An Agent-Based Boom-Bust Business Cycle Model with Search-for-Yield and Heterogeneous Expectations in the Bond Market

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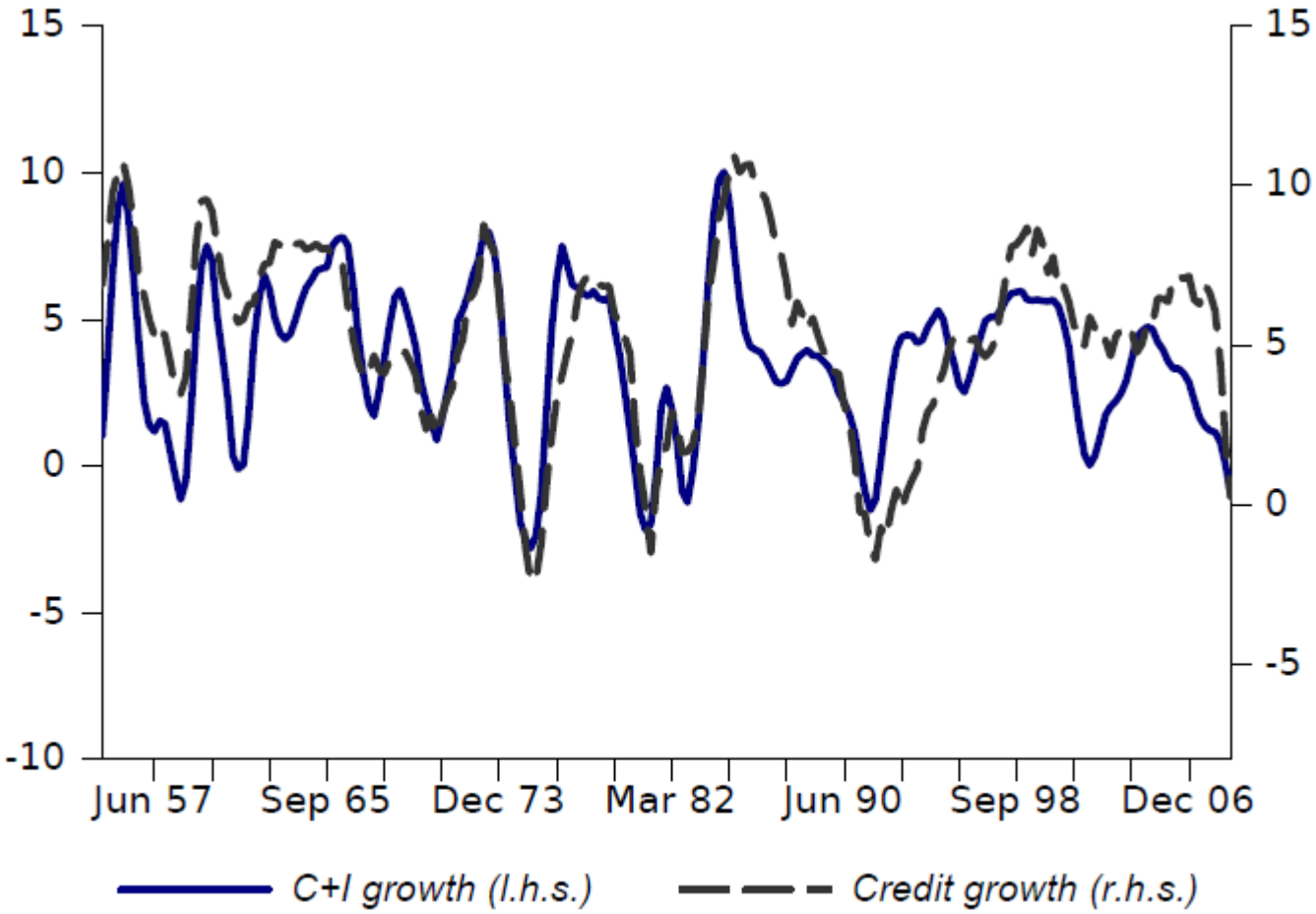
Disclaimer

This is work in progress.

