Market Liquidity and Financial Fragility

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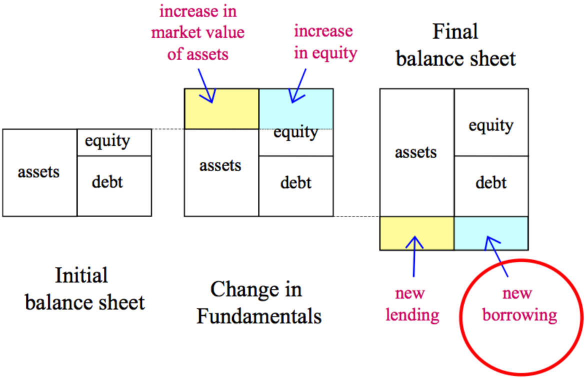
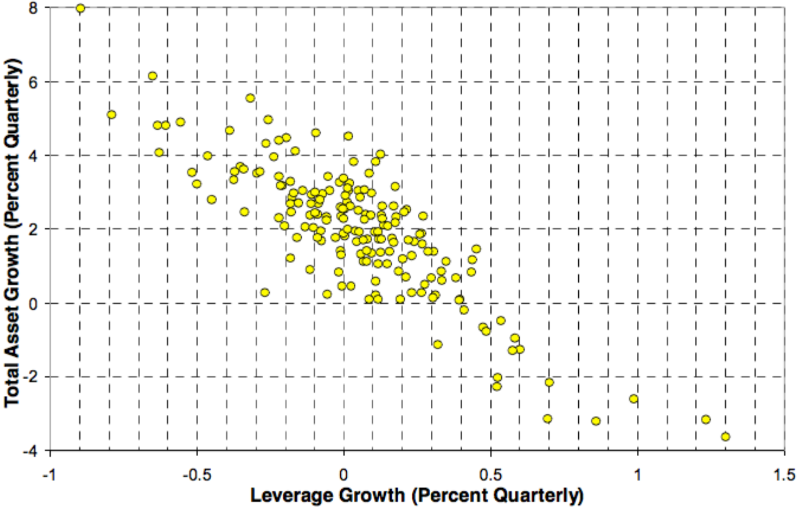
Motivation

- Excess market liquidity, in the form of easy access to credit and the easiness of buying and selling assets, seems to precede financial crises
- Market liquidity is heavily influenced by government and central bank policies, e.g. monetary policy
- Through their actions, therefore, governments and central banks around the world affect the likelihood of crises
- 2007-2009 global financial crisis showed the need to design and implement macro-prudential policies, by definion focusing on measures of systemic risk
- As far as a measure of systemic risk is concerned, the topology of financial markets matters, making network analysis very suitable
- Question: how government and central bank policies (by affecting market liquidity) impact systemic risk (by leading to changes in financial networks)?

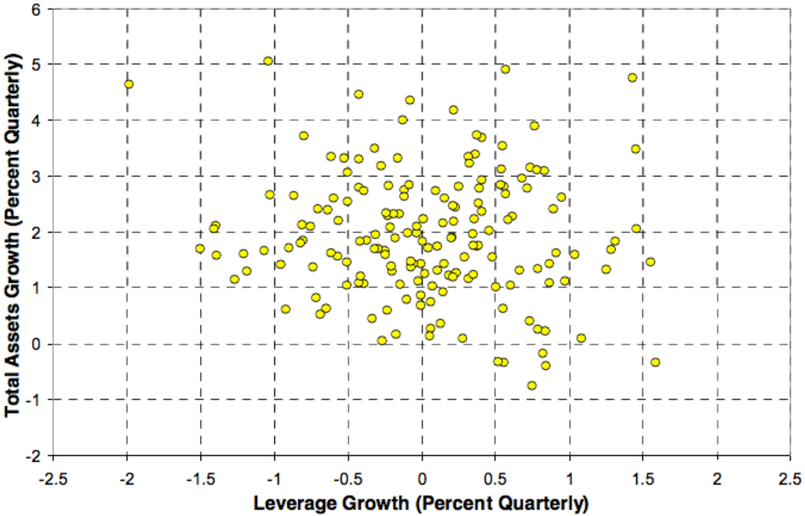
Financial Intermediaries' Balance-Sheet (Shin, 2009)



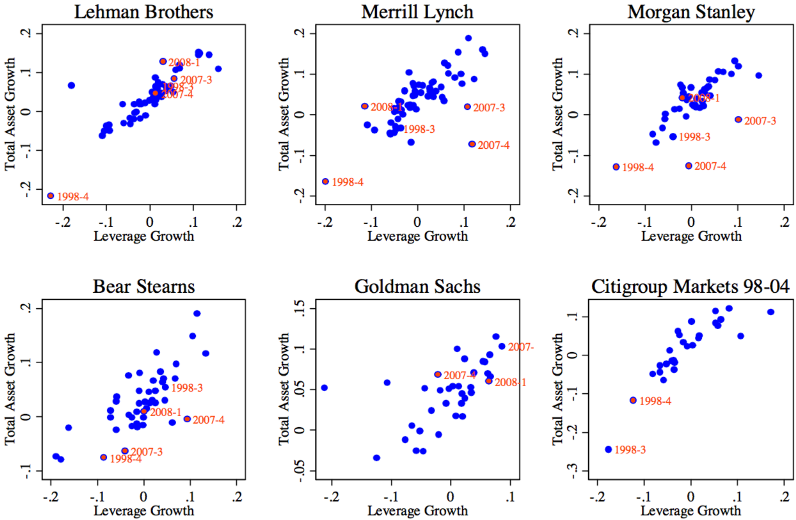
Liquidity and Leverage (Adrian & Shin, 2008): HHolds



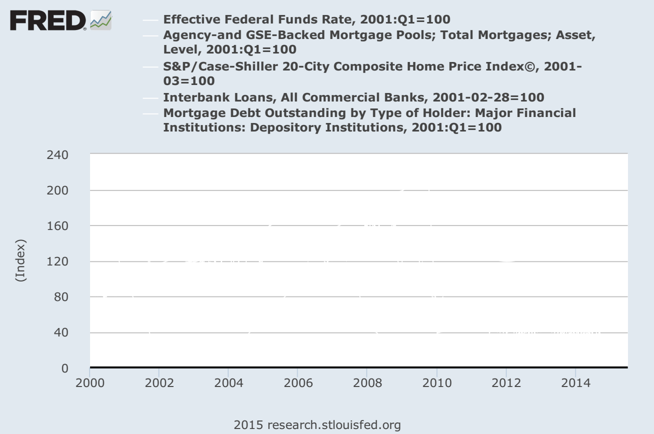
Liquidity and Leverage (Adrian & Shin, 2008): CBanks



Liquidity and Leverage (Adrian & Shin, 2008): IBanks



Liquidity and Interbank Lending



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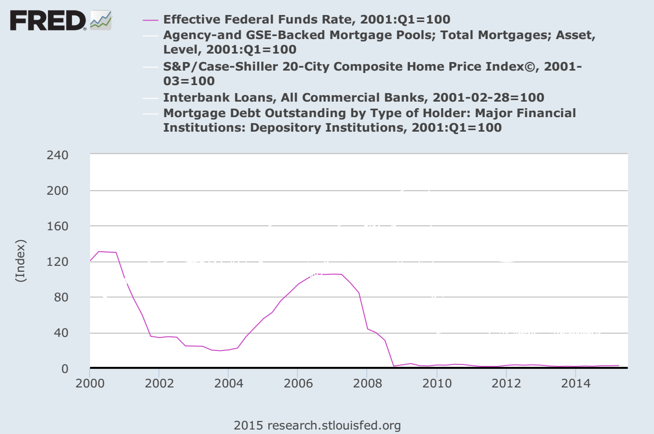

