All-or-nothing payments and financial network fragility

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The views expressed herein are the authors' and do not necessarily reflect the views of the Federal Reserve Bank of Chicago or the Federal Reserve System.

Roadmap

Background

- **G-20 Mandate: most swap contracts to be centrally cleared**
  - **Dodd-Frank Act Title VII, EMIR**
  - **Presumption: central clearing more robust than bilateral**
  - **<u>Key tradeoff</u>:**
    - **Benefits of multilateral netting, vs.**
    - **Danger of concentrating risk in a single node**
      - **Requires pre-funded default fund**
      - **Resources used for default fund not available to satisfy CM obligations**

Background

- **Relative robustness of central clearing depends on payout practice in the event of a default**
  - **<u>Pro rata</u>: defaulter's remaining resources are distributed to obligors in partial satisfaction of obligations**
    - **Plausible for time horizon months or years**
    - **Bankruptcy proceeding**
  - **<u>All-or-nothing</u>: no partial payments in default**
    - **Realistic for time horizon up to a few days**
      - No incentives for partial payment
      - Explains liquidity hoarding behavior

Research questions

- **For a given bilateral financial network, when does central clearing improve robustness?**
  - **Impact of network topology?**
    - **Distribution of liabilities**
    - **Distribution of connections**
    - **Opportunities for multilateral netting**
  - **Impact of payout practice in the event of default?**
    - **All-or-nothing vs. pro-rata**
  - **"Stress test" framework – choose calibrations that put the bilateral network close to default**

Literature

- **Generalized Eisenberg and Noe, (2001) framework**
- **CCP risk management practices:**
  - CME Group, LCH.Clearnet, ICE Clear Credit rule books
  - Duffie and Zhu, (2011); Pirrong, (2011); Ross, (2015)
  - Insolvency reports – MF Global, Lehman Brothers
- **Contagion due to interconnectedness:**
  - Brazil – Cont, Moussa, and Santos, (2012)
  - CDS: Markose et al., (2009); Peltonen et al., (2013)
- **Network topology and network resilience:**
  - Acemoglu et al., (2013); Georg, (2011); Gai and Kapadia, (2010)

Framework

- **Generalized Eisenberg and Noe structure**
  - N agents
  - e_i = exogenous resources of agent I
  - $L_{ij} \geq 0$ = amount owed by agent i to agent j

$$L = \begin{bmatrix} 0 & L_{12} & \cdots & L_{1N-1} & L_{1N} \\ L_{21} & 0 & \cdots & L_{2N-1} & L_{2N} \\ \cdot & & & & \cdot \\ \cdot & & & & \cdot \\ \cdot & & & & \cdot \\ L_{N1} & & & L_{NN-1} & 0 \end{bmatrix}$$

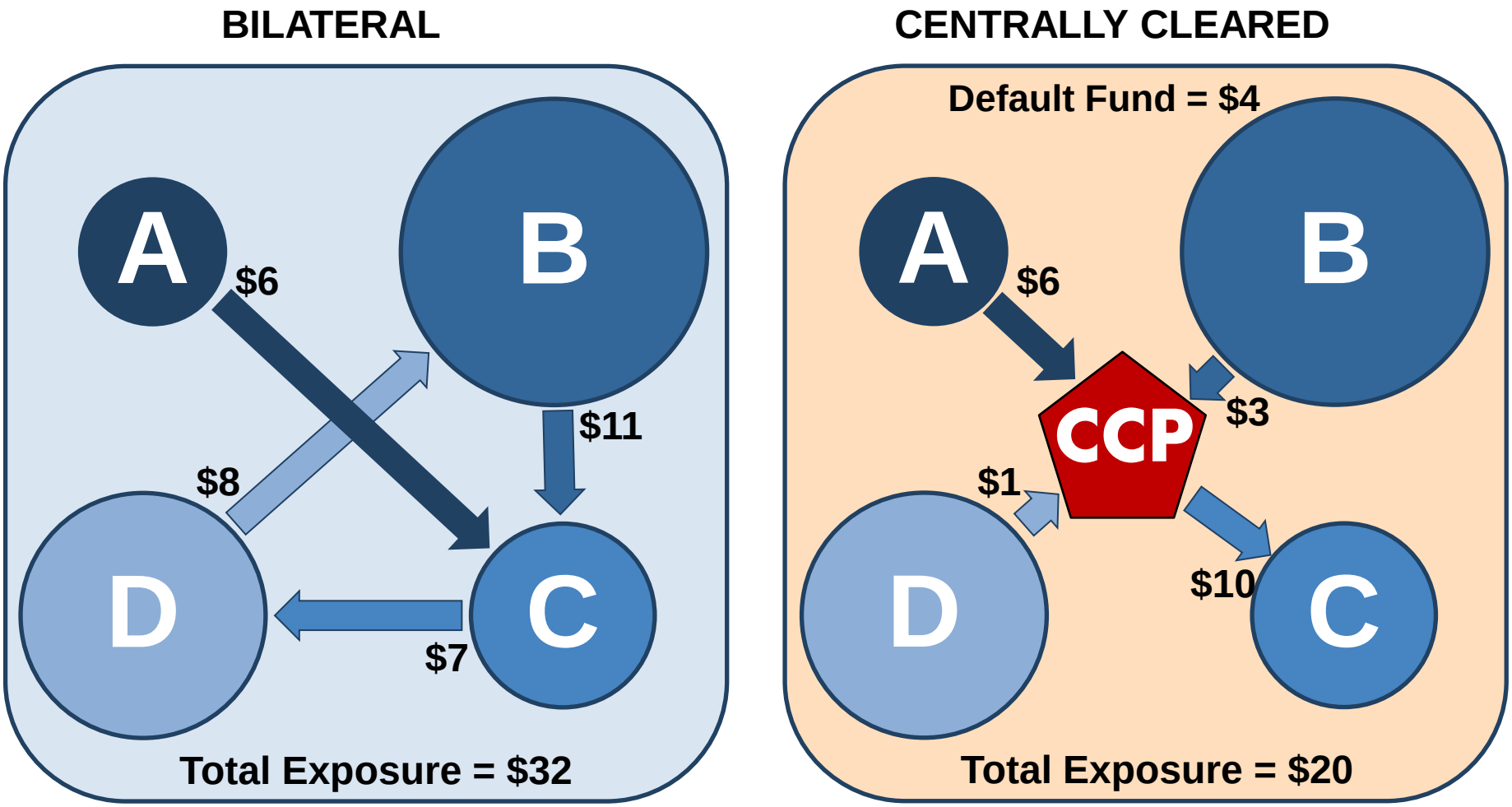
Framework

- **New node (CCP) is introduced as a single counterparty**
  - CCP must have a matched book
    (total payments due from CCP = total payments due to CCP)

$$\sum_{i=1}^{N} L^{ccp}_{N+1,i} = \sum_{i=1}^{N} L^{ccp}_{i,N+1}$$

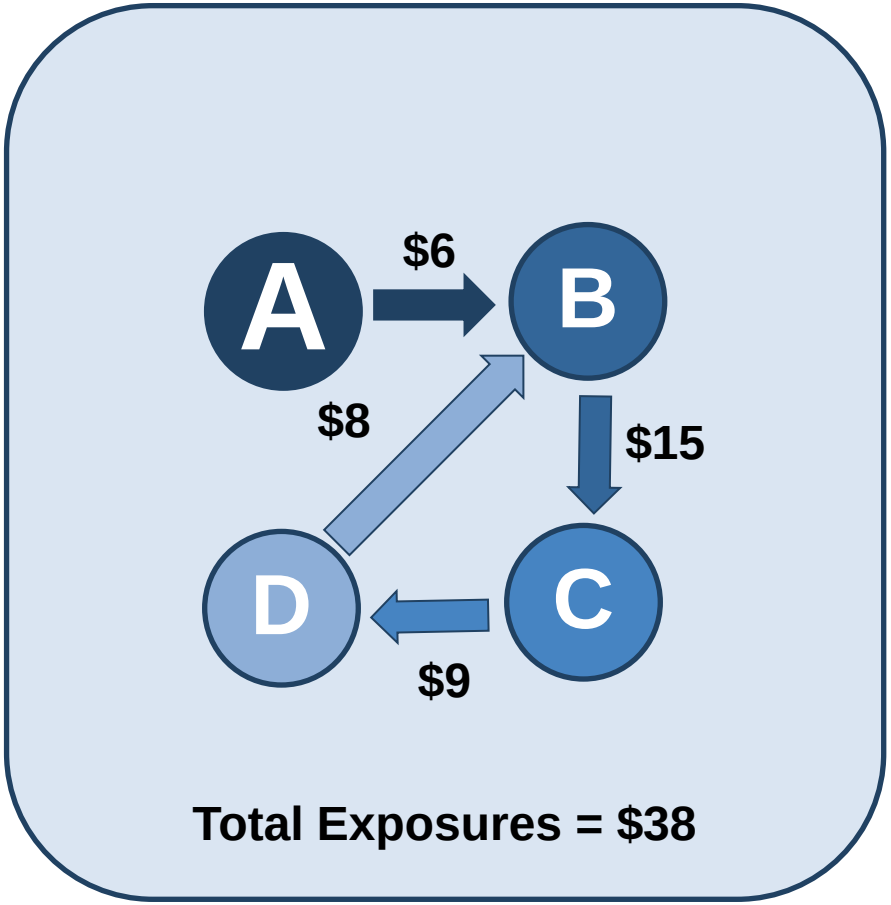
$$L^{ccp} = \begin{bmatrix} 0 & 0 & \cdots & 0 & L^{ccp}_{1,N+1} \\ 0 & 0 & \cdots & 0 & L^{ccp}_{2,N+1} \\ \cdot & & & & \cdot \\ \cdot & & & & \cdot \\ \cdot & & & & \cdot \\ 0 & 0 & 0 & 0 & L^{ccp}_{N,N+1} \\ L^{ccp}_{N+1,1} & L^{ccp}_{N+1.2} & \cdots & L^{ccp}_{N+1.N} & 0 \end{bmatrix}$$

Framework


BILATERAL
A
B
C
D
$6
$11
$8
$7
Total Exposure = $32
CENTRALLY CLEARED
Default Fund = $4
A
B
C
D
CCP
$6
$3
$1
$10
Total Exposure = $20

Framework

BILATERAL



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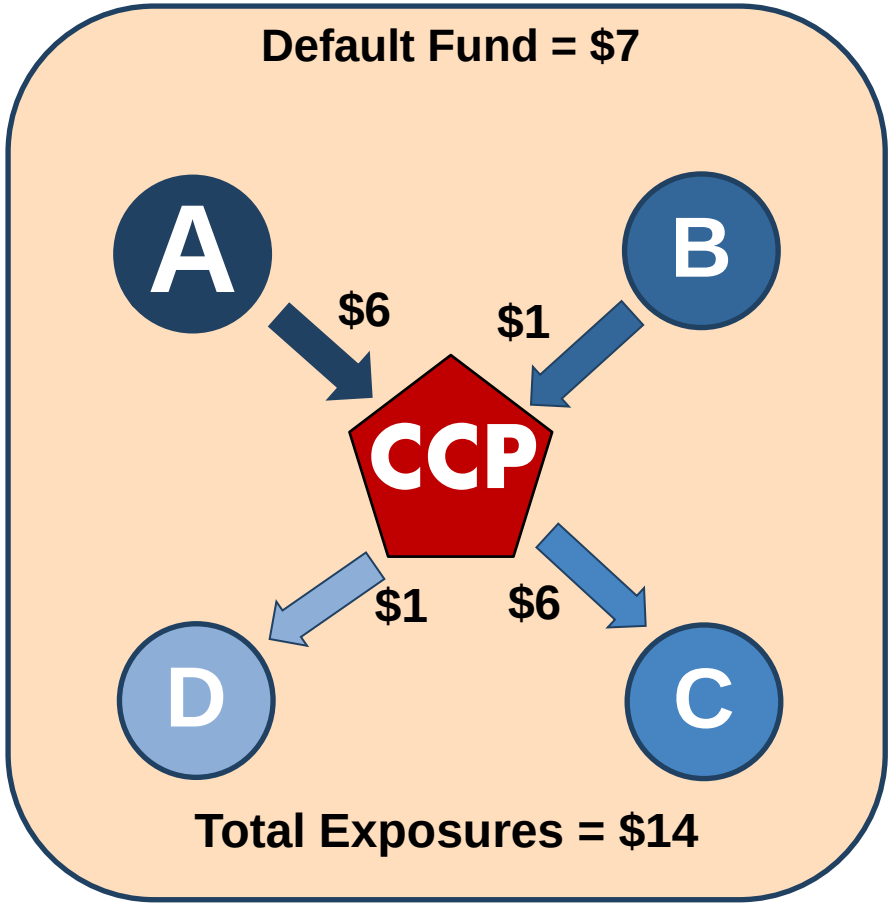

Framework

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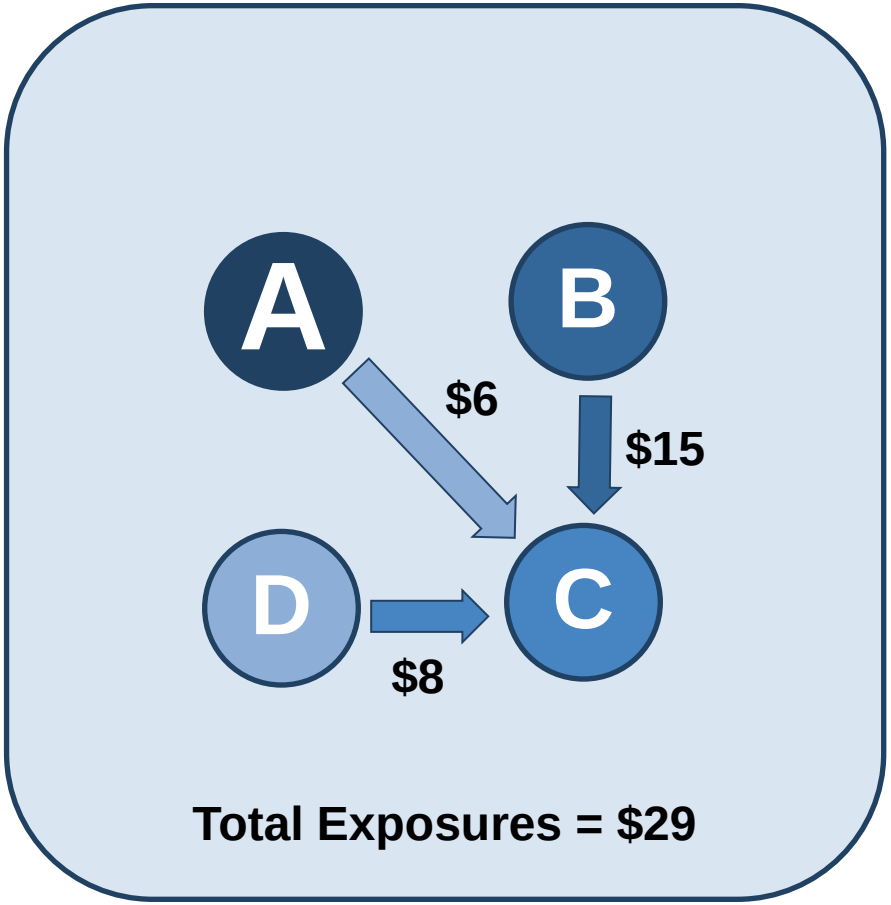

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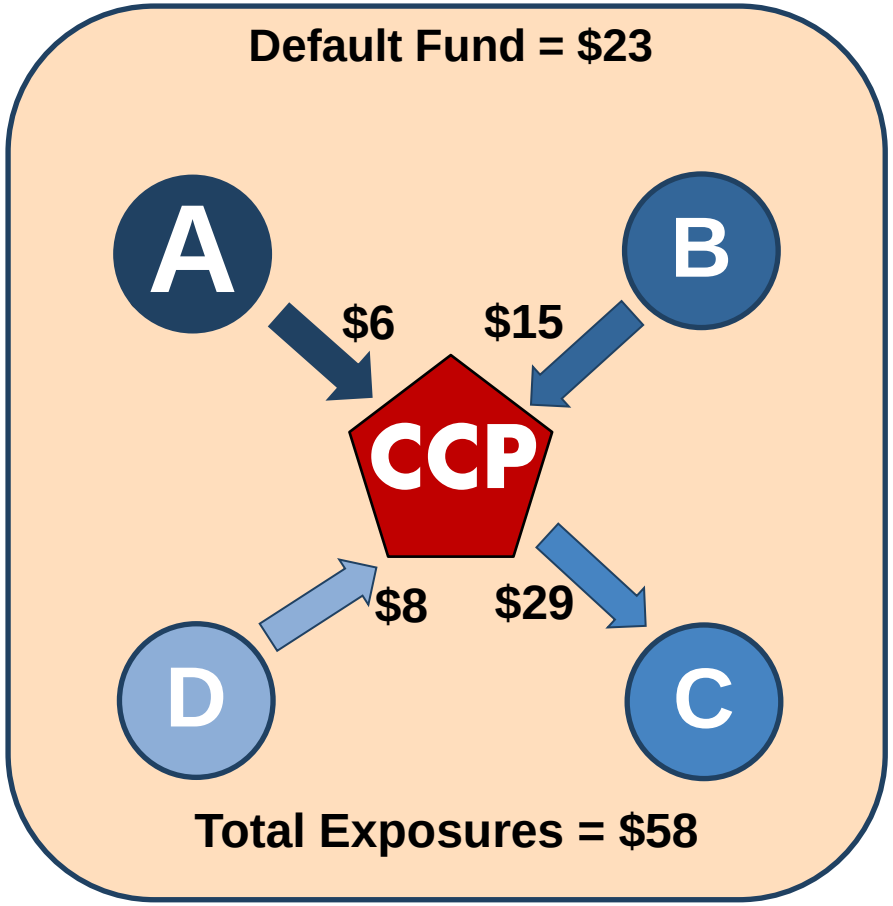


Framework

- **Monte Carlo stress test methodology:**
  - Draw random scale-free adjacency matrix
  - Draw random obligations
    - Gamma, Uniform
  - Compute corresponding centrally cleared network
  - Size default fund according to “cover-2” standard
    - Individual node’s default fund contribution proportional to node’s gross obligations
  - Each node’s baseline external resources = default fund contribution plus minimum additional to ensure no defaults.
  - Stress the baseline:
    - Reduce resources of the three most central nodes by random shock.
    - Compute clearing vector under pro rata, all-or-nothing
    - Compare aggregate defaults: bilateral vs. centrally cleared.

