Entidades de Contrapartida Central

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Outline

1. An introduction to CCPs
2. Derivatives CCPs and Risk Management
3. Residual Risk
4. CoMargin
5. Conclusion and Policy Implications

Structure of the Presentation

1. Define
- Identify risk events of interest
- Develop a framework
- Provide insights into previously unknown risks and trade offs

2. Measure
- Quantify risks and trade offs

3. Manage
- Support decision/policy processes
- Narrow down priors to make choices
- Make policies based on principles (as opposed to rules)

"You cannot measure what is not defined
and you cannot manage what you cannot measure"

1. An introduction to CCPs

1.1. What is a CCP?

What is a Central Counterparty (CCP)?

"An entity that **interposes itself** between counterparties to contracts traded in one or more financial markets, becoming the buyer to every seller and the seller to every buyer and thereby **ensuring the performance** of open contracts."

- Principles for Financial Market Infrastructures (CPSS-IOSCO, 2012)

Que es una Entidad de Contrapartida Central?

"Una entidad que se interpone entre las contrapartes de un contrato que se comercializa en uno o mas mercados financieros. La entidad de contrapartida central se vuelve el comprador de cada vendedor y el vendedor de cada comprador para asegurar el desempeño de los contratos."

- Traducción del autor del contenido en
Principles for Financial Market Infrastructures (CPSS-IOSCO, 2012)

A las entidades de contrapartida central también se les conoce como:

- Cámaras de compensación
- Cámaras de contrapartida
- Cámaras de compresión
- CCPs

Clearing and Settlement

- CCPs rely on two common functions (or stages) to fulfill their obligations:

1. **Clearing**
   - "The process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement, potentially including the netting of transactions and the establishment of final positions for settlement." (BIS, 2012).
   - "Sometimes this term is also used (imprecisely) to cover settlement" (BIS, 2012).

2. **Settlement**
   - "The discharge of an obligation in accordance with the terms of the underlying contract" (BIS, 2016).

CCPs and Risk Management

- CCPs rely on netting and collateral for their risk management:
  - **Netting**
    - "The offsetting of obligations between or among participants … thereby reducing the number and value of payments or deliveries needed to settle a set of transactions" (BIS, 2012).
  - **Collateral**
    - "An asset or third-party commitment that is used by a collateral provider to secure an obligation vis-à-vis a collateral taker." (BIS, 2012)
  - **Margin**
    - "In the context of clearing activity, collateral that is collected to protect against current or potential future exposures resulting from market price changes or in the event of a counterparty default." (BIS, 2005)
  - **Initial Margin (IM)**
    - "Collateral that is collected to cover potential changes in the value of each participant's position (that is, potential future exposure) over the appropriate closeout period in the event the participant defaults." (BIS 2012)
  - **Variation Margin (VM)**
    - "Funds that are collected and paid out to reflect current exposures resulting from actual changes in market prices." (BIS, 2012)

Financial Stability Challenges

- **CCPs face the following challenges:**
  - Ensuring proper risk management and alignment of risk management practices with the PFMIs
  - Assessment of exposures to clearing members (CMs) and other CCPs
  - Configuration of a robust waterfall
  - Collection of IM that reflects contributions to systemic risk
  - Management of non-default losses (e.g., investment, custody, and operational risk)
  - Etc.

- **Regulators face the following challenges:**
  - The failure of a CCP could pose a major systemic risk shock
  - Aligning the incentives of CMs and CCPs to enhance the public good of financial stability
  - Monitoring the compliance of CCPs with the PFMIs
  - Assessing and managing risks not contained in CCPs that could become systemic
  - Assessing exposures of CMs across CCPs (often in different jurisdictions)
  - Etc.

CCPs, Financial Stability and Public Goods

Table 1: Classification of goods

	Excludable Only paying participants can have access to the good.	**Non-excludable** Non-paying market participants can have access to the good.
Rivalrous Consumption by one consumer prevents simultaneous consumption by other consumers.	Private goods	Common-pool goods
Non-rivalrous Consumption by one consumer does not prevent simultaneous consumption by other consumers. Marginal cost of production is zero.	Club goods	Public goods

Source: Cerezetti, Cruz-Lopez, Manning and Murphy (2019)

1.2. A Payments CCP

Payment Systems

- A **payments system** is "a set of instruments, procedures, and rules for the **transfer of funds** between or among participants; the system includes the **participants** and the **entity operating the arrangement**" (BIS, 2012).

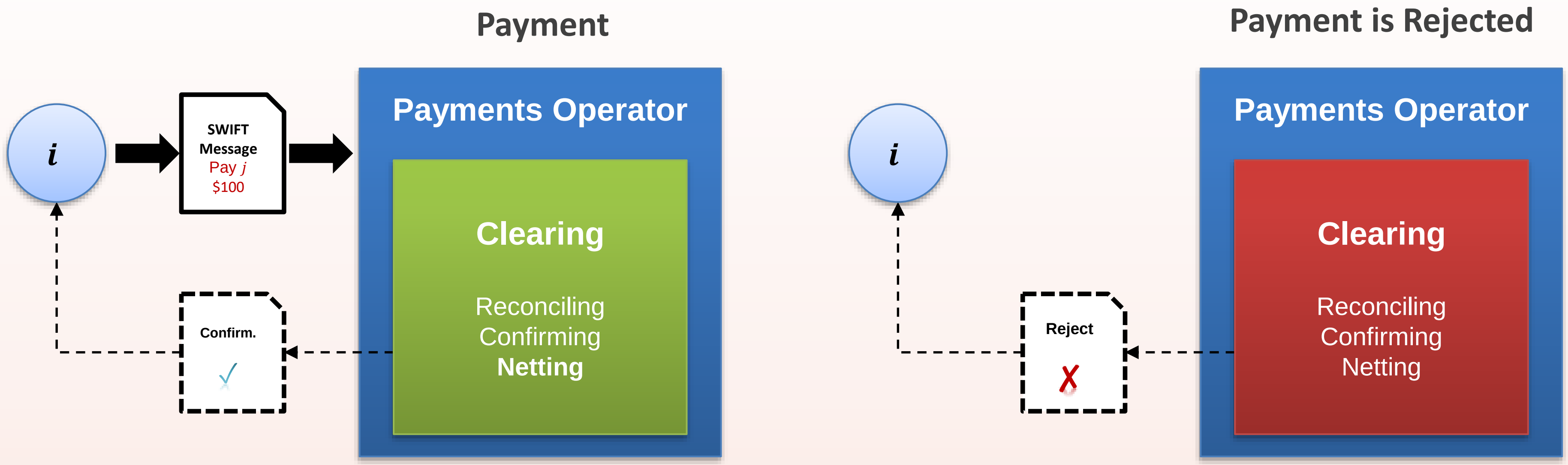
- A **large value payment system (LVPS)** is "a funds transfer system that typically handles **large-value and high-priority payments**" (BIS, 2012).

- **Common types of payment systems:**
  - **Real Time Gross Settlement (RTGS) systems**
    - Clearing and settlement functions occur simultaneously and on a gross basis.
    - There is immediate transfer of settlement funds across the accounts of direct participants (DPs).
    - Because settlement is immediate, defaults cannot occur inside the system.
    - Lack of (or limited) netting makes these systems inefficient in terms of collateral.
  - **Deferred net settlement (DNS) systems**
    - Messages are submitted and cleared, but settlement takes place at the end of the payments cycle.
    - Separation of clearing and settlement allows for netting of payments.
    - Because settlement is not immediate, defaults can occur inside the system.
    - Use of bilateral or multilateral netting increases collateral efficiency.

The Clearing Function

1. Clearing

- "The process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement, potentially including the **netting** of transactions and the establishment of final positions for settlement." (BIS, 2012).
- **"Sometimes this term is also used (imprecisely) to cover settlement"** (BIS, 2012).

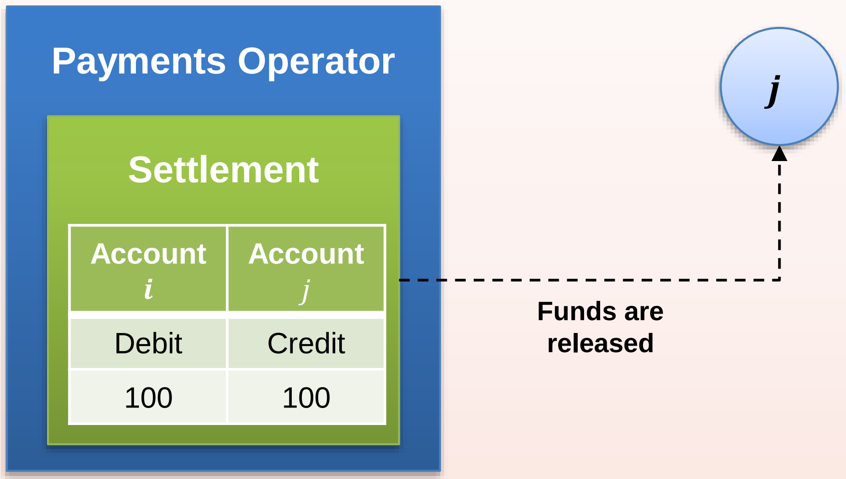


The Settlement Function

2. Settlement

- "The discharge of an obligation in accordance with the terms of the underlying contract" (BIS, 2016).
- "The release of payment obligations between two or more parties by transferring funds between them" (Bank of Canada, 2016).

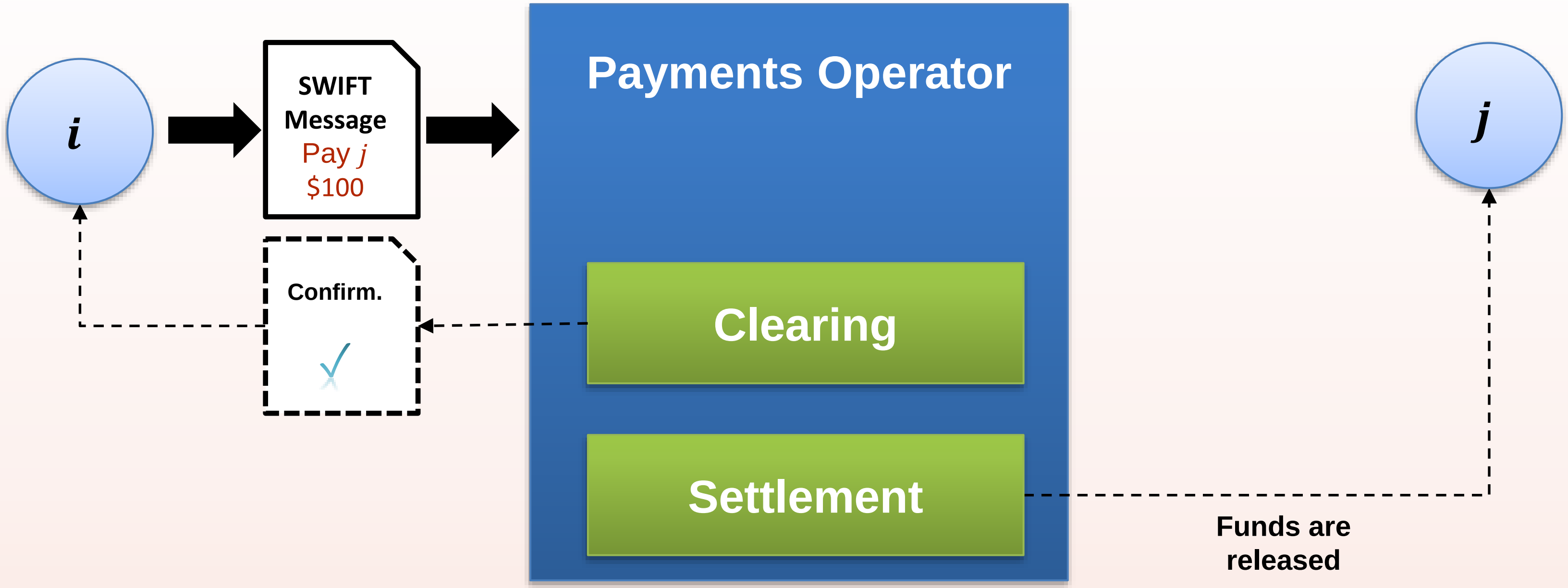
- **Example:**
  - Assume the **PO clears the payment order** in our previous example.
  - The PO transfers **"settlement funds"** (usually central bank reserves) from i to j to settle the obligation.



