The network origins of aggregate fluctuations: a demand-side approach

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Aim of the paper

Exploring the network origins of aggreagate fluctuations from a **demand-side** perspective, by building an *aggregate structural model with agent-based features* (Gouri Suresh and Setterfield, 2015) to explicitly account for:

- *Network interactions* among agents.
- Role of *conventional decision-making* on firms' investment decisions.

"Completing the square"

- Gabaix (2011): "supply granularity" of aggregate fluctuations.
- Dosi et al. (2019): "demand granularity" of aggregate fluctuations.
- Acemoglu et al. (2012): "supply-side" network origins of aggregate fluctuations.
- Our contribution: "demand-side" network origins of aggregate fluctuations.

The basic model

The model is expressed by the recursive interaction of this system:

$$g_{jt}^{i} = \alpha_{jt} + \left(g_u + \frac{g_r \pi}{v} \right) u_{jt-1} \tag{1}$$

$$u_{jt} = \frac{v}{s_\pi \pi} g_{jt}^{i} \tag{2}$$

$$\Delta\alpha_{jt} = \alpha(\Delta u_{jt-1}, \Delta\bar{u}_{t-1}) \tag{3}$$

The system is completed by the following aggregation procedure:

$$K_t = \sum_{j=1}^{n} (1 + g_{jt}^{a}) K_{jt-1}$$

$$g_t^{a} = \frac{K_t - K_{t-1}}{K_{t-1}}$$

$$u_t = \frac{v}{s_\pi \pi} g_t^{a}$$

Table 1: Setting and revising the state of long run expectations (SOLE).

Criteria	Effect on SOLE
$\alpha_{jt} < 0$	$\alpha_{jt} = 0$
$g^a_{jt} = \frac{s_\pi \pi}{v}$	$\alpha_{jt} = \alpha'_{jt} = \frac{s_\pi \pi}{v} - \left(g_u + \frac{g_r \pi}{v}\right)$
$\kappa \Delta u_{jt-1} + (1-\kappa)\Delta \bar{u}_{t-1} \geq c$ *and* $1 - u_{jt-1} \geq \phi \Delta u_{jt-1}$	$\Delta \alpha_{jt} = \varepsilon$
$\kappa \Delta u_{jt-1} + (1-\kappa)\Delta \bar{u}_{t-1} > -c$ *and* $\kappa \Delta u_{jt-2} + (1-\kappa)\Delta \bar{u}_{t-2} \leq -c$ *and* $1 - u_{jt-1} \geq \phi \Delta u_{jt-1}$	$\Delta \alpha_{jt} = \varepsilon$
$\kappa \Delta u_{jt-1} + (1-\kappa)\Delta \bar{u}_{t-1} \leq -c$	$\Delta \alpha_{jt} = -\varepsilon$
$\kappa \Delta u_{jt-1} + (1-\kappa)\Delta \bar{u}_{t-1} < c$ *and* $\kappa \Delta u_{jt-2} + (1-\kappa)\Delta \bar{u}_{t-2} \geq c$	$\Delta \alpha_{jt} = -\varepsilon$
$1 - u_{jt-1} < \phi \Delta u_{jt-1}$	$\Delta \alpha_{jt} = -\varepsilon$

If none of the above conditions is satisfied, then the SOLE remains *constant* and the firm converges to a steady-state rate of capacity utilization

The extended model

Modeling firms' investment decisions through a "complex adaptive system" perspective (Arthur, 2014, Chapter 1), according to two variables:

1. Economic "fundamental": individual rate of capacity utilization.
2. Keynesian "beauty contest": average rate of capacity utilization of neighboring firms.

Analyzing the impact of three network structures:

1. Random network (Erdős and Rényi, 1959).
2. Preferential attachment (Barabási and Albert, 1999).
3. Small world (Watts and Strogatz, 1998).

