Systemic risk

Networks and Contagion effects in Financial Markets
A research agenda

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Agenda

I define Systemic Risk as the risk of contagion in the Financial System

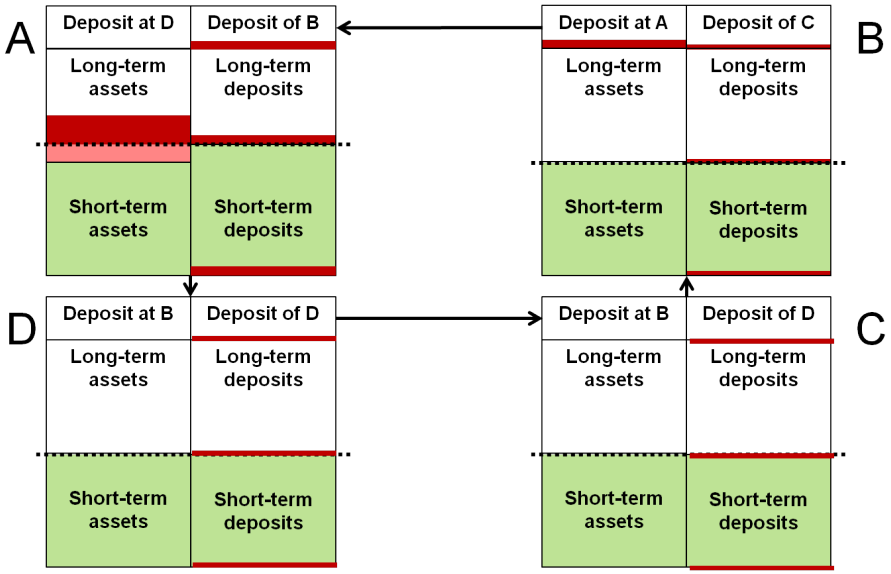
There is no commonly accepted definition of Systemic Risk, but contagion among financial institutions is often considered a central aspect:

- IMF: Systemic risk is defined as *"large losses to other financial institutions induced by the failure of a particular institution due to its interconnectedness"* (Global Financial Stability Report, April 2010)
- ECB: *"Systemic risk (in the narrow and broad sense) can then be defined as the risk of experiencing systemic events in the strong sense"*, i.e. *"institution(s) affected in the second round or later actually fail as a consequence of the initial shock, although they have been fundamentally solvent ex ante"* (ECB Working Paper 35, November 2000)

Financial contagion is concerned with the cascading of losses after a shock

F Allen, D Gale (2000) Financial contagion. Journal of Political Economy 108(1):1-33

- Consider a system financial institutions linked via bilateral loans
- A default of one institution creates losses for the creditors, potentially triggering a default cascade
- The existence of circles creates a simultaneity problem for finding the solution of the default cascade



Eisenberg/Noe show how to compute the result of a contagion scenario

L Eisenberg, T Noe (2001) Risk in Financial Systems. Management Science 47(2):236-249

Eisenberg/Noe consider a stylised balance sheet model:

- Every solvent bank fully repays its liabilities
- Every insolvent bank repays the remainder of its asset value
- i.e. insolvent banks transfer their other assets plus the payments they receive from debtor banks

Balance sheet of bank i	
Interbank claims: $\Pi'(p)_i$	Equity: $e_i + \Pi'(p)_i - \bar{p}_i$
Other assets: e_i	Liabilities: $\bar{p}_i$

They show that there exists a **clearing payment vector** p^*:

$$p^* = \begin{cases} \bar{p}_i & \text{if } e_i + (\Pi' p^*)_i \geq \bar{p}_i \\ e_i + (\Pi' p^*)_i & \text{otherwise} \end{cases}$$

Rogers/Veraart extend the Eisenberg/Noe-framework to include liquidation costs

L Rogers, L Veraart (2013) Failure and rescue in an interbank network. Management Science 49(4):882-898

Rogers/Veraart introduce several adaptions to the Eisenberg/Noe-algorithm:

- Recovery value under default $\alpha \in [0,1]$ for other assets
- Recovery value under default $\beta \in [0,1]$ for interbank assets
- General shock $\gamma \in [0,1]$ to other assets

$$p^* = \begin{cases} \bar{p}_i & \text{if } \gamma e_i + (\Pi' p^*)_i \geq \bar{p}_i \\ \gamma\alpha e_i + \beta(\Pi' p^*)_i & \text{otherwise} \end{cases}$$

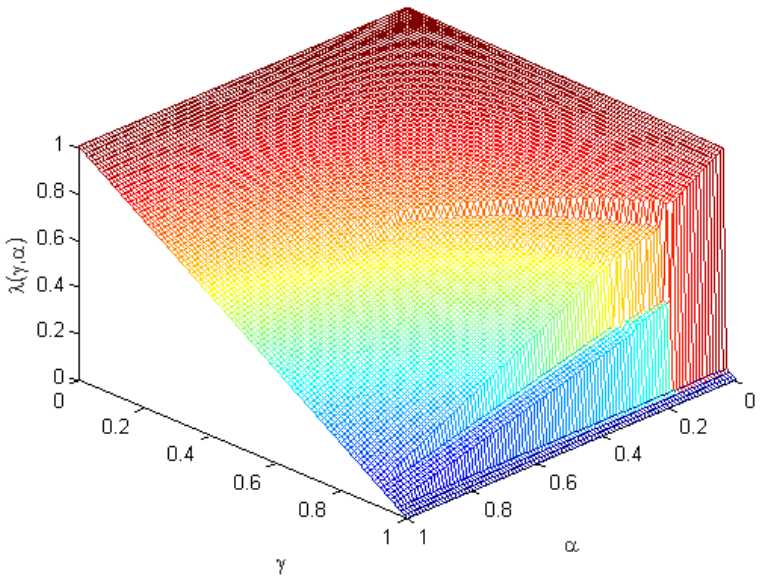
They define a bailout as a merger and show that bailout incentives exist only if there are liquidation costs, i.e. either $\alpha < 1$ or $\beta < 1$

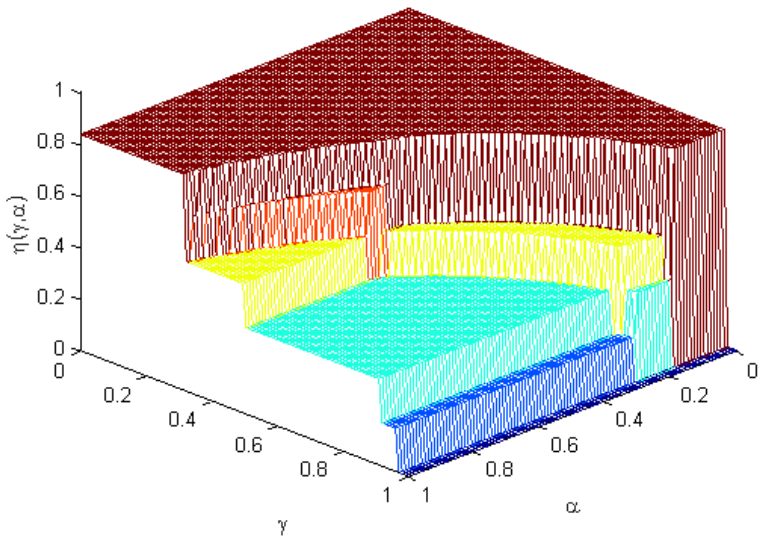
Rogers/Veraart propose a method for visualizing systemic risk

L Rogers, L Veraart (2013) Failure and rescue in an interbank network. Management Science 49(4):882-898

For a given financial system, plot the two functions (example):

- $\lambda(\gamma, \alpha)$ for the fraction of asset values lost
- $\eta(\gamma, \alpha)$ for the fraction of bankruptcies





Cifuentes et al. study the effects of fire sales under contagion on asset prices

R Cifuentes, G Ferrucci, H Shin (2005) Liquidity Risk and Contagion. Journal of the European Economic Association 3(2/3):556-566

The model:

- Banks hold liquid and illiquid assets, whereby only illiquid assets attract capital requirements
- If banks' capitalization falls under regulatory thresholds, banks have to sell the illiquid asset
- The price of the illiquid asset is determined by an inverse demand function $p = e^{-\zeta \sum_i s_i}$
- All banks are affected by the fall in the value of the illiquid asset

Simulation results:

- The forced sale of illiquid assets increases price cyclicality
- Spillover effects increase the number of defaults after a shock

Caccioli et al. perform an empirical analysis of contagion effects

F Caccioli, JD Farmer, N Foti, D Rockmore (2015) Overlapping portfolios, contagion and financial stability. Journal of Economic Dynamics and Control 51:50-63

Caccioli et al. perform an empirical analysis using quarterly data on the Austrian interbank network from 2006-2008
They study the impact of a general and idiosyncratic shocks under two different mechanisms:

- The result of a depreciation of a common asset, followed by a default cascade
- An individual bank is assumed to be bankrupt, triggering contagion and fire sales. Every defaulted bank causes further devaluation of the common asset

The results of these simulations are plotted against together with the pure effects of the asset devalution, to highlight the impact of network effects

Caccioli et al. perform an empirical analysis of contagion effects

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Results (figures taken from Caccioli et al. 2015):

- Without fire sales, network effects do not play a significant role
- With fire sales, network effects play a very significant role

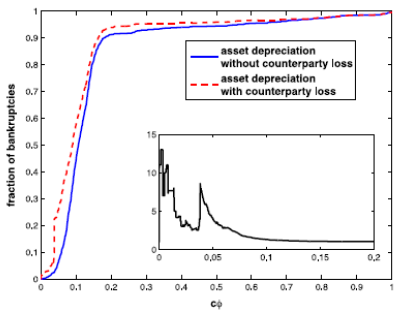

Figure: Without fire sales

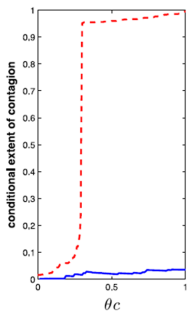

Figure: With fire sales

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Available data

- Confirmed: Quarterly data on full Austrian interbank network 08Q1-11Q4
- Confirmed: Stylized Balance sheet data on Austrian banks 08Q1-11Q4
- tbc: Detailed balance sheet, exposures and profit&loss data
- tbc: all above data until 14Q4

All data are confidential and not yet cleared, so no results can be shown yet

Empirical data analysis

Research questions

- Are network effects significant without liquidation costs?
- What impact does the network have under exogeneously/endogenously determined liquidation costs?
- What can be learnt from the Rogers/Veraart plots? Can the information be aggregated into a new systemic risk measure?
- How did the network evolve since the crisis?

