TOGETHER FOREVER OR SEPARATED FOR LIFE: STRESS TESTS OF CENTRAL COUNTERPARTIES IN CASE OF MERGED AND SEPARATED DEFAULT FUNDS

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ABSTRACT

The role of the central counterparties on the market is to take over the counterparty risk during the trading on stock exchanges. To fulfill its role, a CCP needs to maintain financial resources that can absorb losses in case of the default of a clearing member. A default waterfall system is operated by CCPs, one of which element is the default fund (DF) contribution by members. Our paper focuses on the default fund design a central counterparty (CCP) operates and the stress test applied to quantify the size of it. There is always a trade-off between the margin requirements and the default fund regarding risk-sharing and their sizes. Two possible designs are presented, therefore, our paper analyzes the default funds, and the cross-guarantee between CMs, from the viewpoint of having a joint or separated default fund for different markets. In the risk management system of several CCPs the size of the default fund is linked to the result of the stress tests. Applying stress on the proposed model, results show that from the market participants' perspective that are present only on the spot market a merged market is not in their favour, while for those, who are present on both markets benefit from the merged markets. From the CCPs point of view, on one hand the most prudent step to take is to clear the markets separately, since the overall value of the guarantees would be higher in this case, but on the other hand from competition point of view, the lower margin and default fund values can strengthen a CCPs position in acquiring and keeping clearing members.

INTRODUCTION

The 2008 crisis exposed how vulnerable our financial system was. Since then was straightforward, that there is an urgent need to reinforce the financial stability and to strengthen the resilience of the system. In the "non-banking" field of finance major improvements have been started and as a result, central counterparties gradually became systematically important institutions on the financial markets. Through their valuation process and novation, CCPs enhance transparency, so procedures for outstanding positions of defaulting members to surviving members are also in the main focus. "CCPs also have so-called assessment powers over surviving members to specify the replenishment of the funds used in the mutualized loses of the defaulting members" (Markose et al, 2017. pp. 114).

Robustness to default risk is crucial for all CCPSs, therefore a default waterfall system is operated. Murphy (2017) presents the three typical resources of the waterfall system: the initial margin, the so-called skin-in-the-game aka a small amount of the CCP's own capital and the default fund. This latter item is a mutualized layer of resources provided by clearing members. In our analysis we omit the role of the skin-in-the-game.

Contribution to literature

Our paper addresses the design of an overall risk-bearing among the clearing members in two scenarios. We analyze the effect of the default fund designs by considering it is better to have segregated funds for different markets, in this case for spot and derivative trades on the securities' market, or a common default fund shall be operated among the clearing members of the CCP. It is a major aspect of how the presence of the

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central counterparty changes the risk-bearing mechanisms. Theoretically, the positions of the spot market may have an effect on the prices of the derivatives market and vice versa. Our research aim is to analyze how spot and derivative positions affect each other and how the default fund contributions to segregated and aggregated funds would behave. We calculate the size of the default fund based on the result of stress tests. CCPs' beneficial presence in different markets is proven by several researchers. Central counterparties do mitigate counterparty risk and are prepared to withstand under "extreme but plausible market conditions". However, the default of the CCP itself becomes a systemic risk, triggering the collapse or at least weakening the resilience of an industry or economy. Duffie et al. (2015) claims that this event on the financial stability would have dramatic effects. Based on this, we search how does aggregated and separated funds have different effects, putting different financial burden on market participants, which we will measure with the size of the default funds and the size of the margin requirements.
The paper proceeds as follows: At first the regulatory background is presented followed by current research and results in this field. The second part of the paper gives insight of the model used. Results and further researches are then followed by conclusion.

Regulatory background

Risk allocation, therefore, is a crucial point in the strategy of a CCP. Armenti, et al. (2018) argue that the risk management of banks and CCPs have an effect on the risk in the financial system from a systemic point of view. They also point out the importance of the losses regarding these institutions during the analysis of their systemic effect. Biais et al. (2012) explain the risk allocation implications of central clearing activity. Due to moral hazard problems, they bring reason that CCPs shall not offer full insurance against counterparty credit risk. Later in 2016, they show that margin requirements, together with central clearing, can preserve the risk-prevention incentives by inducing the optimal level of risk monitoring and can accomplish the mutualization benefits of risk-sharing (Biais et al., 2016).
Many have criticized the risk CCPs carry as "being too big to fail" due to their constant growing importance (Cont, 2015, Berlinger et al. 2018). Markose (2012) introduces the concept of too interconnected to fail as well. Authorities have put great attention to strengthen the global safeguards for central clearing, by adopting the CPMI-IOSCO Principles for Financial Market Infrastructures in 2012, dedicated Financial Stability Board guidance and the European Market Infrastructure Regulation in 2012.
Authorities implementing the EMIR have included skin-in-the-game (SIG) requirements for CCPs. CCP SIG is given precedence in the waterfall structure ahead of the loss mutualization based on the prefunded default fund contributions of surviving CCP members (Markose et al., 2017). EMIR Article 48 outlines the key responsibilities of a CCP in managing a default. The default waterfall is the financial safeguards available to a CCP. An order is also specified in which they would be expended in the event of a clearing member's (CM) default. To fulfill its role, a CCP needs to maintain financial resources that can absorb losses. These are the elements of the so called default waterfall including the following items (EMIR, Article 48.):