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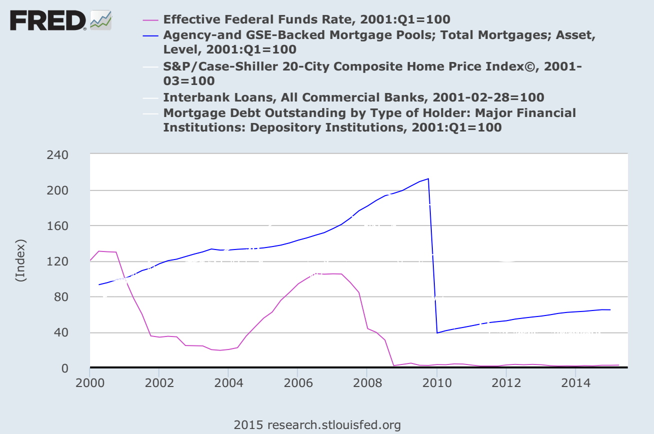
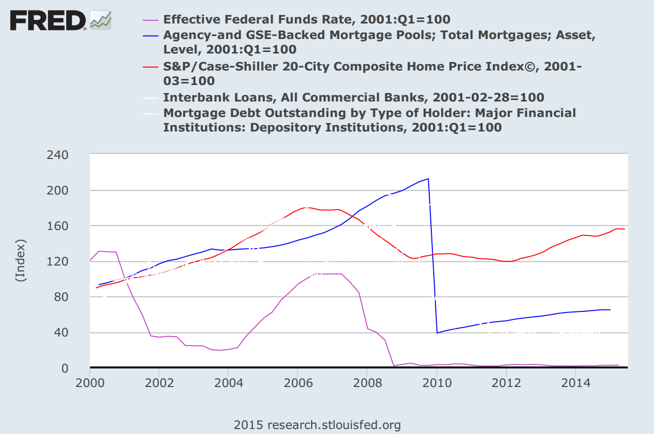


Liquidity and Interbank Lending



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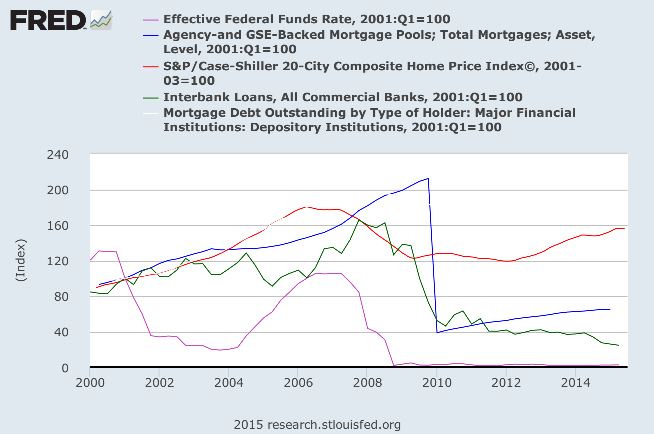
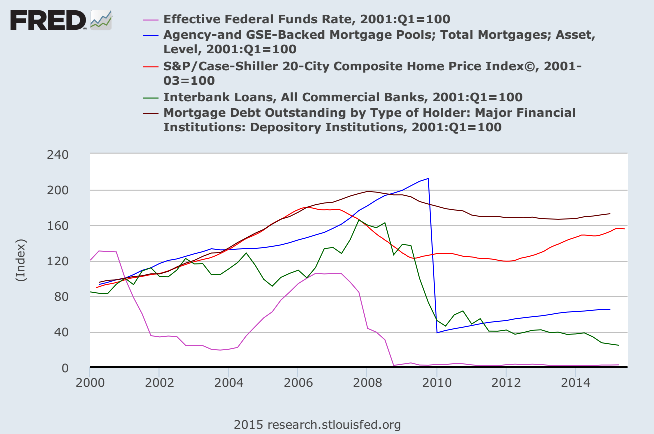


Liquidity and Interbank Lending



Related Literature

- **Financial crises:**
  - Diamond and Dybvig (JPE, 83); Shleifer and Vishny (JF, 92); Allen and Gale (EJ, 00), Abreu and Brunnermeier (ECTA, 03); Geanakoplos (NBER, 10); Brunnermeier and Pedersen (RFS, 09); Morris and Shin (AER, 98), He and Xiong (RFS, forth); Caballero and Krishnamurthy (JF, 08), Mendoza and Quadrini (JME, 10), Mendoza (AER, 10);
- **Financial networks:**
  - Rochet and Tirole (JMCB, 96), Kyiotaki and Moore (97), Allen and Gale (JPE, 00), Freixas et al (JMCB, 00), Eisenberg and Noe (MS, 01), Lagunoff and Schreft (JET, 01), Cifuentes et al (JEEA, 05), Nier et al (JEDC, 07), Brusco and Castiglionesi (JF, 07), Caballero and Simsek (11), Zawadowski (11);
- **Network formation:**
  - Leitner (JF, 05), Babus (09), Castiglionesi and Navarro (11), Cohen-Cole et al (11);
- **Government intervention:**
  - Huang and Xu (EER, 99), Gorton and Huang (AER, 04), Schneider and Tornell (RES, 04), Corsetti et al (JME, 06), Morris and Shin (JIE, 06), Acharya and Yorulmazer (JFI, 07), Ennis and Keister (AER, 09), Diamond and Rajan (11), Farhi and Tirole (AER, forth).

Network Structures (Allen & Gale, 2000): Complete

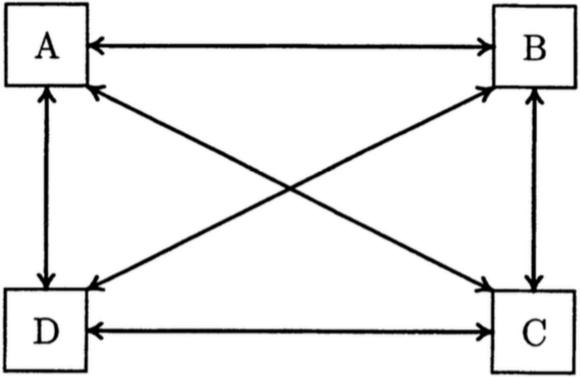


FIG. 1.—Complete market structure

Network Structures (Allen & Gale, 2000): Incomplete

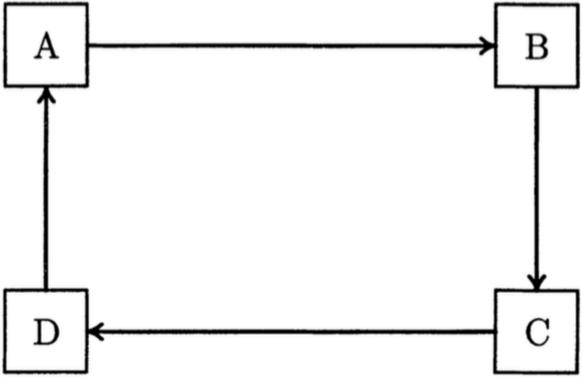


FIG. 2.—Incomplete market structure

Network Structures (Allen & Gale, 2000): Disconnected

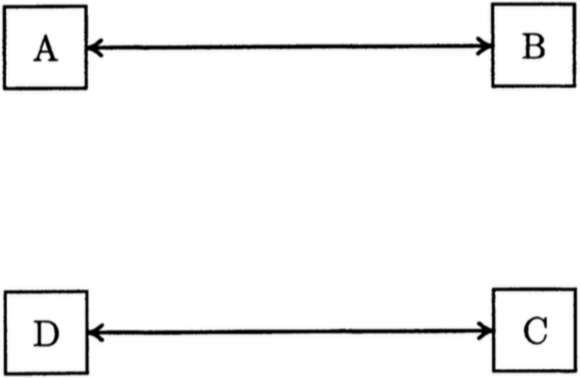
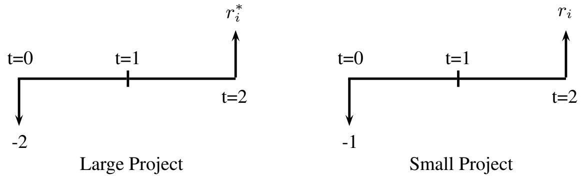


FIG. 3.—Disconnected incomplete market structure

Model

- 1-good (\$), three-period economy, $t = 0, 1, 2$;
- Economy divided in N regions, $N = \{1, \ldots, N\}$;
- Each region has a representative bank from $\mathbb{B}^N = \{B^1, \ldots, B^N\}$
- Any bank has available two types of long-term, positive NPV projects:
  - A large project that pays r_i^* at $t = 2$ and costs \$2 at $t = 0$;
  - A small project that pays r_i at $t = 2$ and costs \$1 at $t = 0$.