Framework

- **Measure of relative CCP robustness =**

  (Fraction of obligations defaulted on in bilateral case) – (Fraction of obligations defaulted on under central clearing)

- Depends on payment assumptions when a participant defaults
  - Bilateral case: does defaulter pay remaining resources to obligors on a pro-rata basis?
  - Central clearing: will a defaulting clearing member make a partial payment to the CCP?
  - (Assumption regarding CCP payout in the event of a CCP default don't materially affect relative CCP robustness.)

Results

- **Relative Robustness of Central Clearing**

Obligation/exposure distribution	Payout assumptions	Prob. CCP more robust
Gamma	Bilateral AON; Clearing Member AON	**57%**
	Bilateral AON; Clearing Member Pro-Rata	**62%**
	Bilateral Pro-Rata; Clearing Member AON	**23%**
	Bilateral Pro-Rata; Clearing Member Pro-Rata	**40%**
Uniform	Bilateral AON; Clearing Member AON	**64%**
	Bilateral AON; Clearing Member Pro-Rata	**64%**
	Bilateral Pro-Rata; Clearing Member AON	**26%**
	Bilateral Pro-Rata; Clearing Member Pro-Rata	**31%**
Uniform: Squared for big banks	Bilateral AON; Clearing Member AON	**59%**
	Bilateral AON; Clearing Member Pro-Rata	**62%**
	Bilateral Pro-Rata; Clearing Member AON	**14%**
	Bilateral Pro-Rata; Clearing Member Pro-Rata	**18%**

Results

Regress CCP Robustness in the Monte Carlo simulations on benefits from ML netting and size of default fund

- Measure of benefits from ML netting: total bilateral obligations minus CCP obligations
- Depends on obligation/exposure distribution

Regressor	Obligation/Exposure Distribution		
	Gamma	Uniform	Uniform: Squared for big banks
Benefits from ML Netting	0.001	0.0026	0.002
Size of Default Fund	0.0006	0.0032	-0.0009

Results

- **Regress CCP Robustness on Network Characteristics**

Characteristic	Measure	Sign
Interconnectedness	Number of waves in bilateral defaults	Pos
Fragility	Max eigenvalue of relative exposure matrix	Pos
Maximum obligation		Pos
Out-degree Concentration	Herfindahl index	Pos
	Maximum out-degree	Pos
Obligation concentration	Herfindahl index	Pos
Maximum exposure		Neg
In-degree Concentration	Herfindahl index	Neg
	Maximum in-degree	Neg
Exposure concentration	Herfindahl index	Neg

Results (draft)

- **Comparison of pro-rata to all-or-nothing payment assumption (example)**

# Nodes	# Edges	Avg. Degree	Total Value	Shock
40	51	1.275	595	Fail 2 random nodes

Payment Assumption	Network Structure	Defaulted Value	% of Total Value	# of Defaulted Nodes	% of Defaulted Nodes	# of Default Waves	CCP Defaults?
PRO-RATA	Bilateral	19.39	3.26%	6	15%	1	n/a
	Centrally Cleared	14.59	2.45%	2	5%	0	NO
ALL-OR-NOTHING	Bilateral	564	94.79%	33	82.5%	5	n/a
	Centrally Cleared	170	28.57%	19	47.5%	2	YES

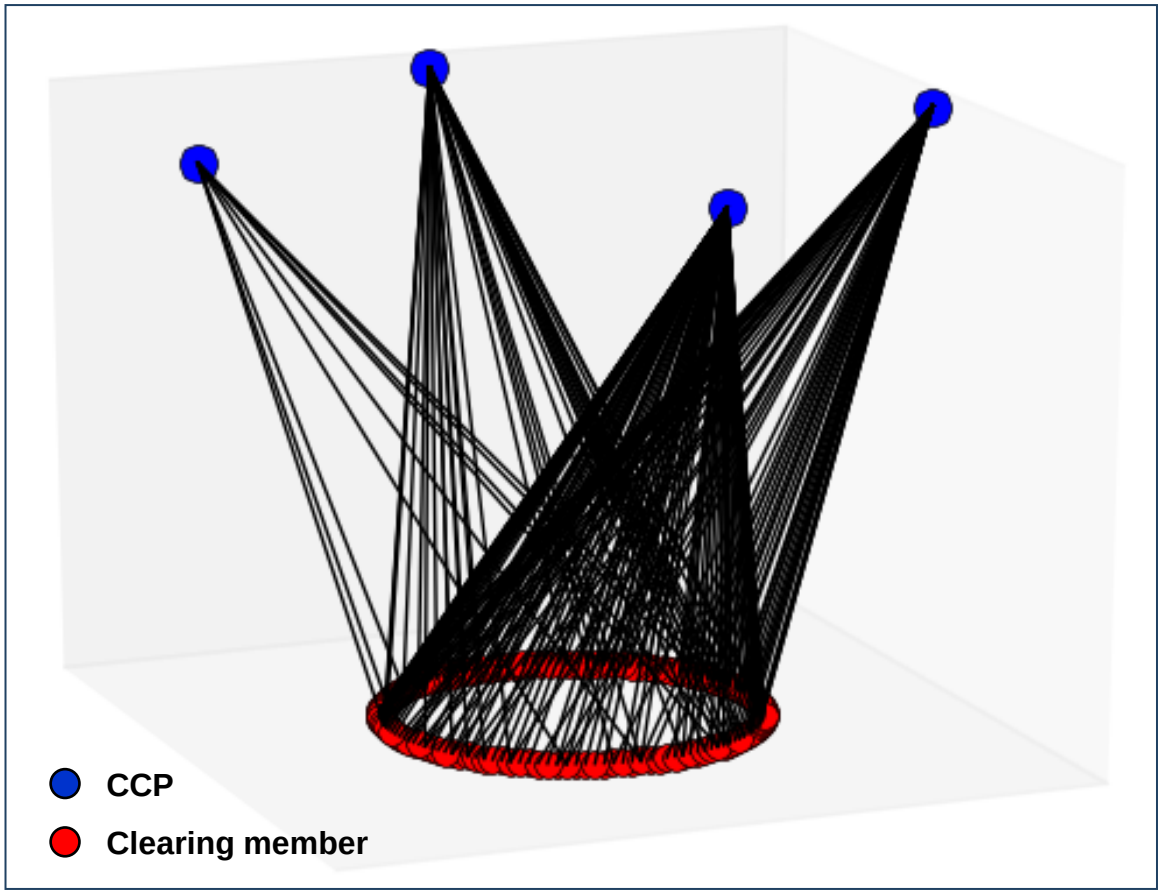
Results (draft)

- **Probability distribution of failures in a CCP network compared to the Bilateral network stressed – same shock**

	Payment Assumptions		Uniform Dist.	Gamma Dist.
1	Bilateral (pro-rata)	vs. CCP (pro-rata) & CM_(pro-rata)	77.43%	78.83%
2	Bilateral (pro-rata)	vs. CCP (pro-rata) & CM (AoN)	92.88%	93.61%
3	Bilateral (pro-rata)	vs. CCP (AoN) & CM (AoN)	100.00%	
4	Bilateral (AorN)	vs. CCP (pro-rata) & CM (pro-rata)	0.07%	1.18%
5	Bilateral (AorN)	vs. CCP (pro-rata) & CM (AoN)	1.34%	2.37%
6	Bilateral (AorN)	vs. CCP (AoN) & CM (AoN)	33.76%	55.00%

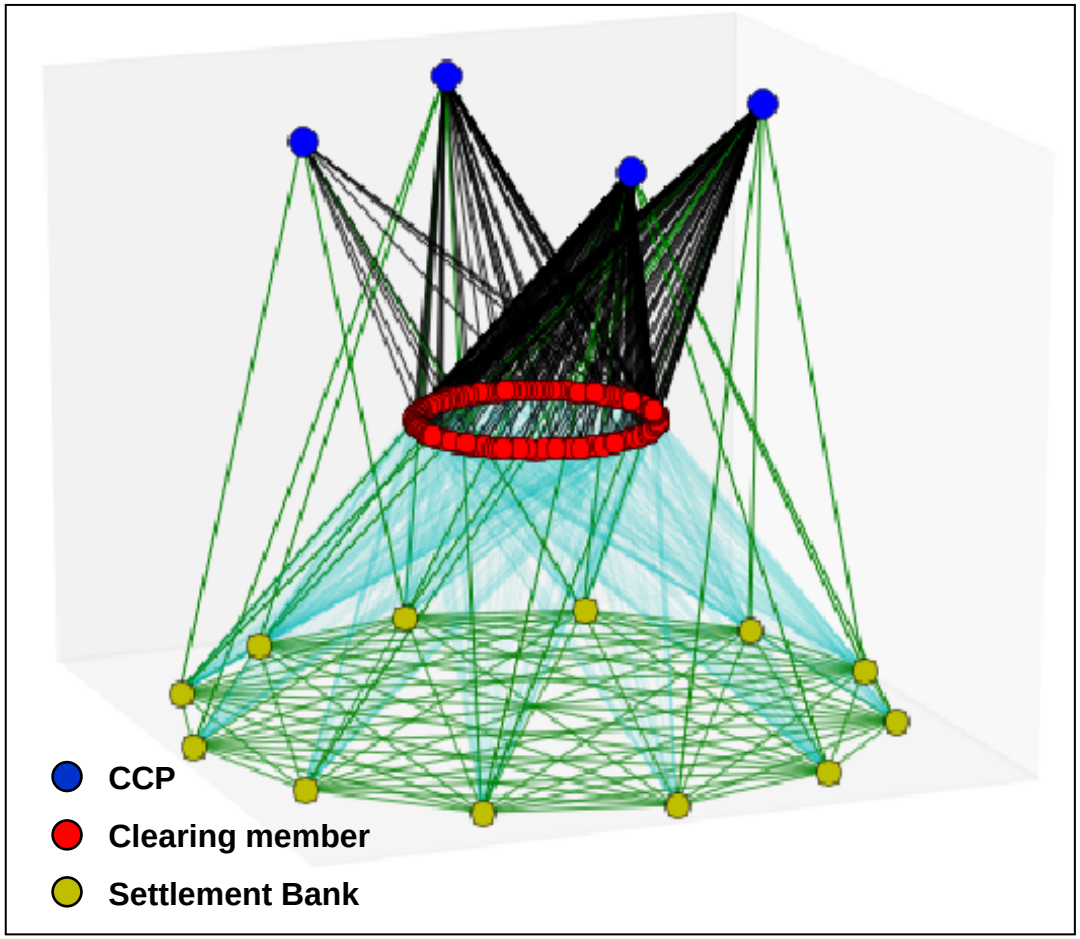
Next Steps

- **Network fragility in a network with multiple CCPs**



Next Steps

- **Impact of settlement banks on network fragility**



Summary

- ~~Pro-rata~~ **vs. all-or-nothing ✔**
- **Bilateral vs. centrally cleared**
- **Policy:**
  - Should we mandate Central Clearing?
  - PFMI Cover 2?
- **One size doesn't fit all**
  - In a substantial fraction of simulations bilateral is more robust than CCP

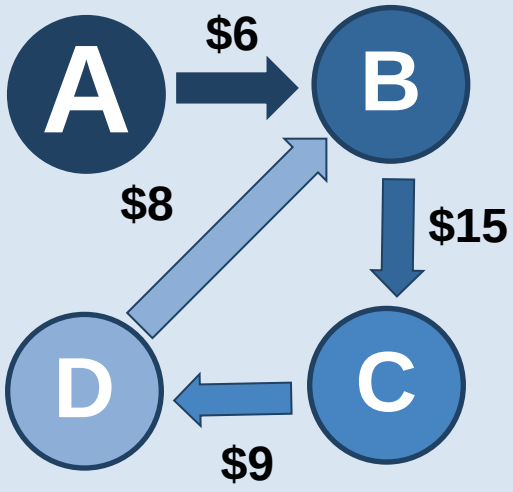
Appendix

“Thus, for the system to be safer it is not sufficient to ensure that trades are standardized and that they are mandated to be cleared through CCPs, but also it is necessary that CCPs be “bullet proof.”

William C. Dudley, Remarks at the Harvard Law School's Symposium on Building the Financial System of the 21st Century, Reforming the OTC Derivatives Market (March 22, 2012)

Example: Multilateral Netting under "All-or-Nothing"

BILATERAL



Total Exposures = $38

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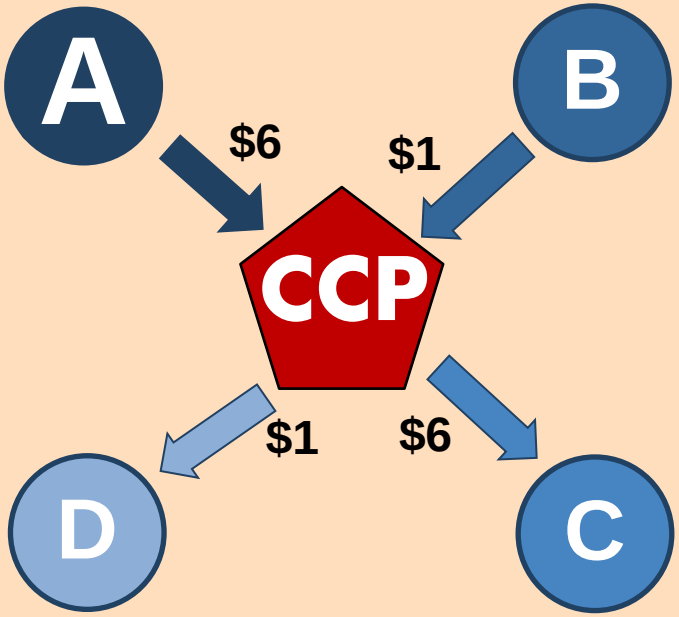

Total Exposures = $14

Example: Multilateral Netting under "All-or-Nothing"

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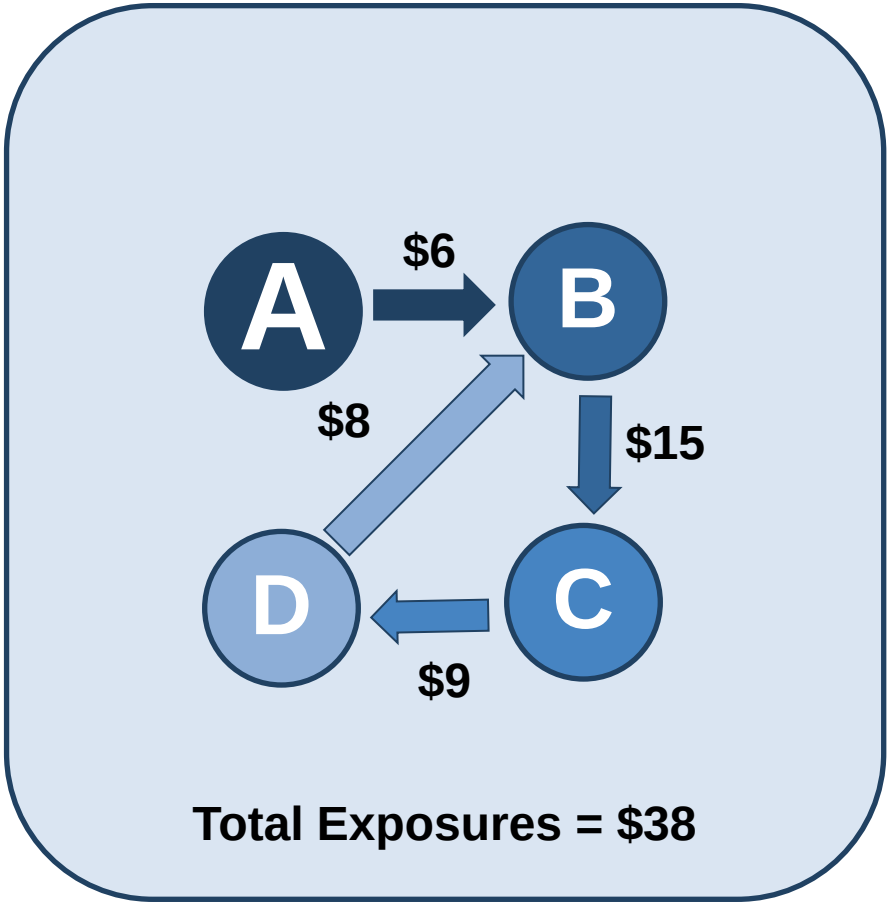

