Contagion in Financial Networks

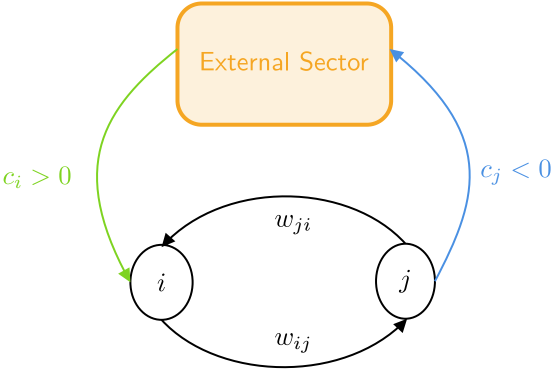
Leonardo Massai, Fabio Fagnani, Giacomo Como

leonardo.massai@polito.it

Department of Mathematical Sciences (DISMA) , Politecnico di Torino

Outline

Introduction

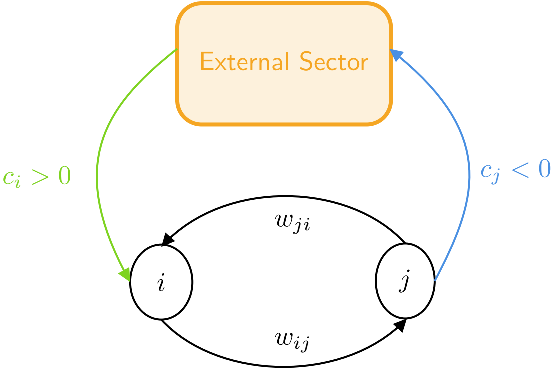


- w_{ij} inter-bank liability;
- $c_i > 0$ positive money inflow;
- $c_j < 0$ outside debt.

Everything is fine

In normal conditions, every bank i can meet its total liability: $w_i = \sum_j w_{ij}$.

Introduction

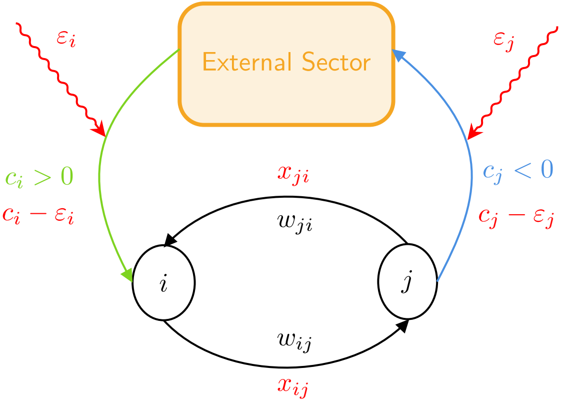


- w_{ij} inter-bank liability;
- $c_i > 0$ positive money inflow;
- $c_j < 0$ outside debt.

Everything is fine

In normal conditions, every bank i can meet its total liability: $w_i = \sum_j w_{ij}$.

Introduction



- Shocks ε hit the network by reducing c;
- Nodes may default and not be able to pay their liabilities (direct effect);
- Shocks propagate across the network because of reduced payments (indirect effect).

Clearing Vectors

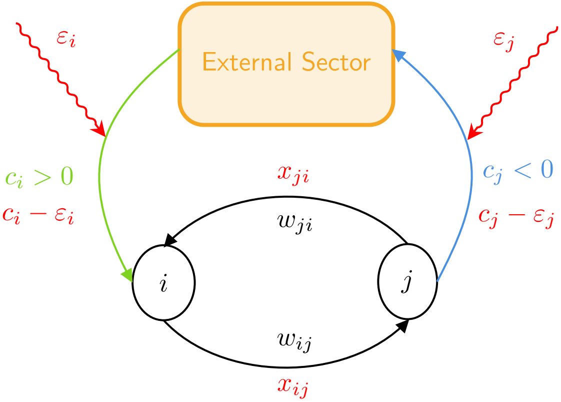
x is a set of consistent payments after the shock:

$$x = \mathcal{S}_0^w(P'x + c - \varepsilon)$$

where $(P)_{ij} = \frac{w_{ij}}{w_i}$ and $\mathcal{S}_0^w$ is a saturation:

- Notice that any solution is such that $x \in \mathcal{L}_0^w := \{x \in \mathbb{R}^n \ : \ 0 \leq x \leq w\}$

Introduction



- Shocks ε hit the network by reducing c;
- Nodes may default and not be able to pay their liabilities (direct effect);
- Shocks propagate across the network because of reduced payments (indirect effect).