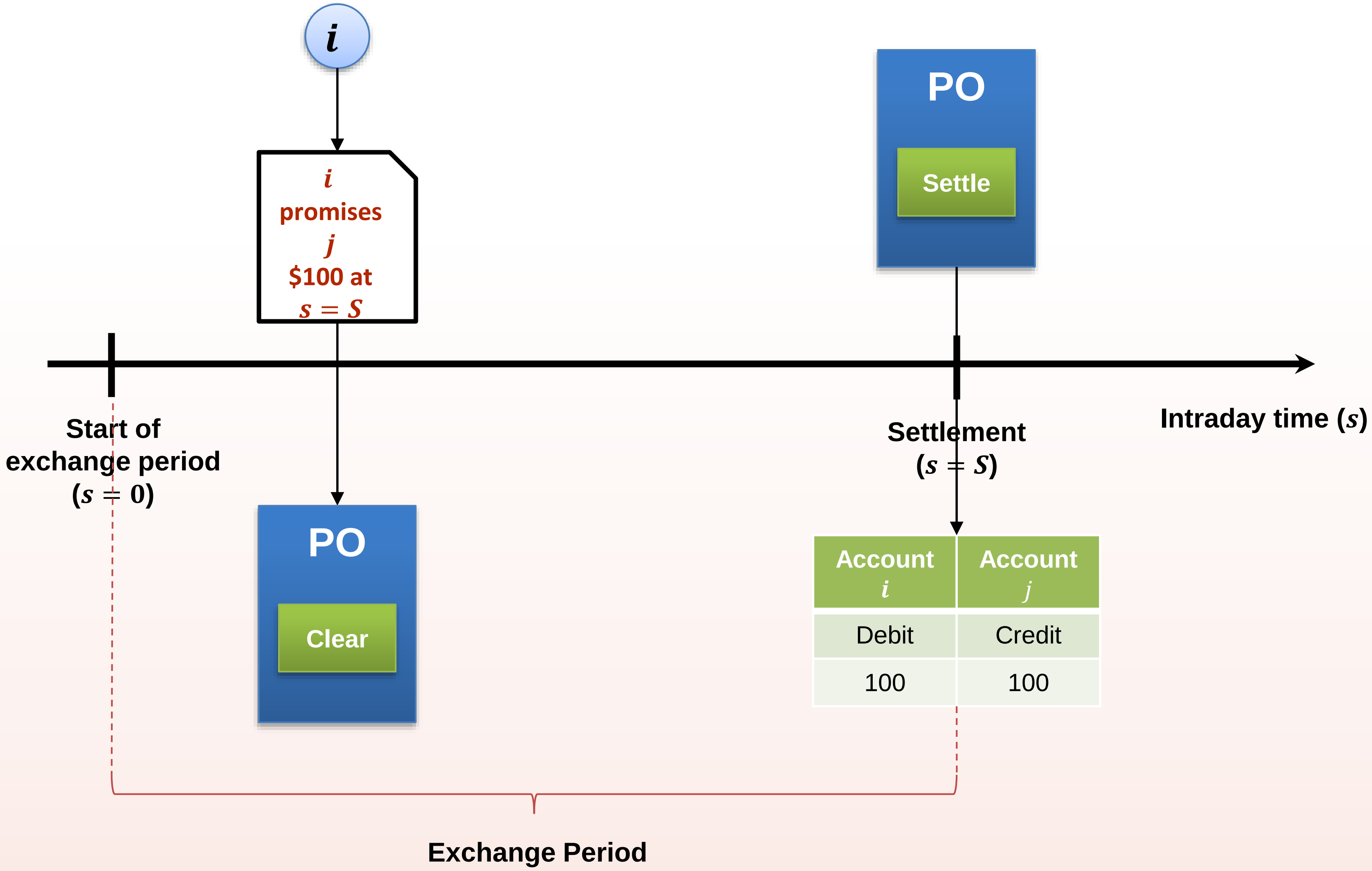
Clearing, Settlement and Counterparty Risk

Counterparty Risk:

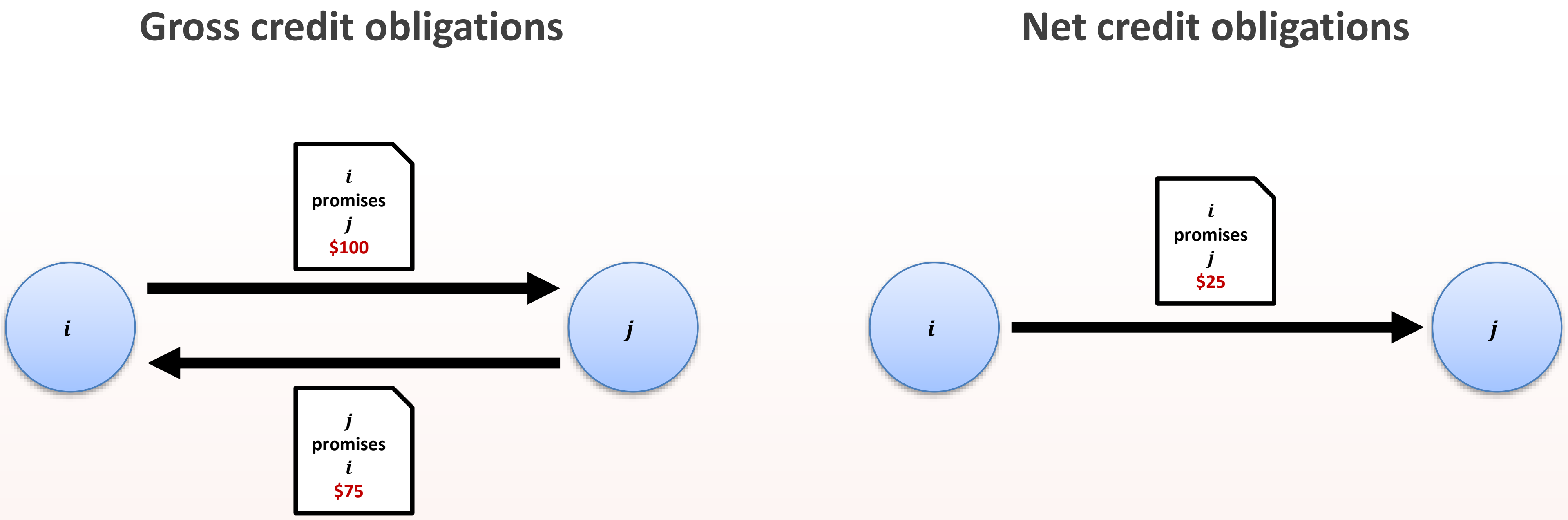
- If **clearing and settlement are not simultaneous**, then **counterparty risk arises.**
- The PO manages credit risk with **collateral requirements** and **loss-sharing provisions.**



Clearing and Settlement



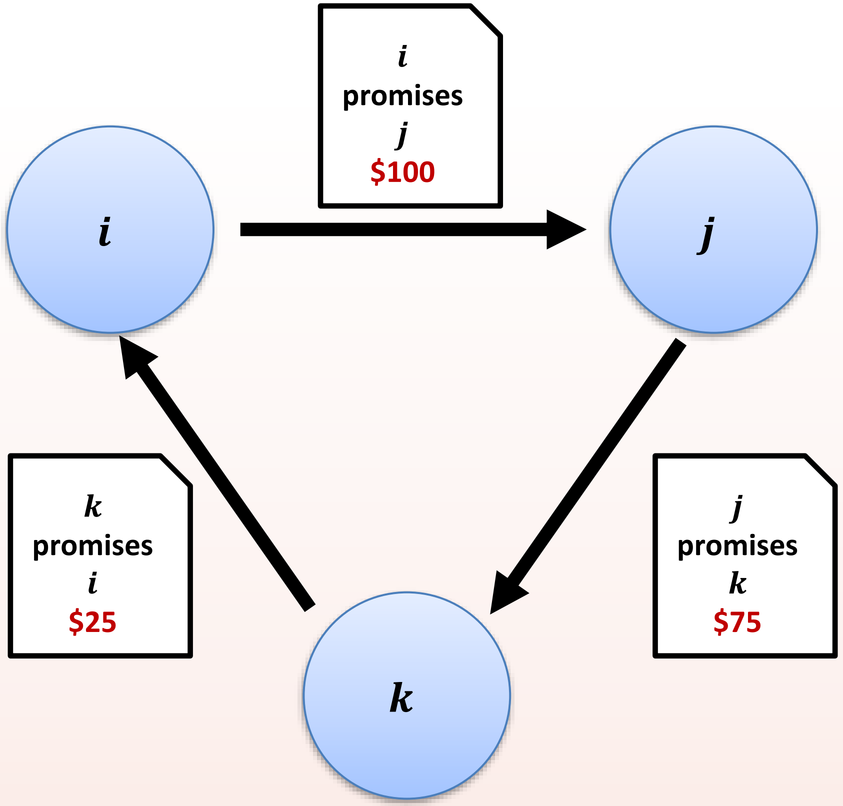
Bilateral Netting



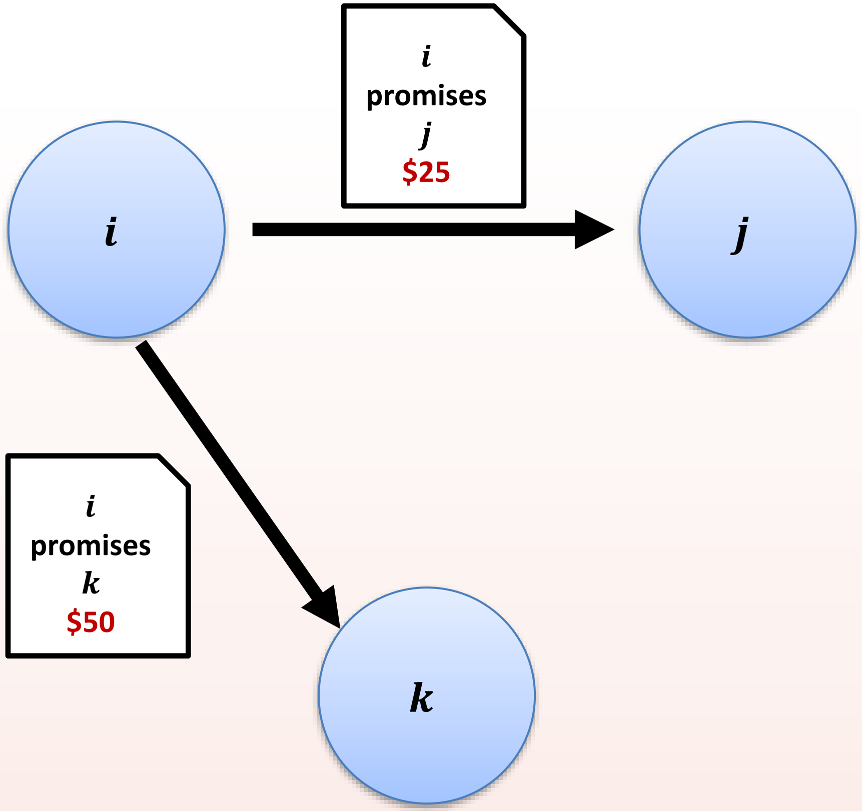
Netting is "the **offsetting of obligations** between or among participants … thereby reducing the number and value of payments or deliveries needed to settle a set of transactions" (BIS, 2012).