Our interest is in the sensitivity of aggregate fluctuations to the **eigenvector centrality** (x_j) of a firm's linked network neighbours, and the **weight** (ω) that a firm attaches to the weighted average capacity utilization of its linked network neighbours ($\bar{u}_{\Theta_j}$):

$$x_j = \frac{1}{\lambda_1} \sum_{l=1}^{N} a_{jl} x_l \tag{4}$$

$$\bar{u}_{\Theta_j} = \frac{\sum\limits_{l \in \Theta_j} u_l x_l^{\omega}}{\sum\limits_{l \in \Theta_j} x_l^{\omega}} \tag{5}$$

The reaction function of individual firms in updating the SOLE (Equation (3)) now reads as follows:

$$\Delta \alpha_j = \alpha(\Delta u_{jt-1}, \Delta \bar{u}_{\Theta_{jt-1}}) \tag{6}$$

Simulation

For each network structure, we simulate the impact of x_j and ω on aggregate fluctuations ($\hat{\sigma}_u$) by setting $\kappa = 0.5$ (each firms attach equal weight to changes in their own circumstances and changes in the weighted average rate of capacity utilization of linked neighbours when revising their SOLE).

We vary $\omega \in [0, 4]$ in discrete increments of 0.1 (a new network configuration is generated for each repetition of the model, and this configuration then remains unchanged over the entire range of variation in ω).

We perform 50 repetitions, thus generating 2,050 observations of $\hat{\sigma_u}$, through which we analyze the impact on aggregate fluctatuons.

Every simulation entail 50 firms and the initial shock to the individual rate of capacity utilization is set to $\Delta u_{j0} \sim N(0, \sigma_u), \forall j$.

Results

Figure 1: Aggregate fluctuations and the impact of weight: Random network.

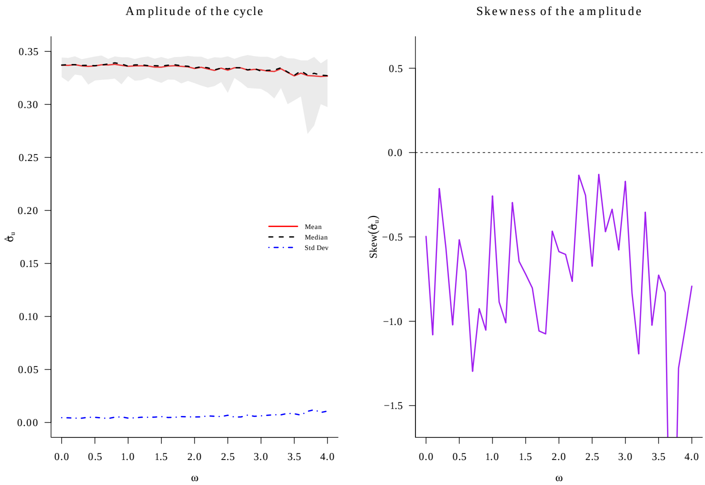


Figure 2: Aggregate fluctuations and the impact of weight: Preferential attachment.