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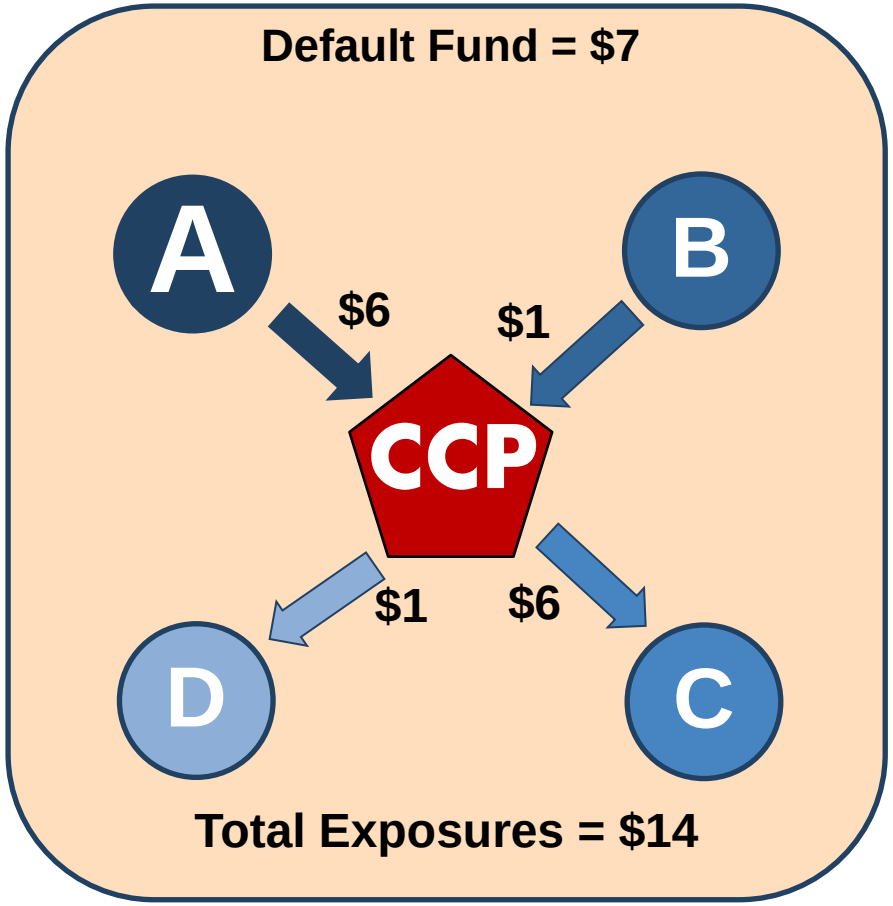

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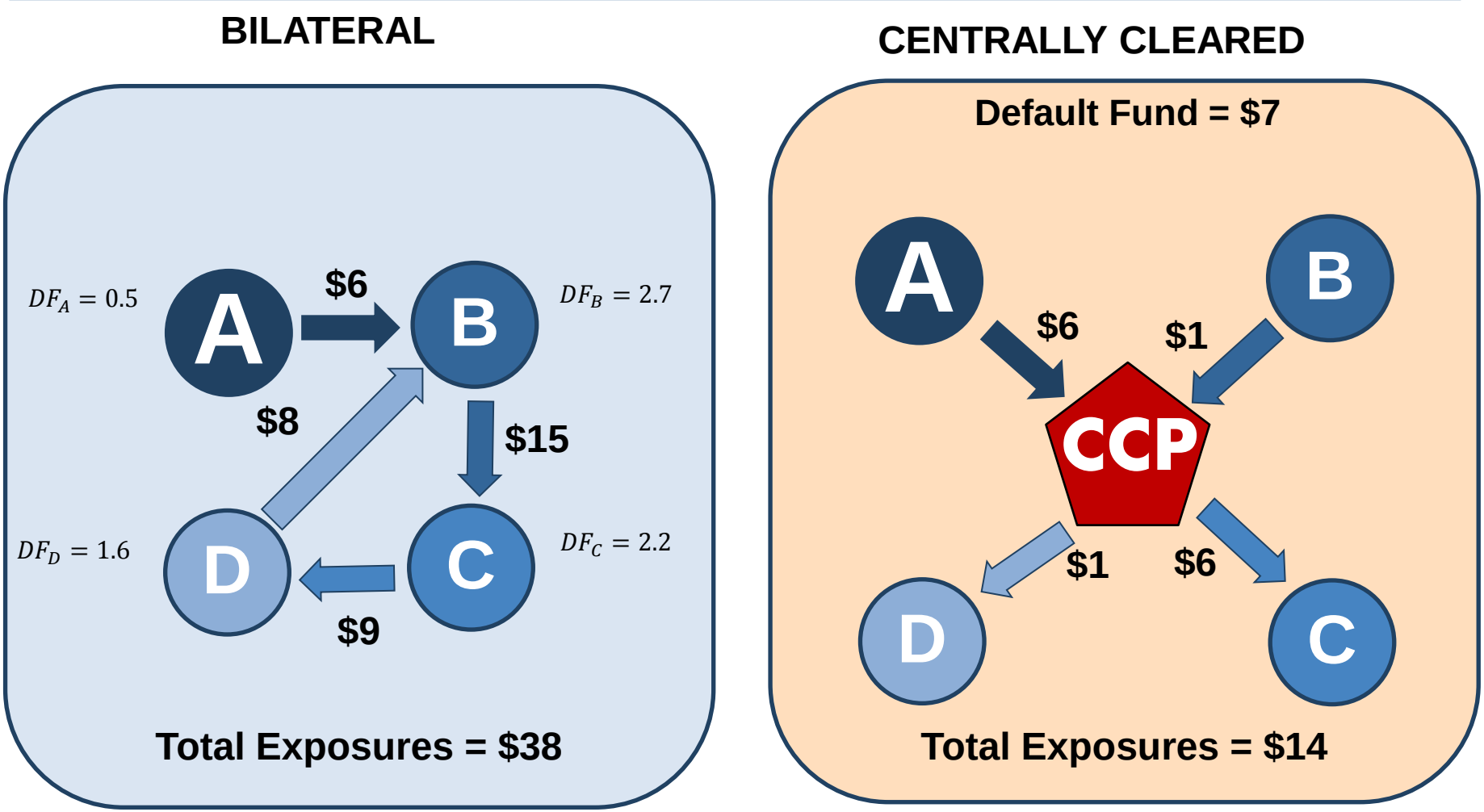

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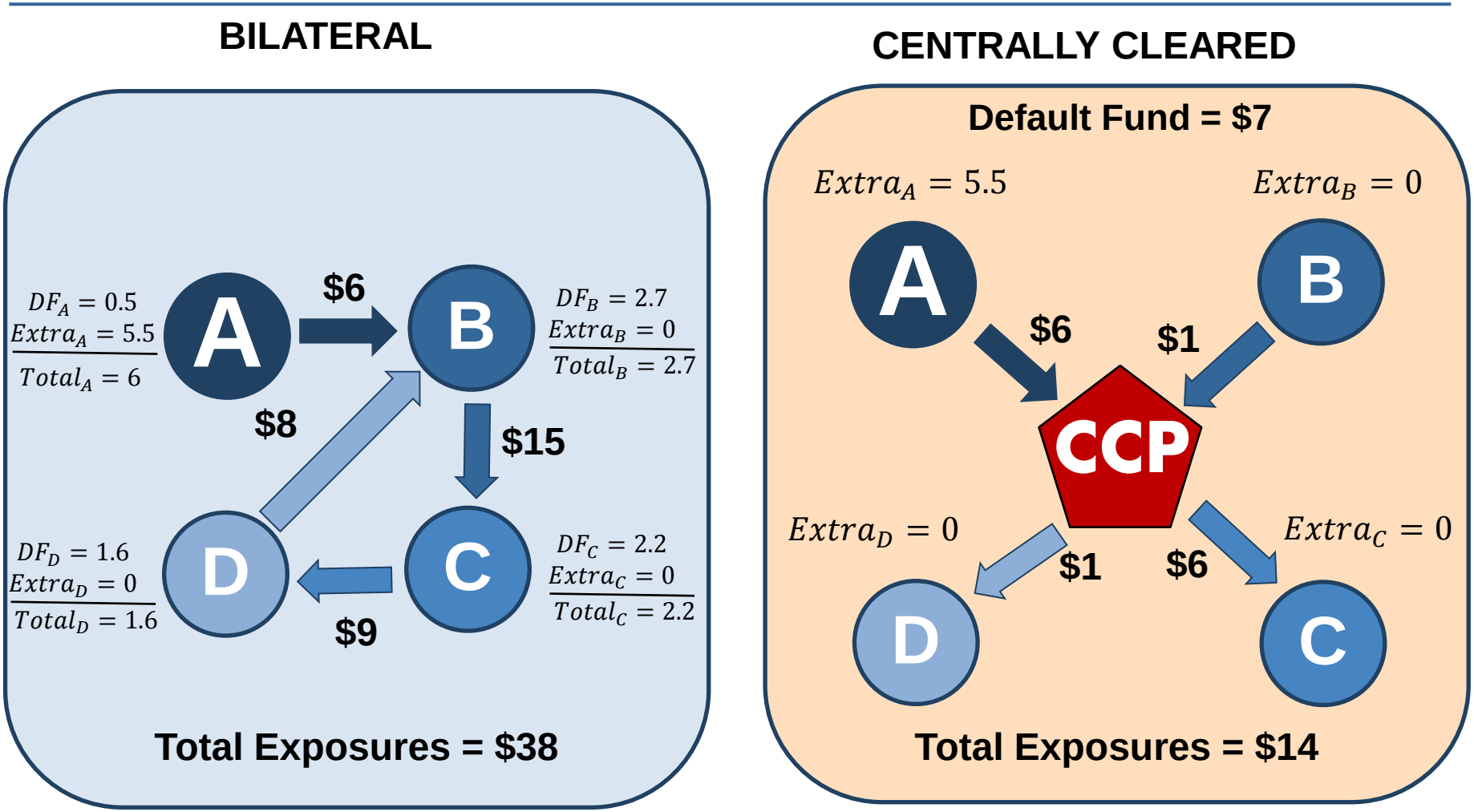
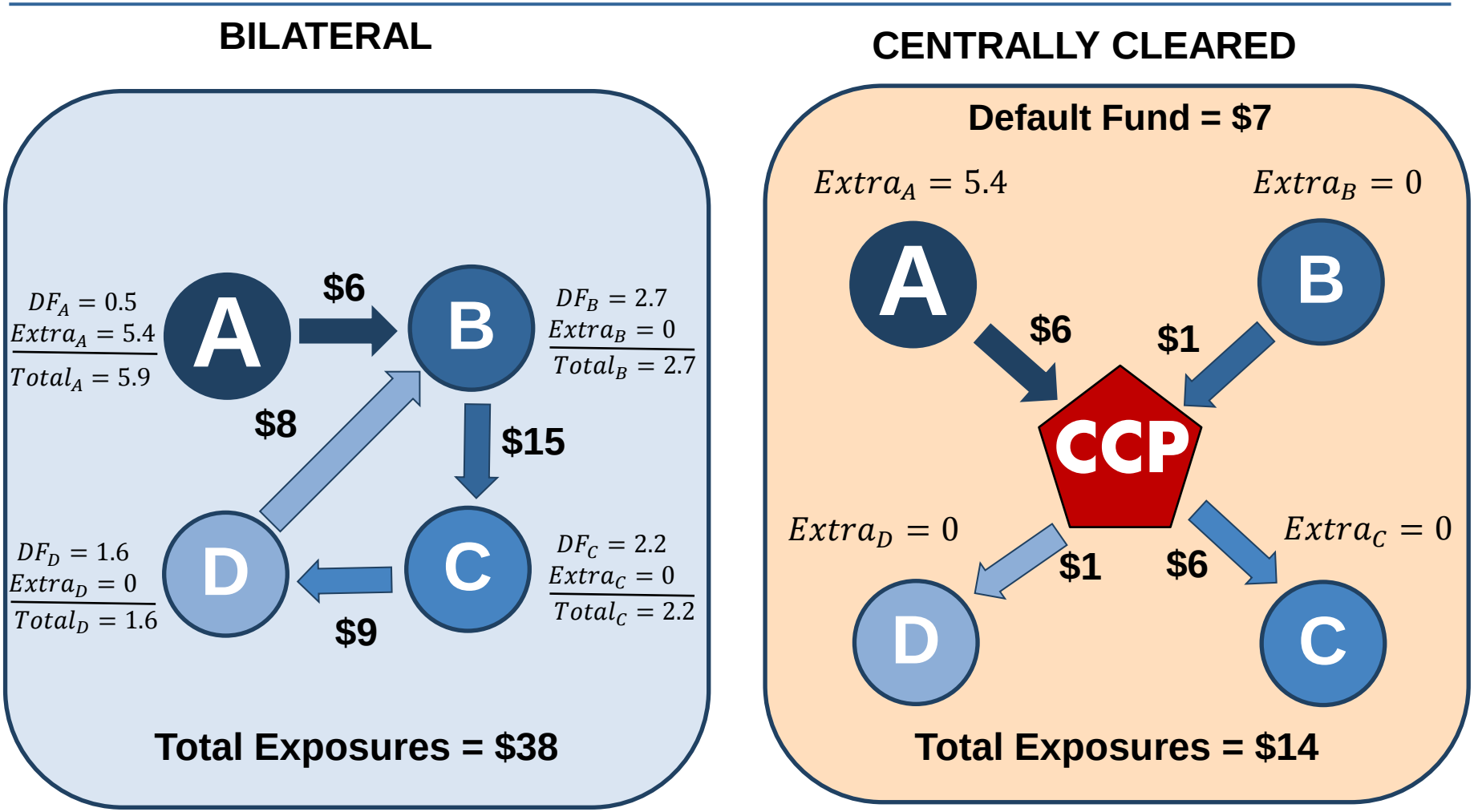


Stress A under "All-or-Nothing"



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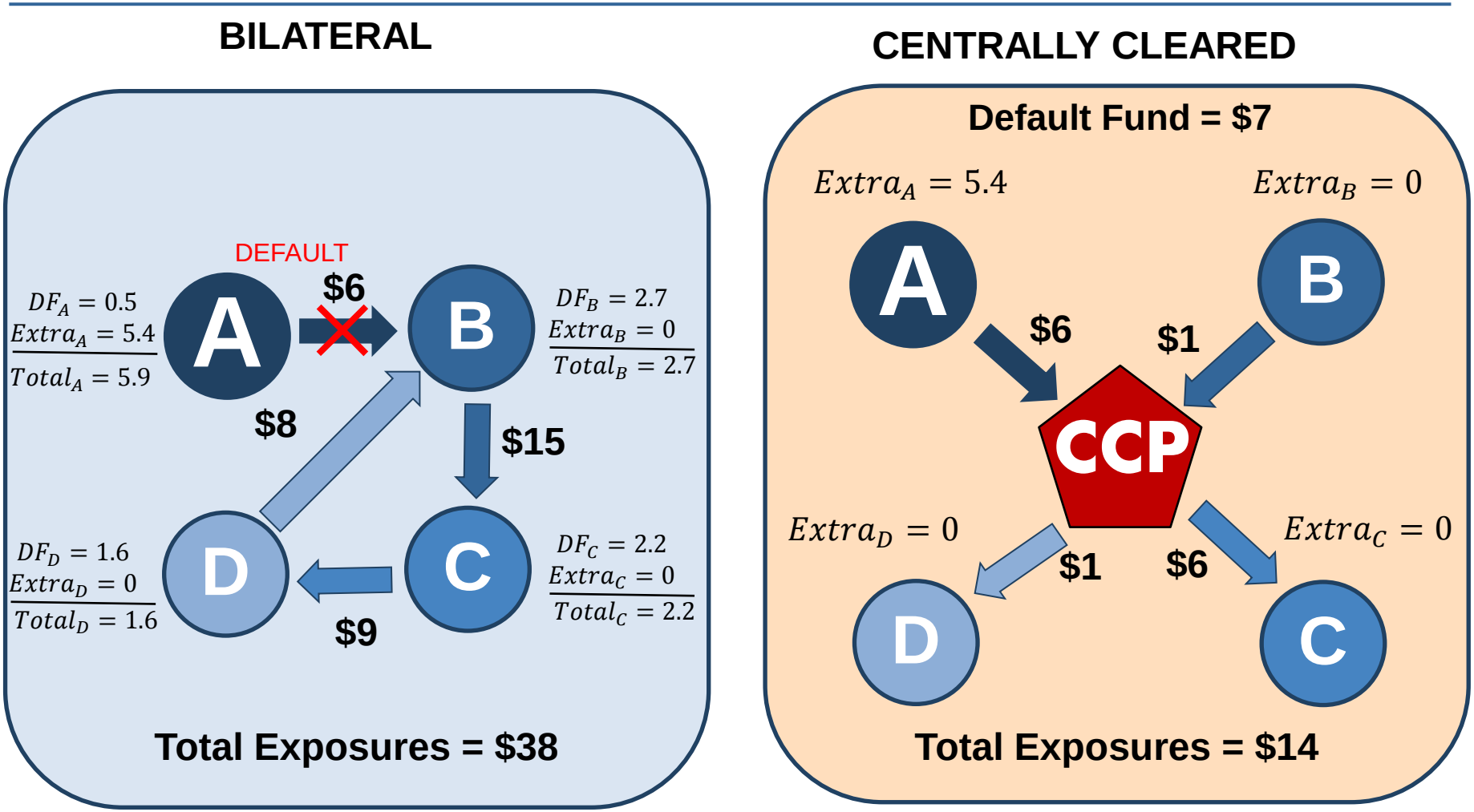

