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Impact of contingent payments on systemic risk in financial networks

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Abstract

In this paper we study the implications of contingent payments on the clearing wealth in a network model of financial contagion. We consider an extension of the Eisenberg–Noe financial contagion model in which the nominal interbank obligations depend on the wealth of the firms in the network. We first consider the problem in a static framework and develop conditions for existence and uniqueness of solutions as long as no firm is speculating on the failure of other firms. In order to achieve existence and uniqueness under more general conditions, we introduce a dynamic framework. We demonstrate how this dynamic framework can be applied to problems that were ill-defined in the static framework.

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A Proof of Proposition 3.17

Proof

Firstly, as in (6), the clearing wealths as a function of initial endowments are defined by

$$\begin{aligned} V(x) = x + \Pi (V(x))^\top [\bar{p}(V(x)) - V(x)^-]^+ - \bar{p}(V(x)). \end{aligned}$$

We will prove continuity by utilizing the closed graph theorem (see, e.g., [2, Theorem 2.58]) noting that Proposition 3.6 provides us with the condition that the clearing wealths map into a compact set. Theorem 4 of [34] immediately provides the monotonicity of the clearing wealths.

Fix $x \in \mathbb {R}^{n+1}_+$ and let $\mathcal {X}= x + [-1,1]^{n+1}$ be a closed compact neighborhood of x in the full Euclidean space $\mathbb {R}^{n+1}$. Then we can define $V^x: \mathcal {X}\rightarrow \mathbb {R}^{n+1}$ as the restriction (and possible expansion to negative terms) of the domain of V to $\mathcal {X}$. The graph of V^x is given by:

$$\begin{aligned} {\text {graph}}V^x= & {} \Bigg \{(\hat{x},\hat{V}) \in \mathcal {X}\times \prod _{i \in \mathcal {N}_0} \left[x_i-1-\sum _{j \in \mathcal {N}_0} \bar{L}_{ij} , x_i+1+\sum _{j \in \mathcal {N}} \bar{L}_{ji}\right] \; | \; \hat{V}\\= & {} \hat{x} + \Pi (\hat{V})^\top [\bar{p}(\hat{V}) - \hat{V}^-]^+ - \bar{p}(\hat{V})\Bigg \}. \end{aligned}$$

To see that \({\text {graph}}V^x\) is closed let \((\hat{x}^k,\hat{V}^k)_{k \in \mathbb {N}} \subseteq {\text {graph}}V^x \rightarrow (\hat{x},\hat{V})\), then immediately

$$\begin{aligned} \hat{V}= & {} \lim _{k \rightarrow \infty } \hat{V}^k = \lim _{k \rightarrow \infty } \left[\hat{x}^k + \Pi (\hat{V}^k)^\top [\bar{p}(\hat{V}^k) - (\hat{V}^k)^-]^+ - \bar{p}(\hat{V}^k)\right] \\= & {} \hat{x} + \Pi (\hat{V})^\top [\bar{p}(\hat{V}) - \hat{V}^-]^+ - \bar{p}(\hat{V}) \end{aligned}$$

by continuity of the nominal liabilities matrix L. Therefore by the closed graph theorem we immediately recover that \(V^x\) is continuous for any \(x \in \mathbb {R}^{n+1}_+\), which implies that V is continuous at any x as well and thus \(V: \mathbb {R}^{n+1}_+ \rightarrow \mathbb {R}^{n+1}\) is a continuous mapping. \(\square \)

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