- Regions have continuums of depositors, each with \$1 and utility:

$$U^i(c_1, c_2) = \begin{cases} c_1, & \text{with probability} \quad \omega_i, \\ c_2, & \text{with probability} \quad 1 - \omega_i. \end{cases}$$

Banks' Interaction Process

- At date 0, banks meet each other, randomly, in a pairwise fashion
- Assuming an even number N of banks, there will be $N-1$ rounds of interaction, so that, with four banks,

$$\text{Round 1: } \left(B^1 \leftrightarrow B^2, B^3 \leftrightarrow B^4\right)$$
$$\text{Round 2: } \left(B^1 \leftrightarrow B^3, B^2 \leftrightarrow B^4\right)$$
$$\text{Round 3: } \left(B^1 \leftrightarrow B^4, B^2 \leftrightarrow B^3\right)$$

- At each round of interaction, banks collect \$1 from depositors, receive e_i as an equity endowment, and with that they decide whether to:

  (i) Invest in a small project;
  (ii) Borrow from the other bank to invest in a large project;
  (iii) Lend to the other bank.

Maturity Mismatch

- Banks partially finance long-term investments (projects or loans) with short-term funds (from early depositors)
- Banks are assumed to be cash-constrained at t=1, i.e., they are forced to sell - before maturity - a fraction of the investment in projects and loans in order to service early depositors
- Premature sell of assets at $t = 1$ comes at a fire-sale cost:
  (i) One unit of payoff of a large project can be sold at $\rho^* < 1$;
  (ii) One unit of payoff of a small project can be sold at $\rho < 1$.
- Large projects are most costly to be prematurely liquidated:

$$0 < \rho^* < \rho < 1.$$

Government Intervention

- Government reduces fire-sale costs by enhancing the market liquidity of projects and loans at $t = 1$
- Discount factors associated with the premature sell of assets are now:

  (i) Large projects: $\rho^* + \gamma^* (1 - \rho^*)$;
  (ii) For small projects, $\rho + \gamma (1 - \rho)$.

- No government intervention, $\gamma^* = \gamma = 0$: original fire-sale cost
- Full government intervention, $\gamma^* = \gamma = 1$: no fire-sale cost
- Too-big-to-fail policy: $\gamma^* > \gamma$

Effect of Government Intervention on Liquidity

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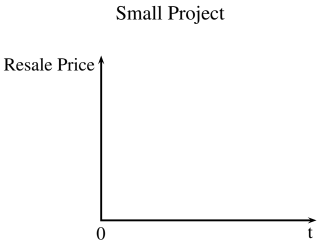
Small Project

Large Project

Effect of Government Intervention on Liquidity



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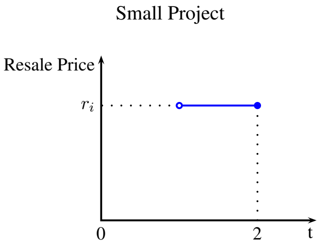

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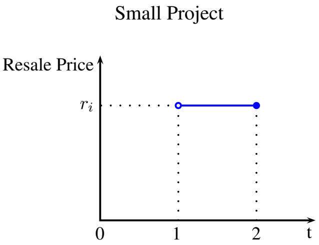

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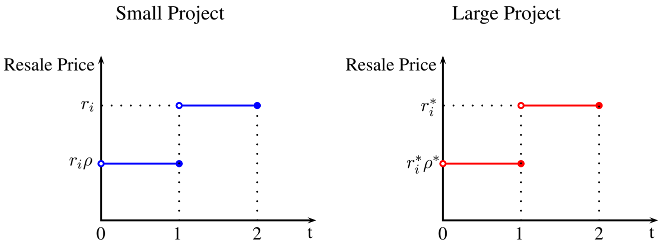

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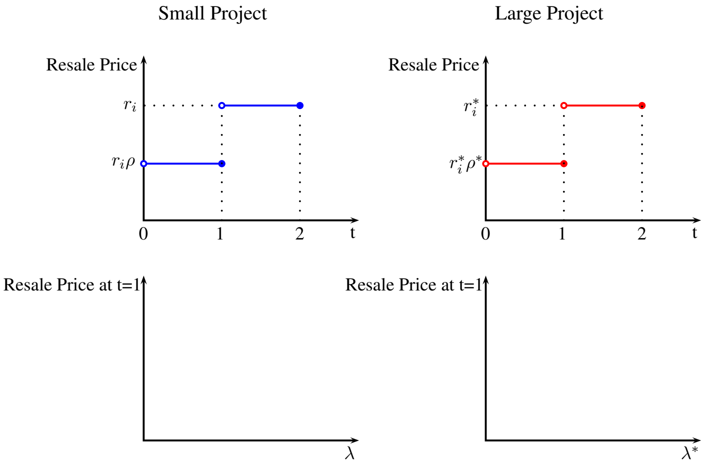

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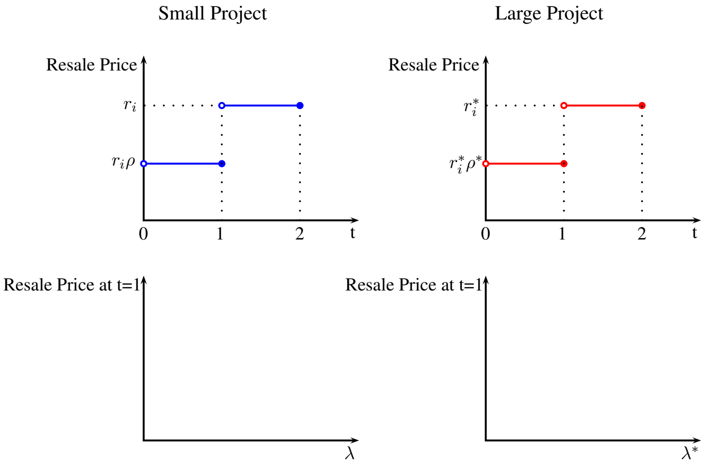
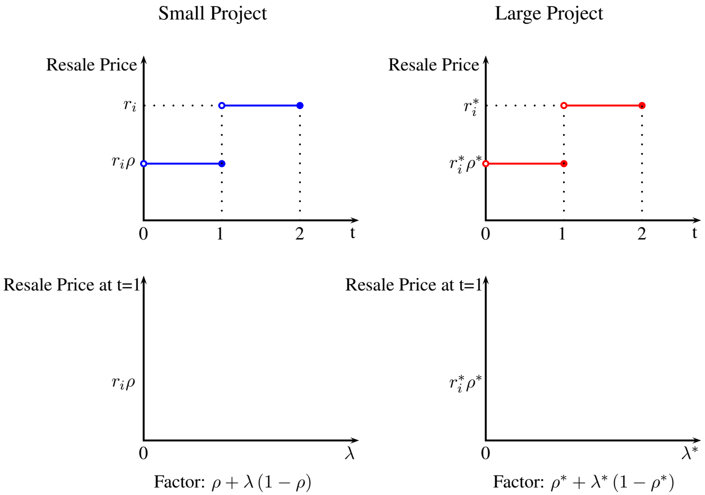


Factor: $\rho + \lambda (1 - \rho)$

Factor: $\rho^* + \lambda^* (1 - \rho^*)$

Effect of Government Intervention on Liquidity



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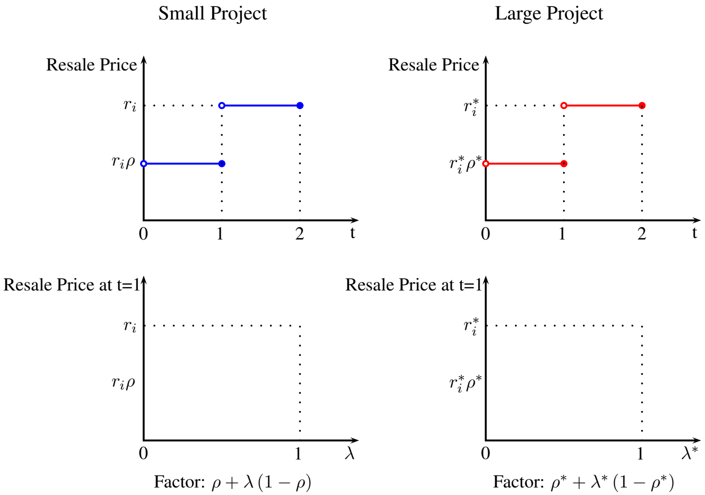