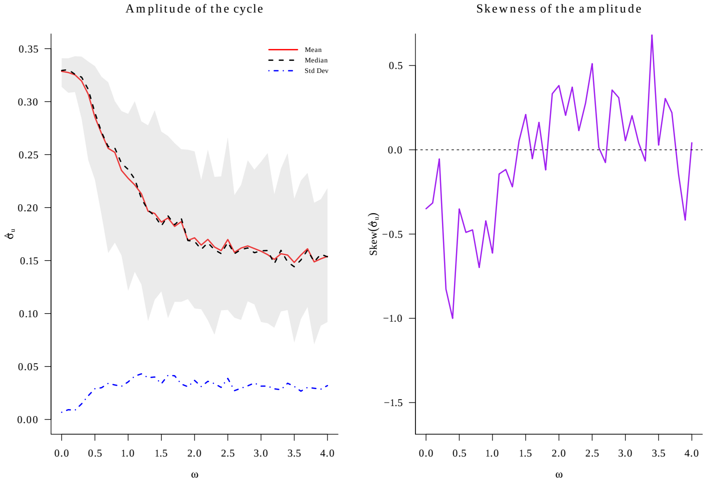
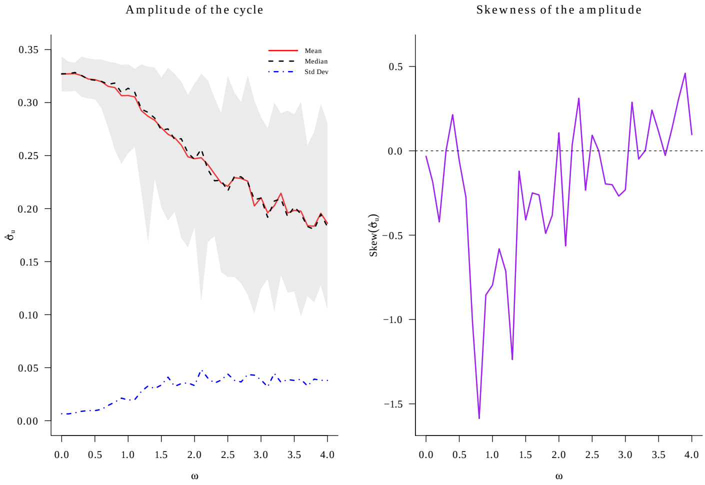


Figure 3: Aggregate fluctuations and the impact of weight: Small world.



Econometric analysis

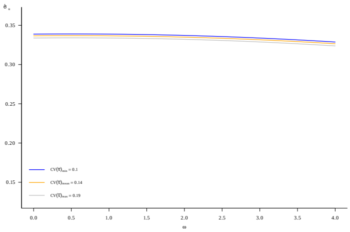
We analyze the impact that the following network metrics on aggregate fluctuations by means of this linear regression:

$$\hat{\sigma}_u = \gamma_0 + \gamma_1 \omega + \gamma_2 \omega^2 + \gamma_3 CV(\bar{x}_j) + \xi \quad (7)$$

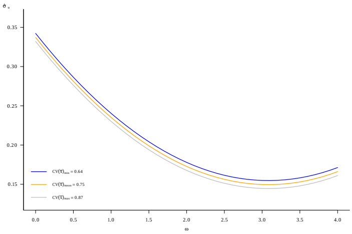
Table 2: Regression results

	RN	*PA*	*SW*
ω	0.001*	−0.122***	−0.050***
	(0.0005)	(0.002)	(0.002)
ω^2	−0.001***	0.020***	0.002***
	(0.0001)	(0.001)	(0.001)
$CV(\bar{x}_j)$	−0.053***	−0.045**	−0.081***
	(0.010)	(0.021)	(0.006)
Constant	0.344***	0.371***	0.377***
	(0.001)	(0.016)	(0.003)
Observations	2,050	2,050	2,050
Adjusted R^2	0.210	0.750	0.708
Notes:			*p<0.1; **p<0.05; ***p<0.01

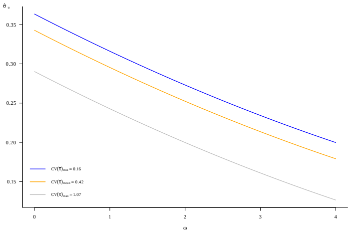
Figure 4: The joint effects of ω and $CV(\bar{x}_j)$ on aggregate volatility.



(a) Random network.



(b) Preferential attachment.



(c) Small world.

Conclusions

Our results suggest that in general, centrality has a stabilizing effect on the aggregate economy:

- As firms attach more weight to centrality, macroeconomic volatility declines.
- The amplitude of aggregate fluctuations falls as the coefficient of variation of eigenvector centrality rises.

Networks in which there are fewer more central firms acting as aggregators and disseminators of information have a stabilizing effect on the aggregate economy.

Our analysis also suggests that typical aggregative demand-led models of growth and fluctuations can be imbued with micro-foundational features that advance our understanding of the dynamics of a demand-led economy.

Thank ***You!***

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