Clearing Vectors

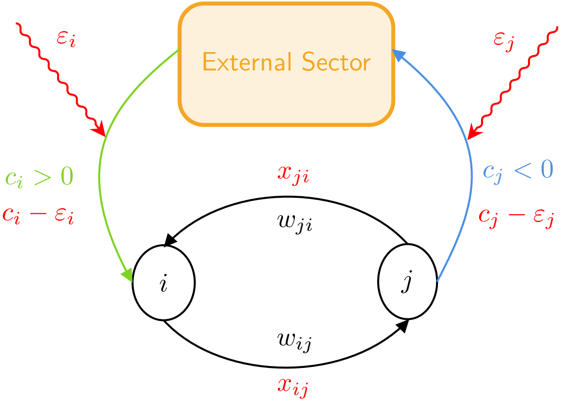
x is a set of consistent payments after the shock:

$$x = \mathcal{S}_0^w(P'x + c - \varepsilon)$$

where $(P)_{ij} = \frac{w_{ij}}{w_i}$ and $\mathcal{S}_0^w$ is a saturation:

- Notice that any solution is such that $x \in \mathcal{L}_0^w := \{x \in \mathbb{R}^n \ : \ 0 \leq x \leq w\}$

Introduction



- Shocks ε hit the network by reducing c;
- Nodes may default and not be able to pay their liabilities (direct effect);
- Shocks propagate across the network because of reduced payments (indirect effect).

Clearing Vectors

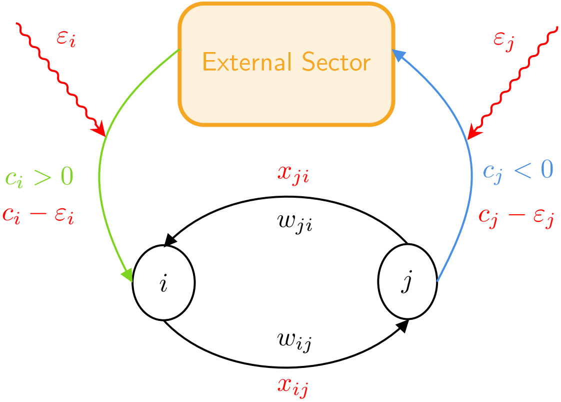
x is a set of consistent payments after the shock:

$$x = \mathcal{S}_0^w(P'x + c - \varepsilon)$$

where $(P)_{ij} = \frac{w_{ij}}{w_i}$ and $\mathcal{S}_0^w$ is a saturation:

- Notice that any solution is such that $x \in \mathcal{L}_0^w := \{x \in \mathbb{R}^n \ : \ 0 \leq x \leq w\}$

Introduction



- Shocks ε hit the network by reducing c;
- Nodes may default and not be able to pay their liabilities (direct effect);
- Shocks propagate across the network because of reduced payments (indirect effect).

Clearing Vectors

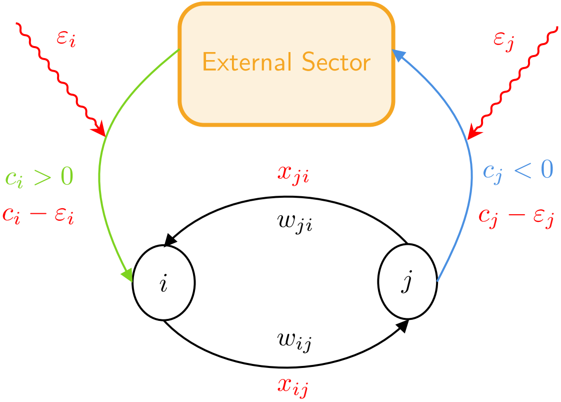
x is a set of consistent payments after the shock:

$$x = \mathcal{S}_0^w(P'x + c - \varepsilon)$$

where $(P)_{ij} = \frac{w_{ij}}{w_i}$ and $\mathcal{S}_0^w$ is a saturation:

- Notice that any solution is such that $x \in \mathcal{L}_0^w := \{x \in \mathbb{R}^n \;:\; 0 \leq x \leq w\}$

Introduction



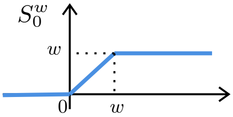
- Shocks ε hit the network by reducing c;
- Nodes may default and not be able to pay their liabilities (direct effect);
- Shocks propagate across the network because of reduced payments (indirect effect).

Clearing Vectors

x is a set of consistent payments after the shock:

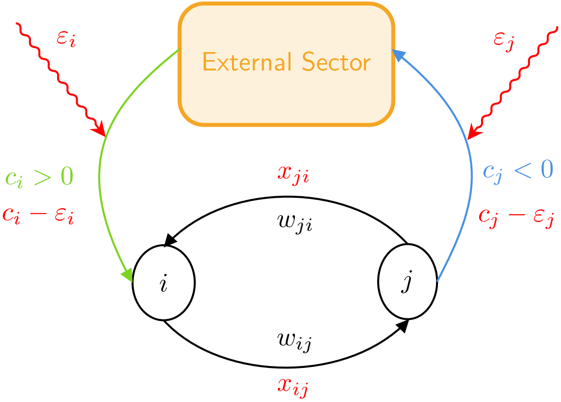
$$x = \mathcal{S}_0^w(P'x + c - \varepsilon)$$

where $(P)_{ij} = \frac{w_{ij}}{w_i}$ and $\mathcal{S}_0^w$ is a saturation:



- Notice that any solution is such that $x \in \mathcal{L}_0^w := \{x \in \mathbb{R}^n \ : \ 0 \leq x \leq w\}$

Introduction



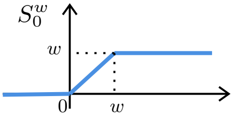
- Shocks ε hit the network by reducing c;
- Nodes may default and not be able to pay their liabilities (direct effect);
- Shocks propagate across the network because of reduced payments (indirect effect).

Clearing Vectors

x is a set of consistent payments after the shock:

$$x = \mathcal{S}_0^w(P'x + c - \varepsilon)$$

where $(P)_{ij} = \frac{w_{ij}}{w_i}$ and $\mathcal{S}_0^w$ is a saturation:



- Notice that any solution is such that $x \in \mathcal{L}_0^w := \{x \in \mathbb{R}^n \ : \ 0 \leq x \leq w\}$

Existence and Uniqueness of Clearing Vectors

- Existence of clearing vectors follows from Brower fixed point Theorem.
- One can prove that it always exist a maximal and a minimal solution $\bar{x}$ and $\underline{x}$ respectively.

In general however the solution will not be unique:

Example

Consider the network consisting of two nodes only depicted below with $P = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $w = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $c = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.

It is immediate to check that any vector of the form $x = \begin{bmatrix} t \\ t \end{bmatrix}$, $t \in [0, 1]$ is a clearing vector.

Existence and Uniqueness of Clearing Vectors

- Existence of clearing vectors follows from Brower fixed point Theorem.
- One can prove that it always exist a maximal and a minimal solution $\bar{x}$ and $\underline{x}$ respectively.

In general however the solution will not be unique:

Example

Consider the network consisting of two nodes only depicted below with $P = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $w = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $c = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.

It is immediate to check that any vector of the form $x = \begin{bmatrix} t \\ t \end{bmatrix}$, $t \in [0, 1]$ is a clearing vector.

Existence and Uniqueness of Clearing Vectors

- Existence of clearing vectors follows from Brower fixed point Theorem.
- One can prove that it always exist a maximal and a minimal solution $\bar{x}$ and $\underline{x}$ respectively.

In general however the solution will not be unique:

Example

Consider the network consisting of two nodes only depicted below with $P = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $w = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $c = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.

It is immediate to check that any vector of the form $x = \begin{bmatrix} t \\ t \end{bmatrix}$, $t \in [0, 1]$ is a clearing vector.

