{i}}_{\mathrm{t-1;l}}; \mathrm{TM}^{\mathrm{i}}_{\mathrm{t-1;s}}$ values obtained from the previous optimisation are used, real values adjusted for the impact of changes in margin requirements are used as liquidity indicators:

$$
\begin{cases} CM^i_{t-1;l} + VaR^i_{t;1\%} - TR^i_{t;l}, & \text{если } CM^i_{t-1;l} - \alpha_t * TM^i_{t;l} + VaR^i_{t;1\%} < 0 \\ 0, & \text{иначе} \end{cases}
$$

$$
\cdot Q\left(\widehat{default}; l\right) \cdot min\left(OI^i_{t-1;l}; \widehat{OI^i_{t;l}}\right) +
$$

$$
\begin{cases} CM^i_{t-1;s} - VaR^i_{t;99\%} + TR^i_{t;s}, & \text{если } CM^i_{t-1;s} - \alpha_t \cdot TM^i_{t;s} - VaR^i_{t;99\%} < 0 \\ 0, & \text{иначе} \end{cases} \quad (12)
$$

$$
\cdot Q\left(\widehat{default}; s\right) \cdot min\left(OI^i_{t-1;s}; \widehat{OI^i_{t;s}}\right) +
$$

$$
+\left(\widehat{TA^i_{t;l}} + \widehat{TA^i_{t;s}}\right) \cdot fees_t
$$

$$
rf_{t-1} \cdot \left(CM^i_{t-1;l} \cdot min\left(OI^i_{t-1;l}; \widehat{OI^i_{t;l}}\right) + CM^i_{t-1;s} \cdot min\left(OI^i_{t-1;s}; \widehat{OI^i_{t;s}}\right)\right)
$$

,

$\hat{x}$ – means that the value depends on $\mathrm{TM}^{\mathrm{i}}_{\mathrm{t-1;l}}; \mathrm{TM}^{\mathrm{i}}_{\mathrm{t;l}}$ or on $\mathrm{TM}^{\mathrm{i}}_{\mathrm{t-1;s}}; \mathrm{TM}^{\mathrm{i}}_{\mathrm{t;s}}$;

α – exchange parameter for estimating the minimum permissible volume of margin requirements.

Dependence of the indicator $\hat{x}$ from the size of margin requirements is estimated by the method proposed in an earlier study [Potapov, 2023], i.e. a regression model of ARMAX type is built, for which a set of exogenous factors is fixed, but the model coefficients are re-estimated every day for each asset for each type of participant and type of position on a horizon of one calendar year. To forecast the value of $\hat{x}$ from $t-1$ to t values of all exogenous parameters, except for the size of margin requirements, as it is used for optimisation, are used actual values. Optimised values of margin requirements are limited according to regulatory requirements:

$$
\forall\, i,t\ for\ long\ position: Prob\left(dP^i_t < -TM^i_{t-1;l}\right) \le 1\%
$$

$$
\forall\, i,t\ for\ short\ position: Prob\left(-dP^i_t < -TM^i_{t-1;s}\right) \le 1\% \quad (13)
$$

The third chapter identifies the data used for the ongoing study. It uses margined futures, the underlying assets of which are shares, and margined options on margined futures, the underlying assets of which are shares, traded between 26.03.2014 and 31.12.2021. The source of data is the official website of Moscow Exchange and the central counterparty of Moscow Exchange - National Clearing Centre. The start date of this period was chosen because the publication of risk parameter values for futures session assets started on this day, which makes it possible to replicate the actual

values of Moscow Exchange's collateral. The end date of this period is because since February 2022 there has been no trading for a long time, and after the resumption of trading there was increased volatility in the market with reduced liquidity.

Derivatives whose underlying assets are equities are considered primarily because of the many different underlying assets and high liquidity. If not just one asset class is used, but, for example, also futures and options on currency pairs, it is difficult to interpret the results due to different pricing models, risk factor properties and explanatory variables for liquidity.

The following data are also excluded from the analysis:

- derivatives whose underlying assets are indices, as the collateral for them is not assessed as for individual derivatives but taking into account the collateral for their components;
- derivatives for which there was a trading interruption before the end of the study period, which is a consequence of low liquidity, change of specification and issue with a new ticker or other reasons;
- derivatives with preferred stocks as the underlying asset. They are not considered in this paper for the same reason as derivatives with an underlying asset in the form of indices - such assets have a strong correlation with ordinary shares and cannot be considered as stand-alone derivatives;
- derivatives with too low liquidity - this factor is critical as the paper uses the relationship between margin requirements and liquidity to solve the central counterparty problem;
- derivatives for which there are less than 2 years of observations (trading information): one year is required to assess the relationship between collateral and liquidity, and one year is required to test the reliability of the margin system.