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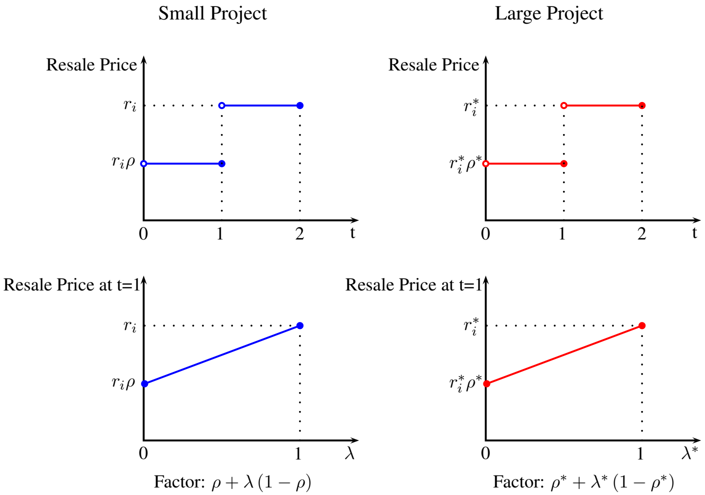

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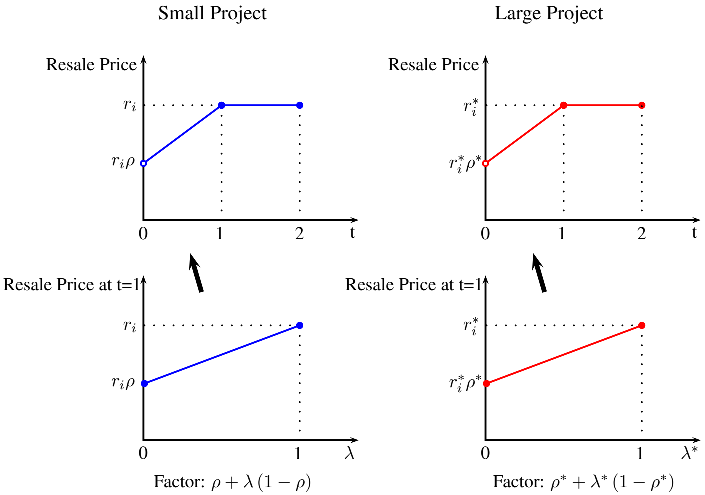

Timeline of Events

- $t = 0$:
  1. Banks meet pairwise, randomly, deciding at each meeting:
     (i) Whether or not to form a link (extend or take a loan)
     (ii) How much to invest in the short-term asset
     (iii) How much of the long-term asset (project or loan) to sell in order to service early depositors

- $t = 1$:
  1. Banks execute the selling strategy
  2. Together with the investment in the short-term asset, proceeds are used to pay early depositors

- $t = 2$:
  1. Payoffs from long-term assets (projects and loans) are realized, with the fraction not previously sold accruing to the banks
  2. Banks pay late depositors and clear positions with other banks, consuming the remainings as profits

Network Formation Process

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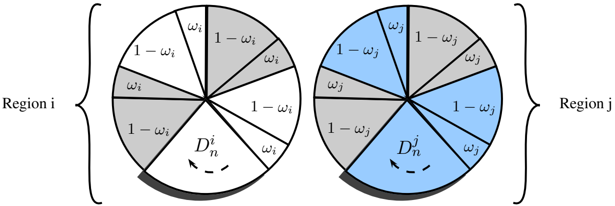

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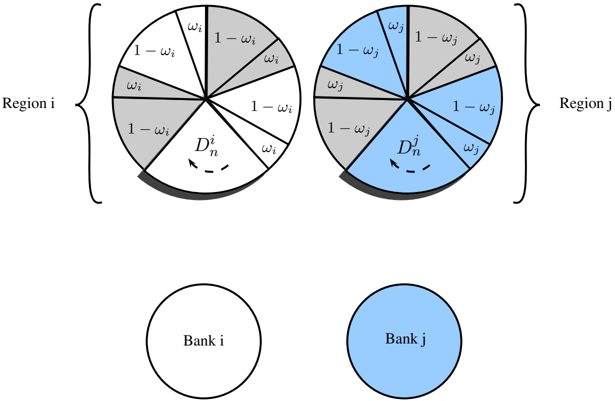

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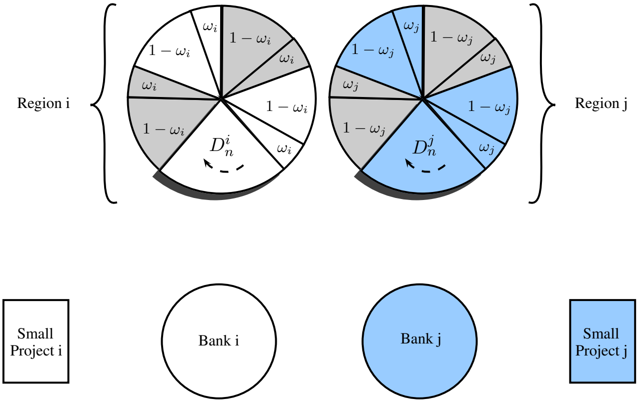

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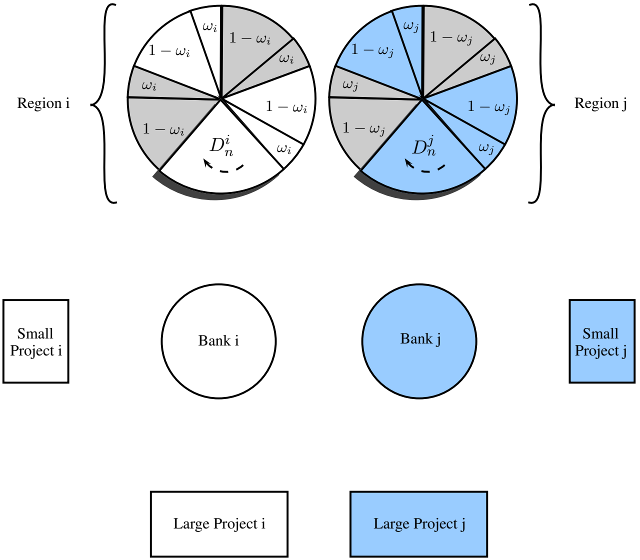
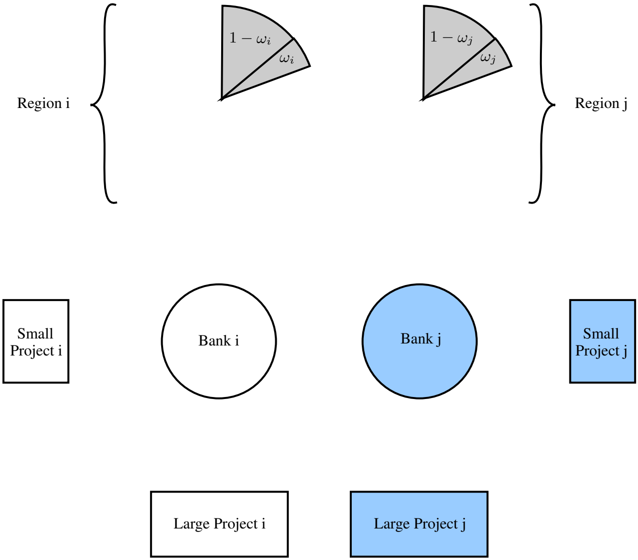