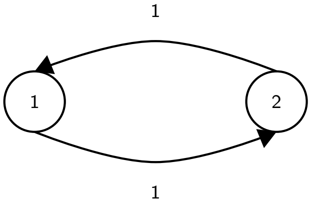
Existence and Uniqueness of Clearing Vectors

- Existence of clearing vectors follows from Brower fixed point Theorem.
- One can prove that it always exist a maximal and a minimal solution $\bar{x}$ and $\underline{x}$ respectively.

In general however the solution will not be unique:

Example

Consider the network consisting of two nodes only depicted below with $P = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $w = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $c = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.



It is immediate to check that any vector of the form $x = \begin{bmatrix} t \\ t \end{bmatrix}$, $t \in [0, 1]$ is a clearing vector.

The Out-Connected Case

Theorem (Uniqueness for out-connected graphs)

Let P be an out-connected matrix, then the clearing vector is unique.

- We can partition any graph in a transient part $\mathcal{T}$ and trapping sets $\mathcal{U}$. I.e. $\mathcal{V} = \mathcal{T} \cup (\cup_k \mathcal{U}_k)$;
- $P_\mathcal{T}$ is out-connected $\implies$ the solution $x_\mathcal{T}$ is unique.

- What about the solution on $\mathcal{U}$? Notice that $P_\mathcal{U}$ is stochastic and irreducible.

The Out-Connected Case

Theorem (Uniqueness for out-connected graphs)

Let P be an out-connected matrix, then the clearing vector is unique.

- We can partition any graph in a transient part $\mathcal{T}$ and trapping sets $\mathcal{U}$. I.e. $\mathcal{V} = \mathcal{T} \cup (\cup_k \mathcal{U}_k)$;
- $P_\mathcal{T}$ is out-connected $\implies$ the solution $x_\mathcal{T}$ is unique.

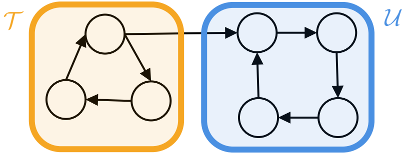
- What about the solution on $\mathcal{U}$? Notice that $P_\mathcal{U}$ is stochastic and irreducible.

The Out-Connected Case

Theorem (Uniqueness for out-connected graphs)

Let P be an out-connected matrix, then the clearing vector is unique.

- We can partition any graph in a transient part $\mathcal{T}$ and trapping sets $\mathcal{U}$. I.e. $\mathcal{V} = \mathcal{T} \cup (\cup_k \mathcal{U}_k)$;
- $P_{\mathcal{T}}$ is out-connected $\implies$ the solution $x_{\mathcal{T}}$ is unique.



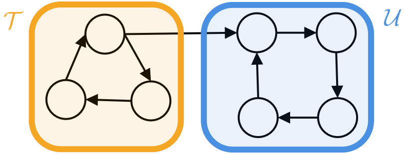
- What about the solution on $\mathcal{U}$? Notice that $P_{\mathcal{U}}$ is stochastic and irreducible.

The Out-Connected Case

Theorem (Uniqueness for out-connected graphs)

Let P be an out-connected matrix, then the clearing vector is unique.

- We can partition any graph in a transient part $\mathcal{T}$ and trapping sets $\mathcal{U}$. I.e. $\mathcal{V} = \mathcal{T} \cup (\cup_k \mathcal{U}_k)$;
- $P_{\mathcal{T}}$ is out-connected $\implies$ the solution $x_{\mathcal{T}}$ is unique.

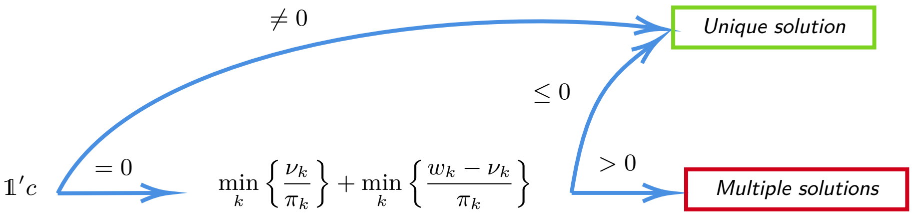


- What about the solution on $\mathcal{U}$? Notice that $P_{\mathcal{U}}$ is stochastic and irreducible.

