Microeconomic Shocks and Macroeconomic Fluctuations in a Dynamic Network Economy

Niels Anthonisen,
Mount Allison University

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Motivating Question

Can macroeconomic fluctuations (that is, business cycles) arise as the consequence of numerous independent shocks to individual firms?

In other words:

Can microeconomic shocks generate macroeconomic fluctuations?

Argument Against Invokes the Law-of-Large-Numbers

- The sum of many of small independent shocks will involve a great deal of “averaging out,” with positive shocks cancelling negative shocks.
- and so if the number of these shocks is large, then their aggregate effect will be negligible relative to the size of the economy.
- I refer to this as the **diversification hypothesis**.

Argument in Favour: Granular Hypothesis

- **Xavier Gabaix**: "The Granular Origins of Aggregate Fluctuations," *Econometrica*, 2011.
- Proposes a mechanism whereby independent firm-level shocks can generate macroeconomic fluctuations.
- Two ingredients to the Granular Hypothesis:
  1. The empirical fact that firm-sizes in the U.S. - or at least, its upper tail - are distributed according to a Pareto distribution with infinite variance.
  2. Firms coexist in a network structure.

The Mechanism of the Granular Hypothesis

The Granular Hypothesis:

- The Pareto distribution of firm-sizes produces a Pareto distribution of firm-level shocks.
- These include a small number of very large shocks that - because of their small number - do not cancel in accordance with the LLN.
- These large shocks are then propagated across the economy by a network of economic linkages.

Acemoglu et al

Another important contribution to this literature is

- "The Network Origins of Aggregate Fluctuations," by Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi, *Econometrica* 2012.
- Also constructs a network economy and explores the Granular Hypothesis.
- However the focus is on sectors of the economy rather than firms.

Introduction

The paper builds a network economy that differs from those of Gabaix and Acemoglu et al in two fundamental respects.

FIRST: Economies in this paper are dynamic.

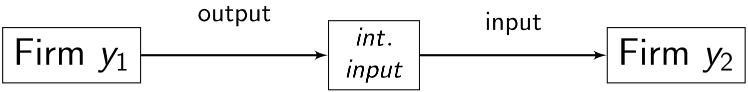
IN CONTRAST: The models of both Gabaix and Acemoglu et al are static.

SECOND: Firms in this paper are connected by income-expenditure linkages.

IN CONTRAST: Economic units (firms or sectors) in both Gabaix and Acemoglu et al are connected by input-output linkages.

This paper:

The two other papers

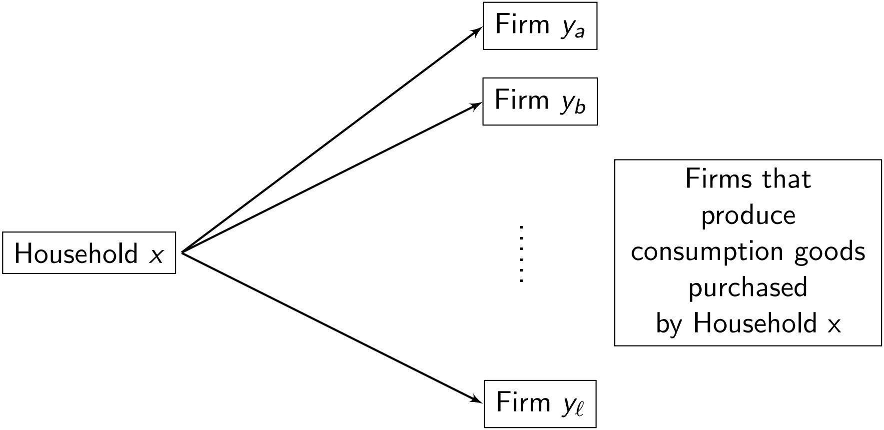


Structure of the Model

There are

- m households: $H = \{x_1, \ldots, x_m\}$
- n firms $F = \{y_1, \ldots, y_n\}$.