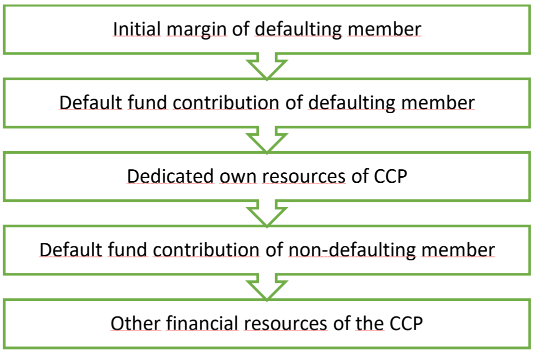

Figure 1: Default waterfall

The first resources available are the margin requirements. According to Figure 1, a CCP can only use the margin of the defaulting member, but not the survivors', to cover losses. Based on EMIR Article 41 and chapter VI. of the regulatory technical standards (RTS, 2013), the level of margin requirements shall be set to cover potential market losses in the clearing member's positions in normal market conditions, based on the calculation of a statistical model. The parameters of the statistical model should be the following in case of non-OTC financial assets: confidence level at least 99%; lookback period is 250 days that includes a stressed period, liquidation period is at least 2 days – since the settlement on the stock exchanges is T+2 days. Procyclicality shall also be taken into consideration – different procyclicality handling methods are analyzed by Berlinger et al. (2018).
The second layers of protection are the default fund contribution sources of the defaulting members (EMIR Article 42, RTS Chapter VII.). Regulators ask CCPs to implement an internal policy framework for defining the types of extreme but plausible market conditions that could expose it to greatest risk. As it can be seen in Figure 1, the fourth layer of the default waterfall is not only for cover losses to extreme market conditions, but it is also a cross guarantee between clearing members.
The default waterfall has an important role in identifying liquidity risk as well regarding the default of the clearing members. Principle 7 CPSS-IOSCO and the EMIR regulation states that CCPs should meet the Cover 2 requirement, which means that CCPs should have sufficient liquidity – guarantee fund and skin-in-the-game – to cover the simultaneous default of the two clearing members – and their affiliates - that would generate the largest exposure to the CCP (Parkinson, 2014).

If all resources of the defaulting member are exhausted, own funds of the CCPs, namely the skin-in-the-game, the non-defaulting member's assets within the default fund will be used in order to protect the whole system. Afterward, if the default waterfall is still insufficient, recovery and resolution regimes are being put into force (Cont, 2015).

According to this, there is always a trade-off between the margin requirements and the default fund regarding risk-sharing and their sizes. Namely, if the margin is greater/lower, causing the default fund to be lower/greater, the cross-guarantee will be lower/greater within the default waterfall.

In our paper, the focus will be on the default funds, and the cross-guarantee between CMs, from the viewpoint of having a joint default fund of different markets – derivatives and spot market – by using stress test. We apply this method, since in the risk management system of several CCPs the size of the default fund is linked to the result of the stress tests (KELER CCP, 2019).

According to EMIR (2012, Article 49.), stress tests should be used for testing and measuring the risk management models of the CCPs in extreme but plausible market conditions. The supplementation of EMIR, the RTS (2013) states, that historical and hypothetical scenarios should be used, and the default of the CM with the highest, or the second and third highest (max(1;2+3)) exposure should be covered by CCPs.