Multilateral Netting

Gross credit obligations



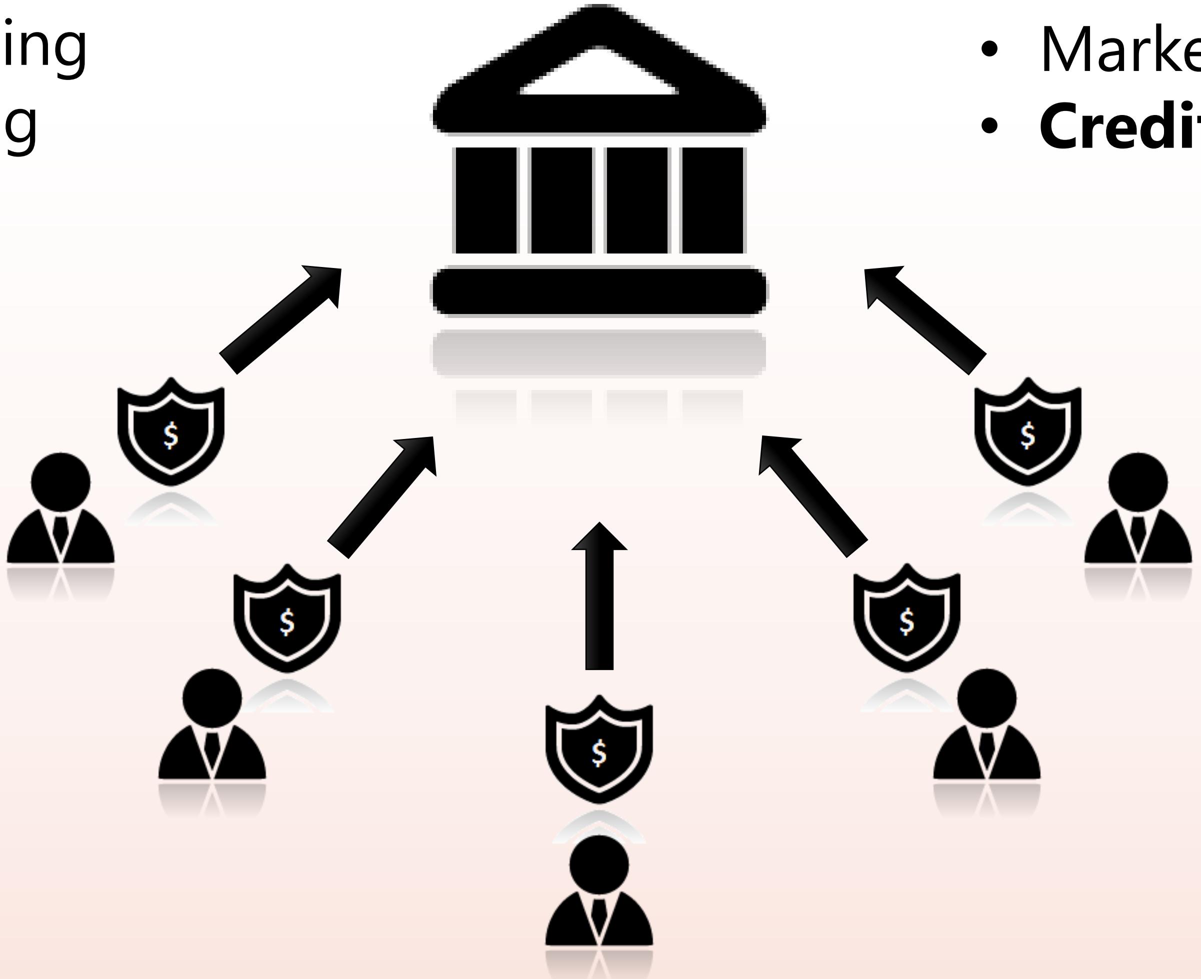
Possible Arrangement of Net credit obligations



1.3. A Derivatives CCP

CCPs: Trading and Risk Management

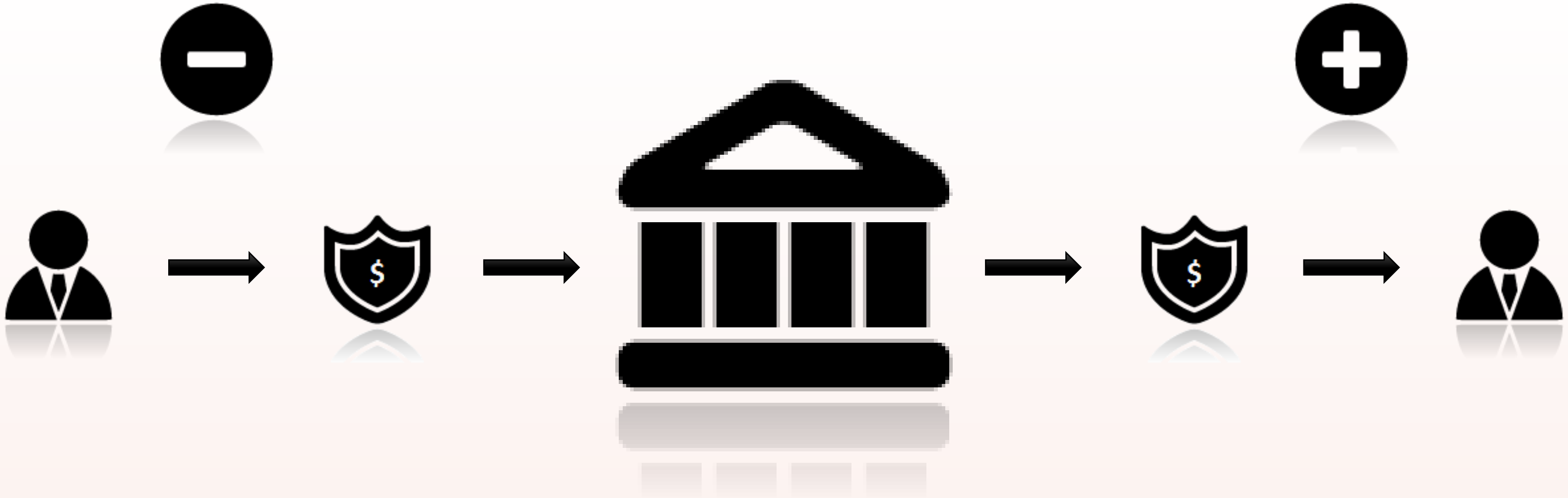
- Confirming
- Matching
- Settling



- Market Risk Neutral
- **Credit Risk Concentration**

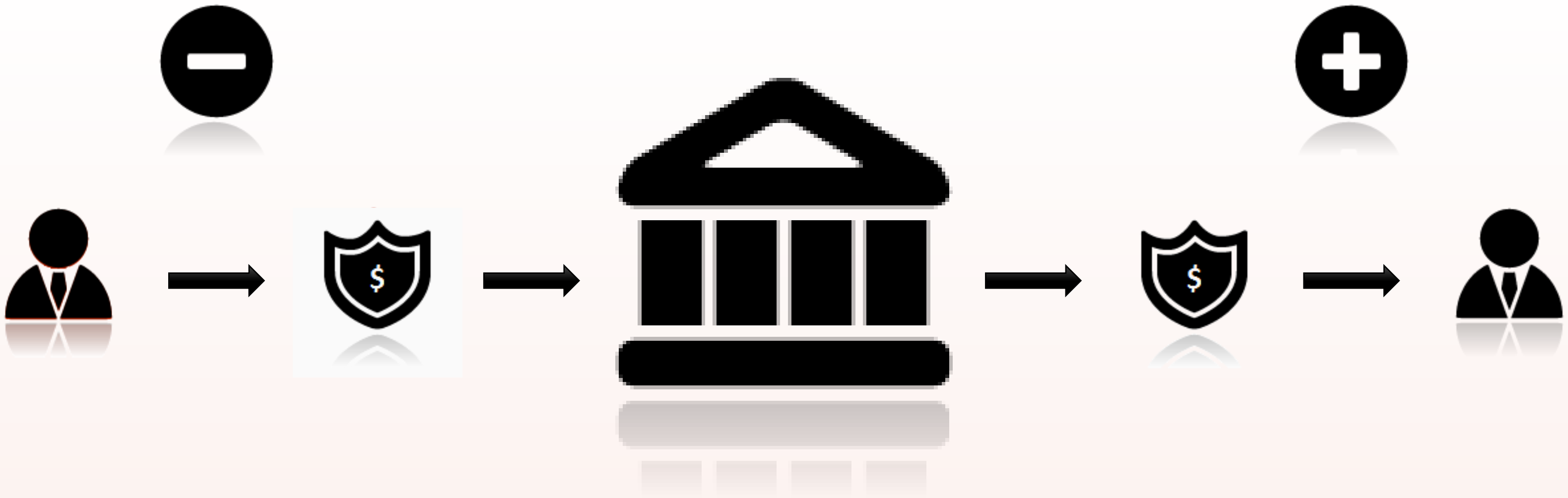
CCPs: Expected Mechanism

Mark to Market



CCPs: Default Risk

Mark to Market



CCPs: Systemic Risk

Examples: Paris 1973, Kuala Lumpur 1983, Hong Kong 1987
(Bernanke, 1990; Knott and Mills, 2002; Duffie, 2013b; and Bignon and Vuillemey, 2017).

Why is this important?

- **OTC derivatives reforms**
  - **Push to centrally clear OTC derivatives**
    (e.g., Acharya et al., 2009; US Congress' OTC Derivatives Market Act of 2009; US Department of Treasury, 2009; Duffie, Li, and Lubke, 2010; Cruz-Lopez et al., 2013; Cruz-Lopez et al., 2019; Cont, 2017; Wooldridge, 2017).
  - **Need for well-functioning clearing facilities**
    (e.g., Acworth, 2009; Pirrong, 2009; Duffie and Zhu, 2010; Benos et al., 2016; Cruz-Lopez et al., 2011 and 2017; Menkveld, 2017; Huang, et al., 2018).

- **Systemic importance of a CCP**
  - **Failure of a clearing house represents a major systemic shock**
    (e.g., Acharya, et al., 2009; Pirrong, 2011; Duffie, et al., 2010; Duffie, 2013a; Menkveld, 2013 and 2017; and Cruz-Lopez, 2019).

2. Derivatives CCPs and Risk Management

2.1. Initial Margin and Default Waterfalls

Typical CCP Waterfall

Risk Management

- Netting of Positions (Closing Defaulter's Positions)
- Defaulter's IM (and Additional Margins)
- Defaulter's DF

Recovery

- **CCP Capital (Skin in the Game)**
- **Non-Defaulters' DF**
- Contingent Resources
  (e.g., Additional DF contributions, Lines of Credit)
- Service Continuity
  (e.g., VM Haircuts or Loss Distribution)
- **Remaining CCP Capital**
- Voluntary Service Continuity

Resolution

- **Closure**

Principles for Financial Market Infrastructures

- The baseline to measure residual risk comes from the **PFMIs (CPSS-IOSCO, 2012):**
  - "An FMI should maintain sufficient financial resources to cover its **credit exposure to each participant fully with a high degree of confidence".**
  - "In addition, a CCP that is involved in activities with a more-complex risk profile or that is systemically important in multiple jurisdictions should maintain additional financial resources sufficient to cover a wide range of potential stress scenarios that should include, but not be limited to, **the default of the two participants and their affiliates that would potentially cause the largest aggregate credit exposure to the CCP** in extreme but plausible market conditions."
  - "All other CCPs should maintain additional financial resources sufficient to cover a wide range of potential stress scenarios that should include, but not be limited to, **the default of the participant and its affiliates that would potentially cause the largest aggregate credit exposure to the CCP** in extreme but plausible market conditions."

The SPAN System

- Introduced by the CME in 1988. It is currently used by more than 50 derivatives exchanges including the CME and CDCC.
- **Sixteen Scenarios** applied **on a firm by firm basis**.
- Divides the portfolio in **contract families** (i.e., groups of contracts that share the same underlying asset).
- Margin requirements for each contract family are set independently and differences in times to expiration are not taken into account at this point.
- The collateral estimate for the entire portfolio requires **aggregation rules set by the clearing house** (e.g., intra-commodity and inter-commodity spreads).

SPAN Scenarios

Scenario	Underlying Asset Price Change	Volatility Change	Time to Expiration
1	0	+ volatility range	$-1/252$
2	0	- volatility range	$-1/252$
3	$+1/3$ x price range	+ volatility range	$-1/252$
4	$+1/3$ x price range	- volatility range	$-1/252$
5	$-1/3$ x price range	+ volatility range	$-1/252$
6	$-1/3$ x price range	- volatility range	$-1/252$
7	$+2/3$ x price range	+ volatility range	$-1/252$
8	$+2/3$ x price range	- volatility range	$-1/252$
9	$-2/3$ x price range	+ volatility range	$-1/252$
10	$-2/3$ x price range	- volatility range	$-1/252$
11	$+3/3$ x price range	+ volatility range	$-1/252$
12	$+3/3$ x price range	- volatility range	$-1/252$
13	$-3/3$ x price range	+ volatility range	$-1/252$
14	$-3/3$ x price range	- volatility range	$-1/252$
15	Positive extreme change	0	$-1/252$
16	Negative extreme change	0	$-1/252$

Data Description

Item	Number	Comments
Clearing members	48	There is entry and exit in the sample, so the number of clearing members varies over time.
Trading Days	2066	The sample period is from 2 January 2003 to 31 March 2011.
Underlying Assets	3	The three underlying assets are: 1. Yield on the three-month Canadian bankers' acceptance. 2. Yield on the ten-year Government of Canada Bond Futures 3. Level of the S&P/TSX 60 Index
Three-Month Canadian Bankers' Acceptance Futures Contracts (BAX)	45	Delivery dates range from January 2003 to December 2013.
Ten-Year Government of Canada Bond Futures Contracts (CGB)	34	Delivery dates range from March 2003 to June 2011.
S&P/TSX 60 Index Standard Futures Contracts (SXF)	34	Delivery dates range from March 2003 to June 2011.
Total futures contracts	113	These represent all the futures contracts (i.e., all delivery dates) written on the three underlying assets during the sample period.
Active firm accounts	21	We report results only for this type of account.
Active client accounts	23	
Active omnibus accounts	16	

Note: The table presents an overview of the data set used in the empirical analysis, which was obtained from the Canadian Derivatives Clearing Corporation. An account is considered to be active on a given day if it has an open interest (i.e., long or short position at the end of the trading day) in at least one underlying asset.