Structure of the Model



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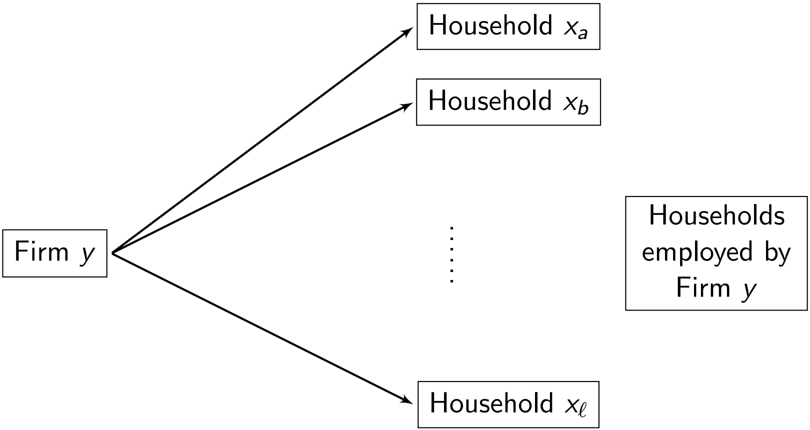
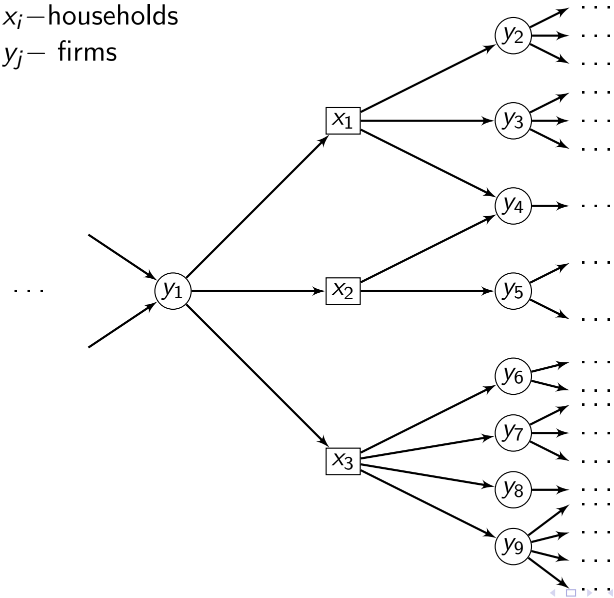


Structure of the Model

x_i − households

y_j − firms



Demographics

- Time is discreet and extends from $-\infty$ to $+\infty$.
- There are overlapping generations of two-period-lived agents.
- In each time period m new agents are born, one at each household.
- Thus in every time period, each household is inhabited by two agents, a young agent born in the current period, and an old agent born in the previous period.
- Agents produce when young and consume when old.
- All transactions involve an exchange of a good or service for fiat currency: goods are purchased with currency, and wages are paid with currency.

Households: Transactions

Events from the perspective of a generic agent born at household $x_1 \in H$ in period t:

- Young agent at x_1 is employed by firm $y_1 \in F$.
- In period t, young agent at x_1 sells her labour to firm y_1 in period t in exchange for cash.
- She then carries the cash forward into period $t + 1$.
- In $t + 1$, the agent, now old, uses the currency to purchase consumption goods produced by firms y_2, y_3, and y_4.

Firms: Transactions

- Firms are infinitely-lived.
- Events from the perspective of a generic firm, y_4:
  - In period t, the firm y_1 hires workers that inhabit households x_1, x_2, and x_3, and produces consumption goods according to a production function for which labour is the only input.
  - The firm then sells these commodities to households not shown, but implied the arrows.
  - All revenue obtained from the sale of goods is passed on to workers in the form of wages.

Productivity Shocks

- In every time period, each individual firm experiences an output shock.
- The output shock at firm y follow an $AR(1)$ process with log-normally distributed disturbances. In particular,

$$\log z_{t+1}(y) = \phi \log z_t(y) + \log u_{t+1},$$

$0 < \phi < 1$, and $\log u_{t+1} \sim N(0, \sigma^2)$.