The Stochastic Irreducible Case

Theorem (Uniqueness for the stochastic irreducible case)

Let P be an irreducible stochastic matrix; let π be its unique invariant probability measure and $\nu = \frac{1}{2}\sum_{k\geq 0}\left(\frac{I+P'}{2}\right)^k c$. *Then it holds:*



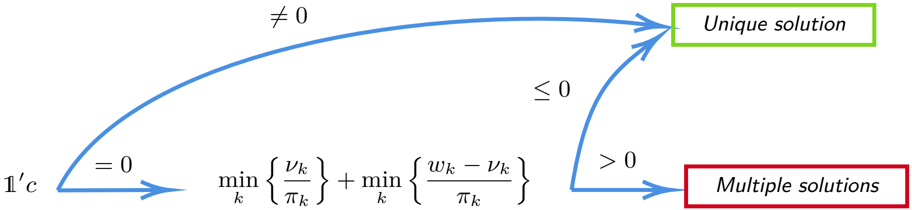
- In case we have multiple solutions, we have that:

$$\mathcal{X} = \left\{ x = \nu + \alpha\pi \ : \ -\min_k\left\{\frac{\nu_k}{\pi_k}\right\} \leq \alpha \leq \min_k\left\{\frac{w_k-\nu_k}{\pi_k}\right\}\right\}$$

The Stochastic Irreducible Case

Theorem (Uniqueness for the stochastic irreducible case)

Let P be an irreducible stochastic matrix; let π be its unique invariant probability measure and $\nu = \frac{1}{2}\sum_{k\geq 0}\left(\frac{I+P'}{2}\right)^k c$. *Then it holds:*

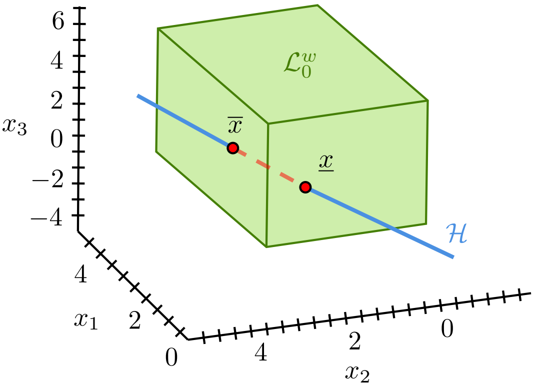


- In case we have multiple solutions, we have that:

$$\mathcal{X} = \left\{ x = \nu + \alpha\pi \ : \ -\min_k \left\{\frac{\nu_k}{\pi_k}\right\} \leq \alpha \leq \min_k \left\{\frac{w_k - \nu_k}{\pi_k}\right\}\right\}$$

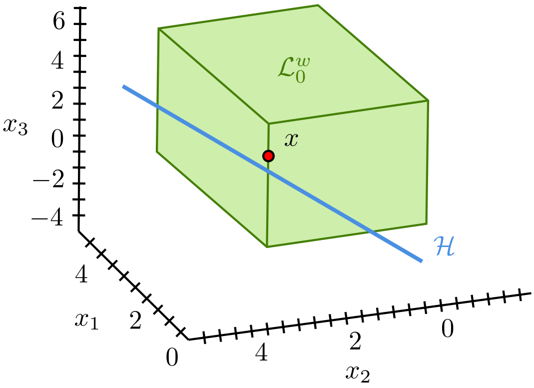
A geometrical Interpretation

When $\mathbb{1}'c = 0$, we have multiple solutions when the line $\mathcal{H} = \{x \in \mathbb{R}^n \; : \; x = \nu + \alpha\pi\}$ intersects non trivially the lattice $\mathcal{L}_0^w$.



(a) Multiple solutions (the red dots and segment).

$$\min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\} > 0$$



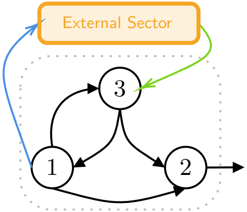
(b) Unique solution (the red dot).

$$\min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\} \leq 0$$

The General Case

The Out-Connected Case

Unique solution.