Network Formation Process: Autarky



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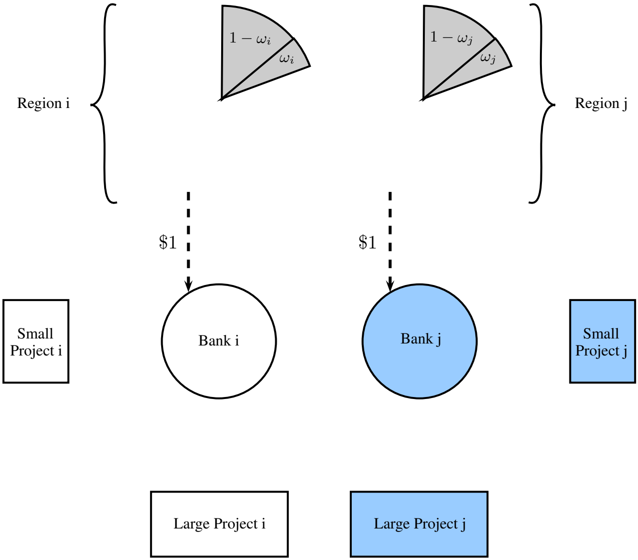

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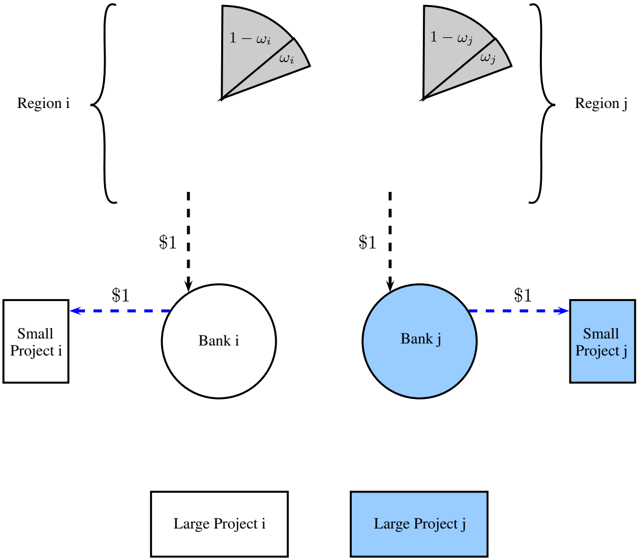

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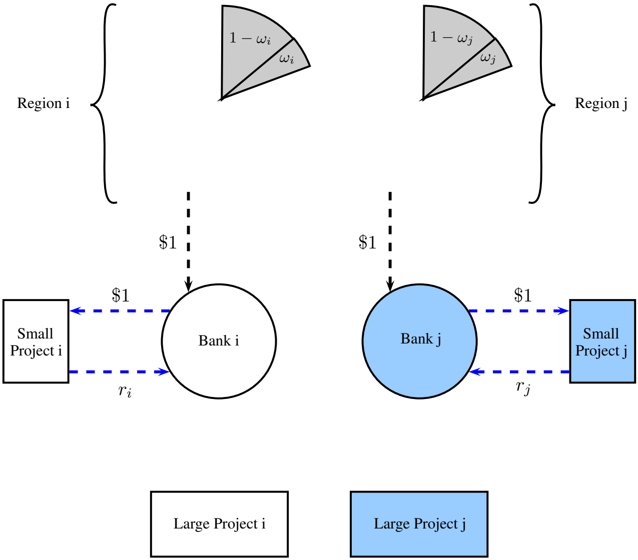

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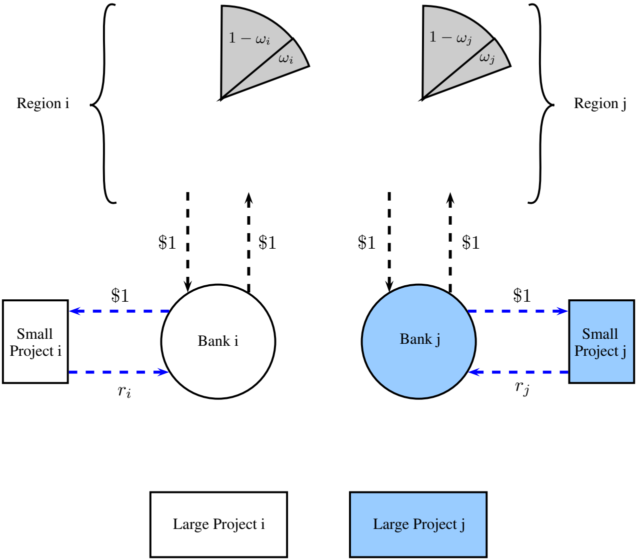

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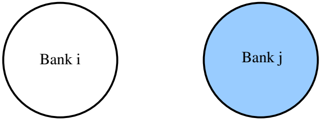
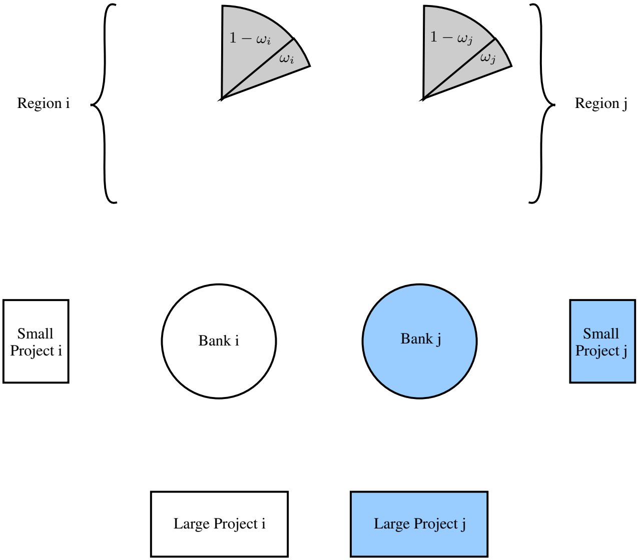


Network Formation Process: j to i



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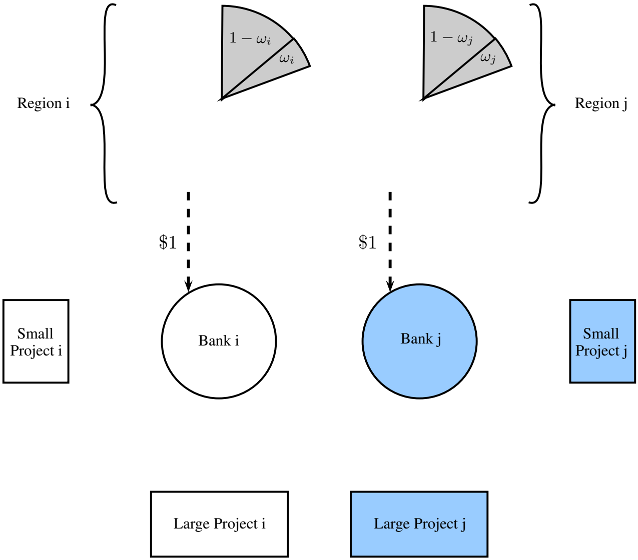

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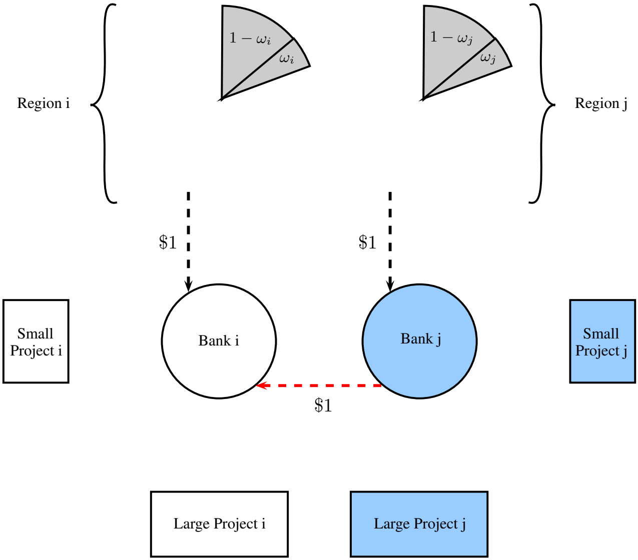