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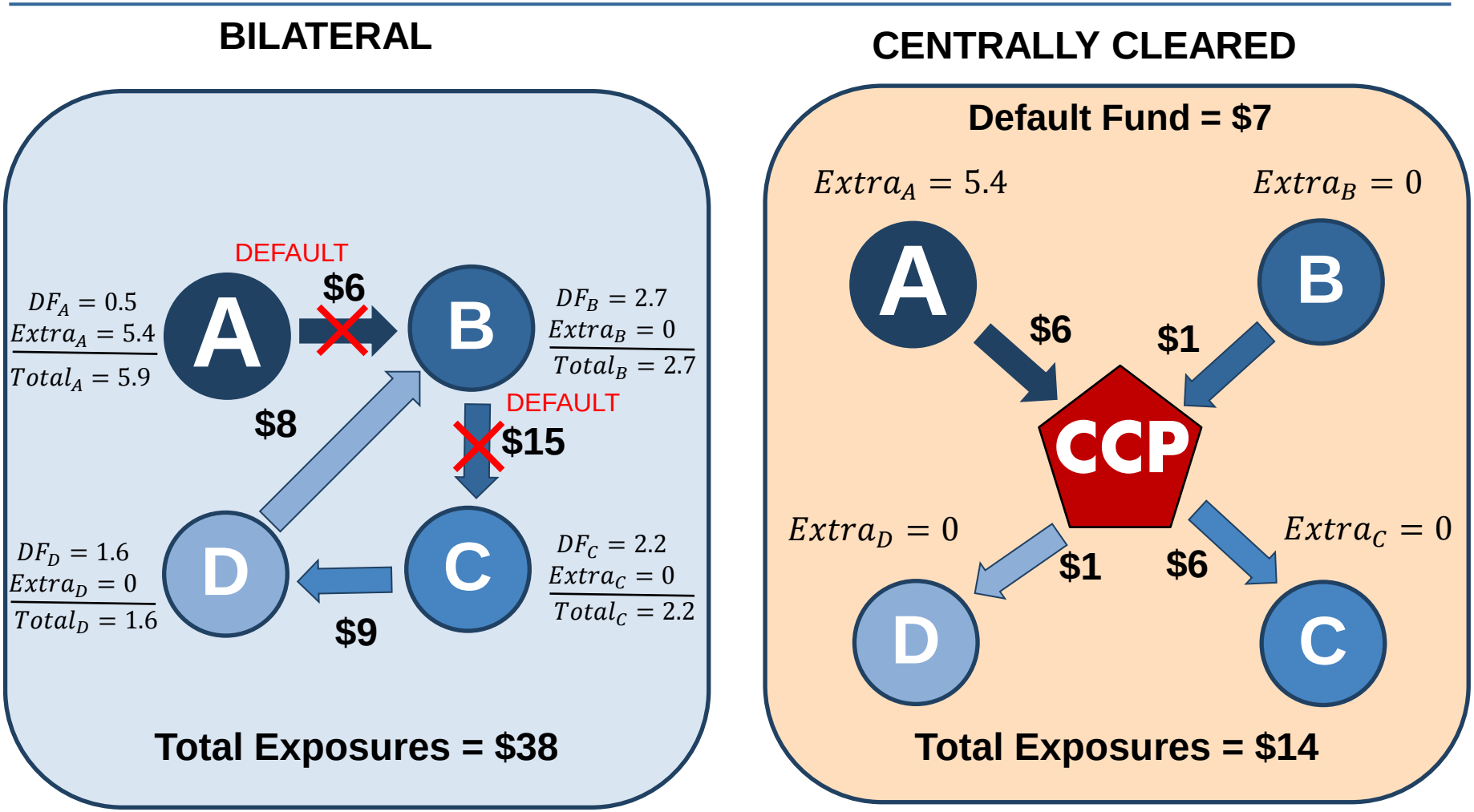

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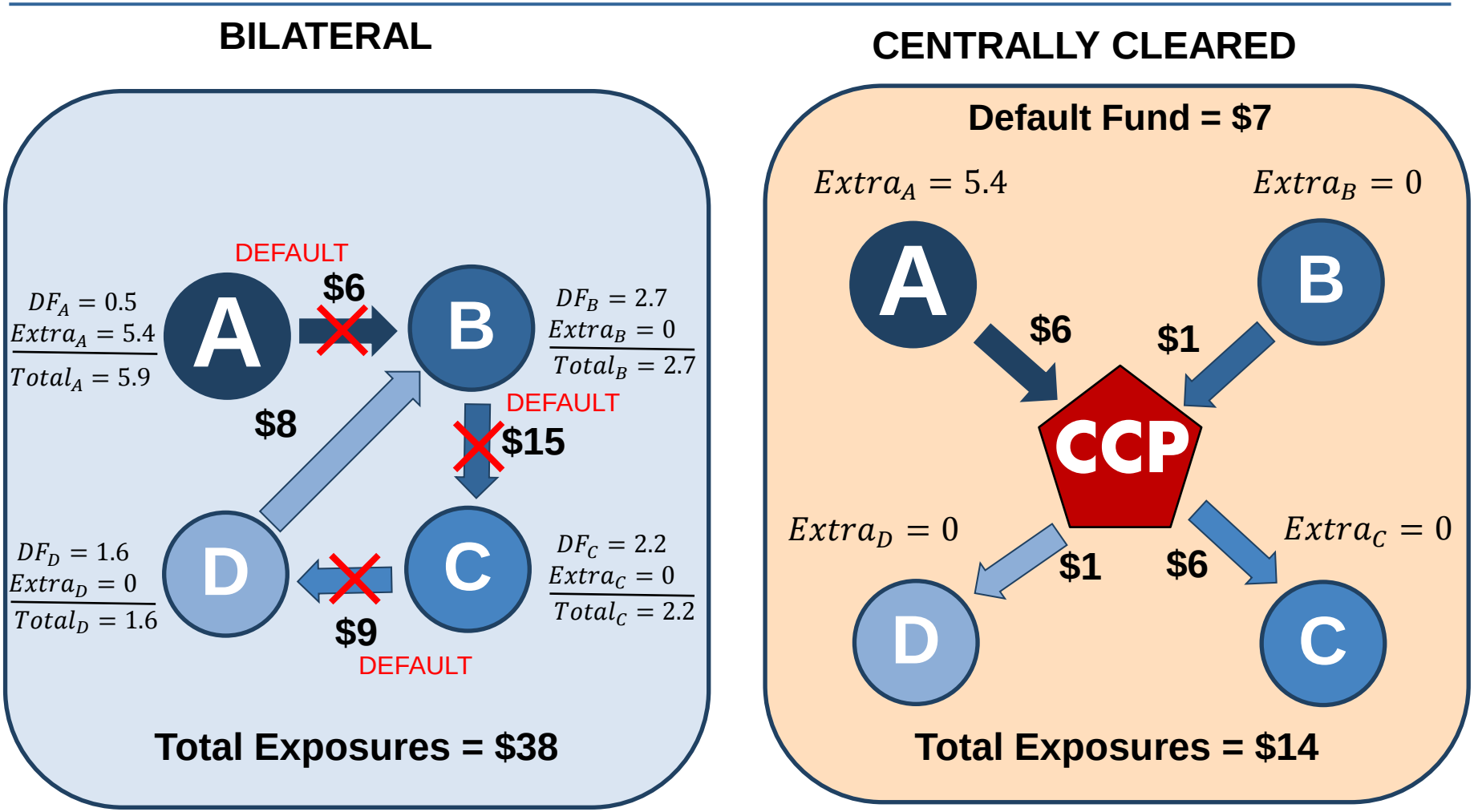

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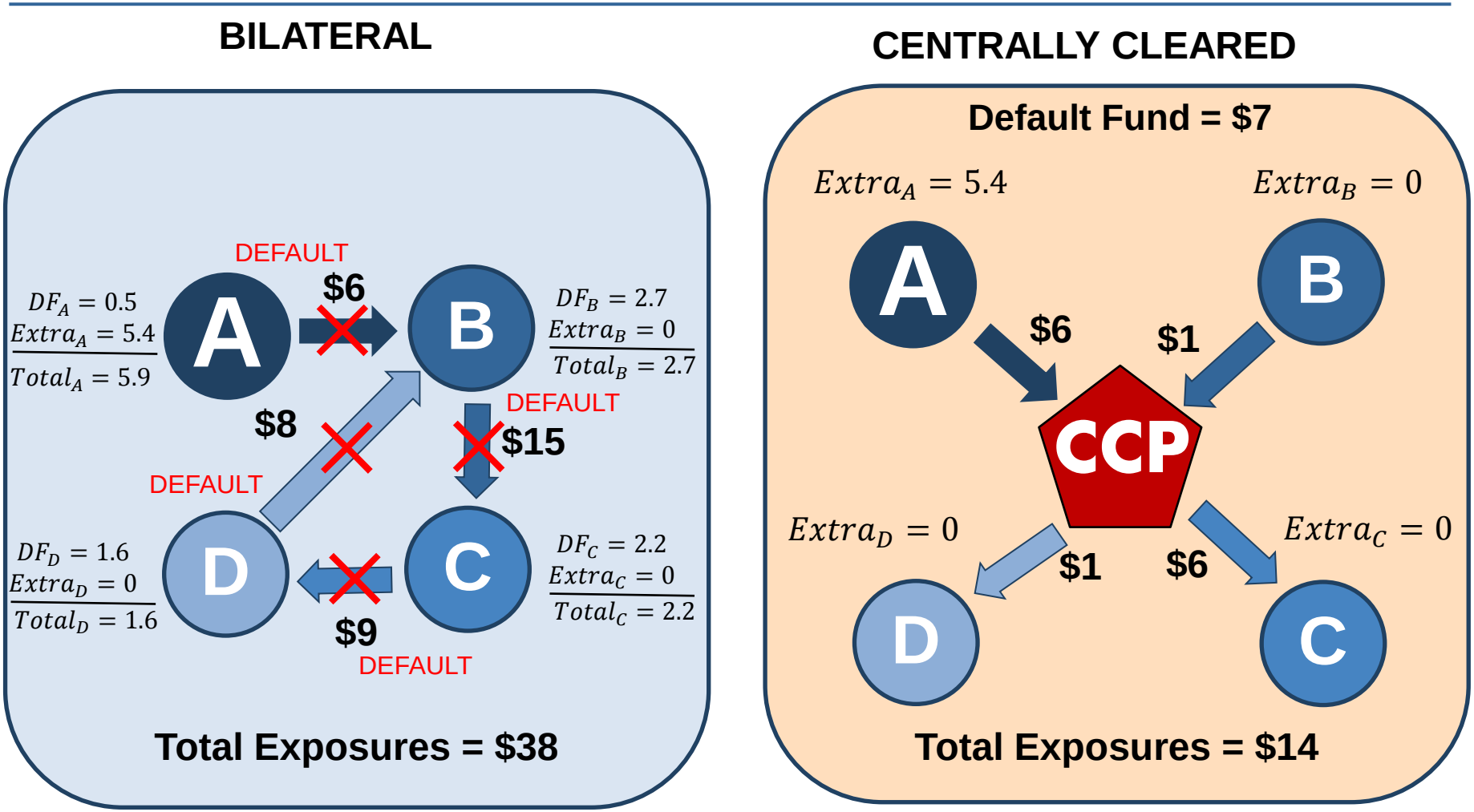

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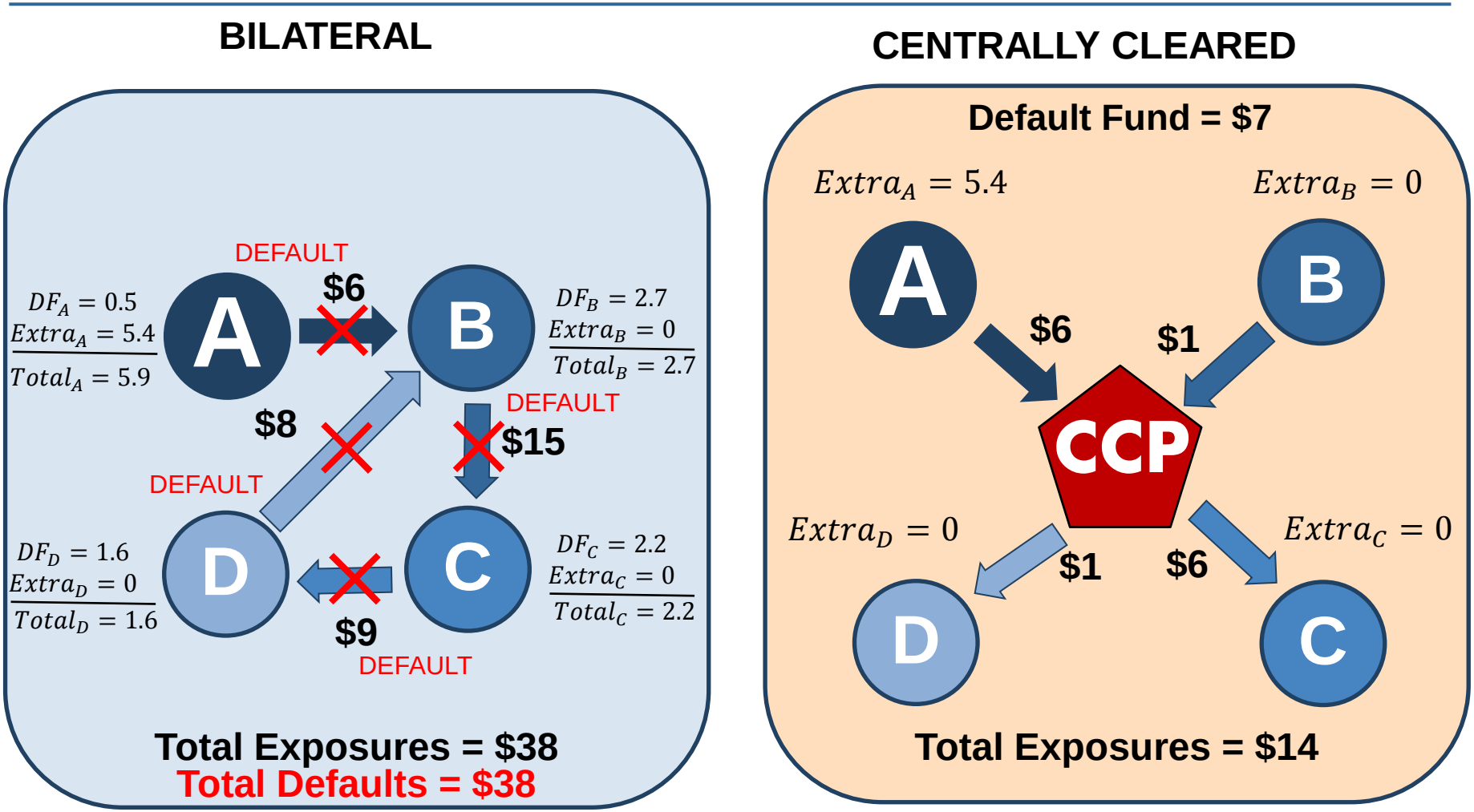