Stress tests

Stress tests are techniques that measure the effects of rarely occurring events that are not measurable by the usual toolkit on financial institutions (Madar, 2010). Typically, institutions or regulators define independent event systems, outline changes in risk factors, and then determine the extent of losses suffered in different scenarios. The exact course of preparing stress tests is described in detail by Hilbers and Jones (2004). These tests have two purposes, on the one hand, to ensure the availability of adequate resources at the level of individual institutions and, on the other hand, to identify systemic risks on the financial markets. There are several types of stress tests based on different grouping principles by:

1) complexity: sensitivity analysis or scenario building (BCBS, 2009),
2) source of scenarios: historical or hypothetical (Hull, 2015),
3) number of risks taken into account: one or more risk factors (Banai et al. 2013),
4) number of assets tested,
5) time horizon of the survey: from days to years analysis
6) bottom-up or top-down analysis (DNB, 2017, MNB, 2016),
7) examination of individual institutions or a complete financial system (Cihák, 2007).

Literature of stress test

Since central counterparties are becoming the great pillars of the financial system, they opened the field for researchers as well. The regulatory framework may be vague in several aspects, so many studies aim to add knowledge in order to find the most suitable methodologies and models for the CCPs and for regulators, too. A wide variety of models have been developed in order to determine the adequate methodology of stress testing. The design of stress scenarios were analyzed by Canabarro (2013).

Poce et al. (2018) tested the adequacy of the default fund from a network-based stress test point of view, where they analyzed the network of CMs on the fixed income market. Their main result was, that setting a default fund to cover insolvencies only on a cover 2 basis may not be adequate, and only very conservative default funds – that cover the losses of several CMs – can face the losses resulting from distress spillovers. The interconnectedness of the financial markets was also analyzed by Battiston et al., 2016 and Iori et al. (2006) and was also proven that the "financial distress spreads among financial institutions through direct exposures and indirect exposures through common assets ownership" (Acemoglu et al., 2015). Capponi et al. (2017) provide evidence in relation to studies that aim to analyze the effectiveness of the current standard in absorbing default losses in distressed market scenarios by emphasizing the equilibrium and socially optimal choice of risk-taking. The Cover 2 proposal by the regulator is highly criticized. Paddrik and Young (2017) show that the simultaneous failure of two members could cause network contagion and further lead to insufficient funds at the CCP. Menkveld (2017) shows that crowded trades of dealers could amplify losses of CCPs in stressed scenarios. Campbell and Ivanov (2016) argues that the losses could be more substantial if the exposures of large CCP members are positively correlated than if they are independent.

Ghamami and Glasserman (2017) found that lower default fund requirements reduce the cost of clearing but make CCPs less resilient.

Baker et. al (2016) analyze the distribution of losses to default fund contributions and contingent liquidity requirements for each clearing member identifying wrong-way risks among defaulting parties. Their main conclusion suggests that liquidity is the most important when it comes to members assessing the risks and costs.

EU wide stress test

Both banks and CCPs are considered as systematically important financial institutions, and based on this the regulators carry out regularly EU-wide stress tests for both type of institutions. Compared to the functioning of banks, the "specialties" of CCPs is presented by Berlinger et al. (2016), which will have an effect on their risk management system: 1) high degree of specialization, 2) symmetric exposures, 3) balanced position, 4) cross-guarantee system, 5) deposit dependency and 6) dynamic risk management.

One of the objectives of EMIR is to promote central clearing and ensure safe and resilient CCPs. For CCPs the European Securities Market Authority (ESMA) at least annually initiates and coordinates EU-wide stress tests, the latest was published in February 2019 (ESMA, 2019). Together with local authorities, ESMA applies common methodologies for assessing the effect of different stress scenarios and to identify the shortcomings in the resilience of the institutions.
During the tests, credit-, liquidity-, concentration risk, and reverse credit stress are analyzed. The latest results, communicated in 2017 by ESMA show that since the first test the performance of CCPs have improved and as per their communication “ESMA remains committed to further improve and evolve the methodology and scope of the CCP stress tests and address residual limitations in future exercises” (ESMA, 2018).
Further on, our model will be presented, that includes the methodology used to determine the margin requirements, the stress test applied and the price modelling methodology.

MODEL

Our model is built up as follows:
There will be one CCP on the market, and two financial assets, a stock and a currency. Trades can be fulfilled on the spot market only for the stock, while on the derivative market both call and put options; futures contracts are available for both financial assets.
The price of the two assets will be simulated with arithmetic Brownian motion (ABM) according to Equation 1:

$$dY = \alpha \cdot dt + \sigma * \sqrt{dt} \cdot N(0,1) \qquad (1)$$

where dY is the change in the logreturn during dt time period, α is the expected value of the logreturn, σ is the standard deviation for the logreturn, and N(0,1) is a standard normal random variable. The price will be determined by Equation 2:

$$S_t = S_0 \cdot e^{Y_t} \qquad (2)$$

where t stands for time, and S stands for the price of the asset. We simulate the prices with this method for 7500 days, namely for 30 years, since the EMIR regulation’s Technical Standard states that the stress scenarios should be based on the data of the last 30 years (RTS, Article 30). We also assume correlation between the two financial assets’ prices, with Cholesky decomposition, which means that the relation between the random variables will be the following, based on Equation 3, where ϵ will be a random number used in the ABM of the currency:

$$\epsilon = \rho \cdot N(0,1)_{Stock} + \sqrt{1-\rho^2} \cdot N(0,1)_{Currency} \quad (3)$$