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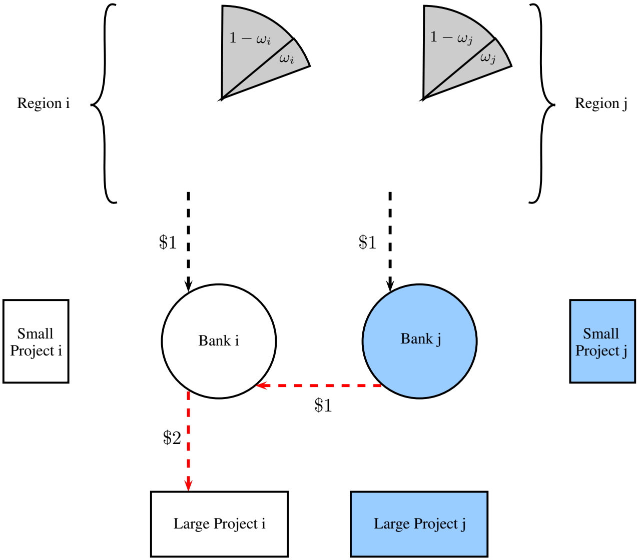

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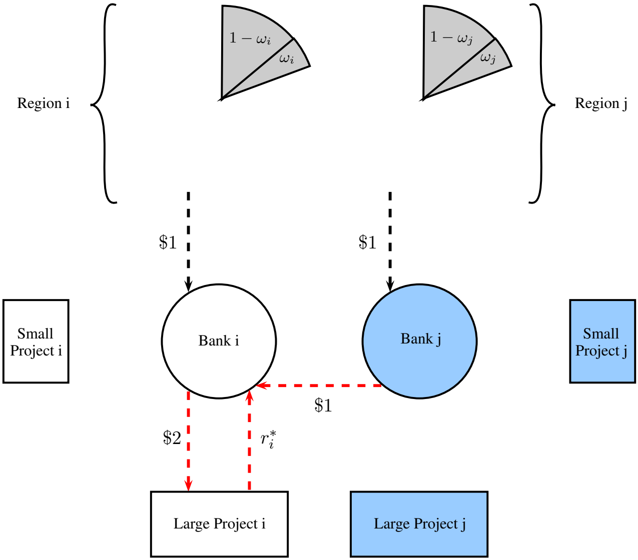

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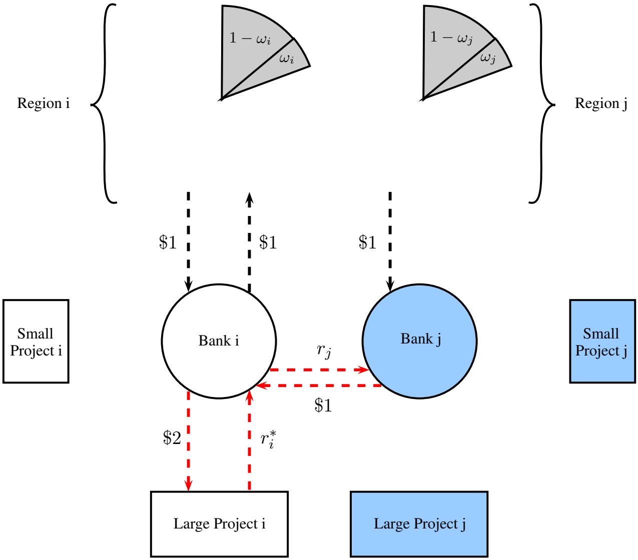

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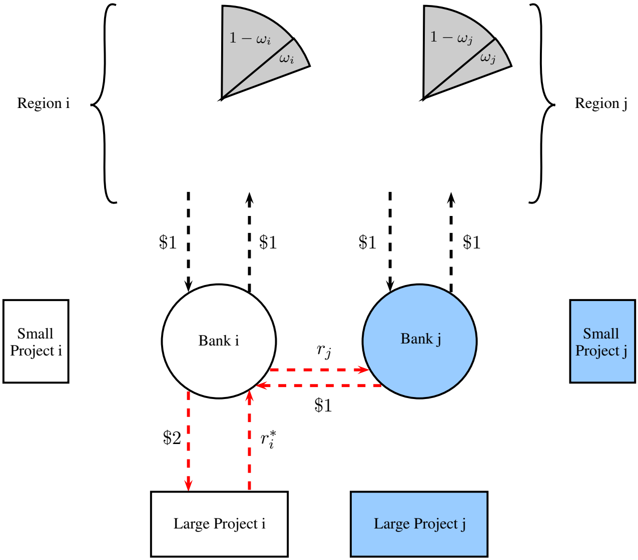

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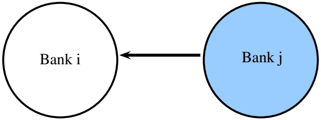

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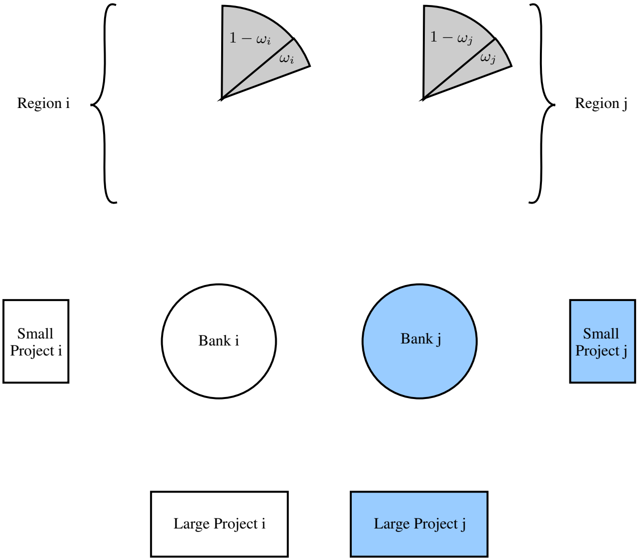

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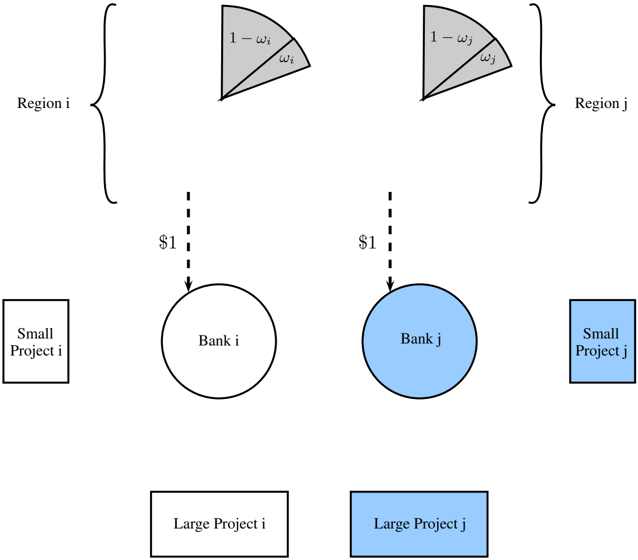

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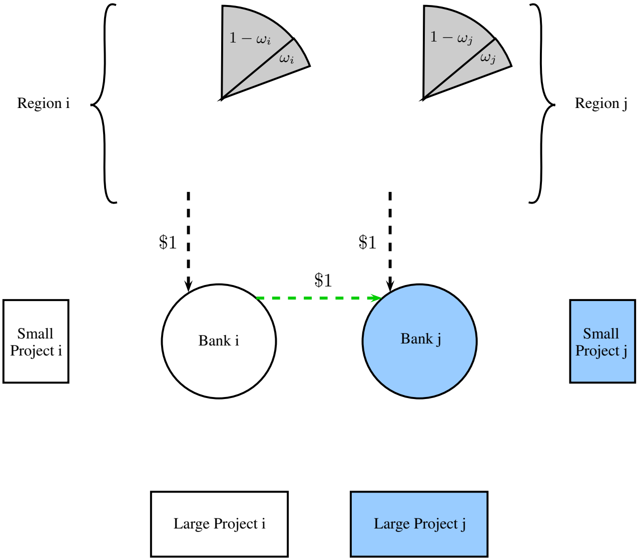