The Stochastic-Irreducible Case

Uniqueness depends on c, i.e. on what is coming from and going to the external environment.

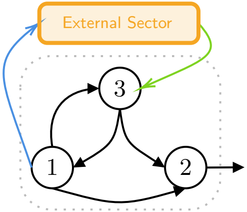
The General Case

- $x_{\mathcal{T}}$ is unique;
- For every trapping set $\mathcal{U}$, we use the Theorem;
- To do so, we also need to consider the input coming from $\mathcal{T}$: $h_{\mathcal{U}} := c_{\mathcal{U}} + P_{\mathcal{U}\mathcal{T}} x_{\mathcal{T}}$

The General Case

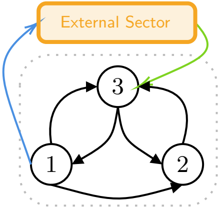
The Out-Connected Case

Unique solution.



The Stochastic-Irreducible Case

Uniqueness depends on c, i.e. on what is coming from and going to the external environment.



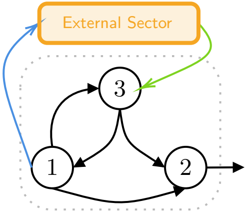
The General Case

- $x_{\mathcal{T}}$ is unique;
- For every trapping set $\mathcal{U}$, we use the Theorem;
- To do so, we also need to consider the input coming from $\mathcal{T}$: $h_{\mathcal{U}} := c_{\mathcal{U}} + P_{\mathcal{U}\mathcal{T}} x_{\mathcal{T}}$

The General Case

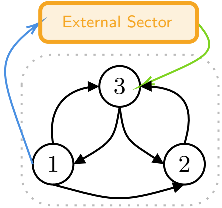
The Out-Connected Case

Unique solution.

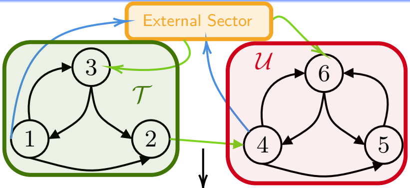


The Stochastic-Irreducible Case

Uniqueness depends on c, i.e. on what is coming from and going to the external environment.



The General Case



- $x_{\mathcal{T}}$ is unique;
- For every trapping set $\mathcal{U}$, we use the Theorem;
- To do so, we also need to consider the input coming from $\mathcal{T}$: $h_{\mathcal{U}} := c_{\mathcal{U}} + P_{\mathcal{U}\mathcal{T}} x_{\mathcal{T}}$

The Dependence of Clearing Vectors on the Shock

Dependence of x on c

- The uniqueness ultimately depends on the input \ output vector c.
- There exists a set of critical vectors c^* such that we have multiple solutions, namely:
$\mathcal{M} = \left\{ c \in \mathbb{R}^n \ : \ \mathbb{1}'c = 0, \ \min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\} > 0 \right\}$

What happens to the solutions when c approaches a critical $c^* \in \mathcal{M}$?

Let $\mathcal{A} = \mathbb{R}^n \backslash \mathcal{M}$ be the set where the solution is unique. Then:

- The map $c \mapsto x(c)$ is continuous on $\mathcal{A}$.
- One can prove that for every $c^* \in \mathcal{M}$,

$$\liminf_{\substack{c \in \mathcal{A} \\ c \to c^*}} x(c) = \underline{x}(c^*) \,, \qquad \limsup_{\substack{c \in \mathcal{A} \\ c \to c^*}} x(c) = \bar{x}(c^*) \,.$$

- This means that the clearing vector undergoes a jump discontinuity at c^*.

The Dependence of Clearing Vectors on the Shock

Dependence of x on c

- The uniqueness ultimately depends on the input \ output vector c.
- There exists a set of critical vectors c^* such that we have multiple solutions, namely:

$$\mathcal{M} = \left\{ c \in \mathbb{R}^n \ : \ \mathbb{1}'c = 0, \ \min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\} > 0 \right\}$$

What happens to the solutions when c approaches a critical $c^* \in \mathcal{M}$?