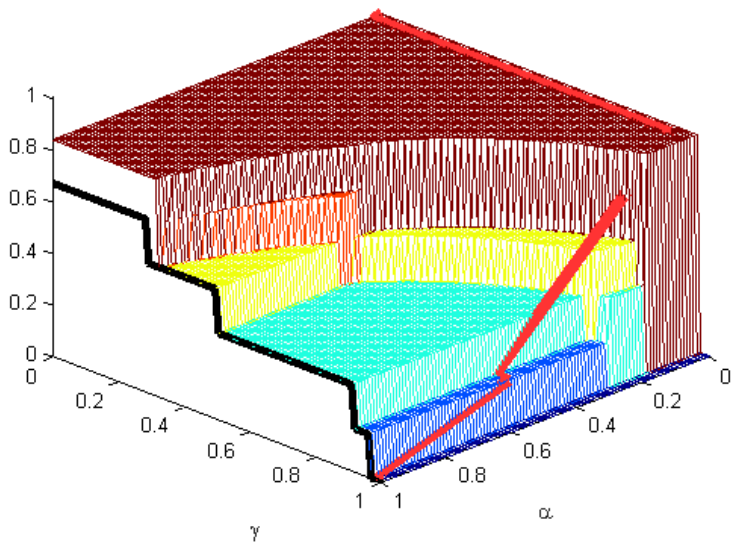
Methodology

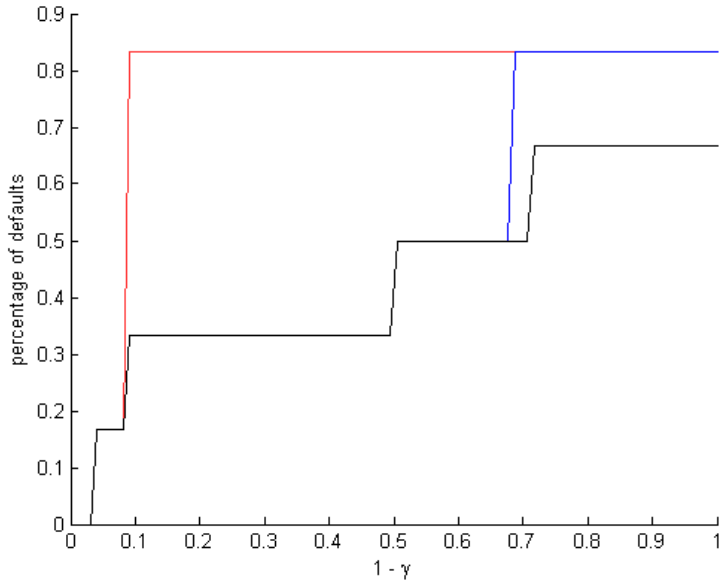
- Similar approach as in Caccioli et al., but employ the Rogers/Veraart algorithm (to solve the simultaneity problem correctly)
- Use a pricing mechanism as in Cifuentes et al. for endogenous price determination

Empirical data analysis

Sample output:

- Black line: impact without network effects
- Blue line: impact with network effects, without liquidation costs
- Red line: impact under endogenous liquidation cost determination
- Mesh: Rogers/Veraart plot





Inferring network information from micro-level data

Research questions

- What can be learnt from single-institution-level micro data about the systemic risk contribution of a bank?
- Potential data items: balance sheet structure (e.g. share of interbank activity), size, interest rate margin, Lerner index

Methodology

- Dependent variables: number of defaults caused by the bank, number of banks causing default and sum of losses caused
- Count variables: positive count-process panel regression
- Sum variable: fixed-effect panel regression

Welfare implications - Theoretical framework

Problem: why do policy-makers care about contagion?

- Without liquidation costs, the consolidated value of the system $\sum_i e_i$ does not change
- Liquidation costs of financial assets do not change their fair value $\rightarrow$ arbitrage for buyer, does not affect consolidated value

Resolution:

- There are non-financial costs from contagion
- Social objective function is to minimize $\sum_i \bar{p}_i - p_i^*$

Individual behavior:

- Banks can choose to transfer funds to defaulted banks to prevent contagion
- Banks want to maximize their equity value

Welfare implications - Results

- Social efficiency is guaranteed under very mild conditions
- Without resolution costs, there is still one possible bailout configuration that is individually rational for all banks
- *Note*: This result differs from the Rogers/Veraart result because the definition of rationality of a bailout here includes indifference
- However, in Nash equilibrium, no bank contributes towards a bailout
- There exists a policy intervention that is free of cost for the policy maker, socially efficient, individually rational and satisfies the conditions of a Pareto optimum

Further ideas

- Assess impact of mark-to-market accounting on crisis dynamics
  - Mark-to-market accounting forces all banks to recognize liquidation costs immediately, increasing contagion losses
  - Quantify the additional contagion impact
- Extend contagion methodology to include credit default swap
  - CDS constitutes an interbank claim between issuer and holder
  - Value of the claim changes under contagion according to fundamentals of the underlying
  - Use Merton model (PD*LGD) to capture changes in the value of the claim
  - Update the interbank network and compute new p^*
  - Potential access to data on European derivatives markets, though highly uncertain
- Use information on portfolio composition and study contagion risk under risk-based shocks

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Conclusion

Status quo:

- Systemic risk is a highly topical issue since the financial crisis
- Theoretical literature on systemic risk focuses on contagion effects
- Interbank data needed for analyzing systemic risk is rare, empirical studies often try to estimate networks e.g. from market data
- I have access to a rare, very rich data set

Research agenda:

- Explore the available data empirically, using methods from the theoretical literature as well as econometric methods
- Contribute to theoretical literature by studying the phenomenon of bailouts from a social and individual perspective

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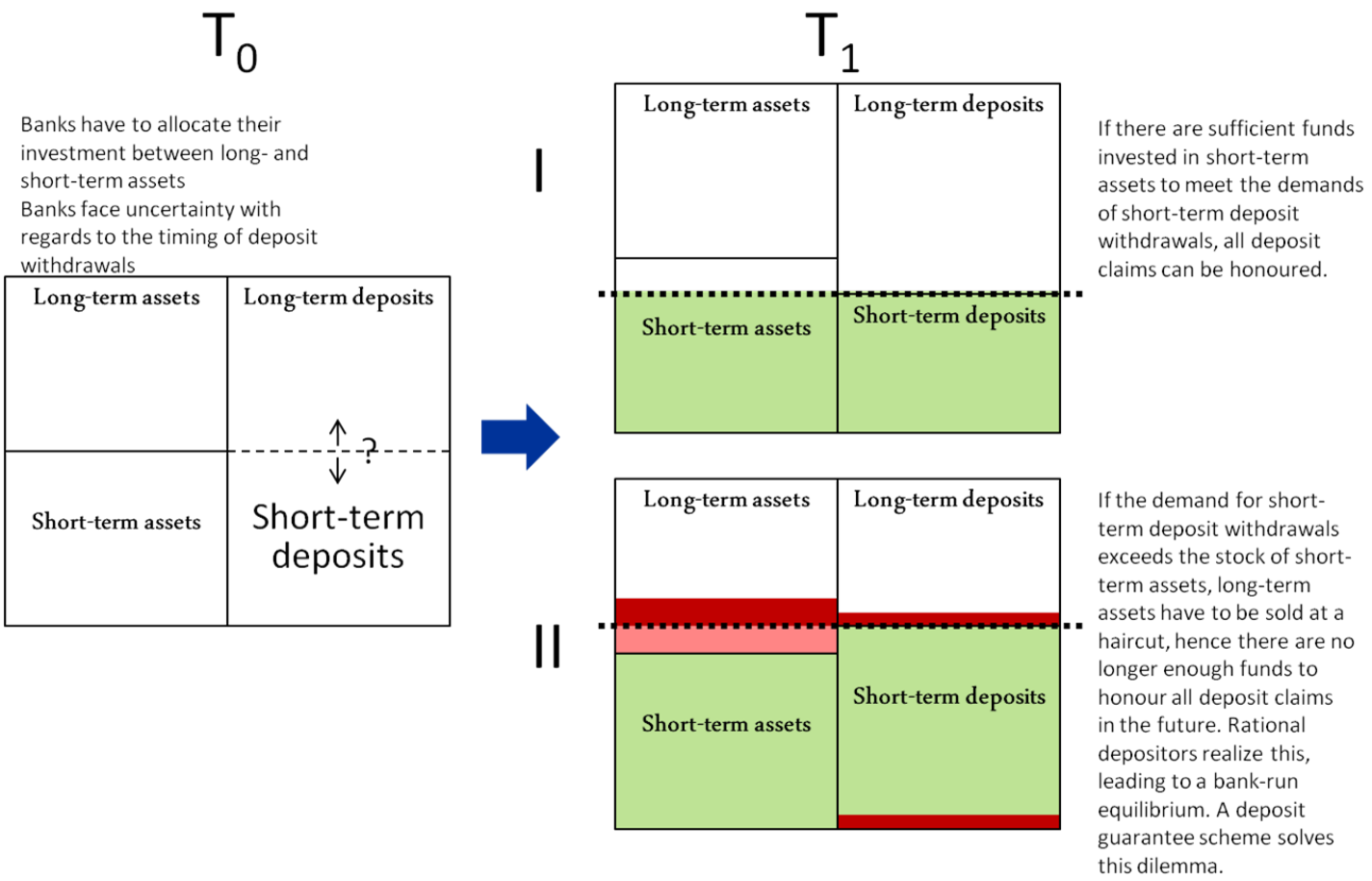
4 Appendix