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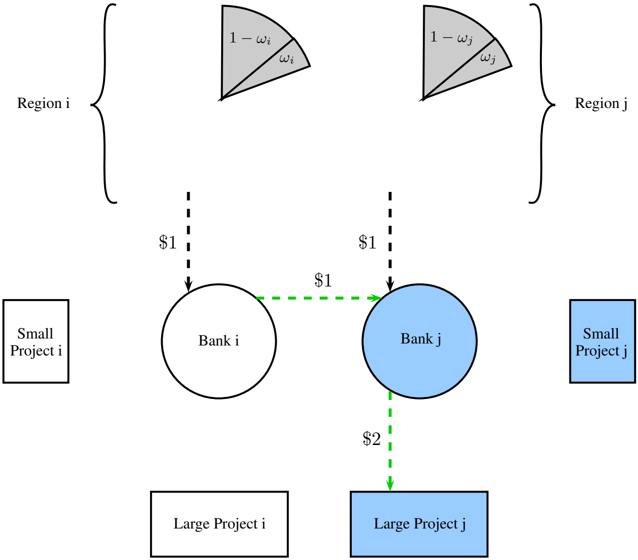

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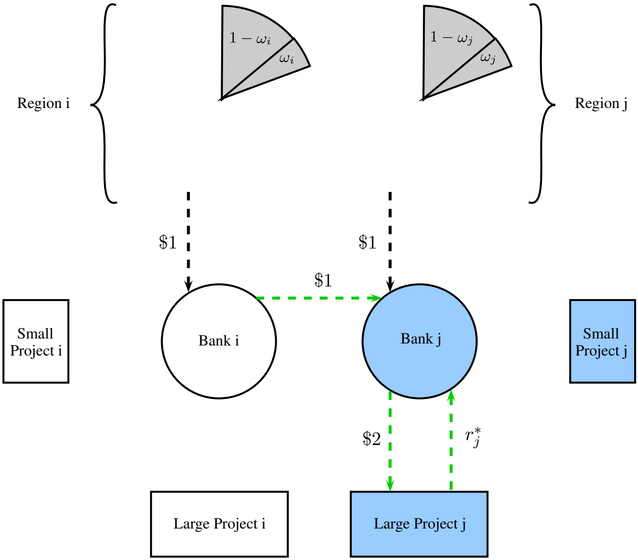

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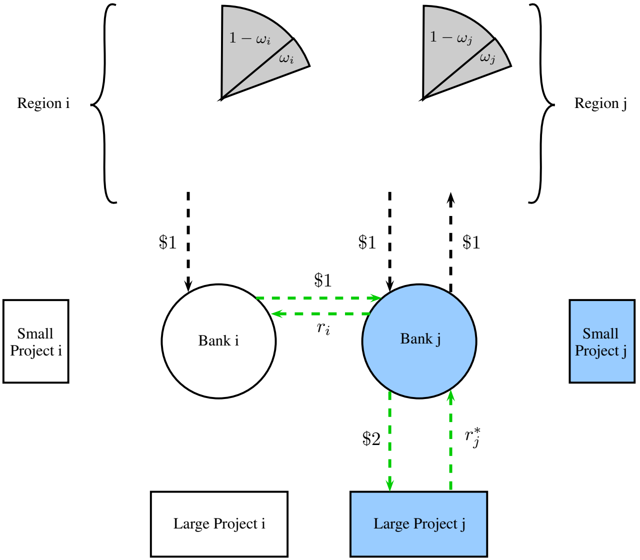

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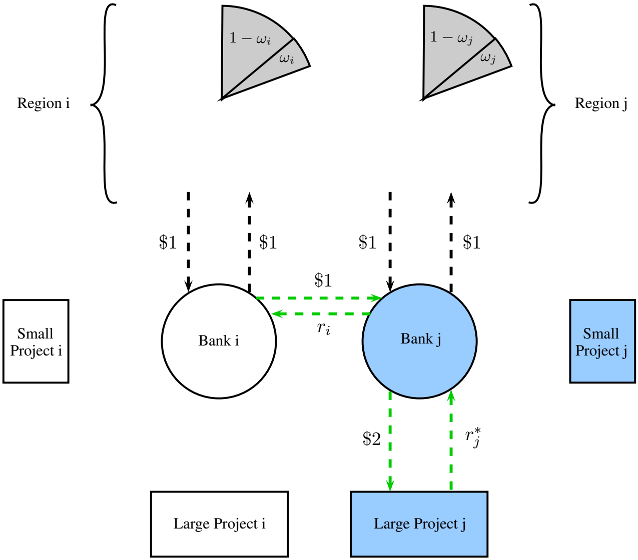

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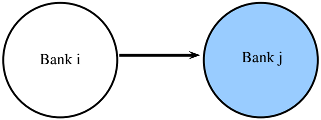
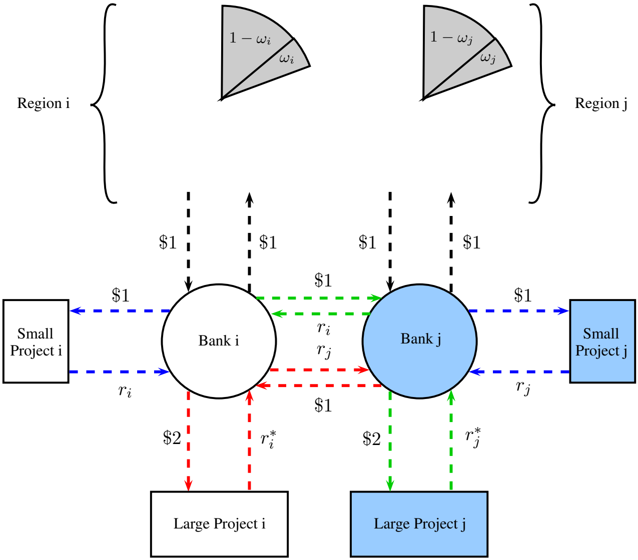


Network Formation Process: Continuation



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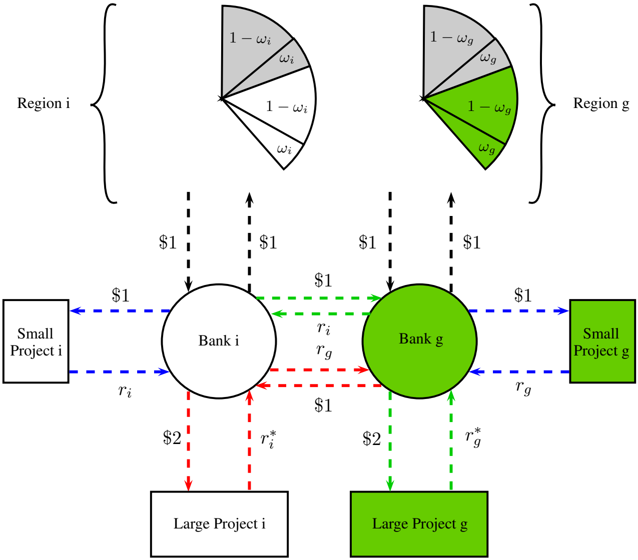

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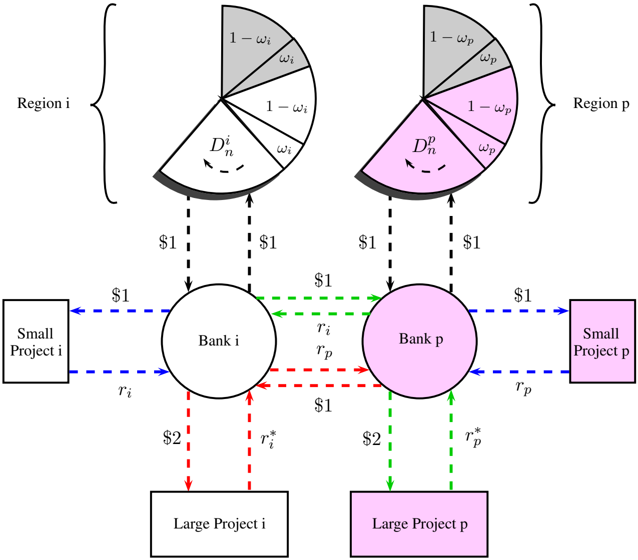