Clearing Members

Number	Name	Number	Name
1	Newedge Canada Inc.	25	Morgan Stanley Canada LTD.
2	RBC Dominion Securities Inc.	26	CFG Financial Group Inc.
3	Union Securities LTD.	27	MF Global Canada Co.
4	T.D. Securities Inc.	28	Haywood Securities Inc.
5	BMO Nesbitt Burns LTD.	29	Goldman Sachs Canada Inc.
6	Macquarie Private Wealth Inc.	30	Timber Hill Canada Co.
7	UBS Securities Canada Inc.	31	Credit Suisse Securities
8	Desjardins Securities Inc.	32	CIBC World Markets Inc.
9	Macquarie Capital Markets Inc.	33	NBCN Clearing Services Inc.
10	Name not reported	34	HSBC Securities (Canada) Inc.
11	Merrill Lynch Canada Inc.	35	Mackie Research Capital Corporation
12	Odlum Brown LTD.	36	Benson-Quinn GMS Inc.
13	Penson Financial Services Inc.	37	Scotia Capital Inc.
14	Dundee securities corporation	38	E*trade Canada Securities Corporation
15	Daex Commodities Inc.	39	Raymond Kames LTD.
16	Canaccord Capital Corporation	40	Lévesque Beaubien Geoffrion Inc.
17	Friedberg Mercantile Group LTD.	41	TD Waterhouse Canada Inc.
18	W.D. Latimer Co. LTD.	42	Citigroup Global Markets Canada Inc.
19	Canadian Imperial Bank of Commerce (CIBC)	43	National Bank of Canada
20	Jones, Gable & Co. LTD.	44	J.P. Morgan Securities Canada Inc.
21	Name not reported	45	Merrill Lynch Canada Inc.
22	Timber Hill Canada Company	46	Name not reported
23	Laurentian Bank Securities Inc.	47	Fidelity Clearing Canada ULC
24	Deutsche Bank Securities LTD.	48	Maple Securities Canada LTD.

Notation

$\boldsymbol{D}$: Number of derivatives securities in the market.

$\boldsymbol{B_{i,t}}$: Collateral Requirement at the end of day *t*.

$\boldsymbol{V_{i,t}}$: Variation Margin (P&L) on day t.

$\boldsymbol{w_{i,t}}$: Vector of weights of CM i at the end of day t in the D derivatives securities.

$\boldsymbol{R_{i,t}}$: Relative Variation Margin

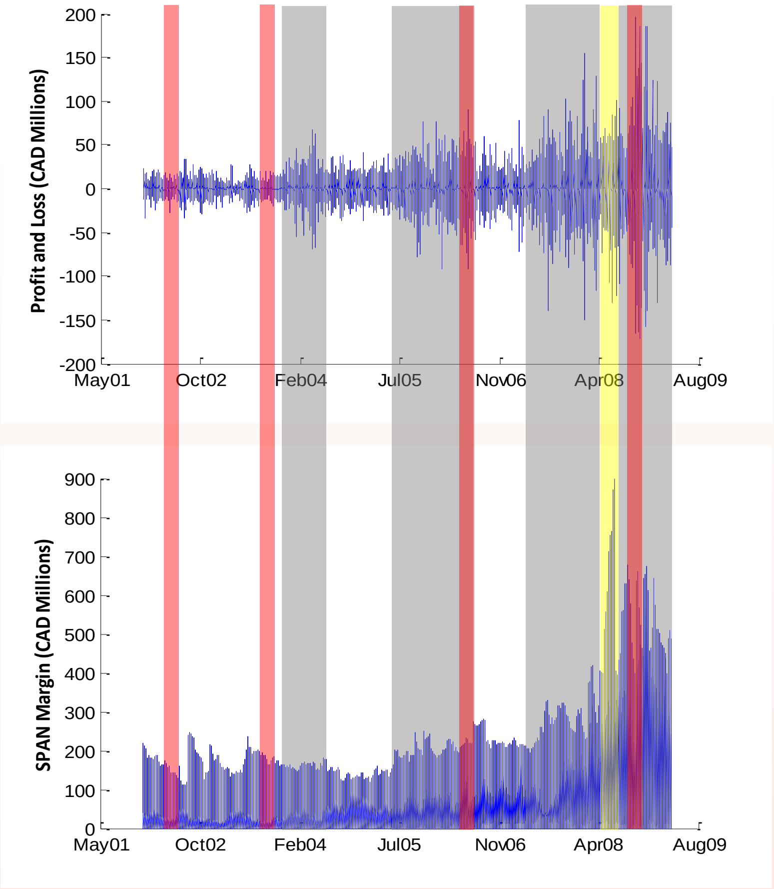
$$\boldsymbol{R_{i,t}} = \frac{\boldsymbol{V_{i,t}}}{\boldsymbol{B_{i,t-1}}}$$

Clearing firm i has a **margin exceedance** at time t if

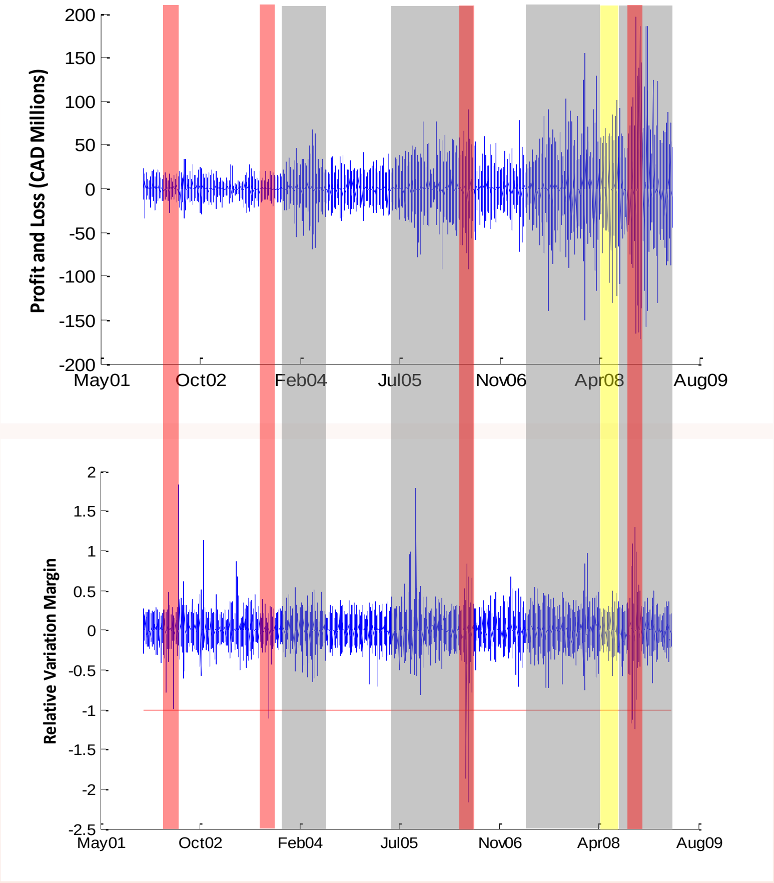
$$\boldsymbol{B_{i,t-1} + V_{i,t} < 0} \quad \text{or equivalently} \quad \boldsymbol{R_{i,t} < -1}$$

Margins at the CDCC from Jan 2002 to Apr 2009

IM is not always responsive to volatility

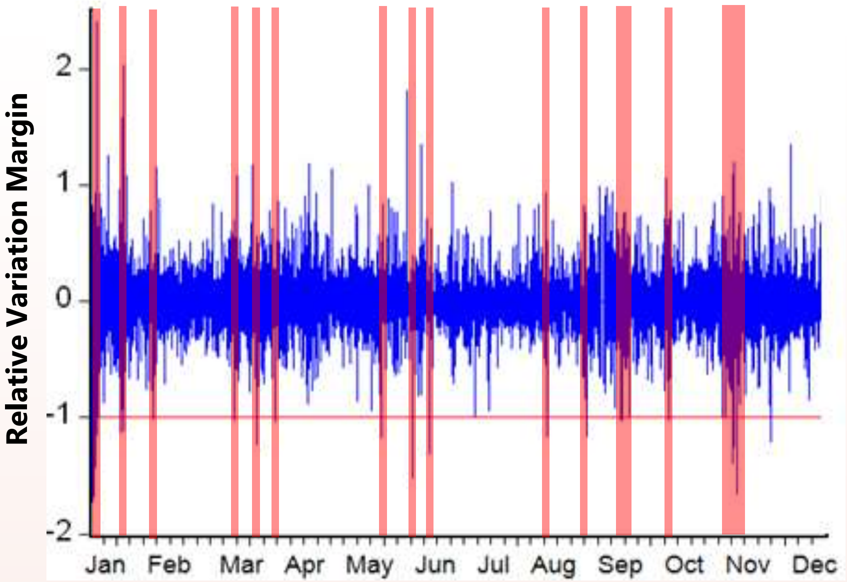


IM deficiencies tend to cluster particularly across large CM and during periods of high volatility

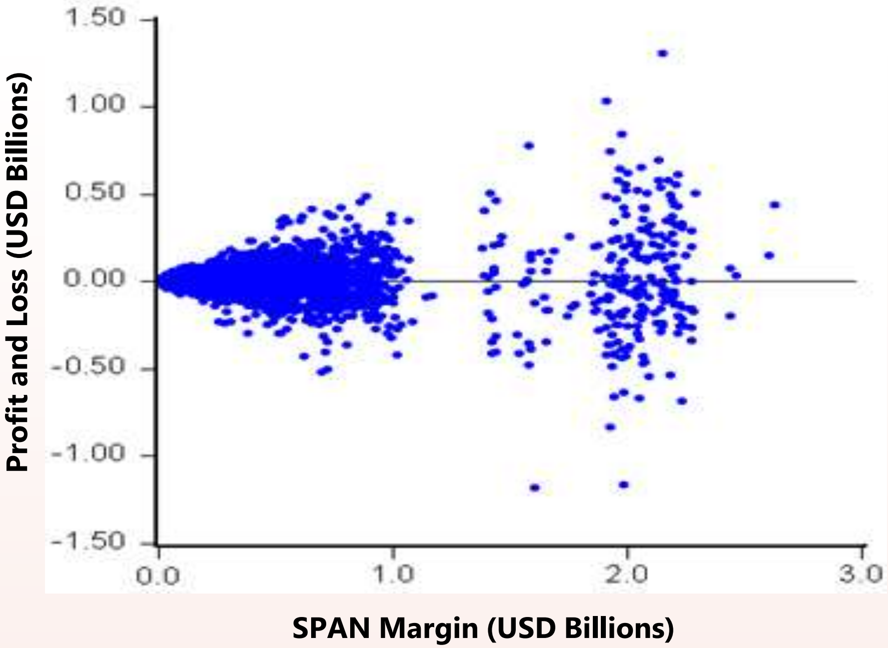


Margins at the CME from Jan 1st to Dec 31st, 2001

IM deficiencies tend to cluster: The ten most extreme relative variation margin losses that affected the ten largest clearing firms occurred on two different trading days.



The **top-10 largest clearing** account on average for approx. **80% of all collateral collected**



Perignon and Jones (2012): Derivatives Clearing, Default Risk, and Insurance

Risk Homogeneity

- **Trade crowdedness:**
  - Similar trading positions.
  - Influenced by individual trading behaviour.
  - Common information set (Jones and Pérignon, 2010).

- **Underlying asset comovement:**
  - Underlying assets returns moving in unison.
  - Determined by aggregate market behaviour.
  - Economic slowdowns and periods of high volatility.