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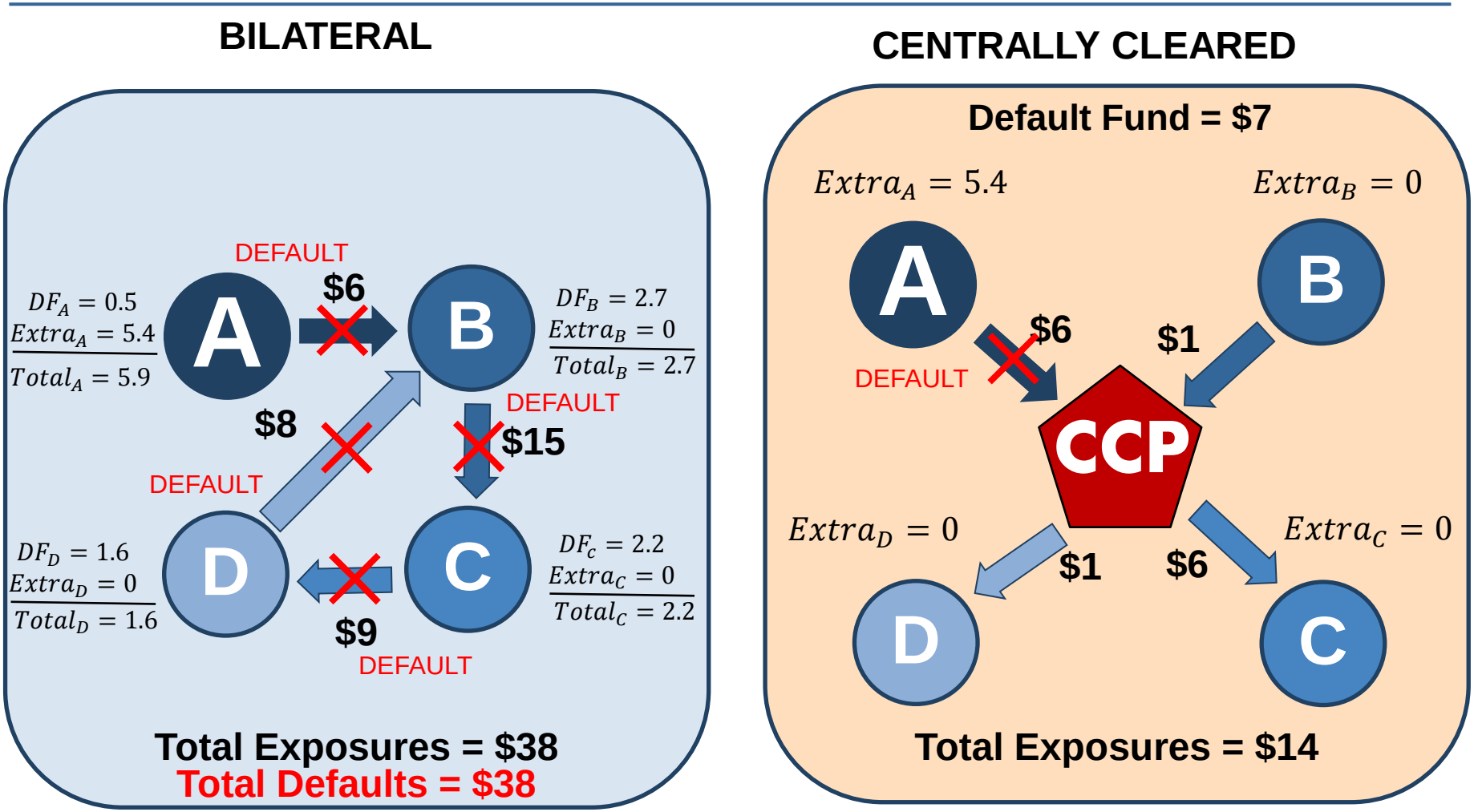

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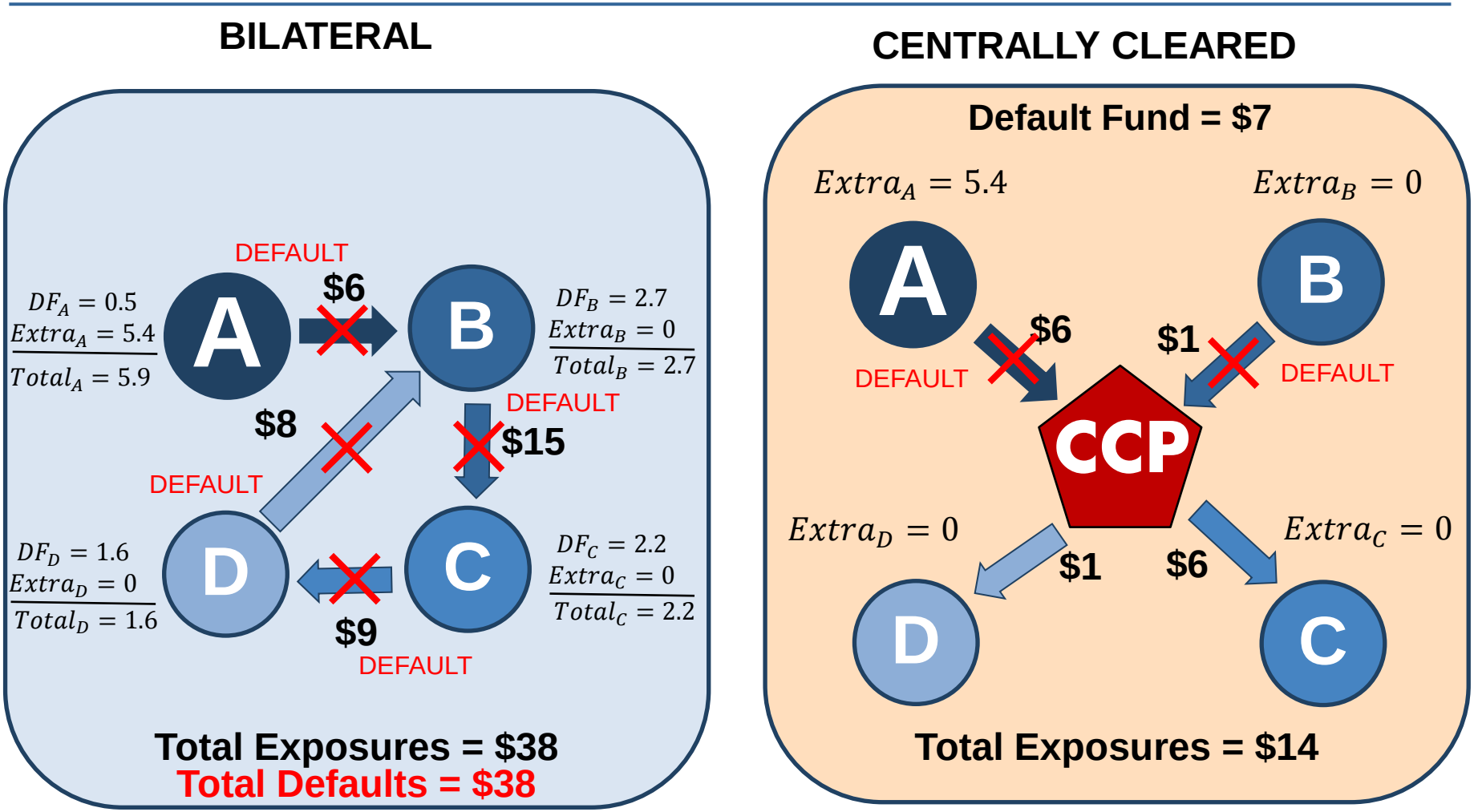

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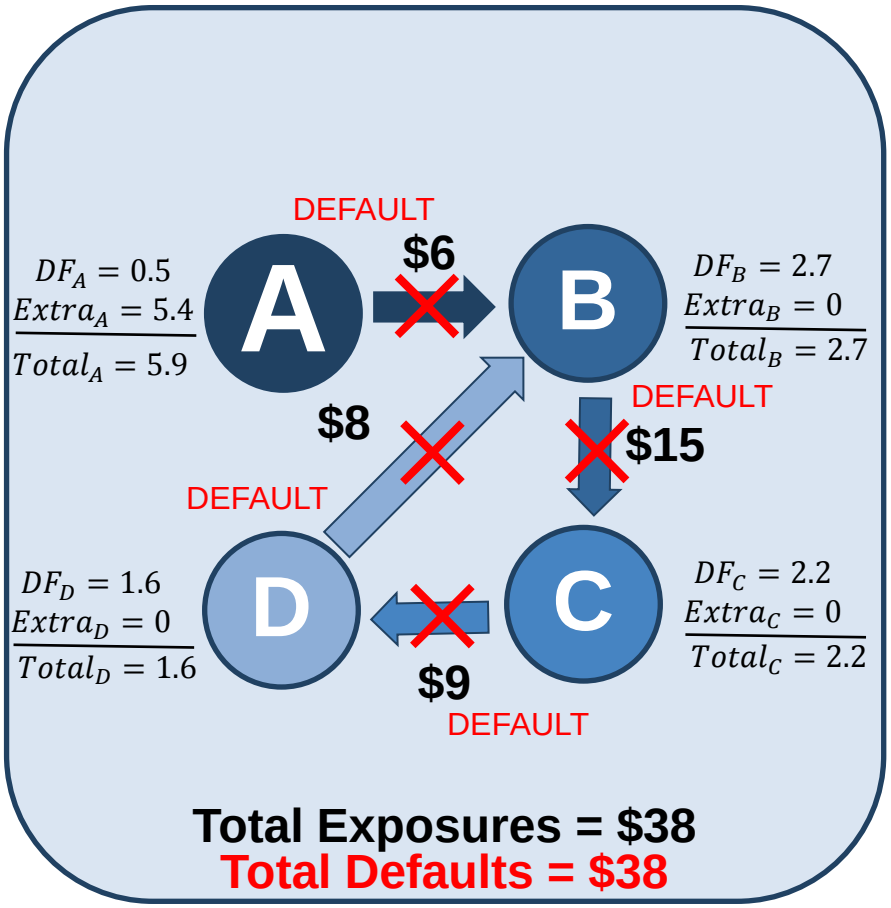
BILATERAL



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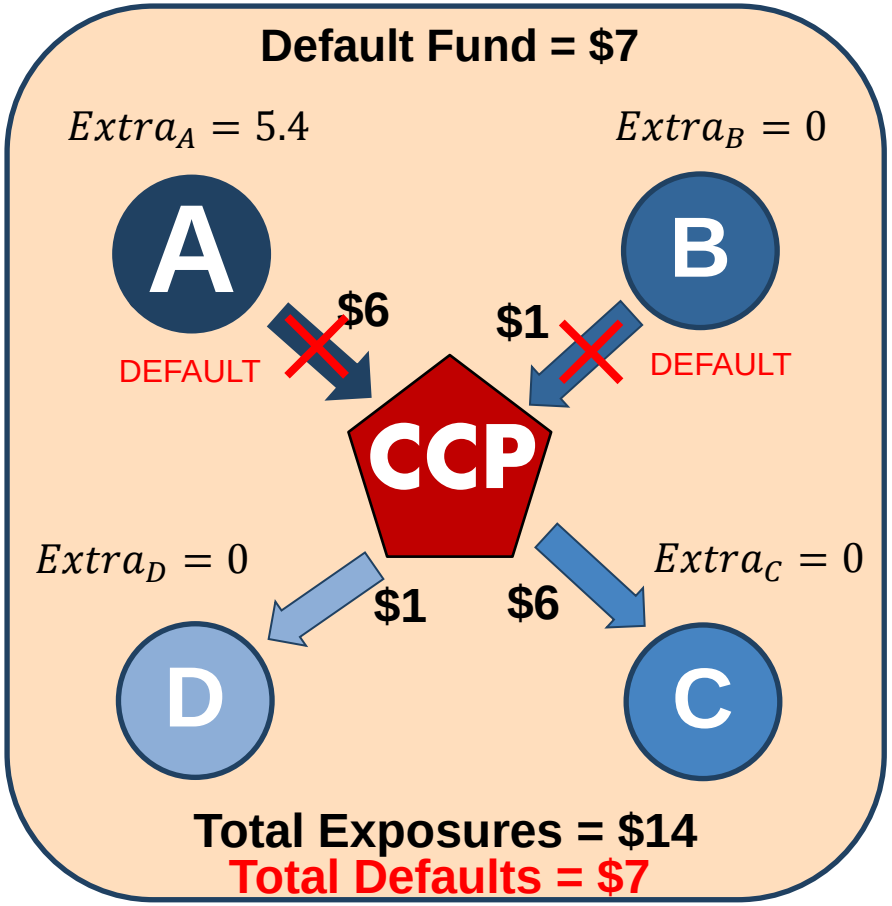

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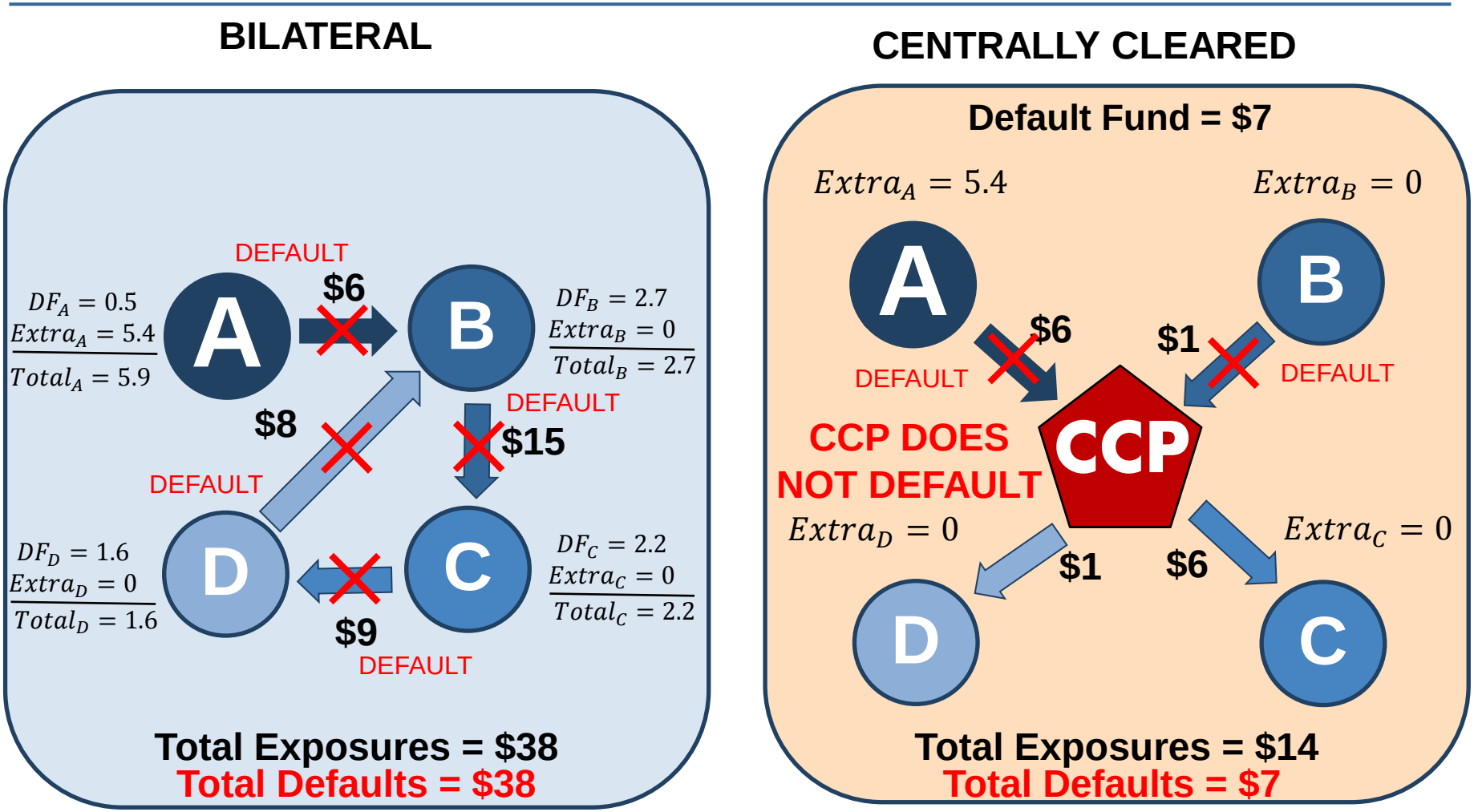

Example: Cost of Default Fund

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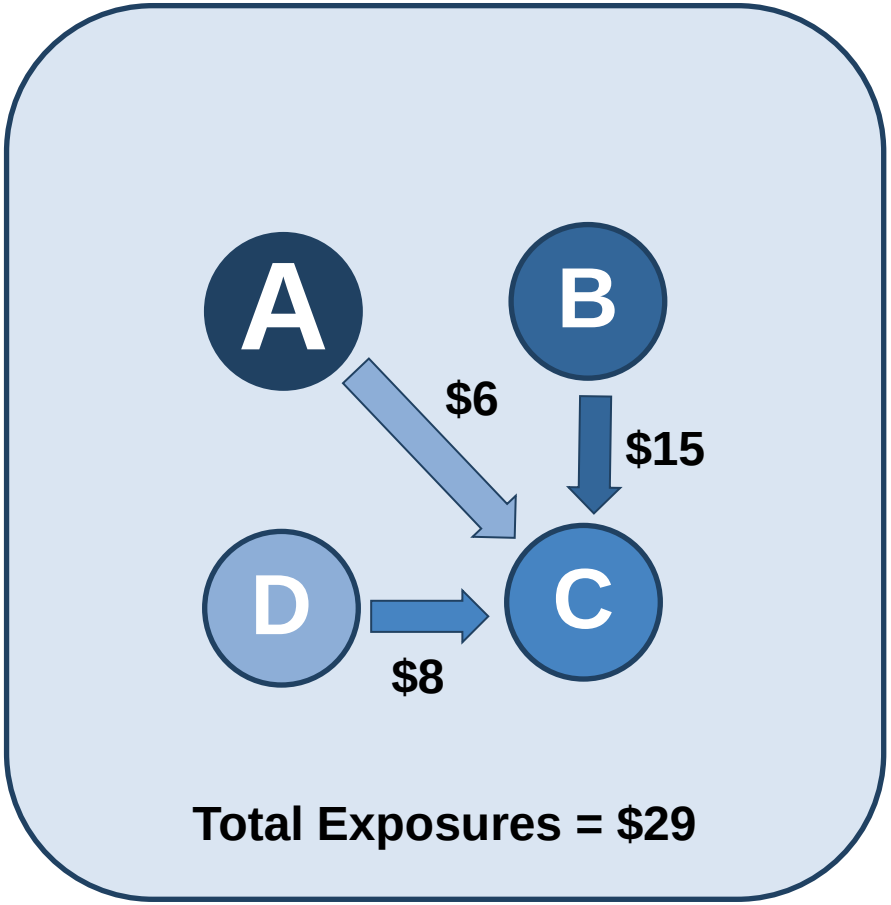