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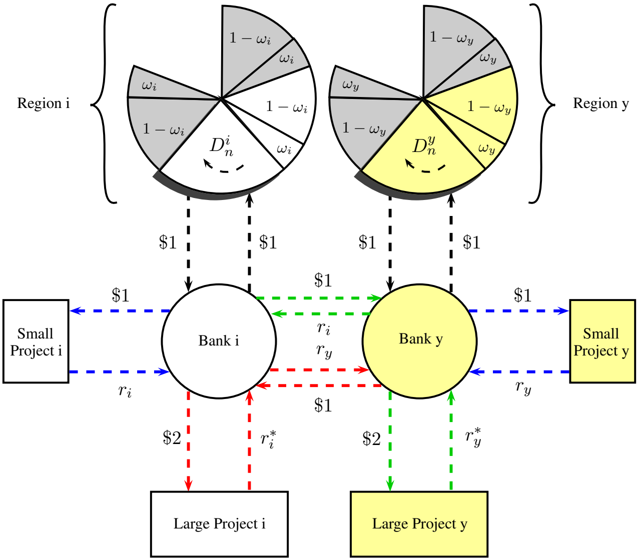

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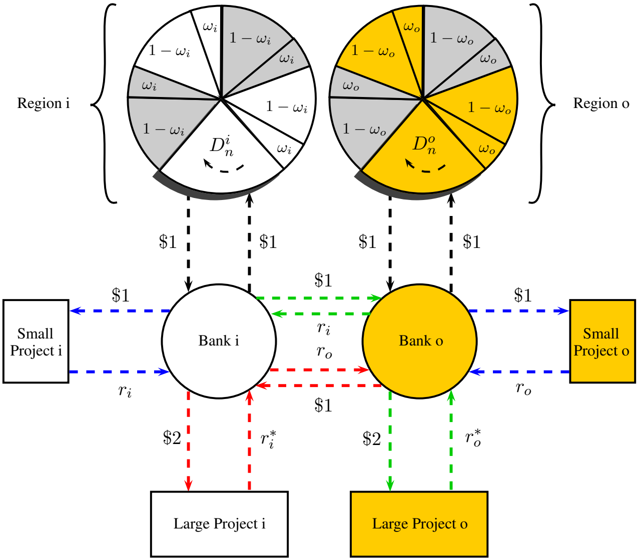


Characterization of the Financial System

- Networks are characterized by the adjacency matrix,

$$X = \begin{bmatrix} 0 & \chi_{12} & \cdots & \chi_{1N} \\ \chi_{21} & 0 & \cdots & \chi_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \chi_{N1} & \chi_{N2} & \cdots & 0 \end{bmatrix},$$

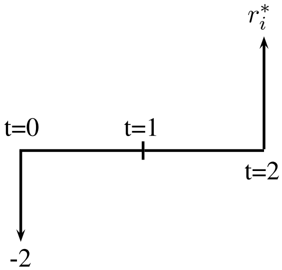
and the parameters of the model,

$$r^* = \begin{bmatrix} r_1^* \\ r_2^* \\ \vdots \\ r_N^* \end{bmatrix} r = \begin{bmatrix} r_1 \\ r_2 \\ \vdots \\ r_N \end{bmatrix} \omega = \begin{bmatrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_N \end{bmatrix} e = \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_N \end{bmatrix}$$

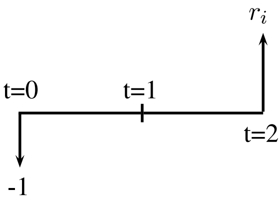
plus the fire-sale and government intervention parameters, ρ, ρ^* and γ and γ^*, respectively

Payoff Shocks

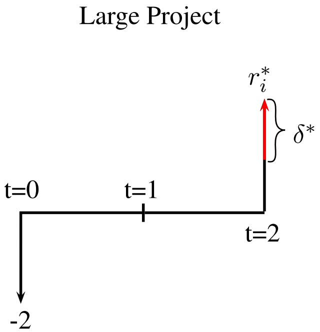
Large Project



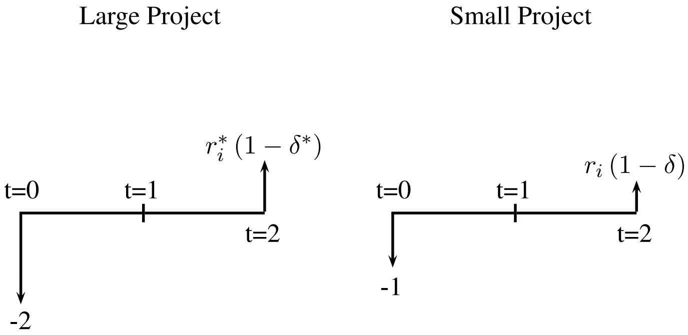
Small Project



Payoff Shocks



Payoff Shocks



Measures of Fragility: Single Shocks

- Consider a network with N banks, and take an arbitrary bank i facing shocks in its projects. The set

$$D^i := \{ j \,|\, \Delta^j > W^j \}$$

contains all those banks that become distressed after bank i is hit by a shock

- The cardinality of this set, $|D^i|$, thus, gives the total number of failures following bank i's shocks
- The index

$$f^i := |D^i|$$

gives, therefore, a measure of the relative fragility of the network to bank i, for a particular realization of shocks that it faces

- By doing the same for every bank $j \neq i$ in the network and combining all the results, for instance taking

$$f := \sum_{i \in N} f^i,$$

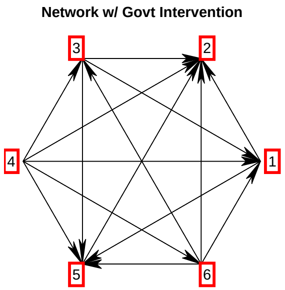
one has a measure of the overall fragility of the network relative to the individual failure of its members

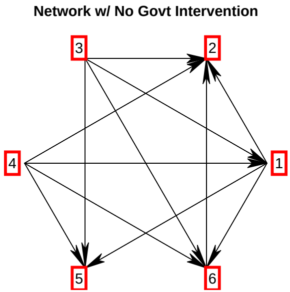
Example

- Network with 6 banks, generated under $\rho^* = 0.05\rho$, $\gamma^* = 0.8$ and $\gamma = 0.3$, and its non-government counterpart, i.e., the one obtained in the same way but with $\gamma^* = \gamma = 0$. The other parameters used are given by:

	$\mathbf{r}^*$	$\mathbf{r}$	ω	e
Bank 1	3.23	1.19	0.05	0.04
Bank 2	3.00	1.01	0.17	0.12
Bank 3	2.22	1.19	0.15	0.11
Bank 4	2.55	1.08	0.09	0.07
Bank 5	2.97	1.00	0.15	0.12
Bank 6	2.71	1.21	0.14	0.10

Example (cont'd)





Government					No Government				
Bank	LR	Links	Failures	Networth	Bank	LR	Links	Failures	Networth
5.00	0.69	4.00	1152.00	4.08	6.00	0.82	3.00	1598.00	1.82
3.00	0.79	2.00	1138.00	1.86	5.00	0.68	3.00	1074.00	3.67
2.00	0.63	5.00	1108.00	6.04	2.00	0.62	4.00	745.00	5.32
1.00	0.67	3.00	1063.00	3.79	4.00	0.91	0.00	572.00	0.50
6.00	0.81	1.00	698.00	1.42	1.00	0.70	2.00	203.00	2.81
4.00	0.91	0.00	0.00	0.50	3.00	0.83	0.00	0.00	0.89

Final Remarks

- Trade-off: networth and fragility
- Introducing measures of welfare and characterizing an efficient frontier of financial networks
- Can the model generate the type of financial networks most typically observed (core-periphery)?
- How to identify networks?