2.2. Proposed Risk Management Methodologies

Literature Review

- **Extreme Dependence**
  - Previous papers focus on **stock or hedge fund returns** (Longin and Solnik, 2001; Ang and Chen, 2002; Poon, Rockinger, and Tawn, 2004; Patton, 2009; and Christoffersen et al., 2010).
  - In Cruz Lopez (WP 2019), I show that in the case of a CCP **asset comovement (correlations and tail dependence) is not as important as trade crowdedness.**

- **Systemic Risk**
  - Adrian and Brunnermeier (2016) introduce ***CoVaR:*** The marginal contribution of a particular institution to the overall systemic risk.
  - Acharya et al. (2016) and Brownlees and Engle (2010) focus on the ***Marginal Expected Shortfall:*** The expected loss of a particular firm conditional on the overall banking sector being in distress.
  - **In Cruz Lopez et al. (2017) and in Cruz Lopez (2019) we measure the negative externalities imposed by market participants. Specifically, we focus on the default waterfall and the risks imposed by interrelated positions on the CCP.**

Literature Review

- **Collateral and CCPs**
  - **Duffie and Zhu (2011)** – Does a central clearing counterparty reduce counterparty risk?
  - Cruz Lopez, Harris and Perignon (2011) - Clearing House, Margin Requirements, and Systemic Risk.
  - Biais, Heider and Hoerova (2012) - Risk-Sharing or Risk-Taking? Counterparty Risk, Incentives and Margins.
  - Canabarro and Duffie (2012) - Measuring and marking counterparty risk.
  - Menkveld (2014) - Crowded Trades: An Overlooked Systemic Risk for Central Clearing Counterparties.
  - Gatarek and Jablecki (2014) - Estimating the risk of joint defaults: An application to central bank collateralized lending operations.
  - Ghamami and Glasserman (2016) - Assess the cost incentives (capital and IM) of clearing OTCD trades.
  - Duffie, Scheicher and Vuillemey (2015) – Central Clearing and Collateral Demand.
  - Vuillemey and Bignon (2016) - The Failure of a Clearinghouse: Empirical Evidence
  - **Menkveld (2017)** – Crowded Positions: An Overlooked Systemic Risk for Central Clearing Parties
  - **Huang, Faruqui and Shirakami (2018)** – Central Counterparty Resolution: The Right Move at the Right Time

Author's Research Pipeline

- **Collateral Markets: Is there enough collateral for central clearing?**
  - The Market for Collateral: The Potential Impact of Financial Regulation (Cruz Lopez, Mendes and Vikstedt, FSR 2013)
  - Mind the Gap: Undercollateralization in the Global and Canadian OTCD Markets (Ch. 15 in *Analyzing the Economics of Financial Market Infrastructures*, 2015)

- **Is there a strong case for clearing OTC derivatives?**
  - Clearing House, Margin Requirements, and Systemic Risk (Cruz Lopez, Harris and Perignon, RFM 2011)
  - Who Pays? Who Gains? CCP Resource Provision in the post-Pittsburgh world (Cruz Lopez, Cerezetti, Manning and Murphy, JFMI 2019)

- **Risk management tools for CCPs**
  - Clearing House, Margin Requirements, and Systemic Risk (Cruz Lopez, Harris and Perignon, RFM 2011)
  - Foreign Reserves and Tail Risks (Cruz Lopez and Rivadeneyra, WP 2017) - We needed to find a good data substitute to work on haircuts!
  - CoMargin (joint with Harris, Hurlin and Perignon, JFQA 2017)
  - Residual Risk and Default Waterfalls in CCPs (WP 2019)
  - Identification of Systemically Important Clearing Members (Cruz Lopez and Smith, ongoing)
  - Margin Requirements and Asset Prices (Cruz Lopez, ongoing)

3. Residual Risk

Based on "Residual Risk and Default Waterfalls in Central Counterparties" (Cruz Lopez, WP 2019).

3.1. Objective and Contributions

Objective

To develop methodology that quantifies the **amount and sources of *residual risk exposures* in CCPs** relative to the coverage suggested in the PFMI (CPSS-IOSCO, 2012).

Questions Addressed in this Paper

- **What are the risk exposures of a CCP to its clearing members (CMs)?**
  - **Net potential future exposures (PFEs):** The risk exposures over a coverage period after taking into account IM and IM+DF

- **What are the sources of risk exposures?**
  - **Trading decisions** that give rise to **crowded trades**
  - **Market conditions** driven by **asset comovement** (**correlations** and **fat tails**.

- **What is the implicit dollar subsidy (or guarantee) granted by a "lender of last resort"?**

Contributions

- **Systemic risk measurement**
  - Residual risk exposures can be used to measure the **risk contribution of CCPs** to the financial system.
- **Risk decomposition**
  - **Trade crowded trades** (actual positions/bets in portfolios).
  - **Underlying asset co-movement** (volatility, correlations and fat tails).
- **Policy assessment**
  - Residual risk exposures could be used to measure the **effectiveness of central clearing regulations.**
  - When mapped in dollar space they could be interpreted as implicit collateral subsidies provided by a **"lender of last resort"**.

3.2. Residual Risk: Estimation and Decomposition

Residual Risk: Concept

- The risk manager sets up an IM system with a ***target coverage level*** α for any individual clearing member.

- If markets were ***fully orthogonal*** (i.e., orthogonal positions and orthogonal underlying asset returns), then $\boldsymbol{\alpha}$ would also determine the joint and conditional coverage level:

$$\Pr\left(V_{i,t+1} \leq -B_{i,t} | \mathbf{C}(V_{j \neq i \in N, t+1})\right) = \alpha$$

$$\Pr\left[\left(V_{i,t+1} \leq -B_{i,t}\right) \cap \mathbf{C}(V_{j \neq i \in N, t+1})\right] = \alpha^{n}$$

Residual Risk: Concept

- However, markets are not *fully orthogonal, and* the ***actual coverage level*** is given by:

$$b_{i,t} = \Pr\left(V_{i,t+1} \leq -B_{i,t} | \mathbf{C}\left(V_{j\neq i\in N,t+1}\right)\right) \tag{7}$$

- Deviations of $b_{i,t}$ from α determine the ***residual credit risk exposure*** accumulated passed to the next stage of the default waterfall in a CCP:

$$\boldsymbol{R_{i,t} = b_{i,t} - \alpha} \tag{8}$$

- We can repeat this exercise for each stage of the default waterfall and obtain the ***residual risk*** that is not collateralized by the CCP.

Residual Risk: Implicit Subsidy

- Since every quantile represents a dollar value, **we can map every residual risk exposure in dollar space.**

- Once again, let asset returns be normally distributed. Then,

$$\Pr\left(V_{i,t+1} \leq -Q_{i,t} | \mathbf{C}\left(V_{j\neq i\in N,t+1}\right)\right) = \alpha \tag{19}$$

$$\boldsymbol{Y_{i,t} = Q_{i,t} - B_{i,t}} \tag{20}$$

- In other words, $Y_{i,t}$ is the ***dollar exposure*** that is not collateralized by the CCP.

Residual Risk: Estimation

$$b_{i,t} = Pr\left(V_{i,t+1} \leq -B_{i,t} | C\left(V_{j \neq i \in N, t+1}\right)\right)$$

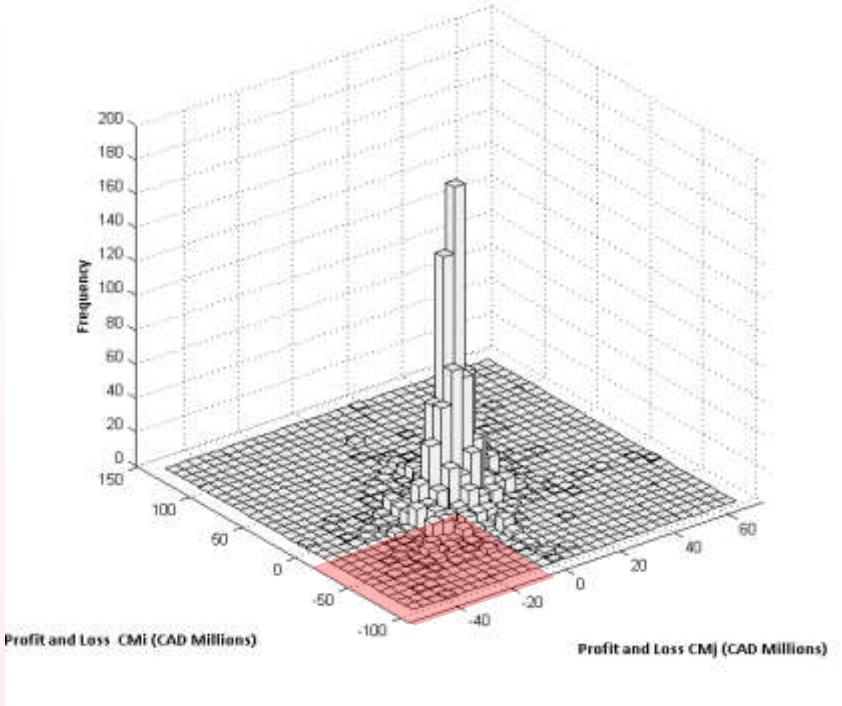
1. Start by taking the trading positions of ***all CMs*** at the end of the trading day.

2. **Using a copula,** consider a series of one-day-ahead scenarios based on the ***joint changes*** in the price of the underlying assets.

3. For each scenario, we mark-to-model the portfolio of all CMs and obtain their hypothetical P&L.

4. Based on these hypothetical P&Ls we **compute the conditional probabilities of margin exceedance.**

Joint P&L Distribution of two representative CMs



Residual Risk: Scenario Generation

1. **Estimation Window:** For each day, t, use a rolling estimation window constructed with the historical returns of the underlying assets (in this paper BAX, CGB, SXF).

2. **Underlying Asset Comovement:** Fit a copula to the estimation window vectors using the Canonical Maximum Likelihood (CML) method:
   - Standardize/filter the data.
   - Use empirical CDF to convert the data to values in the unit cube.
   - Estimate copula parameters using MLE.

3. **Scenarios:** Simulate S scenarios from the estimated copula.

4. **Trade Crowdedness:** Instead of considering each CM in isolation, keep track of the P&Ls of all CMs for each scenario.
   - Obtain a SxN matrix with the joint hypothetical P&Ls for the entire market.

5. **Conditioning Set:** Select the n CMs with the largest ES using VaR(α) as a threshold.
   - Alternatively, use the methodology in Cruz Lopez and Smith (2016): The firms that trigger the largest ES for the CCP (work in progress).

Note: This method is also used in (Cruz Lopez, et al. 2017)

Residual Risk: Decomposition

- Consider two CMs, i and j. Let $\mathbf{C}\left(V_{j \neq i \in N, t+1}\right) = V_{j,t+1} \leq -VaR_{j,t}$ and asset returns be normally distributed, then

$$R_{i,t}^{N(\Sigma)} = b_{i,t}^{N(\Sigma)} - \alpha \tag{9}$$

- The covariance of the portfolio holdings of the two CMs is given by

$$\boldsymbol{\sigma}_{ij,t} = \boldsymbol{w}_{i,t}' \boldsymbol{\Sigma}_t \boldsymbol{w}_{j,t} \tag{10}$$

- Thus, there are two sources of **loss dependence**:
  - **Trade Crowdedness** (from $\boldsymbol{w}_{i,t}$ and $\boldsymbol{w}_{j,t}$)
  - **Asset Correlations** (from $\boldsymbol{\Sigma}_t$)

Residual Risk: Decomposition

- It must be that $r_{i,t}^{TC} = R_{i,t}^{N(\Sigma)}$ when $\Sigma_t = I$,

$$\boldsymbol{r_{i,t}^{TC} \equiv R_{i,t}^{N(I)} = b_{i,t}^{N(I)} - \alpha} \qquad \textbf{(11)}$$

- And as a consequence,

$$r_{i,t}^{Corr} = R_{i,t}^{N(\Sigma)} - R_{i,t}^{N(\mathrm{I})} \qquad (12)$$

$$\boldsymbol{r_{i,t}^{Corr} = b_{i,t}^{N(\Sigma)} - b_{i,t}^{N(I)}} \qquad \textbf{(13)}$$

- Rearranging,

$$\boldsymbol{R_{i,t}^{N(\Sigma)} = r_{i,t}^{TC} + r_{i,t}^{Corr}} \qquad \textbf{(14)}$$

Residual Risk: Decomposition

- Now, let asset returns follow a *Student t* distribution (i.e., returns have fat tails):

$$R_{i,t}^{T(\Sigma,\upsilon)} = b_{i,t}^{T(\Sigma,\upsilon)} - \alpha \qquad (15)$$

- In this case

$$r_{i,t}^{Tail} = R_{i,t}^{T(\Sigma,\upsilon)} - r_{i,t}^{TC} - r_{i,t}^{Corr}$$

$$= \left(b_{i,t}^{T(\Sigma,\upsilon)} - \alpha\right) - \left(b_{i,t}^{N(\mathrm{I})} - \alpha\right) - \left(b_{i,t}^{N(\Sigma)} - b_{i,t}^{N(\mathrm{I})}\right) \qquad (16)$$

$$\boldsymbol{r_{i,t}^{Tail} = b_{i,t}^{T(\Sigma,\upsilon)} - b_{i,t}^{N(\Sigma)}} \qquad \textbf{(17)}$$

- And

$$\boldsymbol{R_{i,t}^{T(\Sigma,\upsilon)} = r_{i,t}^{TC} + r_{i,t}^{Corr} + r_{i,t}^{Tail}} \qquad \textbf{(18)}$$

Residual Risk: Implicit Subsidy

- It must be that $y_{i,t}^{TC} = Y_{i,t}^{N(\Sigma)}$ when $\Sigma_t = I$,

$$\boldsymbol{y_{i,t}^{TC} \equiv Y_{i,t}^{N(I)}} \qquad \textbf{(21)}$$

- And as a consequence,

$$y_{i,t}^{Corr} = Y_{i,t}^{N(\Sigma)} - Y_{i,t}^{N(\mathrm{I})} \qquad (22)$$

$$\boldsymbol{y_{i,t}^{Corr} = Q_{i,t}^{N(\Sigma)} - Q_{i,t}^{N(I)}} \qquad \textbf{(23)}$$

- Rearranging,

$$\boldsymbol{Y_{i,t}^{N(\Sigma)} = y_{i,t}^{TC} + y_{i,t}^{Corr}} \qquad \textbf{(24)}$$

Residual Risk: Implicit Subsidy

- Introducing fat tails with *Student t* distributed asset returns:

$$Y_{i,t}^{T(\Sigma,\upsilon)} = Q_{i,t}^{T(\Sigma,\upsilon)} - B_{i,t} \quad (25)$$

- In this case

$$y_{i,t}^{Tail} = Y_{i,t}^{T(\Sigma,\upsilon)} - y_{i,t}^{TC} - y_{i,t}^{Corr}$$
$$= Y_{i,t}^{T(\Sigma,\upsilon)} - Y_{i,t}^{N(\mathrm{I})} - \left(Y_{i,t}^{N(\Sigma)} - Y_{i,t}^{N(\mathrm{I})}\right) \quad (26)$$

$$y_{i,t}^{Tail} = Y_{i,t}^{T(\Sigma,\upsilon)} - Y_{i,t}^{N(\Sigma)} \quad (27)$$

$$\boldsymbol{y_{i,t}^{Tail} = Q_{i,t}^{T(\Sigma,\upsilon)} - Q_{i,t}^{N(\Sigma)}} \quad \textbf{(28)}$$

$$\boldsymbol{Y_{i,t}^{T(\Sigma,\upsilon)} = y_{i,t}^{TC} + y_{i,t}^{Corr} + y_{i,t}^{Tail}} \quad \textbf{(29)}$$

4. CoMargin

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4.1. Objective and Contributions

Objective

To propose a **new collateral system** that enhances the ***stability*** and ***resiliency*** of central counterparties (CCPs) by accounting for the **interdependence of market participants**.