Let $\mathcal{A} = \mathbb{R}^n \backslash \mathcal{M}$ be the set where the solution is unique. Then:

- The map $c \mapsto x(c)$ is continuous on $\mathcal{A}$.
- One can prove that for every $c^* \in \mathcal{M}$,

$$\liminf_{\substack{c \in \mathcal{A} \\ c \to c^*}} x(c) = \underline{x}(c^*) \,, \qquad \limsup_{\substack{c \in \mathcal{A} \\ c \to c^*}} x(c) = \bar{x}(c^*) \,.$$

- This means that the clearing vector undergoes a jump discontinuity at c^*.

Critical Transitions and Jumps

Jump discontinuity as a financial breakdown

A jump discontinuity means that even a slight change in the asset/shock value c may lead to a catastrophic aggregated loss and to sudden defaults of several nodes.

Loss function

- Consider shock ε that lowers the value of the external asset from c to $c - \varepsilon$;
- Loss function is: $l = \mathbb{1}'(\varepsilon + w - x)$

Jump size of the loss function at $c^* \in \mathcal{M}$

$$\Delta l(c^*) = \liminf_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) - \limsup_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) = \mathbb{1}' \left(\bar{x}(c^*) - \underline{x}(c^*)\right) = \min_k \left\{\frac{\nu_k}{\pi_k}\right\} + \min_k \left\{\frac{w_k - \nu_k}{\pi_k}\right\}$$

Maximal norm of a jump discontinuity

$$\max_{c \in \mathbb{R}^n} ||\bar{x}(c) - \underline{x}(c)||_p^p = \left(\min_k \frac{w_k}{\pi_k}\right)^p ||\pi||^p$$

Critical Transitions and Jumps

Jump discontinuity as a financial breakdown

A jump discontinuity means that even a slight change in the asset/shock value c may lead to a catastrophic aggregated loss and to sudden defaults of several nodes.

Loss function

- Consider shock ε that lowers the value of the external asset from c to $c - \varepsilon$;
- Loss function is: $l = \mathbb{1}'(\varepsilon + w - x)$

Jump size of the loss function at $c^* \in \mathcal{M}$

$$\Delta l(c^*) = \liminf_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) - \limsup_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) = \mathbb{1}' \left(\bar{x}(c^*) - \underline{x}(c^*) \right) = \min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\}$$

Maximal norm of a jump discontinuity

$$\max_{c \in \mathbb{R}^n} ||\bar{x}(c) - \underline{x}(c)||_p^p = \left(\min_k \frac{w_k}{\pi_k} \right)^p ||\pi||^p$$

Critical Transitions and Jumps

Jump discontinuity as a financial breakdown

A jump discontinuity means that even a slight change in the asset/shock value c may lead to a catastrophic aggregated loss and to sudden defaults of several nodes.

Loss function

- Consider shock ε that lowers the value of the external asset from c to $c - \varepsilon$;
- Loss function is: $l = \mathbb{1}'(\varepsilon + w - x)$

Jump size of the loss function at $c^* \in \mathcal{M}$

$$\Delta l(c^*) = \liminf_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) - \limsup_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) = \mathbb{1}' \left(\bar{x}(c^*) - \underline{x}(c^*) \right) = \min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\}$$

Maximal norm of a jump discontinuity

$$\max_{c \in \mathbb{R}^n} ||\bar{x}(c) - \underline{x}(c)||_p^p = \left(\min_k \frac{w_k}{\pi_k} \right)^p ||\pi||^p$$

Critical Transitions and Jumps

Jump discontinuity as a financial breakdown

A jump discontinuity means that even a slight change in the asset/shock value c may lead to a catastrophic aggregated loss and to sudden defaults of several nodes.