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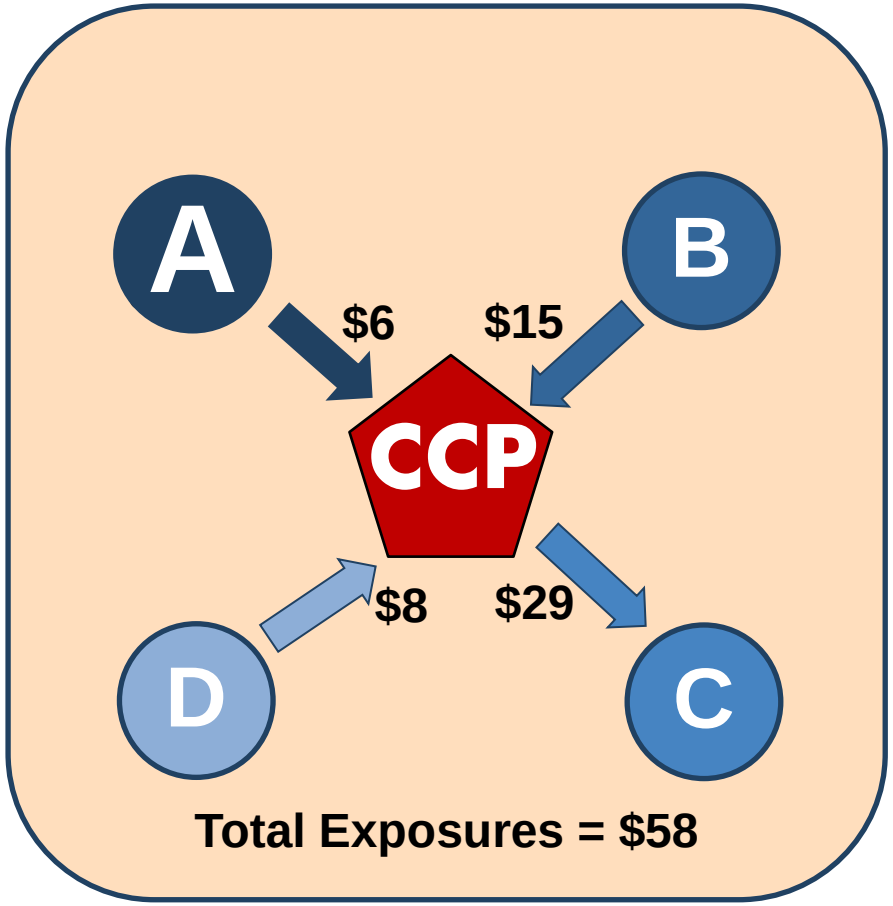

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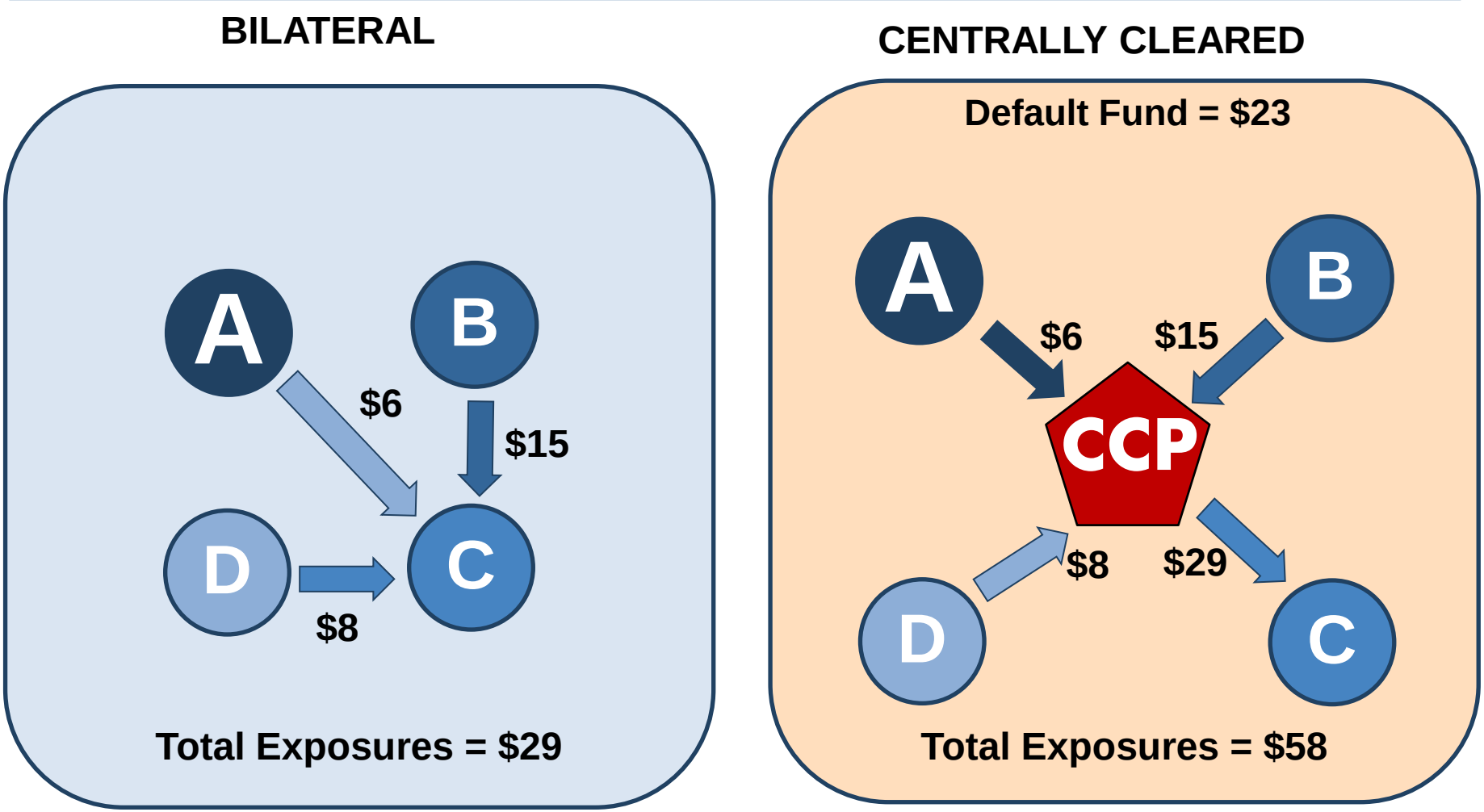

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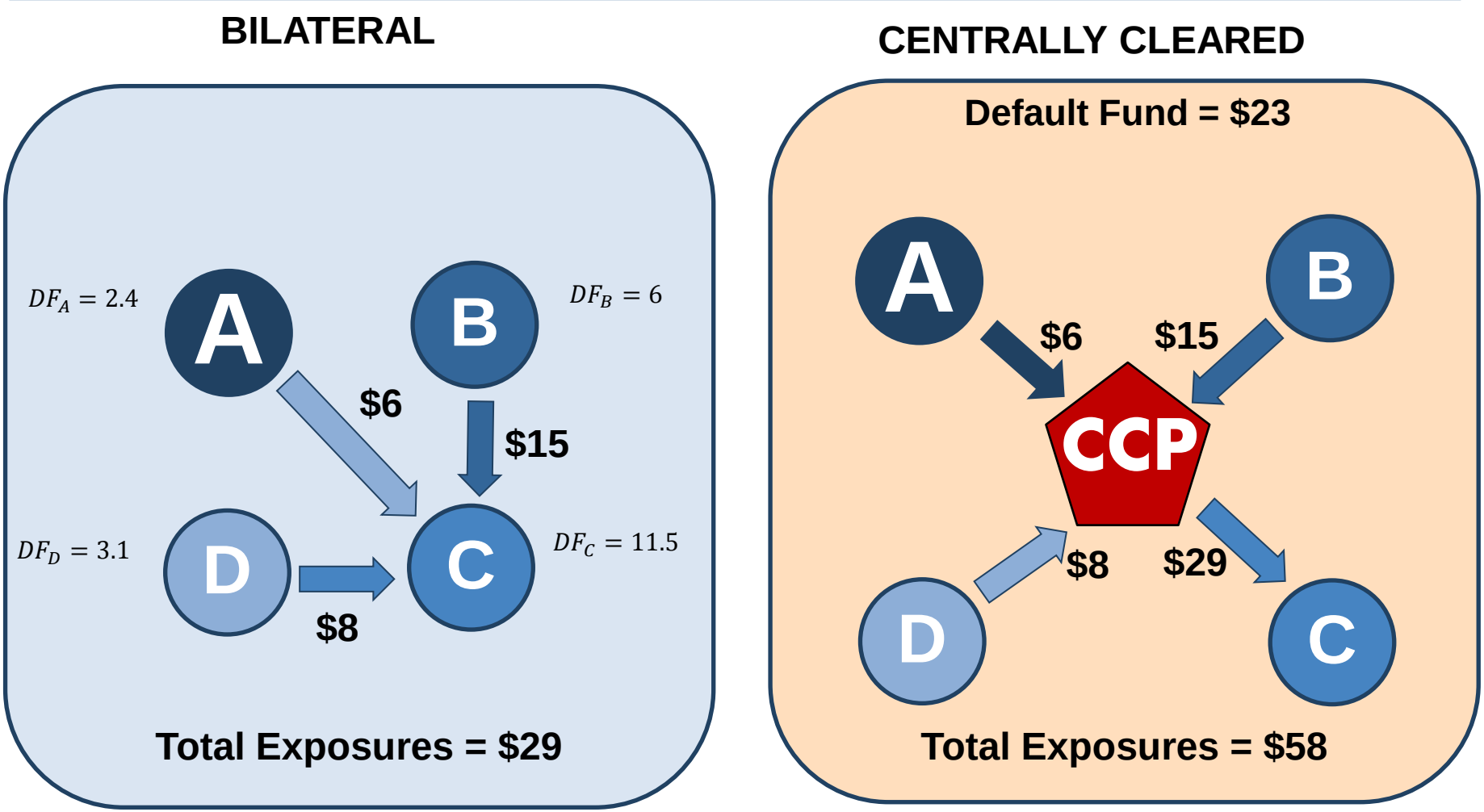

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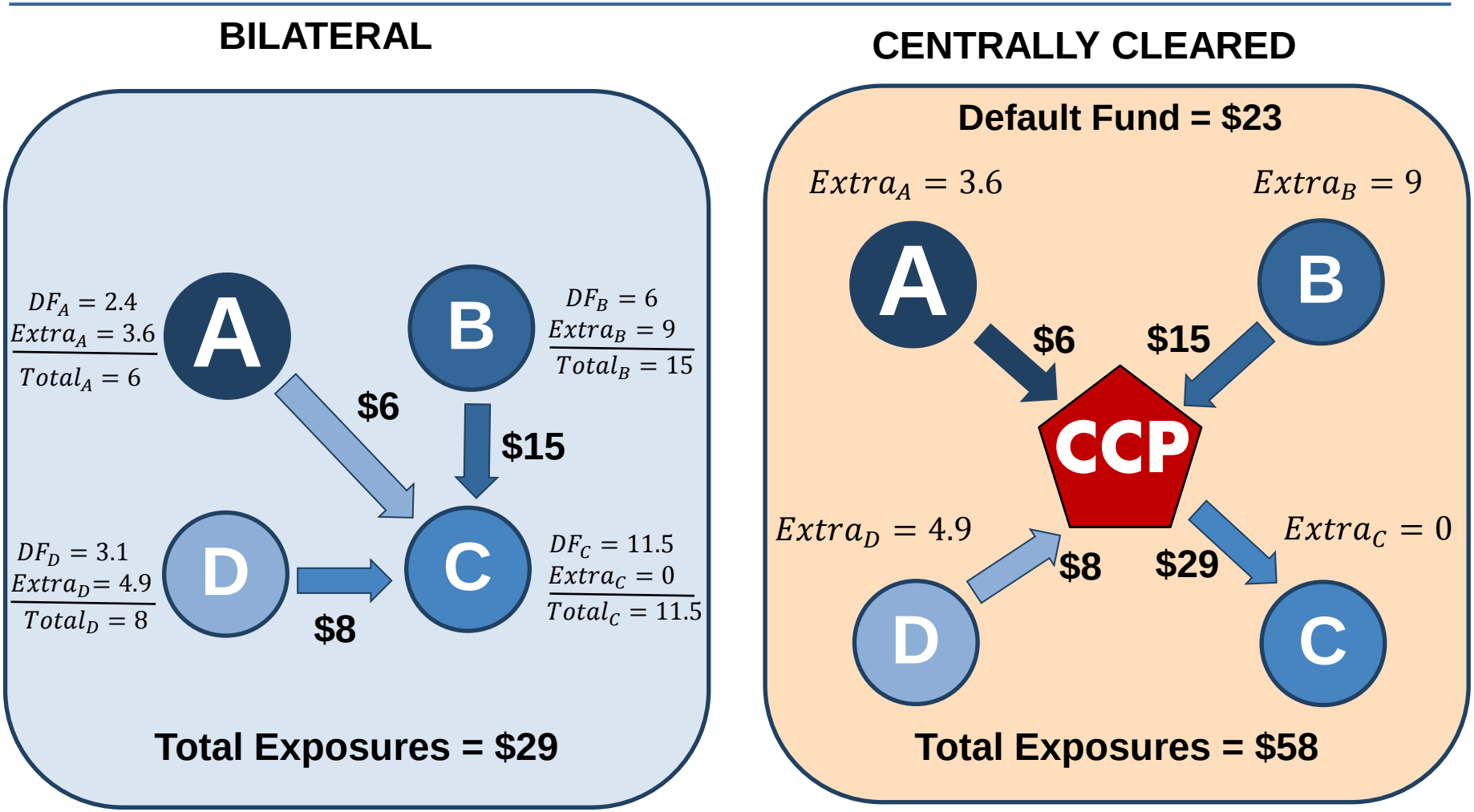

Cost of Default Fund – Stress A

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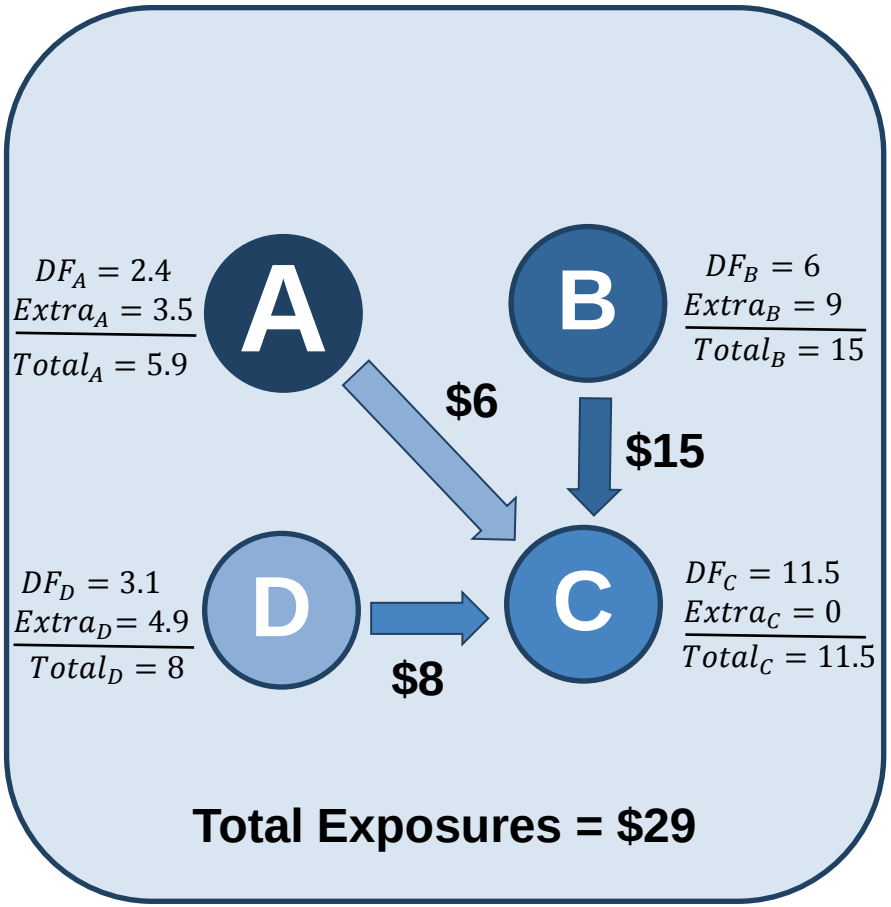