- All $u_t(y)$ are independent, both across the economy, and over time.

- All agents are price takers in all markets and in all time periods.
- The model admits a unique non-explosive dynamic stochastic competitive equilibrium.

Two Assumptions

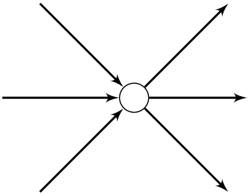
Assumption 1: Each household purchases consumption goods from a single firm.

Assumption 2: The number of households that purchase consumption goods from any given firm equals the number of workers employed by that firm.

Implication of Assumptions

1. **First Assumption Implies** The underlying network can be represented as a directed graph where each vertex represents a firm and each edge represents a household. (The converse is also true.)
2. **Together the Two Assumptions Imply** The in-degree for each vertex equals its out-degree.

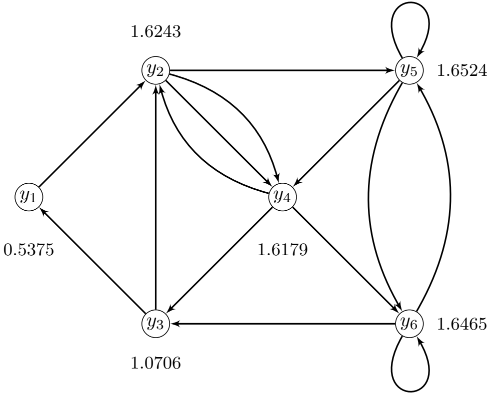
Chief Implication of Assumptions



number incoming edges
= in-degree

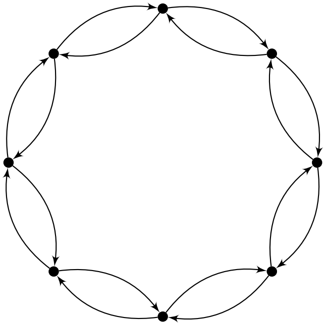
number of outgoing edges
= out-degree

Example 1



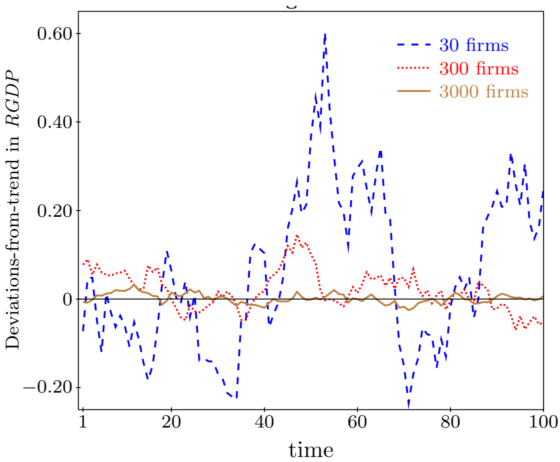
Firms	6
Households	15
$RGDP$	8.149...
$RGDP$/firm	1.358...
$RGDP$/worker	0.543...
σ	0.113...
$\frac{\sigma\{RGDP\}}{RGDP}$	0.283...

Example 2: Cycle Graph



Time Series for Percentage Deviations from Trend in RGDP

Time series for $\frac{RGDP_t - \overline{RGDP}}{\overline{RGDP}}$, $t = 1, \ldots, 100$.



Example 3: Failure of Diversification Hypothesis

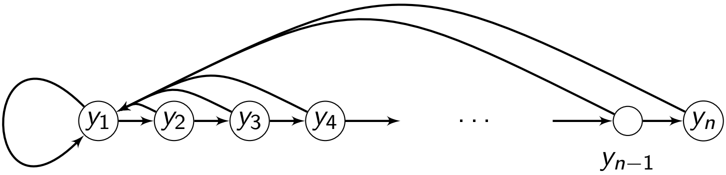


Table 3

n	$RGDP$	$RGDP$/firm	$RGDP$/worker	sd/$RGDP$	$\frac{E\{q_t(y_1)\}}{RGDP}$
5	5.0682...	1.013...	0.563...	0.521...	0.412...
10	6.414...	0.641...	0.337...	0.467...	0.330...
20	6.750...	0.337...	0.173...	0.4564...	0.3138...
50	6.763...	0.135...	0.068...	0.4561...	0.3132...