Loss function

- Consider shock ε that lowers the value of the external asset from c to $c - \varepsilon$;
- Loss function is: $l = \mathbb{1}'(\varepsilon + w - x)$

Jump size of the loss function at $c^* \in \mathcal{M}$

$$\Delta l(c^*) = \liminf_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) - \limsup_{\substack{c \in \mathcal{A} \\ c \to c^*}} l(c) = \mathbb{1}' \left(\bar{x}(c^*) - \underline{x}(c^*)\right) = \min_k \left\{ \frac{\nu_k}{\pi_k} \right\} + \min_k \left\{ \frac{w_k - \nu_k}{\pi_k} \right\}$$

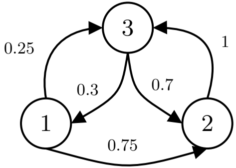
Maximal norm of a jump discontinuity

$$\max_{c \in \mathbb{R}^n} ||\bar{x}(c) - \underline{x}(c)||_p^p = \left(\min_k \frac{w_k}{\pi_k} \right)^p ||\pi||^p$$

Critical Transitions and Jumps

Example

Consider the network below with $P = \begin{bmatrix} 0 & 0.75 & 0.25 \\ 0 & 0 & 1 \\ 0.3 & 0.7 & 0 \end{bmatrix}$ and $w = \begin{bmatrix} 5 \\ 3 \\ 2 \end{bmatrix}$.

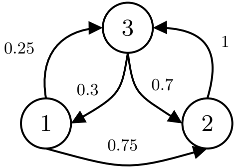


Consider an initial asset $c = [5, 2, 2]'$ and a total shock magnitude $\varepsilon \in [0, 12]$ that hits all nodes uniformly, i.e. $c(\varepsilon) = c - \varepsilon[\frac{1}{3}, \frac{1}{3}, \frac{1}{3}]'$. We expect a jump discontinuity when $\mathbb{1}'c(\varepsilon) = 0 \implies \varepsilon = 9$.

Critical Transitions and Jumps

Example

Consider the network below with $P = \begin{bmatrix} 0 & 0.75 & 0.25 \\ 0 & 0 & 1 \\ 0.3 & 0.7 & 0 \end{bmatrix}$ and $w = \begin{bmatrix} 5 \\ 3 \\ 2 \end{bmatrix}$.

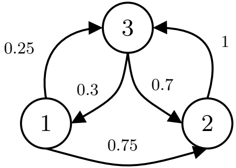


Consider an initial asset $c = [5, 2, 2]'$ and a total shock magnitude $\varepsilon \in [0, 12]$ that hits all nodes uniformly, i.e. $c(\varepsilon) = c - \varepsilon[\frac{1}{3}, \frac{1}{3}, \frac{1}{3}]'$. We expect a jump discontinuity when $\mathbb{1}'c(\varepsilon) = 0 \implies \varepsilon = 9$.

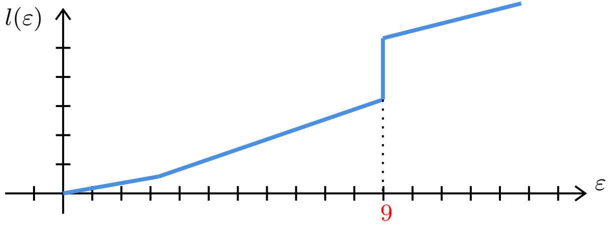
Critical Transitions and Jumps

Example

Consider the network below with $P = \begin{bmatrix} 0 & 0.75 & 0.25 \\ 0 & 0 & 1 \\ 0.3 & 0.7 & 0 \end{bmatrix}$ and $w = \begin{bmatrix} 5 \\ 3 \\ 2 \end{bmatrix}$.



Consider an initial asset $c = [5, 2, 2]'$ and a total shock magnitude $\varepsilon \in [0, 12]$ that hits all nodes uniformly, i.e. $c(\varepsilon) = c - \varepsilon[\frac{1}{3}, \frac{1}{3}, \frac{1}{3}]'$. We expect a jump discontinuity when $\mathbb{1}'c(\varepsilon) = 0 \implies \varepsilon = 9$.



Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Main Results and Future Goals

Main Results

- Sufficient and necessary condition for Uniqueness of clearing vectors;
- Systemic risk measures and existence of critical shocks;
- Structure of solutions with respect to the topological properties of the network.

Ongoing Research

- Optimal policies for risk reduction;
- Analytical results on particular topologies and random graphs;
- Continuous Model.
- Model extensions (fire sales, bankruptcy costs, cross holdings, etc...);

Thank you!