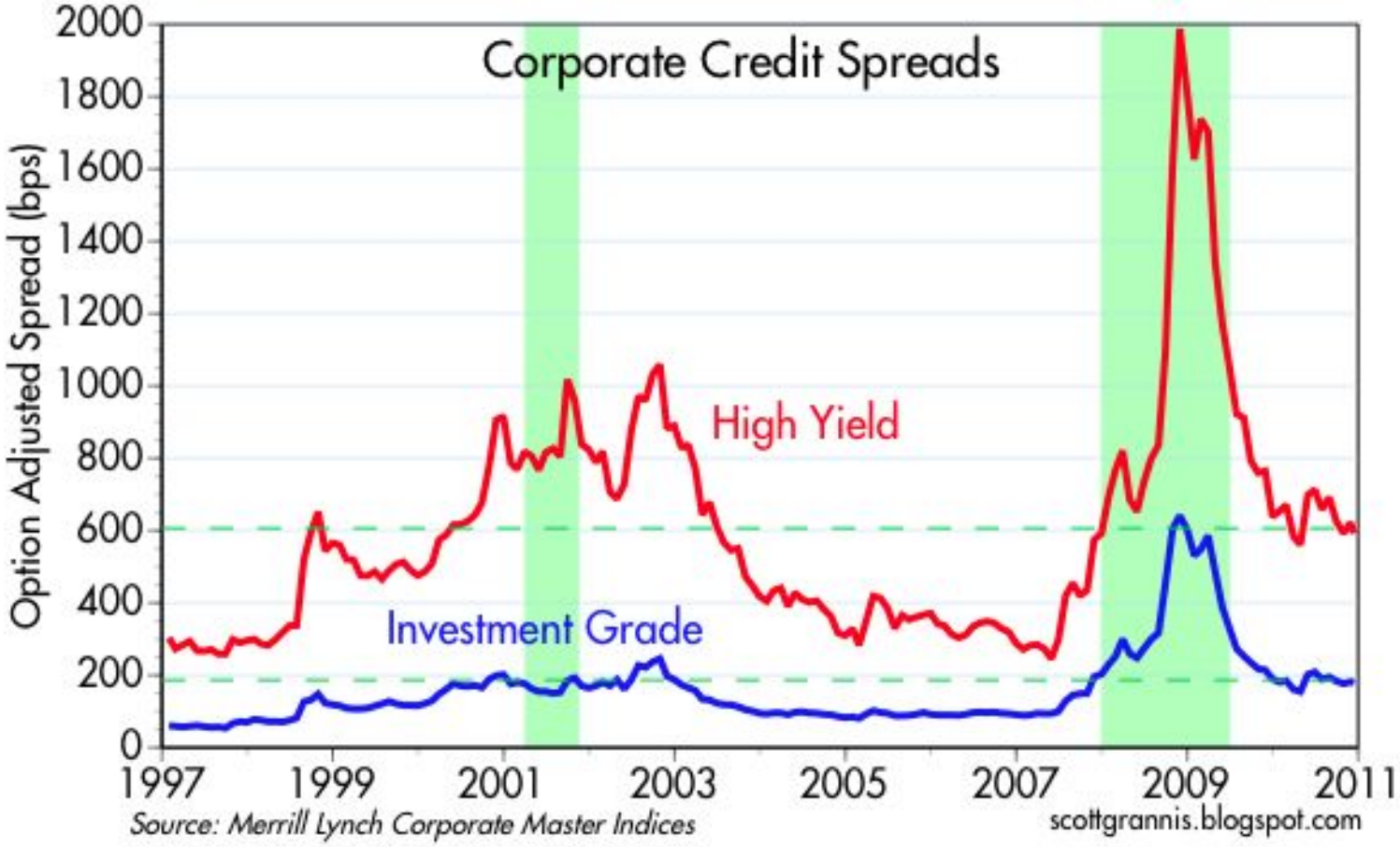

THE
OVERSTONE
CYCLE OF TRADE.
PROSPERITY
EXCITEMENT
CONVULSION
STAGNATION
IMPROVEMENT
CONFIDENCE
SOUTH POLE
WARMING
COMPANY.
BANK
WORKHOUSE