We also simulate stresses in the time series of assets. The occurrence of the stress/shock will be modelled with a Poisson process, while the extent of the shock will be modelled with lognormal distribution.
The parameters for the model are the following according to Table 1:

Table 1: The parameters of the price simulation

	Stock	Currency
Parameters of the arithmetic Brownian motion		
α	10%	5%
σ	15%	10%
S_0	1000 EUR	1000 EUR
dt	1 day	1day
shock parameters that effect the value of the shock		
μ	-20	-20,6
standard deviation	0,7	0,8
decrease of shock	0,97	0,99
shock parameters that effect the date of the shock		
λ	0,005	0,0045

The correlation at the time of the shock will be increased to 0,9, and it will decrease by 0,95 every day, and the minimum value of correlation is set to 0,5.
A realisation of the stock price and one realisation of the shock can be seen in Figure 2 and 3:

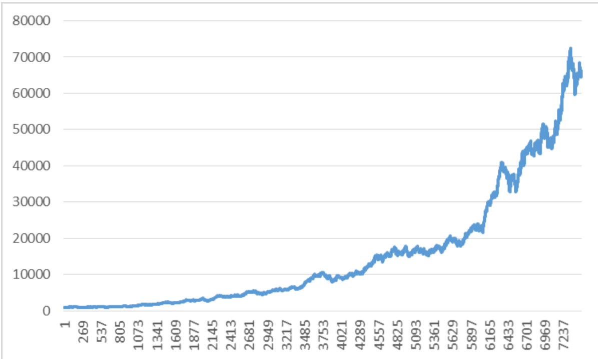

Figure 2: one realisation of stock price

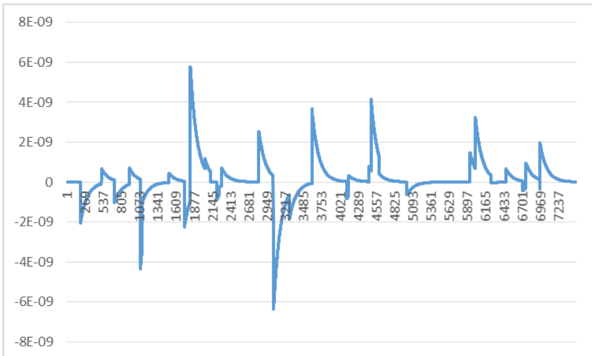

Figure 3: one realisation of shock

Four clearing members are present on the market, with different positions. According to Table 2:

Table 2: Number of positions of the clearing members

Clearing Members:	CM1		CM2		CM3		CM4	
Asset:	Stock	Currency	Stock	Currency	Stock	Currency	Stock	Currency
Name of position:	long staddle + spot	long staddle + futures	protective put	Futures	covered call + short put	Short straddle	Spot	-
Long put	3	5	2					
Short put					5	5		
Long call	3	5						
Short call					3	5		
Long futures				5				
Short futures		5						
Long underlying	4		2		3			
Short underlying							9	

The margin of the underlying assets will be calculated by the method of Béli and Váradi (2016), while the SPAN (Standard Portfolio Analysis of Risk) method will be used to calculate the margins in the case of portfolios. This means the following according to Figure 4. We assume that there will be only risk array, and SOM, which will be 10% of the underlying asset's margin.

Figure 4: SPAN methodology

Table 3: SPAN scenario parameters

Scenario	the change in spot price will be multipled by this amount	the change in standard deviation will be multipled by this amount
1	0,00	1
2	0,00	-1
3	0,33	1
4	0,33	-1
5	-0,33	1
6	-0,33	-1
7	0,67	1
8	0,67	-1
9	-0,67	1
10	-0,67	-1
11	1,00	1
12	1,00	-1
13	-1,00	1
14	-1,00	-1
15	2,00	0
16	-2,00	0

The risk array will contain scenarios for the portfolio according to Table 3. This means that the positions will be revalued with the new underlying prices, and new standard deviations. The scenario that will give the biggest loss will be considered the margin of the portfolio of a certain CM.