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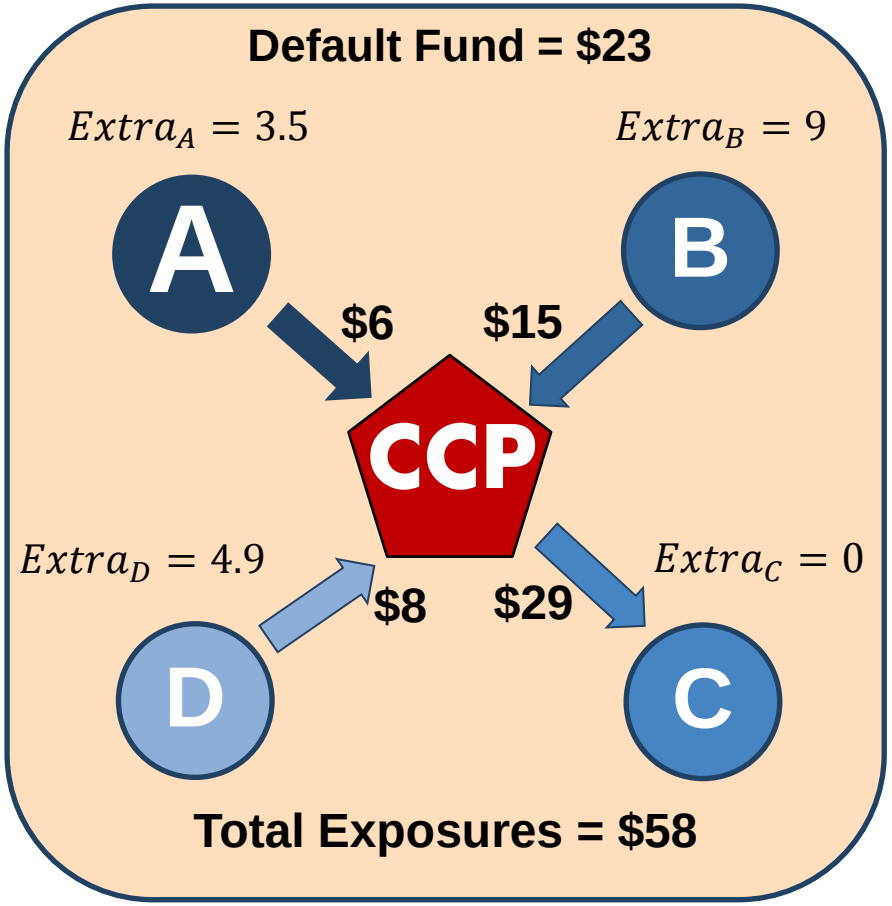

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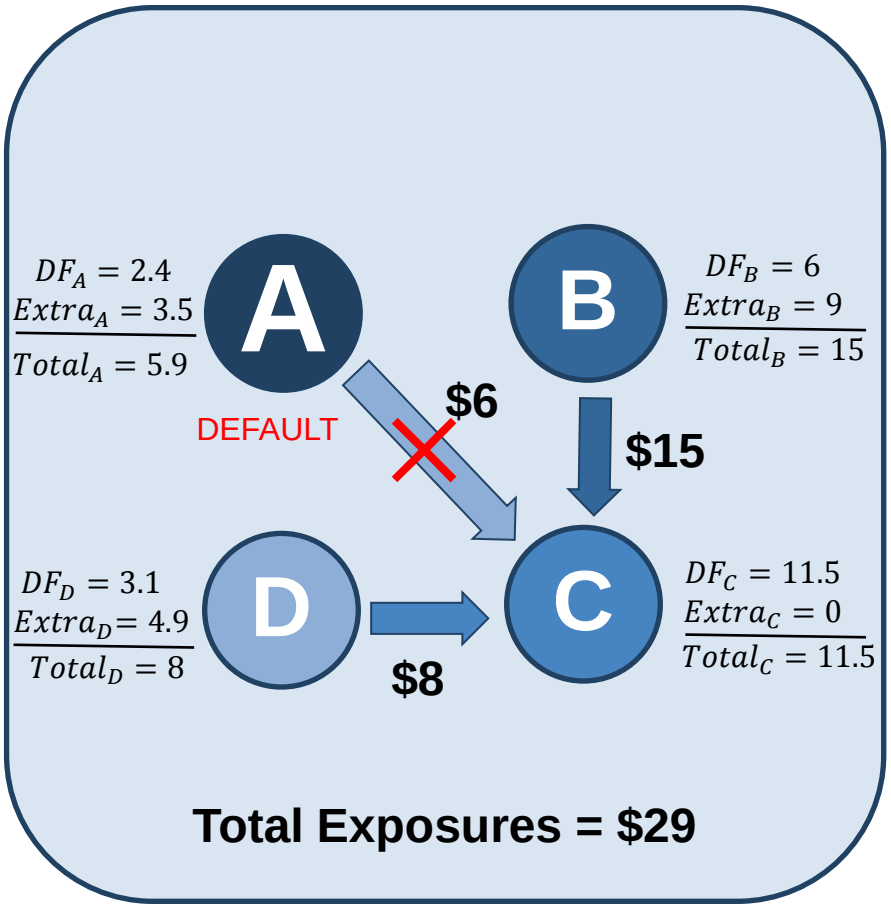

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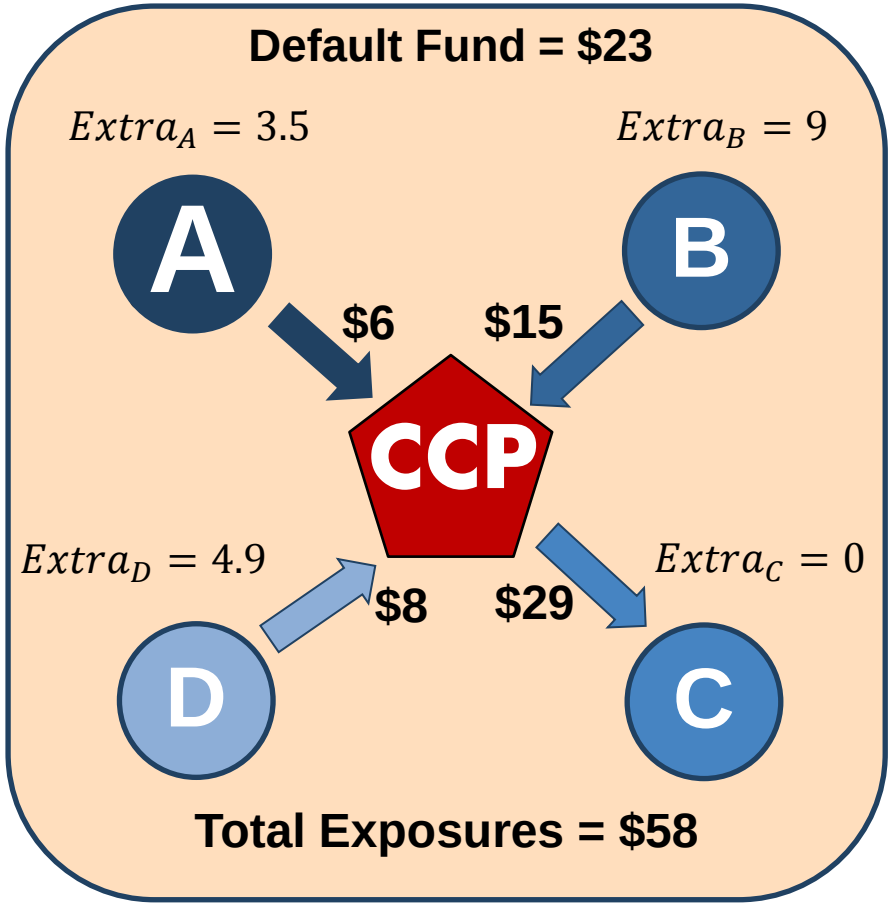

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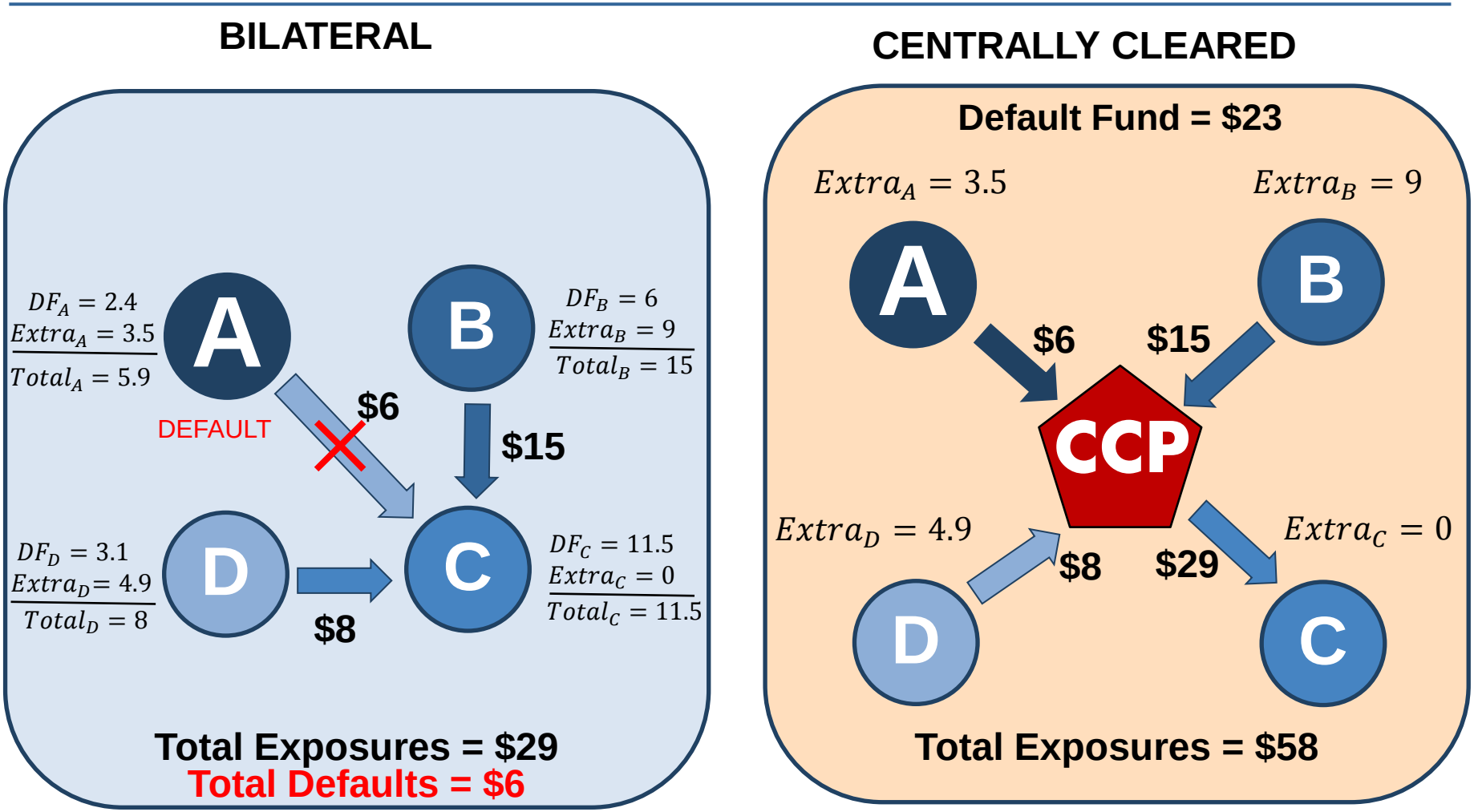

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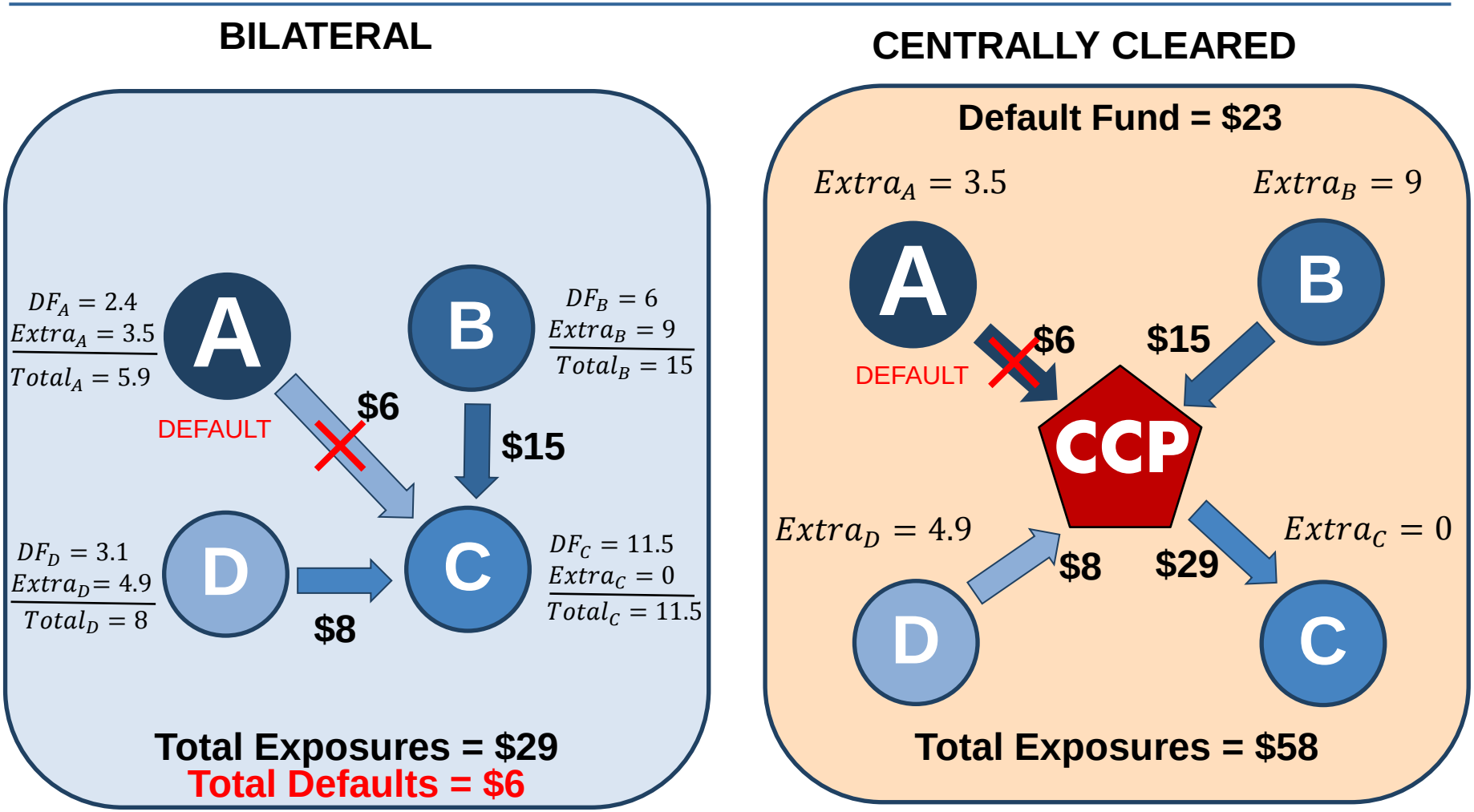

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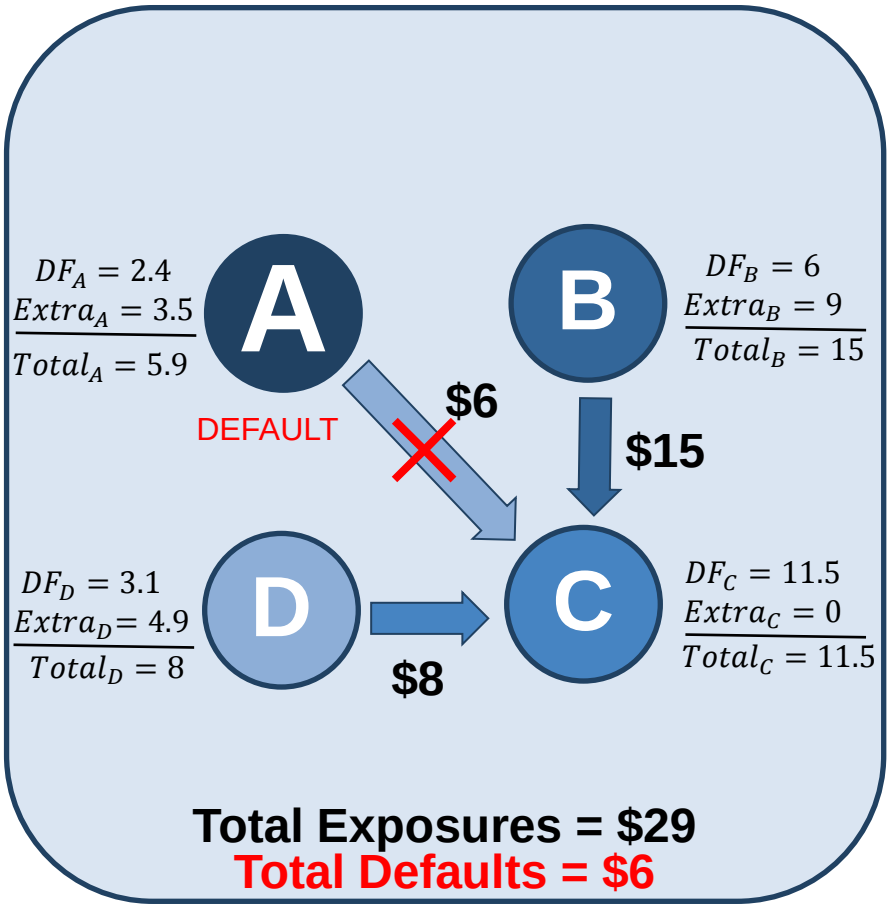