US Demand Growth and Credit Growth



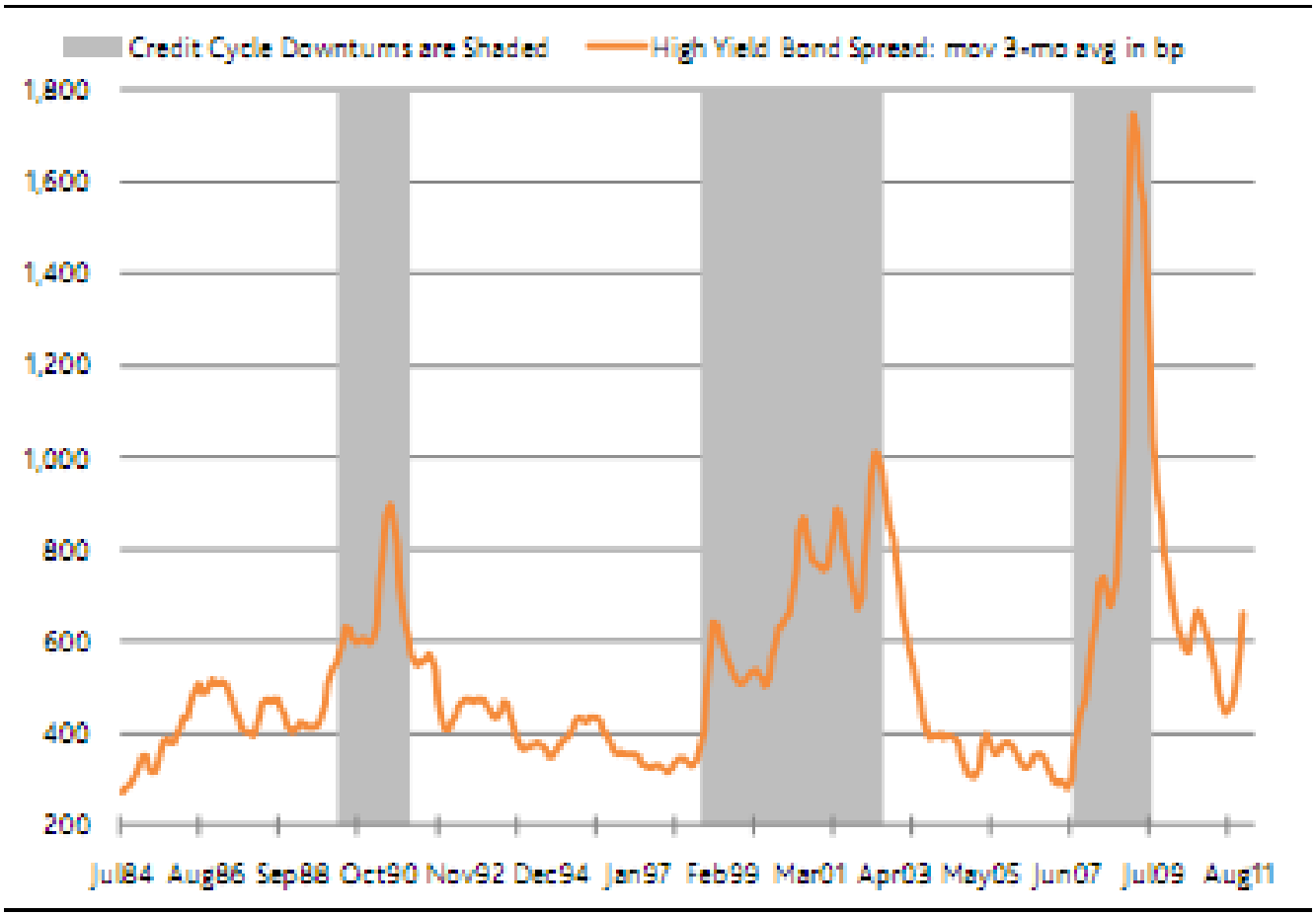
Source: Biggs et al. (2010)

Corporate Credit Spreads



Source: Merrill Lynch (2011)

Corporate Credit Spreads



Source: Merrill Lynch (2011)

Objectives

- To build a bottom-up macro-model which is able to endogenously generate economic fluctuations
- To show how the real sector is affected by the financial sector through credit creation
- To explain the pattern of risk premiums by means of the Minskyan story of *euphoria* and *depressions*

Approach: Agent-Based Modelling

- Features:
  - Allow for many possibly heterogeneous agents
  - Possibly account for interactions among agents (e.g. networks)
  - Bounded rationality
  - Look for emergent behaviour at the aggregate level
  - Empirical validation at statistical level
- Different kind of "microfoundations" from standard DSGE models