For each observation for each asset, an array of parameters was collected, consisting of: asset market value, asset return, VaR value at 1% and 99% confidence intervals, asset buy and sell prices, spread, spread volatility, transaction costs, price

volatility, time to execution, Moscow Exchange risk parameters, trading volume, volume of open positions, number of transactions, number of trading participants, sensitivity coefficients of changes in liquidity indicators to changes in margin requirements, maintenance margin and residual margin values, collateral values, probability of default, funding illiquidity ratio, implied volatility, risk-free rate in currency and in roubles, RTS index yield, coupon-free yield curve values and trading commissions.

Based on the data set collected:

1. The profit of the central counterparty on long and short positions is calculated using FIFO and LIFO liquidity accounting methods for each position for each derivative on each trading day;

2. For derivatives for each underlying asset at each point in time, the sensitivity of liquidity indicators to the size of collateral (coefficients of the model explaining the relationship between liquidity and the size of margin requirements) is reassessed, VaR is estimated, and transaction costs of the central counterparty in liquidating a position are estimated over a 1-year interval;

3. The sensitivity coefficients obtained at step 2 are used to calculate new values of the volume of open positions, trading volume and the volume of illiquidity of funding when margin requirements change for the minimum and optimal size of requirements;

4. The optimal size of margin requirements was calculated by solving the optimization problem of maximizing the profit of the central counterparty by changing the size of margin requirements, taking into account their impact on liquidity;

5. Risk indicators (the share of excess losses over the amount of collateral, frequency and strength of default), liquidity indicators (trading volume and volume of open positions) and profit indicators of the central counterparty are compared. The comparison is performed using bootstrapping procedure, i.e. creating a distribution of sample mean for each sample and using non-parametric tests: Mann-Whitney U test, Wilcoxon signed-rank test and non-parametric distribution comparison test.

The analysis shows that the optimal amount of collateral is between the minimum and actual values. Maximizing the central counterparty's profit through the amount of collateral leads to a statistically significant increase in the frequency and strength of defaults, but at the same time is accompanied by an increase in trading volumes and open positions compared to the existing margin level. The main increase in central counterparty revenues comes from an increase in the amount of funds available for investment, i.e. the product of open positions and residual margin requirements. Although reducing the amount of collateral to the minimum acceptable level would further increase the level of liquidity, it would not lead to a statistically significant increase in total central counterparty revenues.

Conclusions

Analysing the properties of margin as a risk metric and existing margin systems, the following was determined:

1. All methods of derivatives risk assessment have their advantages and disadvantages in use. The most accurate method of assessment is the Monte Carlo method, but due to its complexity and the need to assess risk quickly, it is not used in practice. Instead, a quasi-Monte Carlo method is used, i.e. a set of fixed scenarios of changes in risk parameters. Such method gives an overestimation of the risk, therefore, reduces the positive effect of the implementation of the margining system;

2. Risk metrics based on quantile estimation (VaR) have significant drawbacks - their properties do not meet the coherence criteria and, consequently, lead to inefficiency of the obtained estimate. This means that the obtained risk assessment is not accurate, and to comply with international requirements for the reliability of the margin system, the central counterparty is forced to overestimate the obtained assessment, thereby reducing the positive effect of the system.

The analysis of legislative and regulatory international and local acts allowed to define the requirements to the central counterparty and its possible actions. The assigned amount of margin requirements must cover potential losses on the position on a horizon of one trading day or for the entire period of position liquidation, if any, with

a probability of 99%. At the same time, the central counterparty has the right to use the volume of guarantee collateral for its own investment purposes on the condition of repayment. On this basis, an optimisation problem was constructed linking the profit of the central counterparty, market liquidity and the central counterparty's losses in the event of a bidder's default. According to this problem, the profit of the central counterparty was calculated for the current margin system, for the optimal margin size and the minimum acceptable margin size.

As a result, all 3 models were compared with each other. The comparison was based on such criteria as: frequency and severity of defaults, share of excess losses over the amount of collateral, amount of collateral, relative change in trading volumes and open positions, relative change in central counterparty revenues.

In general terms, we can conclude that the proposed method for estimating the amount of collateral for common stock futures and options on common stock futures is sound. This method allows for a statistically significant increase in both market liquidity and central counterparty profits, subject to regulatory constraints. The method levelled the disadvantages of current methods and, importantly, takes into account the specifics of a particular exchange and real data.

REFERENCES

Publications in periodicals:

1. Acharya V. (2009) A Theory of Systemic Risk and Design of Prudential Bank Regulation. *Journal of Financial Stability*, 5, 3, pp. 224–255.
2. Acharya V., Bisin A. (2014) Counterparty risk externality: Centralized versus over-the-counter markets. *Journal of Economic Theory*, 149, 3, pp. 153–182.
3. Arltova M., Fedorova D. (2016) Selection of Unit Root Test on the Basis of Length of the Time Series and Value of AR (1) Parameter. *Statistica*, 96, 3, pp. 47–64.
4. Artzner P., Delbaen F., Eber J.-M., Heath D. (1999) Coherent Measures of Risk. *Mathematical Finance*, 9, 3, pp. 203–228.
5. Benos E., Ferrara G., Ranaldo A. (2022) Margin Procyclicality and the Collateral Cycle. *Bank of England staff working paper*, 2022, 966, pp. 1–37.
6. Berlinger E., Domotor B., Illes F. (2018) Optimal Margin Requirement. *Finance Research Letters*, 31, C, pp. 1-11.
7. Bernales A., Chen L., Valenzuela M. (2017) Learning and Forecasts about Option Returns through the Volatility Risk Premium. *Journal of Economic Dynamics and Control*, 82, pp. 312-330.
8. Brunnermeier M., Pedersen L. (2009) Market liquidity and funding liquidity. *The Review of Financial Studies*, 22, 6, pp. 2201–2238.
9. Chou R. K., Wang G. H. K., Wang Y-Y. (2014) The Effects of Margin Changes on the Composition of Traders and Market Liquidity: Evidence from the Taiwan Futures Exchange. *SSRN Electronic Journal*, 35, 10, pp. 895-914.
10. Cont R., Deguest, R., Scandolo, G. (2010) Robustness and Sensitivity Analysis Of Risk Measurement Procedures. *Quantitative Finance*, 10, 6, pp. 593–606.
11. Danielsson J., Embrechts P., Goodhart C., Keating C., Muennich F., Renault O., Shin H. S. (2001) An Academic Response to Basel II. LSE Financial Market Group an ESRC Research Centre. *Special paper series*, 130, pp. 1-17.
12. Danielsson J., Shin H. S., Zigrand J.-P. (2012) Endogenous and Systemic Risk. *Quantifying Systemic Risk*, 1, pp. 73-94.

13. Daskalaki C., Skiadopoulos G. (2016) The Effect of Margin Changes on Commodity Futures. *Journal of Financial Services Research*, 22, 3, pp. 129-152.

14. Emmer S., Kratz M., Tasche D. (2015) What Is the Best Risk Measure in Practice? A Comparison of Standard Measures. *Journal of Risk*, 18, 2, pp. 31–60.

15. Jacobs K., Li B. (2022) Option Returns, Risk Premiums, and Demand Pressure in Energy Markets. *Journal of Banking & Finance*, 146, 2, pp. 1-58.

16. Jacobs K., Li B. (2022) Option Returns, Risk Premiums, and Demand Pressure in Energy Markets. *Journal of Banking & Finance*, 146, 2, pp. 1–58.

17. Loon C., Zhong Z. (2014) The Impact of Central Clearing on Counterparty Risk, Liquidity, and Trading: Evidence from the Credit Default Swap Market. *Journal of Financial Economics*, 112, pp. 91-115.

18. Malkhozov A., Mueller P., Vedolin A., Venter G. (2014) Funding Liquidity CAPM: International Evidence. *Meeting Papers Society for Economic Dynamics*, 1165, pp. 1-48.

19. Mayordomo S., Posch P. (2016). Does Central Clearing Benefit Risky Dealers? *Journal of International Financial Markets, Institutions and Money*, 42, pp. 91-100.

20. Ogorelkova N.V. (2011) Derivative Financial Tools Market in Russia: Adjustment Issues. *Herald of Omsk University. Series Economic*s, 3, pp. 172–178.

21. Pang X., Zhu S., Cui X., Ma J. (2023) Systemic Risk of Optioned Portfolios: Controllability and Optimization. *Journal of Economic Dynamics and Control*, 153, pp. 1–47.

22. Potapov A.I. (2023) Assessing the Margin Requirements Impact on the Russian Futures Market Liquidity. *Financial Journal,* 15, 5, pp. 94–116.

23. Potapov A.I. (2024) Options Time Risk-Profile. *HSE Economic Journal*, 27, 1, pp. 108–132.

24. Potapov A.I., Kurbangaleev M.Z. (2023) Comparison of Central Counterparty Risk Assessment Approaches. *HSE Economic Journal*, 27, 2, pp. 196–219.

25. Shaik M., Padmakumari L. (2022) Value-at-risk (VAR) Estimation and Backtesting during COVID-19: Empirical Analysis Based on BRICS and US Stock Markets. *Investment Management and Financial Innovations*, 19, 1, pp. 51-63.

26. Subrahmanyam, A. (1991) Risk Aversion, Market Liquidity, and Price Efficiency. *Review of Financial Studies*, 4, pp. 417–441.

27. Utkin V.S. (2009) The Article is Devoted to the Central Counterparty (CCP) Role in the Financial Market. Finance and Credit, 15, 40, C. 66–70.

28. Utkin V.S. (2010) Central Counterparty on RTS Exchange Markets. Finance and Credit, 16, 7, pp. 36–42.

Documents:

29. BCBS CPMI IOSCO. Basel Committee on Banking Supervision. Committee on Payments and Market Infrastructures. Board of the International Organization of Securities Commissions. (2021) *Review of margining practices*.

30. BCBS. Basel Committee on Banking Supervision. (2005) *Studies on the Validation of Internal Rating Systems*.

31. Federal Law No. 507 dated 05.12.2022 ‘On Amendments to Article 20 of the Federal Law “On Banks and Banking Activities” and the Federal Law “On Insolvency (Bankruptcy)” with regard to the development of financial market instruments’.