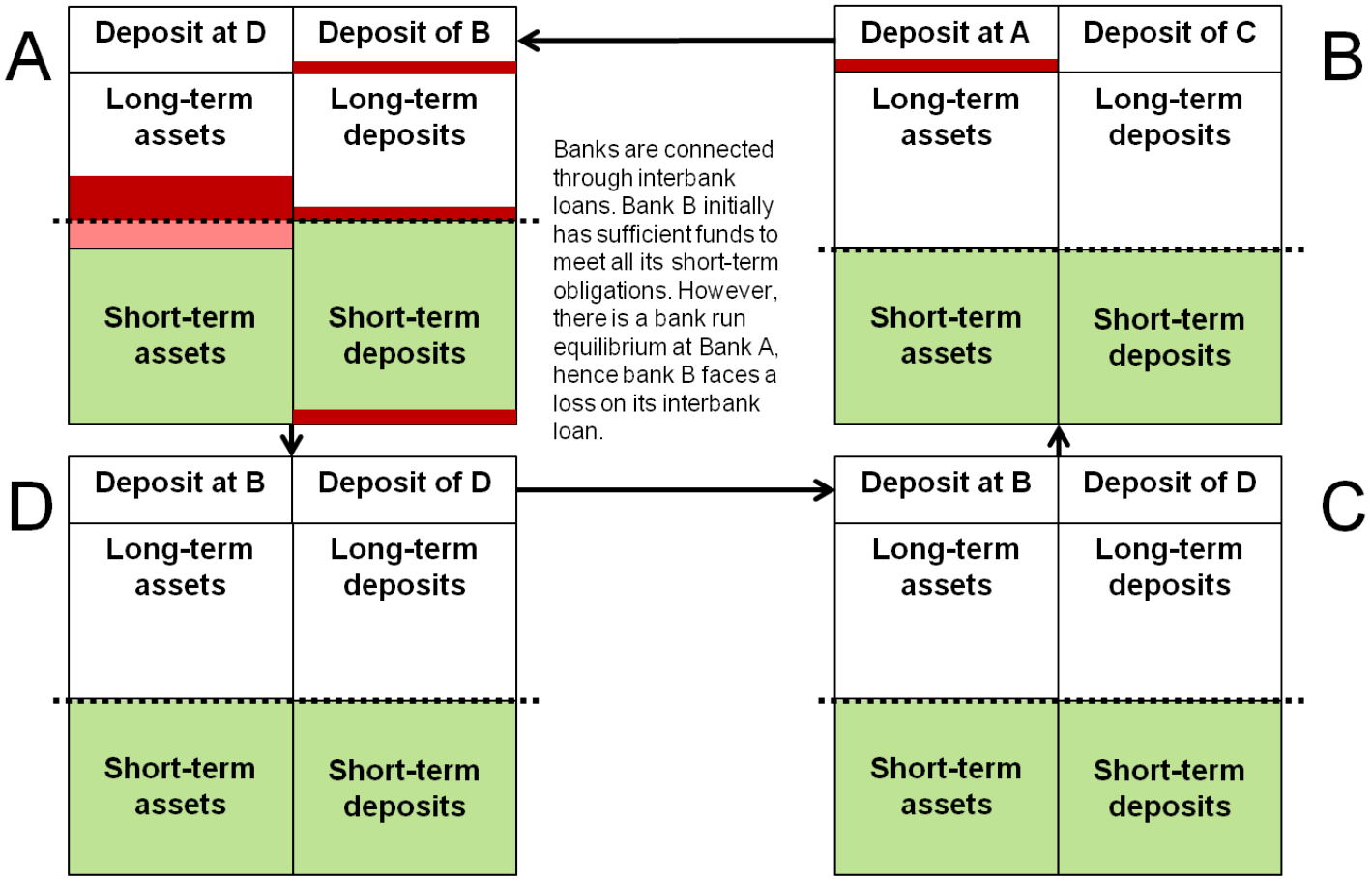
Diamond/Dybvig show that rational behaviour can lead to a bank run

[Diamond1983]



Allen/Gale show that interbank loans can act as a multiplier of losses through default cascades 1/2

[Allen2000]



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