Characteristics of Sound Initial Margins

1. Increase with P&L variability.
2. Increase with risk homogeneity/similarity (i.e., loss dependence).
3. Not be subject to abrupt changes.
4. Be robust to outliers.
5. Be testable ex-post.

VaR Margin: Estimation

The VaR margin, B_i, corresponds to the $\alpha\%$ quantile of the P&L distribution:

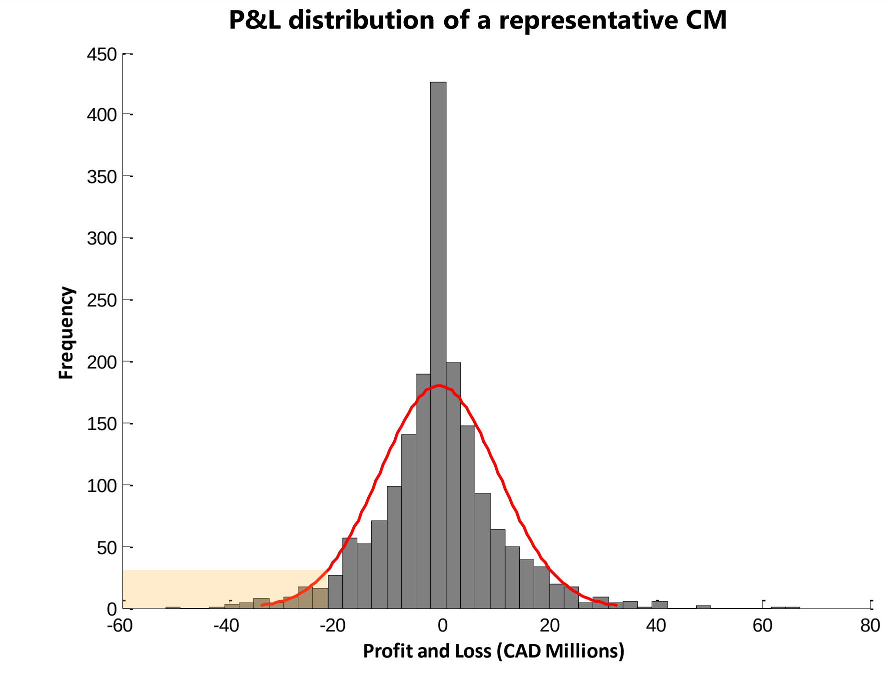
$$\boldsymbol{Pr}\left(\boldsymbol{V}_{\mathbf{i,t+1}} \leq -\boldsymbol{B}_{\mathbf{i},t}\right) = \boldsymbol{\alpha}$$

1. Start by taking the trading positions of *each CM individually* at the end of the trading day.

2. Consider a series of S one-day-ahead scenarios based on the changes in the price and volatility of the underlying assets.

3. For each scenario, mark-to-model the entire portfolio of each CM and compute its *hypothetical P&L* to obtain $\left\{v_{i,t+1}^{s}\right\}_{s=1}^{S}$.

4. Based on these hypothetical P&Ls compute the margin requirement that achieves a target probability of ***individual financial distress.***



CoMargin: Estimation

The CoMargin, $B^{i|j}$, corresponds to the α% conditional quantile of the joint P&L distribution:

$$\boldsymbol{Pr}\left(\boldsymbol{V}_{\mathbf{i,t+1}} \leq -\boldsymbol{B}_{\boldsymbol{t}}^{\mathbf{i}|\boldsymbol{j}} | \boldsymbol{V}_{\mathbf{j,t+1}} \leq -\boldsymbol{B}_{\mathbf{j},\boldsymbol{t}}\right) = \boldsymbol{\alpha}$$

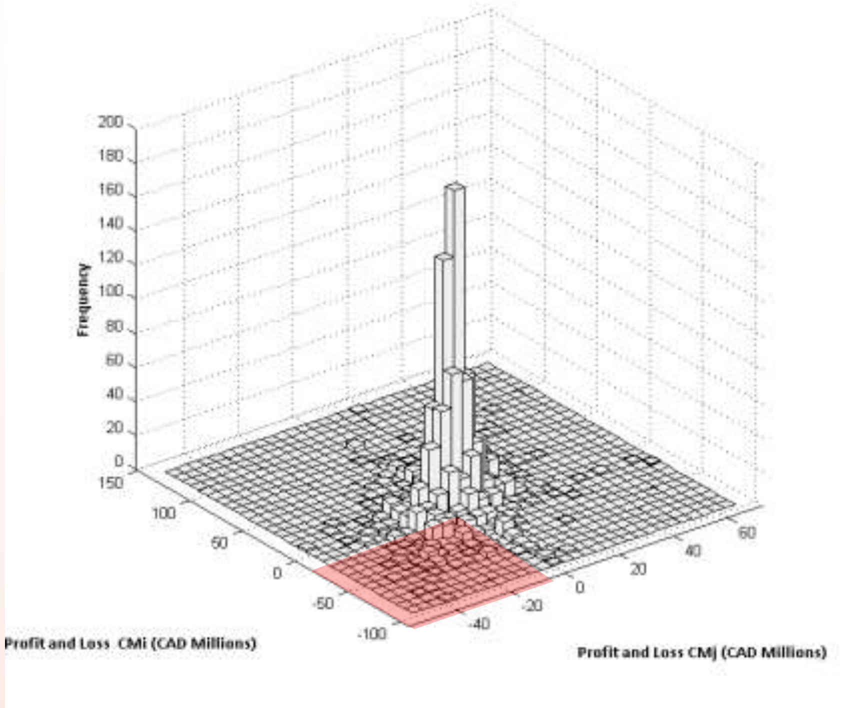
1. Start by taking the trading positions of *each CM individually* at the end of the trading day.

2. Consider a series of S one-day-ahead scenarios based on the changes in the price and volatility of the underlying assets.

3. For each scenario, mark-to-model the entire portfolio of each CM and compute its *hypothetical P&L* to obtain $\{v_{i,t+1}^{s}\}_{s=1}^{S}$.

4. Based on these hypothetical P&Ls we compute margin requirements that target the probability of ***joint financial distress.***

Joint P&L Distribution of two representative CMs



CoMargin: Estimation

- From the S scenarios, we obtain S pairs of simulated P&L for both firms, $\{v_{i,t+1}^{s}, v_{j,t+1}^{s}\}_{s=1}^{S}$.

- Conditional on $B_t^{i|j}$, a simple estimate of the joint probability $\Pr\left[\left(V_{i,t+1} \leq -B_t^{i|j}\right) \cap \left(V_{j,t+1} \leq -B_{j,t}\right)\right]$, denoted $P_t^{i,j}$, is given by:

$$\hat{P}_t^{i,j} = \frac{1}{S}\sum_{s=1}^{S} \mathbf{I}\left(v_{i,t+1}^{s} \leq -B_t^{i|j}\right) \times \mathbf{I}\left(v_{j,t+1}^{s} \leq -B_{j,t}\right)$$

- where $v_{i,t+1}^{s}$ (respectively $v_{j,t+1}^{s}$) corresponds to the s^{th} simulated P&L for the i^{th} member (respectively the j^{th} member).

CoMargin: Estimation

- For each time t and for each firm j, we look for the value $B_t^{i|j}$, such that the distance $\hat{P}_t^{i,j} - \alpha^2$ is minimized:

$$\hat{B}_t^{i|j} = \arg\min_{\left\{B_t^{i|j}\right\}} \left(\hat{P}_t^{i,j} - \alpha^2\right)^2$$

- For each firm, we end up with a time series of CoMargin requirements $\left\{\hat{B}_t^{i|j}\right\}_{t=1}^{T}$ for which confidence bounds can be bootstrapped.

CoMargin: Backtesting

- We can test the conditional probability of financial distress, defined by the CoMargin $B_t^{i|j}$ of firm i.

$$H_0\colon \Pr\left(V_{i,t+1} \leq -B_t^{i|j} | V_{j,t+1} \leq -B_{j,t}\right) = \alpha$$

- Since the null implies that $E\left[\mathbf{I}\left(V_{i,t+1} \leq -B_t^{i|j}\right) \times \mathbf{I}\left(V_{j,t+1} \leq -B_{j,t}\right)\right] = \alpha^2$, then a simple LR test can also be used to assess the conditional probability of financial distress by using the historical paths of P&L for both members i and j, (i.e., $\{v_{i,t+1}\}_{t=1}^{T}$ and $\{v_{j,t+1}\}_{t=1}^{T}$).

CoMargin: Backtesting

- The corresponding LR test statistic, denoted $LR_{i|j}$ takes the same form as LR_i:

$$LR_{i|j} = -2\ln\left[(1-\alpha)^{T-N_{i|j}}\alpha^{N_{i|j}}\right] + 2\ln\left[\left(1-\frac{N_{i|j}}{T}\right)^{T-N_{i|j}}\frac{N_{i|j}}{T}^{N_{i|j}}\right]$$

- Where $N_{i|j}$ denotes the total number of joint past violations observed for both members i and j; that is,

$$N_{i|j} = \sum_{t=1}^{T} \mathbf{I}\left(v_{i,t+1} \leq -B_t^{i|j}\right) \times \mathbf{I}\left(v_{j,t+1} \leq -B_{j,t}\right).$$

CoMargin: Attractive Features

Properties	SPAN Margin	VaR Margin	CoMargin
Reflects P&L variability	Yes	Yes	Yes
Reflects P&L dependence across participants	No	No	Yes
Robust to outliers	No	Yes	Yes
Can be backtested	No	Yes	Yes

CoMargin: Attractive Features

- **Risk identification and separation**
  - Takes into account both the **tail risk** of a given market participant and its **interdependence** with other participants.

- **General and practical**
  - Can be **easily estimated, backtested and generalized** to any number of market participants and **non-linear derivatives.**
  - Allows for **clear segregation** of **IM and DF** and of **firm and customer accounts**.
  - Ideal for derivatives CCPs, but **can be applied to many contexts where counterparty risk needs to be managed** (e.g., OTC derivatives, repos, bank capital, etc.)

CoMargin: Attractive Features

- Let $(V_1, V_2)' \sim N(0, \Sigma)$ where $\Sigma = \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix}$.

- In this setting, the CoMargins for both members, denoted $(B^{1|2}, B^{2|1})$, are defined by $\Pr\left(V_i \leq B^{i|j} | V_j \leq -B_j\right) = \alpha$.