We simulate the margins two different ways, once when the margin and DF will be calculated for the spot and derivative markets as merged markets, and once when they are separated. To calculate the DF, we need to run the stress tests. In case of the stress test, we will use six different scenarios, and calculate, whether in case of each scenario's price change the margin was sufficient to cover the potential losses of each clearing member in case of default, or not, on the last day of our simulation. The value of the default fund will be the scenario, that has the highest loss of the max(1;2+3) exposures according to EMIR. The parameters of the scenarios:

- 4 historical scenarios: 1 & 2: Min/max stock: lowest/highest stock return during the 7500 days, and taking the currency return the same day; 3 & 4: Min/max currency: lowest/highest currency return during the 7500 days, and taking the stock return the same day.
- 2 hypothetical scenarios: Hypothetical one: stock: 5%, currency: 5%.; Hypothetical two: stock: -5%; currency: 5%

As a final step, the default fund (DF) has to be split up between the clearing members according to their ratio of margin payment within the total margin value on the market, according to Equation 4:

$$DF_{CM1} = \frac{Margin_{CM1}}{\sum_{t=1}^{4} Margin_t} \qquad (4)$$

RESULTS

We run the simulation 101 times. Figure 5 shows the values of the default funds in the cases of merged and separated markets in all of our 101 realizations/simulations.

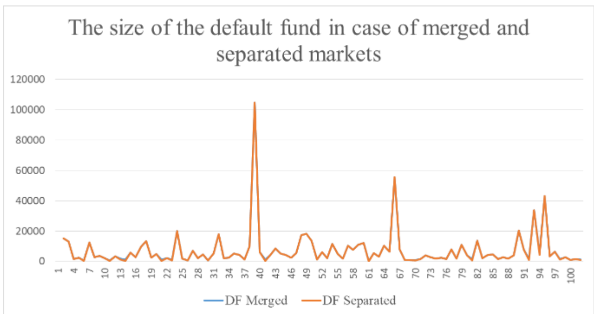

Figure 5: Default fund values

As an overall view, we can say that in only 5 times out of 101 exceeds 20 000 the value of the default funds. Although there is no visible difference on Figure 5 between the merged and separated markets regarding the value of DF as it differs only in 20 cases out of 101.

In 18% of the simulations, the merged DF exceeds the separated DF. The difference varies from 1% to 71,4% with the average of 35,7%. In 2% of the simulations, the separated DF is higher than the merged but the difference is only 0,05%.

What is more interesting is that the total amount of margin was always higher on the separated market, no matter whether the DF was equal with each other or they were different. On average this difference was 13,87% of the margin value of the separated market's margin. The reason is, that those who traded on both markets had to pay margin for both the underlying asset and for its derivatives separately, while on the merged markets, they could be valued as a portfolio, and the possible risk reducing effect could have been taken into account. This is confirmed on the CM level margin as well since those who had assets from both markets could reduce margin on the merged market, while CM4, who was present only on the spot market had to pay the same margin in the merged market, too.

Our other main goal was to examine how the contribution to the default fund changes per each CMs if we calculate on separated or merged markets. As we already stated, the value of the DF does not depend on whether the markets are separated or merged in 80% of the simulations. However, the contribution of each member differs obviously in the two cases.

The rate of contribution of CM3 is lower at every simulation in the merged market compared to the separated markets. In contrast, CM4 should add in more if we operate in the merged market.

In 80% of the simulations, a positive correlation can be noticed between the rate of contribution of CM1 and CM2. In 80% of the realizations, if CM1 adds in more on the merged market, CM2 follows the pattern.

CONCLUSION

We analyzed the contagion effect of merged and separated markets from clearing point of view. Based on our simulation we can conclude, that having a merged market is not in favour of those clearing members, who are present only on the spot market, since they cannot reduce their margin requirement, but have to pay more into the DF, since they have to take over some of the risks of derivative markets. For those, who are present on both markets, the merged markets are better, since they can reduce their margin payments, as they can value the risk of the underlying asset and its derivatives in one portfolio. Also, the CM, who was trading with the highest risk (short straddle) could reduce the default fund contribution as well, so could pass the risk to other members. From the risk management point of view of CCPs the merged markets are not preferred, since the overall value of the margin requirements and the DF contribution were always lower. So a CCP can be the most prudent if clears the markets separately. But on the other hand from competition point of view, the lower margin and DF values can strengthen a CCPs position in acquiring and keeping clearing members.

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