Theoretical Results

1. If firm-sizes in an economy are drawn from a fixed distribution whose variance is finite, then independent firm-level shocks *cannot* generate business cycles.
2. If firm-sizes in an economy are drawn from a Pareto distribution whose variance is infinite, then independent firm-level shocks *can* generate business cycles.

These agree with theoretical results from Gabaix and from Acemoglu et al.

The Pareto Distribution: A Strange, Strange Distribution

- Salient feature of these distributions is a ‘heavy right tail.”
- Place a lot of probability mass (comparatively speaking) on observations that are very large.
- Therefore, the largest element in a random sample is often *very* large compared to the rest of the sample.

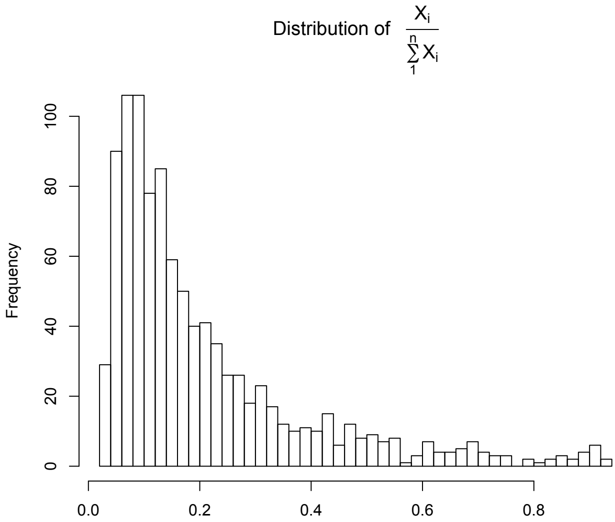
Pareto Distributions; Size of the Largest Element in a Random Sample

Experiment:

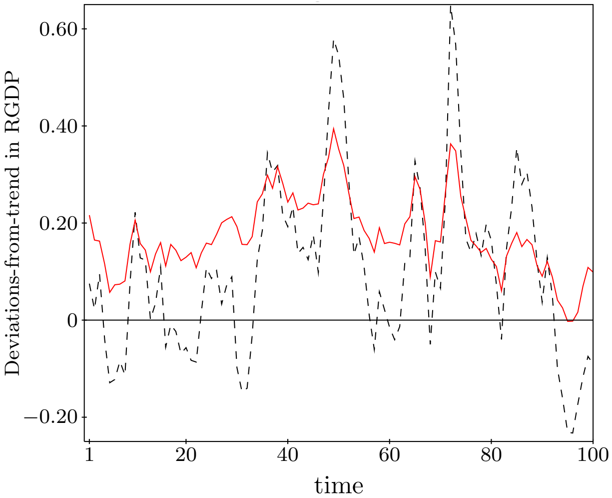
1. Draw 1000 random samples from a discrete Pareto distribution with parameters $\alpha = 2.059$, and $x_{min} = 1$.
2. Each random sample consists of 1000 draws.
3. For sample, $X_1, \ldots, X_{1000}$, compute the statistic

$$\frac{\max\{X_i\}}{\sum_{1=1}^{1000} X_i}$$

4. The following histogram shows the distribution of these1000 values.


Distribution of $\frac{X_i}{\sum_1^n X_i}$
Frequency
0
20
40
60
80
100
0.0
0.2
0.4
0.6
0.8

Firm Sizes Drawn from a Pareto Distribution, Example 1



Firm Sizes Drawn from a Pareto Distribution, Example 2