- The CoMargin for the firm i is the solution to (Horace, 2005):

$$\int_{-\infty}^{-B^{i|j}} g(u; \sigma_i, \sigma_j, \rho) du = \alpha$$

$$g\left(u; \sigma_i, \sigma_j, \rho\right) = \frac{1}{\alpha\sigma_i} \times \phi(\frac{u}{\sigma_i}) \times \Phi(\frac{-B_j/\sigma_j - \rho u/\sigma_i}{\sqrt{1-\rho^2}})$$

CoMargin: Attractive Features

The CoMargin of member *i*:

- increases with the variability of its own P&L, but not with the variability of the P&L of other members.

$$\frac{\partial B^{i|j}}{\partial \sigma_i} > 0 \text{ and } \frac{\partial\, B^{i|j}}{\partial \sigma_j} = 0$$

- converges to VaR Margin when there is no risk homogeneity.

$$B^{i|j} = B_i \text{ when } \rho = 0$$

- increases with risk homogeneity.

$$\frac{\partial B^{i|j}}{\partial \rho} > 0 \text{ and } \lim_{\rho \to 1} B^{i|j} = B_i\,(\alpha^2)$$

4.2. CoMargin: Theoretical Performance

Assumptions

- Four clearing members ($N = 4$).
- Their P&Ls are jointly normally, such that

$$V \sim N(0, \Sigma),\ V = (V_1, V_2, V_3, V_4)' \text{ and } \Sigma = \begin{pmatrix} 1 & \boldsymbol{\rho} & 0 & 0 \\ \boldsymbol{\rho} & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

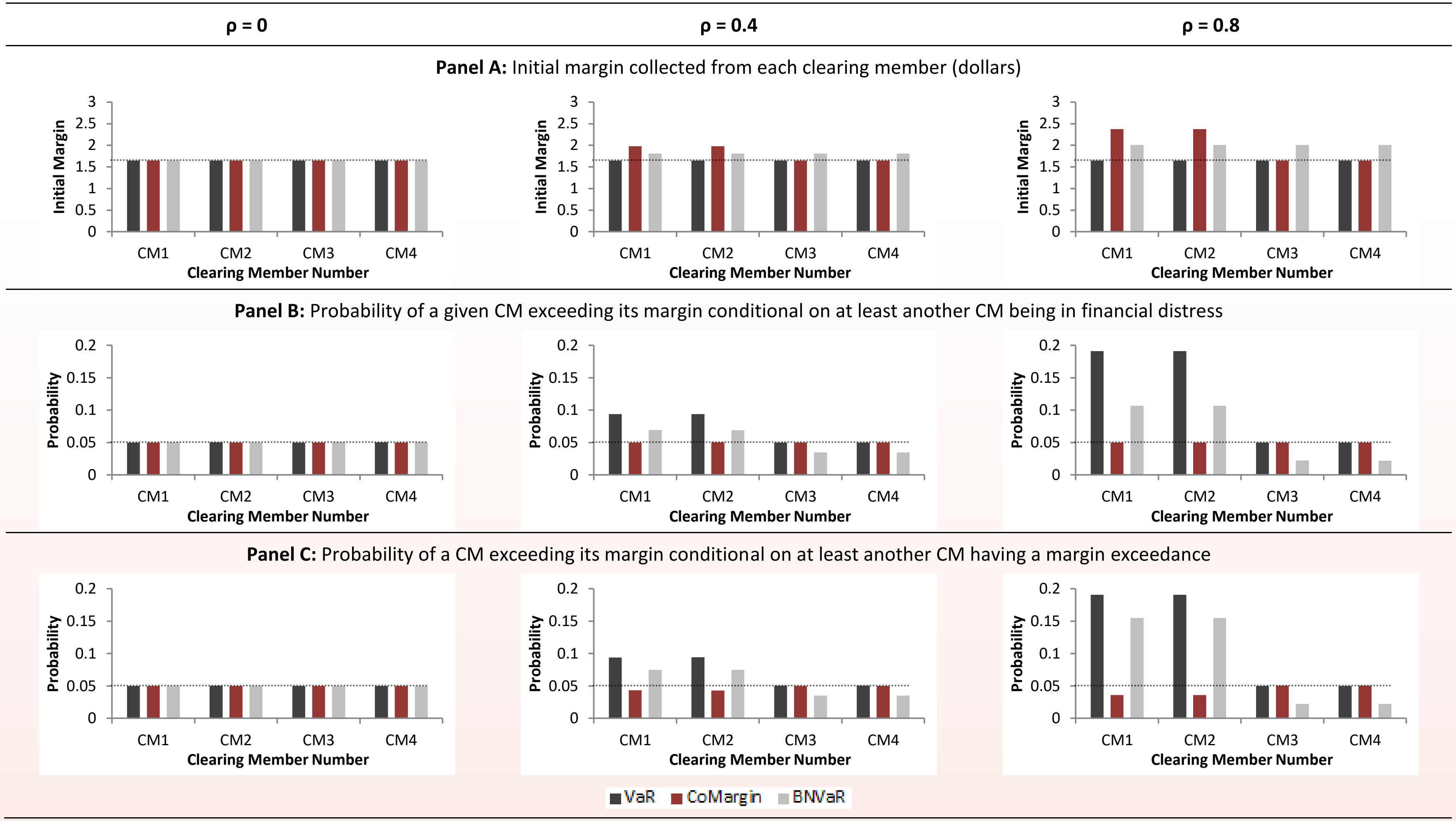
- We consider different levels of the correlation parameter, ρ, that range from 0 to 0.8

NOTE: In the paper **we also let the P&Ls to be Student t distributed** with degrees of freedom υ, $V \sim t_{\upsilon}(0, \Sigma)$. The variance-covariance structure, Σ, is the same as that considered under the normal distribution assumption, but in this case we set ρ=0.4 and let the degrees of freedom decrease from 30 to 5 to account for "fat-tails".

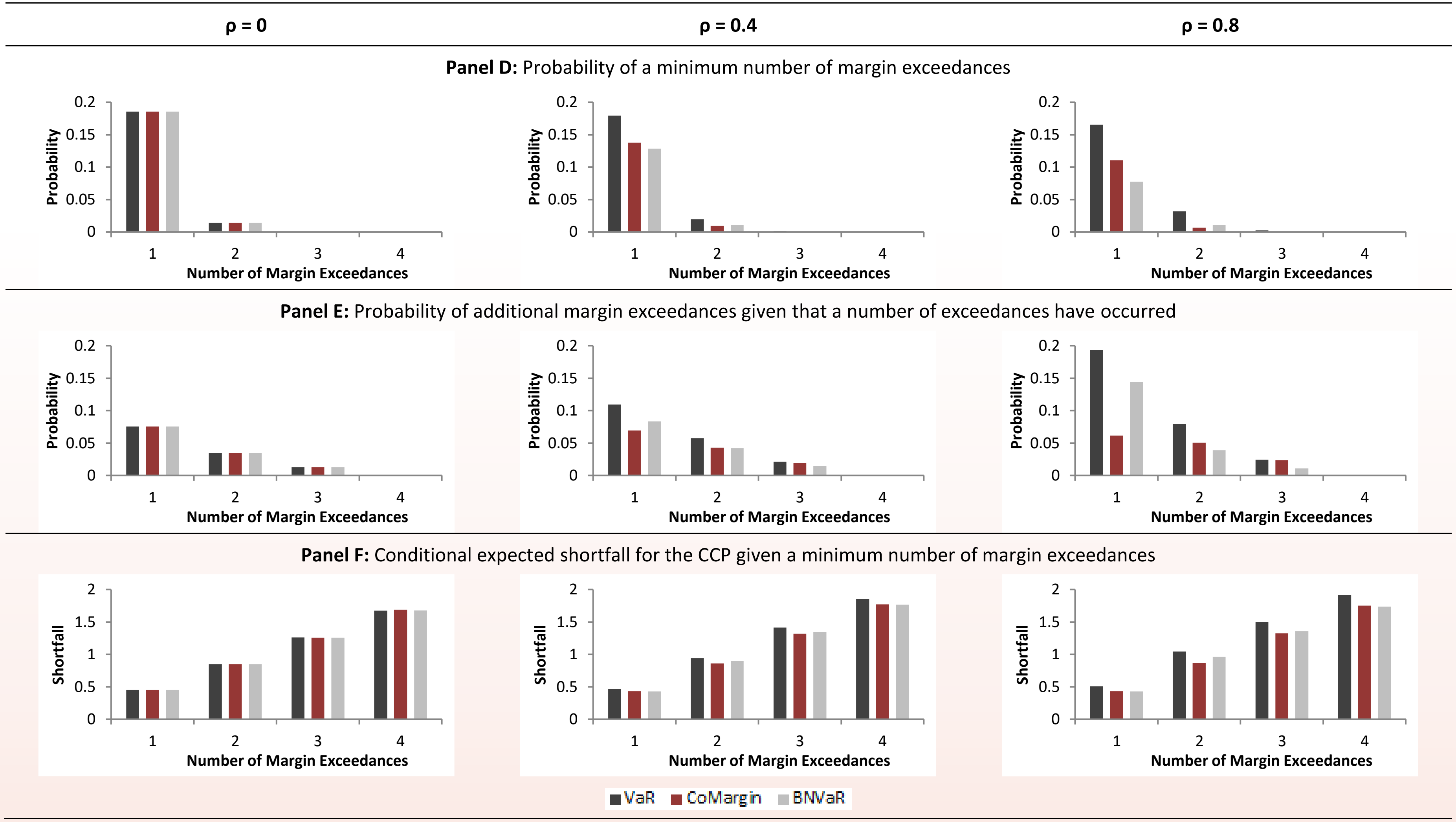
Theoretical Performance

	Jointly Normally Distributed P&Ls				Jointly Student t Distributed P&Ls			
	Unconditional		Conditional on One Exceedance		Unconditional		Conditional on One Exceedance	
	Prob. of at least one Exceedance	Aggregate Shortfall	Prob. of Additional Exceedance	Aggregate Shortfall	Prob. of at least one Exceedance	Aggregate Shortfall	Prob. of Additional Exceedances	Aggregate Shortfall
	$\rho = 0$				$\upsilon = 30, \rho = 0.4$			
VaR	0.185	0.083	0.076	0.451	0.177	0.094	0.123	0.531
CoMargin	0.185	0.083	0.076	0.451	0.115	0.056	0.074	0.485
BNVaR	0.185	0.084	0.076	0.451	0.185	0.098	0.110	0.530
Margin(A)	0.569	0.417	0.290	0.733	0.517	0.404	0.301	0.781
BNA	0.569	0.417	0.290	0.733	0.518	0.404	0.300	0.781
	$\rho = 0.4$				$\upsilon = 10, \rho = 0.4$			
VaR	0.179	0.084	0.109	0.466	0.171	0.119	0.151	0.695
CoMargin	0.138	0.060	0.069	0.433	0.081	0.053	0.091	0.650
BNVaR	0.188	0.088	0.096	0.468	0.178	0.123	0.138	0.689
Margin(A)	0.530	0.392	0.302	0.739	0.487	0.430	0.298	0.884
BNA	0.531	0.392	0.301	0.739	0.487	0.431	0.297	0.883
	$\rho = 0.8$				$\upsilon = 5, \rho = 0.4$			
VaR	0.165	0.083	0.193	0.505	0.164	0.175	0.191	1.067
CoMargin	0.111	0.048	0.062	0.431	0.052	0.060	0.129	1.170
BNVaR	0.203	0.101	0.119	0.500	0.169	0.178	0.179	1.053
Margin(A)	0.491	0.370	0.315	0.753	0.430	0.475	0.292	1.104
BNA	0.495	0.373	0.311	0.753	0.430	0.475	0.292	1.104