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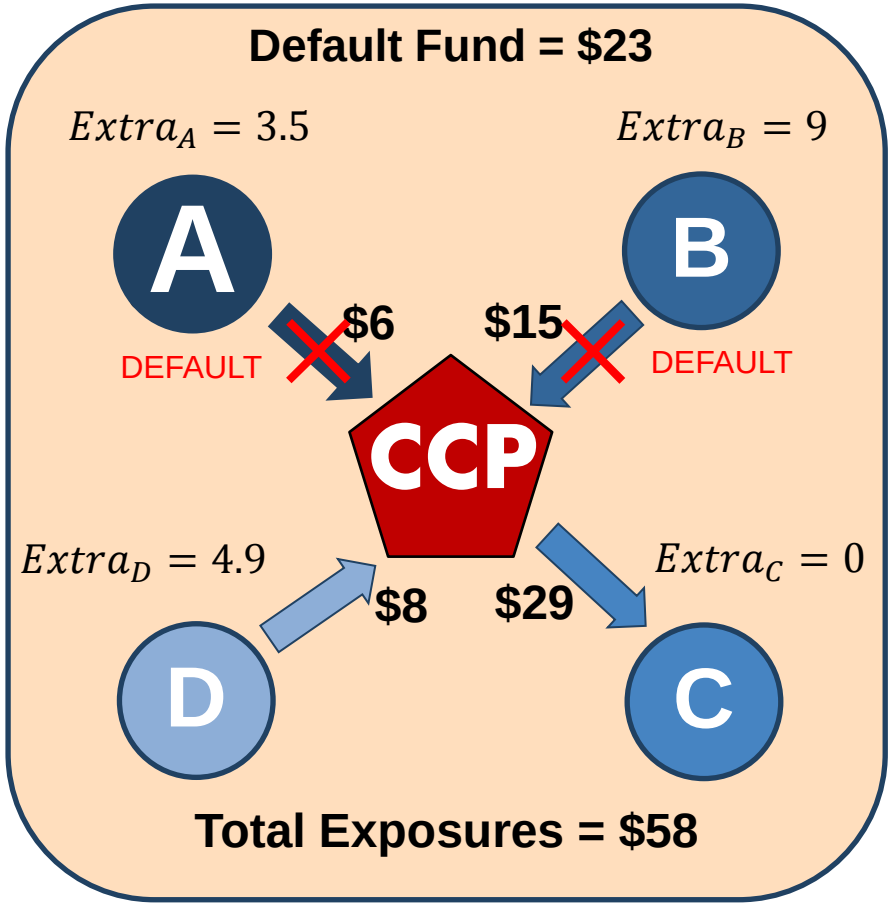

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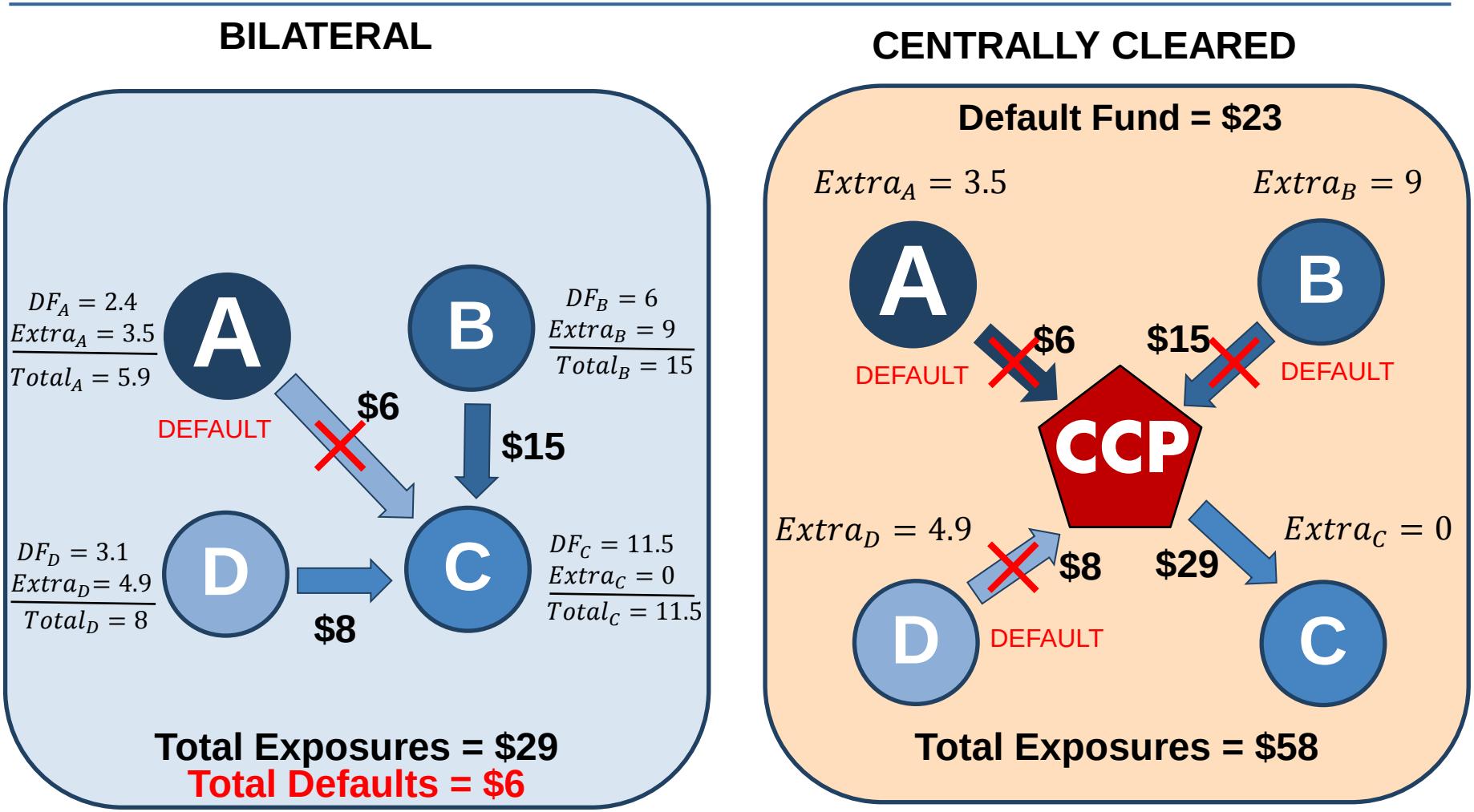
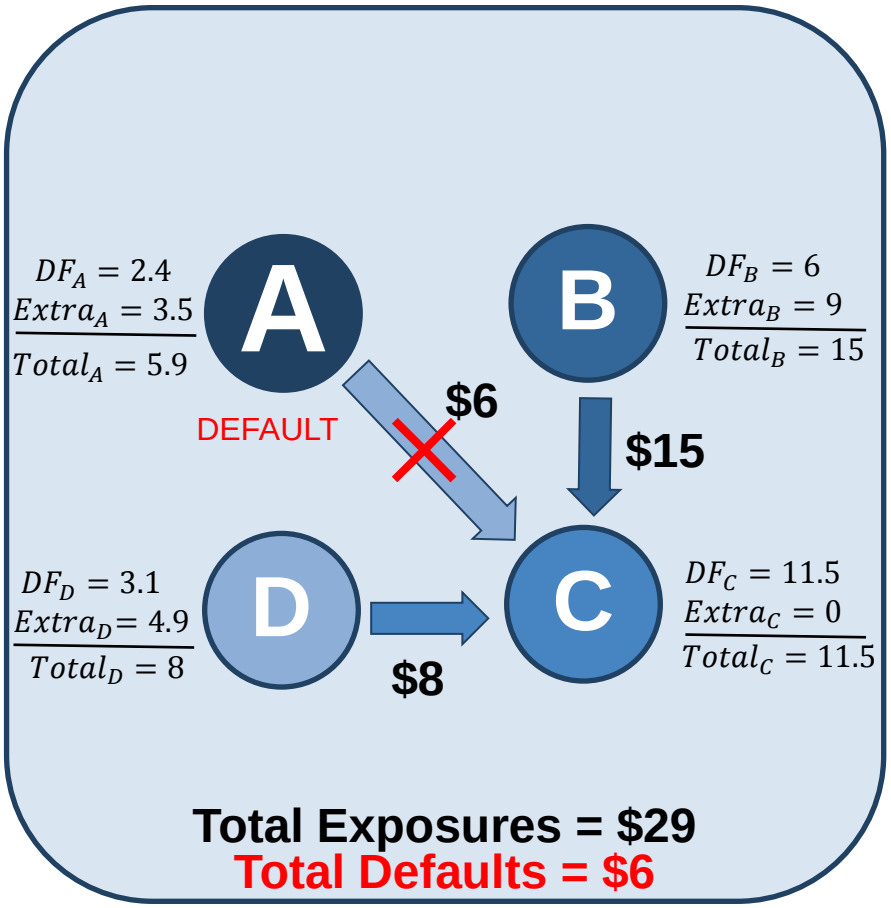
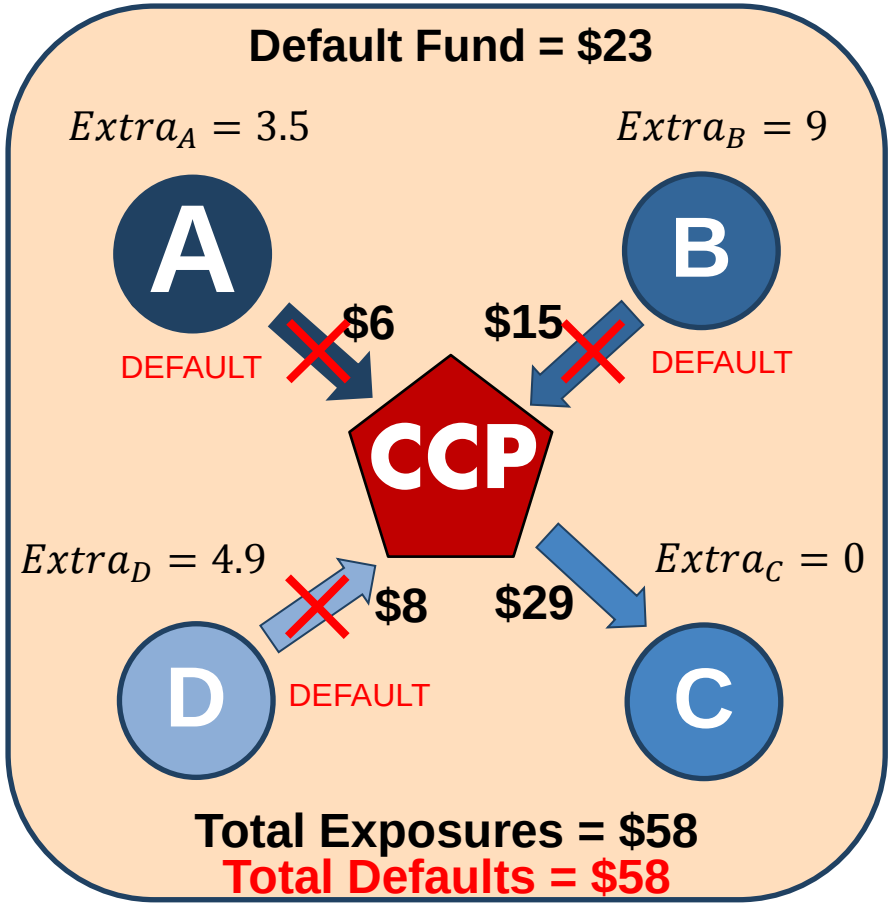


Cost of Default Fund – Stress A

BILATERAL



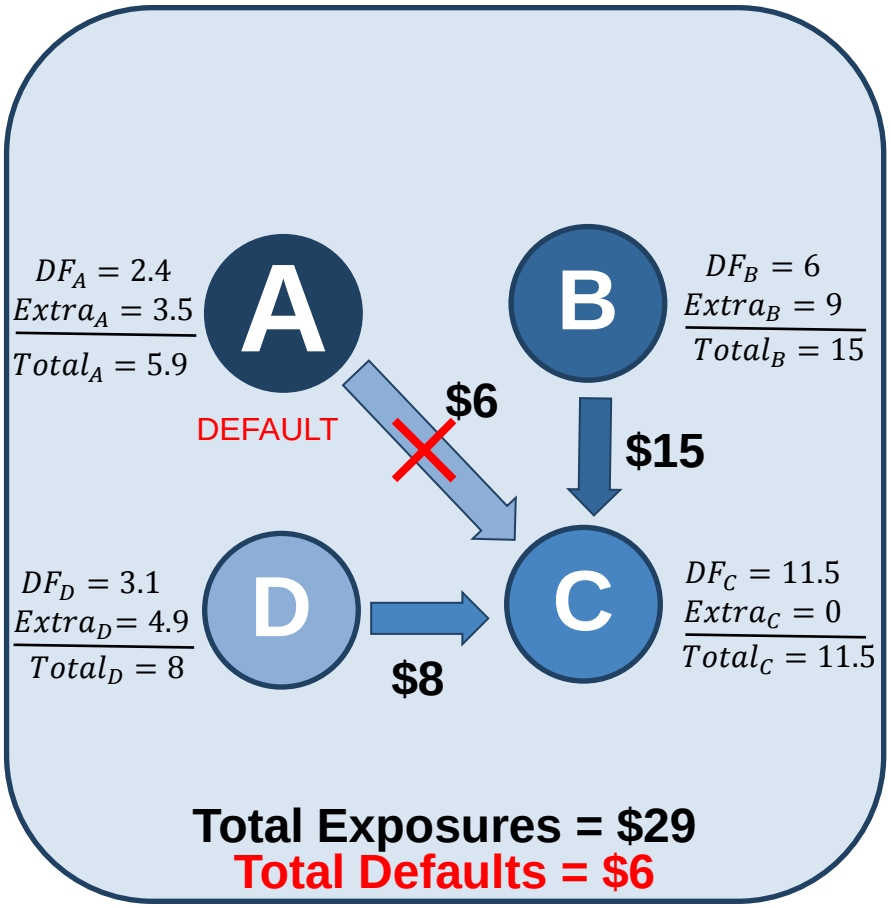
CENTRALLY CLEARED



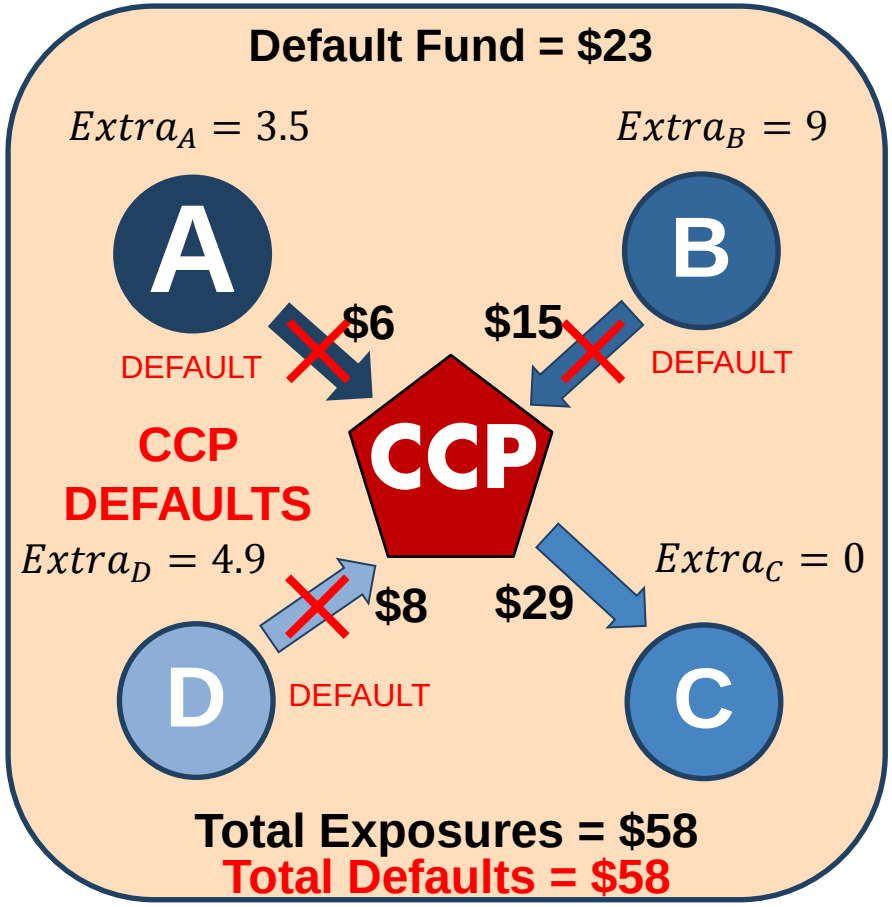
or = $35 if CCP pays pro rata

Cost of Default Fund – Stress A

BILATERAL



CENTRALLY CLEARED



or = $35 if CCP pays pro rata