This model borrows from Chiarella and Di Guilmi (JEDC, 2011)

- Leontief production technology:

$$X_{it} = min[aK_{it}, (1/b)L_{it}], \qquad a, b > 0$$

- Infinitely elastic labour supply. So:

$$X_{it} = a\ K_{it}$$

- Price of good fixed mark-up over production cost:

$$P = (1 + \mu)wb$$

- Firms' expected market share:

$$\mathbb{E}[X_{it}^d] = X_t^d \frac{K_{it}}{K_t}$$

- Actual market share stochastic:

$$X_{it}^d = \mathbb{E}[X_{it}^d](1 + s_{it})$$

with

$$s_{it} = \tilde{s}_{it} \left(1 - \frac{\mathbb{E}[X_{it}^d]}{X_t}\right)$$

and

$$\tilde{s}_{it} \sim U[-0.2, 0.2]$$

- Aggregate demand:

$$X_t^d = wL_t + I_t$$

- Total demand for labour:

$$L_t = bX_t^d$$

- Investment:

$$I_{it} = \alpha e^{-\varrho_{it-1}} + \phi K_{it-1}$$

with

$$K_{it} = K_{it-1} + I_{it}$$

- Firms finance investment by issuing bonds. Profits are used to retire debt. If profits insufficient, debt is rolled over:

$$D_{it} = D_{it-1} - \pi_{it-1} + I_{it}$$

- Profits:

$$\pi_{it} = X_{it}^{d}(P - wb) - \varrho_{it} D_{it}$$

Residual profits are distributed to shareholders (investors)

- A firm fails if debt level exceeds some multiple of its capital stock:

$$D_{it} = D_{it-1} - \pi_{it-1} + I_{it} > c\, K_{it}, \qquad c \geq 1$$

- Can be rephrased in terms of market-share shock:

$$1 + s_{it-1} < \frac{K_{t-1}\left[D_{it-1}(1+\varrho_{it-1}) + I_{it} - cK_{it}\right]}{X^d_{t-1} K_{it-1}(P - wb)}$$

- Financial sector provides credit to firms (no credit rationing)
- Firm's bond's face values are given by

$$P_{izt}^{Bf} = 1 + r + \rho_{izt}$$

with the risk premium determined as

$$\begin{aligned} \rho_{it} &= \frac{D_{it}}{K_{it}}\omega \quad \text{if} \quad \frac{D_{it}}{K_{it}} \geq \bar{v} \quad \text{(risky or 'speculative')} \\ \rho_{it} &= 0 \quad \text{if} \quad \frac{D_{it}}{K_{it}} < \bar{v} \quad \text{(safe or 'hedge')} \end{aligned}$$

with $0 < \bar{v} < c$

- Two types of investors (or investment strategies):
  - fundamentalists (who only invest in safe bonds)
  - chartists (who only invest in risky bonds)
- Market-based bond values become

$$\begin{aligned} P^B_{i1t} &= P^B_{1t} = 1 + rn^f_t \\ P^B_{i2t} &= 1 + (r + \rho_{it})n^c_t \end{aligned}$$

Note: Returns depend on investors' strategies:

- an increase in the number of fundamentalists drives up the price of hedge firms bonds (and consequently pushes down the actual interest paid by hedge firms)

$$\varrho_{1t} = r\left(1 - n_t^f\right)$$

- an increase in the number of chartists drives up the price of speculative firms bonds (and consequently pushes down the actual interest paid by speculative firms)

$$\varrho_{i2t} = \left(r + \rho_{it}\right)\left(1 - n_t^c\right)$$

- Investors switch between two different strategies according to mechanism proposed by Brock and Hommes (Econometrica, 1997):
  - Share of fundamentalists

$$n_{ft+1} = \frac{exp(\beta\gamma_{f,t})}{exp(\beta\gamma_{ft}) + exp(\beta\gamma_{ct})}$$

  - Share of chartists

$$n_{ct+1} = \frac{exp(\beta\gamma_{c,t})}{exp(\beta\gamma_{ft}) + exp(\beta\gamma_{ct})}$$

  with

$$\gamma_{ft} = \pi_{ft} + \eta\pi_{ft-1}$$
$$\gamma_{ct} = \pi_{ct} + \eta\pi_{ct-1}$$

- Profits for investors are given by

$$\pi_f = \sum_i^{N_1} \varrho_{izt} D_{izt} \text{ for } z = 1$$

$$\pi_c = \sum_i^{N_2} \varrho_{izt} D_{izt} \text{ for } z = 2$$

  Note: N_2 only includes surviving (non-bankrupted) firms.