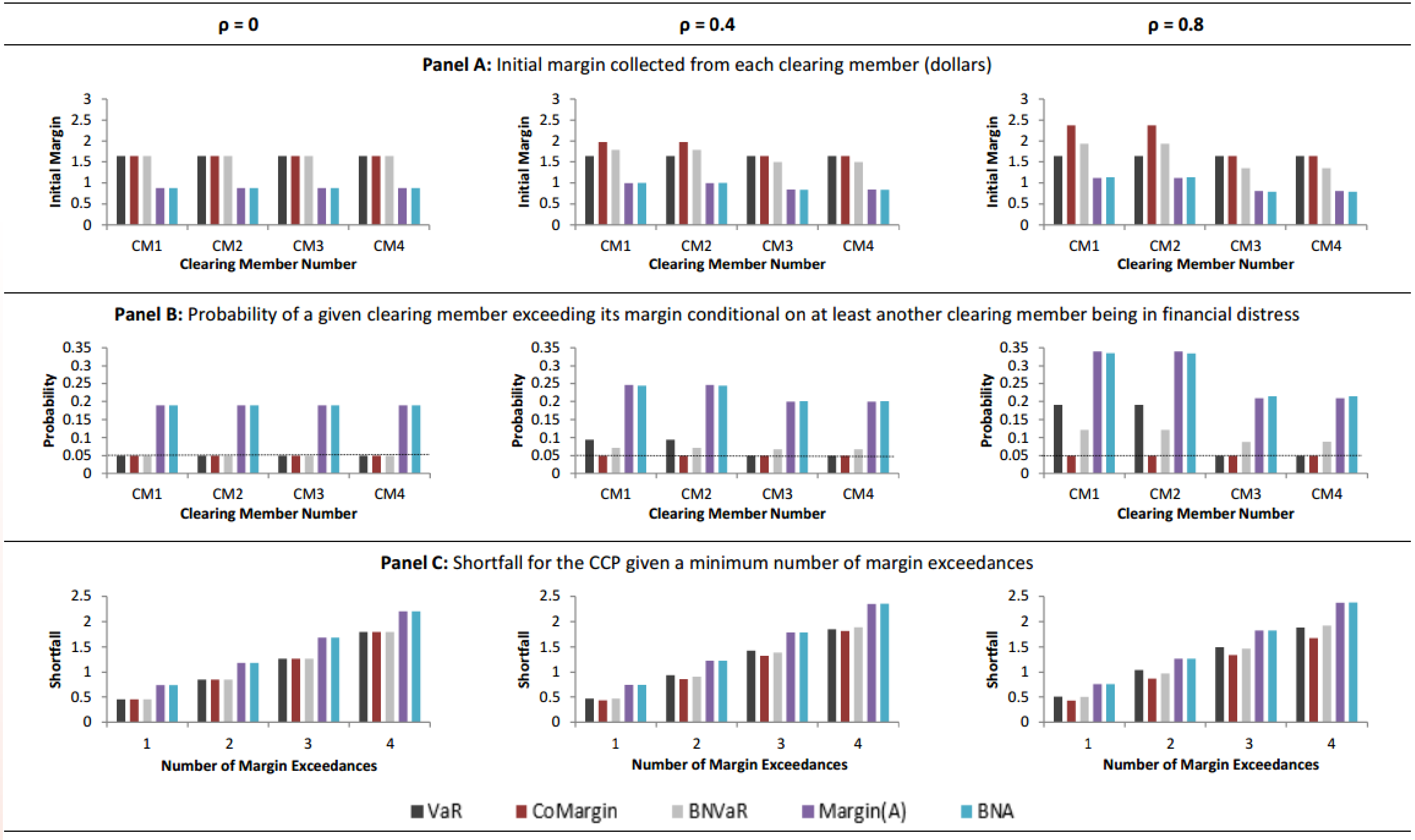
Theoretical Performance (Normal P&L)



Theoretical Performance (Normal P&L)



Theoretical Performance (Normal P&L and Matching α)



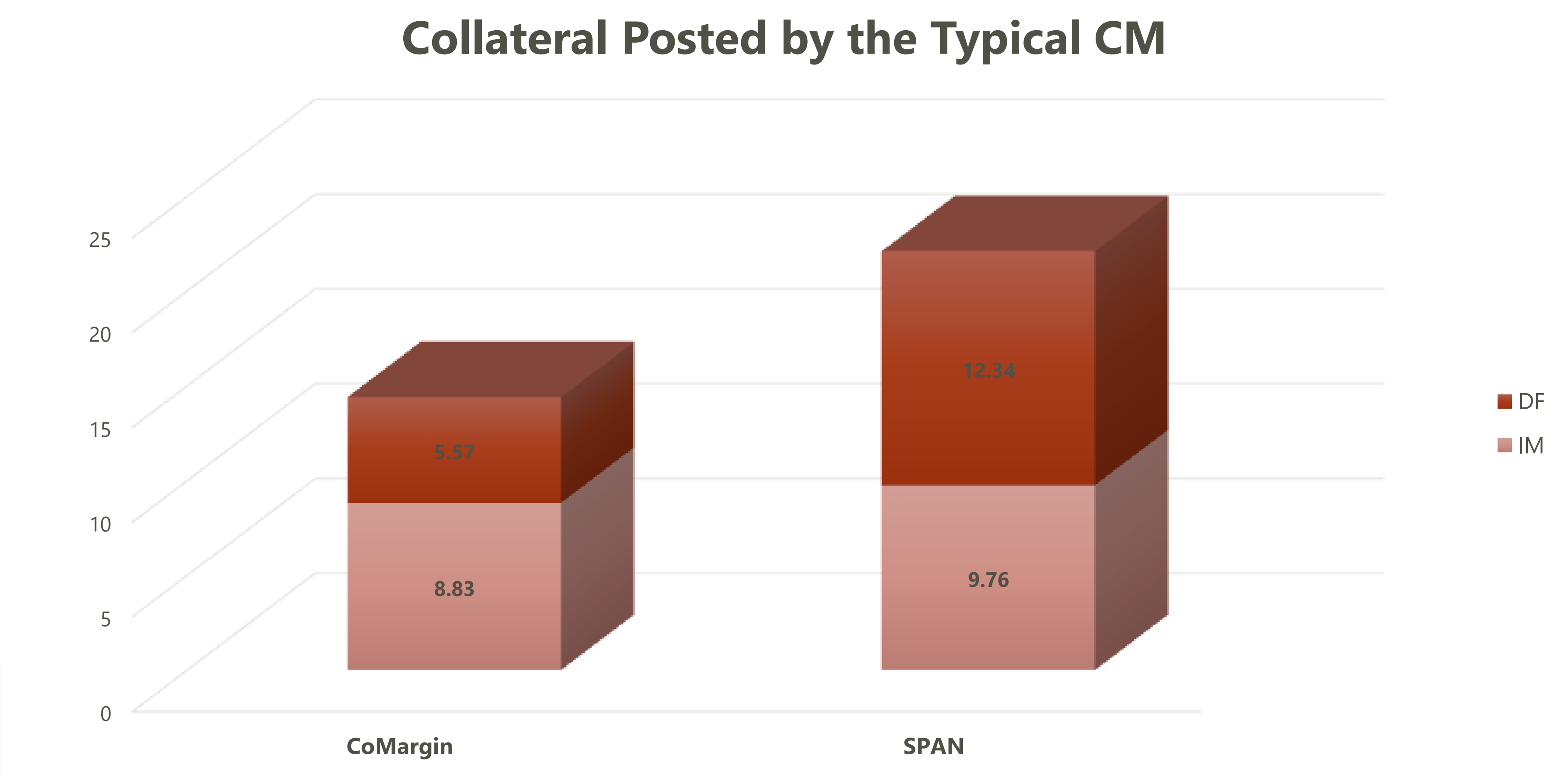
Theoretical Performance: Summary

- **Protects the CCP**
  - **No risk accumulation for the CCP**: When risk homogeneity increases, CoMargin maintains stable probabilities of financial distress.

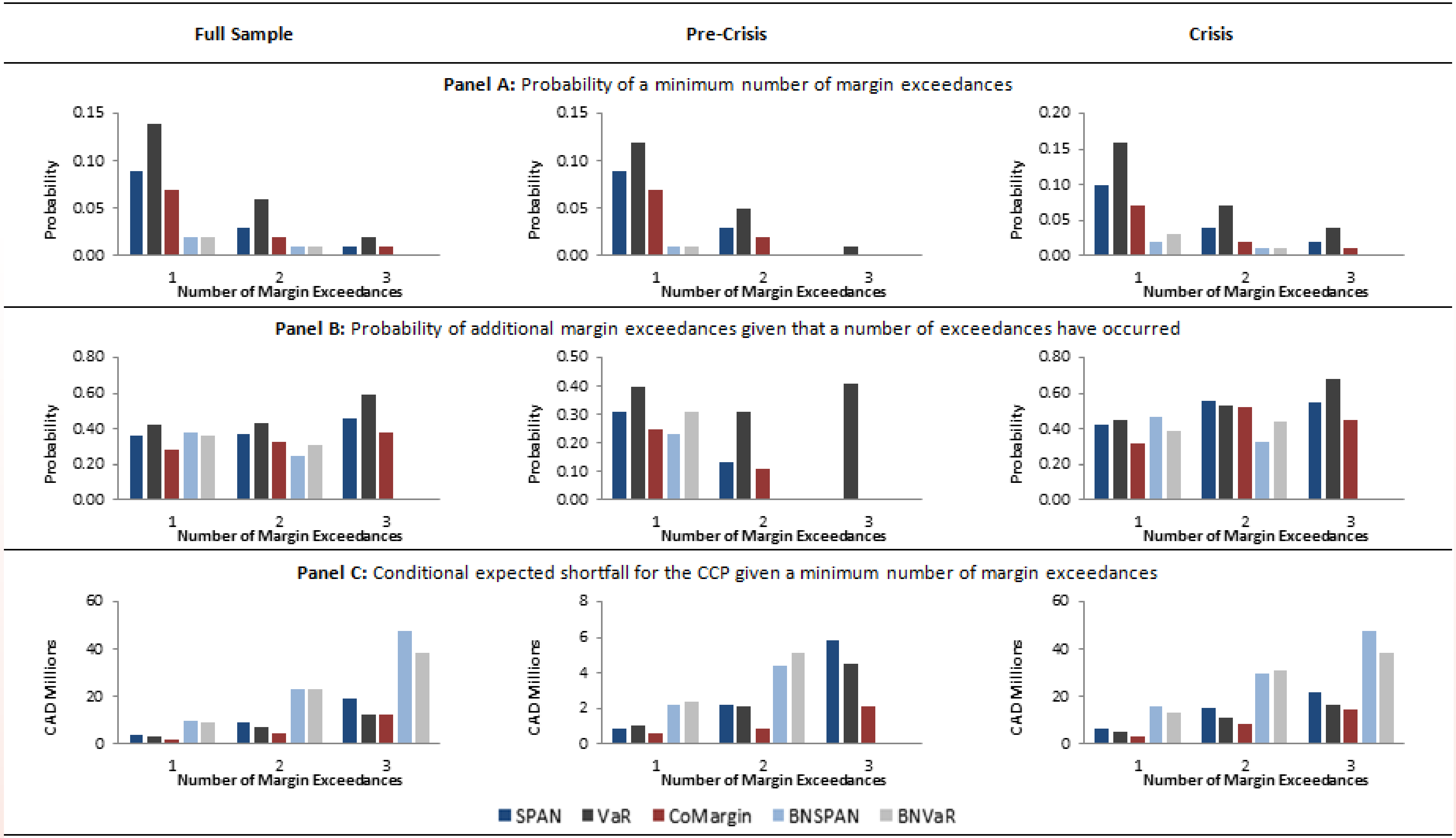
- **Fair and simple**
  - CoMargin **increases only for CMs with similar risk exposures** (i.e., those crowding the market).
  - CoMargin **converges to VaR Margin,** when there is **no risk homogeneity,**

4.3. CoMargin: Empirical Performance

Daily Collateral Funding



Collateral Performance



CoMargin: Summary

- **CoMargin is more efficient (less collateral and better coverage!)**
  - Less collateral through **portfolio-wide netting.**
  - Better coverage through **collateral allocations** that are a function of **loss dependence** (i.e., trade crowdedness and asset comovement).

- **CoMargin enhances the stability of the CCP**
  - It targets and stabilizes the probability of conditional exceedances across clearing members.

- **CoMargin improves the resiliency of the CCP**
  - It actively adjusts the allocation of collateral as a function of market conditions.
  - The magnitude of the margin **shortfall given simultaneous financial distress is minimized** relative to other collateral systems.

- **These conditions greatly reduce systemic risk concerns.**

5. Conclusion and Policy Implications

Conclusions

- **Just because risk did not materialize, it does not mean that it did not accumulate.**
- Residual risk in CCPs accumulated to record levels during the financial crisis.
- The risk of simultaneous distress events is **primarily driven by trade crowdedness** and to a lower extent by underlying market conditions.
- If collateral systems are not adjusted to account for trade crowdedness, CCPs could be left exposed to simultaneous distress events that undermine their stability and that of the entire financial system.

Policy Implications

- **Systemic importance of risk homogeneity**
  - TC must be considered when calculating margin and capital requirements.
  - **If risk managers or policymakers wait to act until volatility (or correlation) increases, it could be too late.**
  - Externalities of trading behaviour should be be internalized.

- **Importance of backtesting**
  - Needed for proper risk management, monitoring and regulation.
  - Measure the residual risk of CCPs to assess if new regulations are decreasing systemic risk.

- **Migration of OTC derivatives to CCPs**
  - Centrally clearing OTCD could potentially increase diversification, but risk might increase if trade crowdedness increases (related to CCP access).
  - Could carry additional risks if margining systems are not upgraded to account for loss dependence.

What are we up to at FNA?

- **About FNA**
  - FNA is a deep technology company and award-winning leader in Regulatory Technology (Regtech) and Supervisory Technology (Suptech) with the mission of making the financial system safer and more efficient.
  - FNA combines industry leading data science capabilities with deep central banking and supervisory expertise.
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  - Winner of the BIS-G20 Techsprint 2020
  - 10 monitors containing 30+ interactive dashboards to explore and monitor the global financial system
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  - For more information and a free trial go to https://www.g20monitor.com/

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  - The FNA Platform allows financial authorities to map and monitor complex financial networks and to simulate operational and financial risks.
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Thank you!