- Evolution of investors' financial wealth:

$$W_{t+1} = W_t + \sum_i^{Ns} \varrho_{it} D_{it} + \Psi \Pi_t - BD_t$$

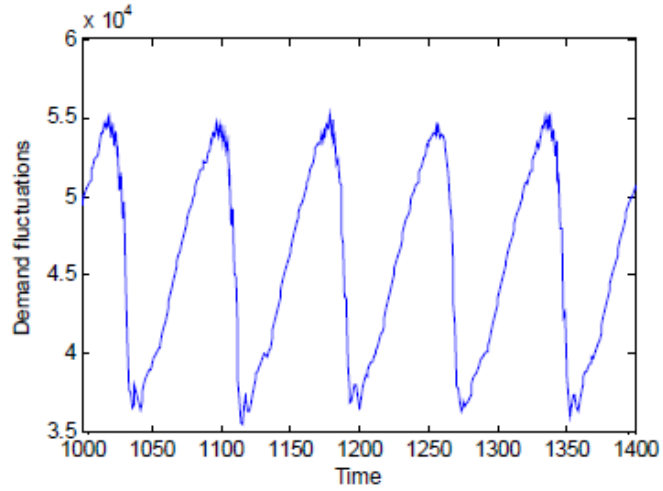
Simulation Results

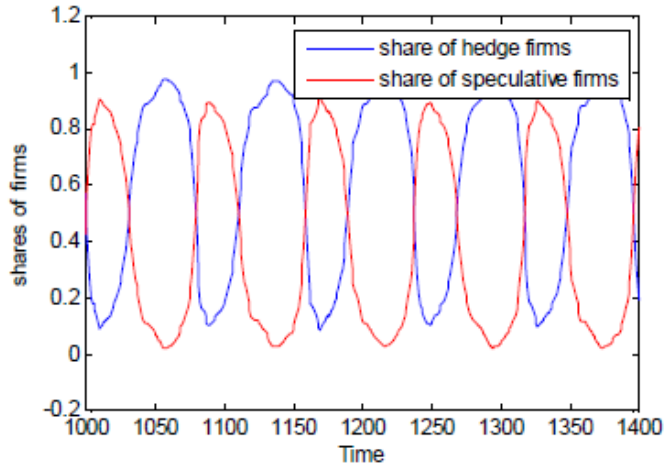
The above model was coded in Matlab and simulated for 1450 periods with the following parameter values:

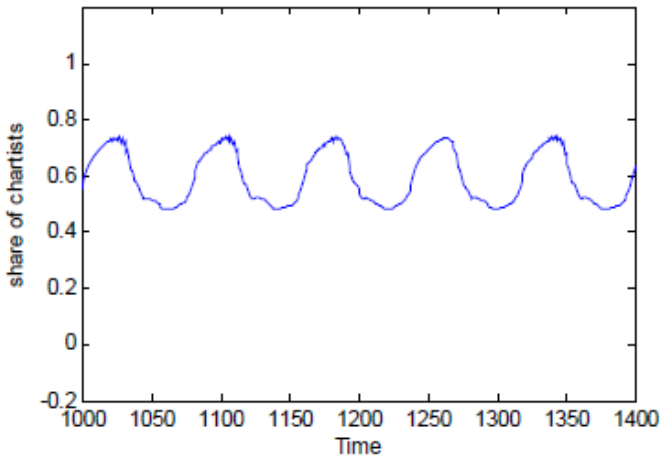
Parameter	Value	Parameter	Value
α	1.65	ϕ	0.01
b	1	a	0.575
μ	0.01	η	0.25
β	0.0001	ω	0.05
Ψ	1	c	2.5
$\bar{v}$	1.2	r	0.03
w	0.95		

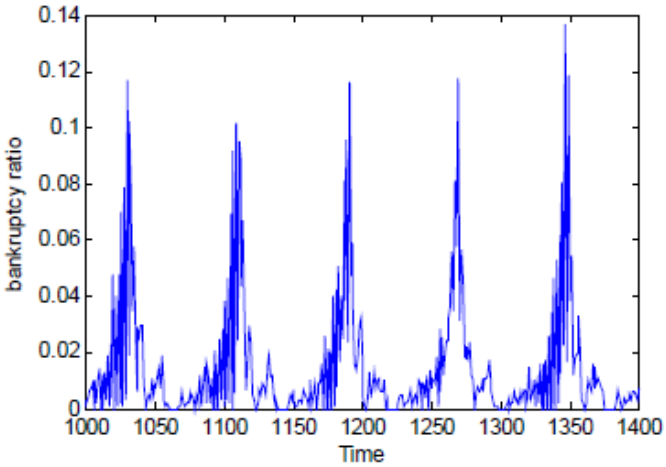
Simulation Results

A Representative Run for the Model Economy



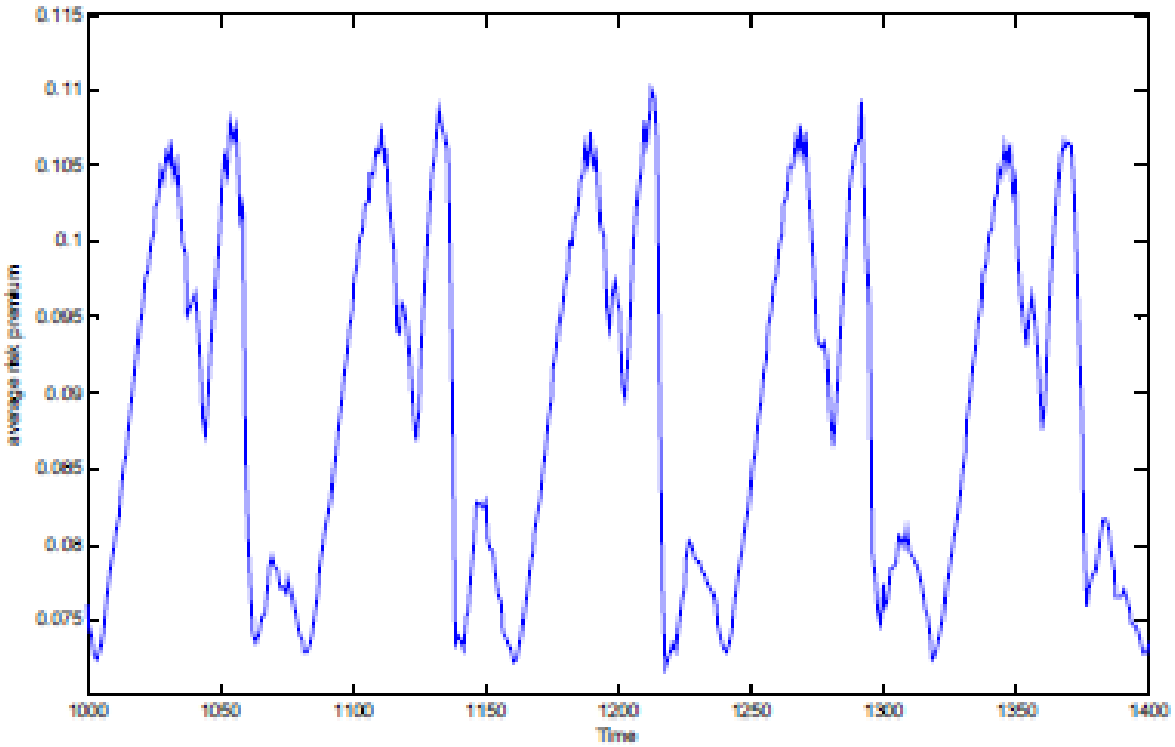






Simulation Results

The Average Risk Premium



The Story in a Nutshell

Expansions:

- Share of chartists rises as number of speculative firms increases
- Larger share of chartists makes credit more affordable for speculative firms which take on more debt to finance investment

Contractions:

- When leverage of speculative firms reaches critical threshold, bankruptcies rise and cause losses for chartists
- Share of fundamentalists rise and cost of financing for remaining speculative firms too
- Speculative firms more likely to default, causing further losses for chartists

$\Longrightarrow$ Cyclical pattern

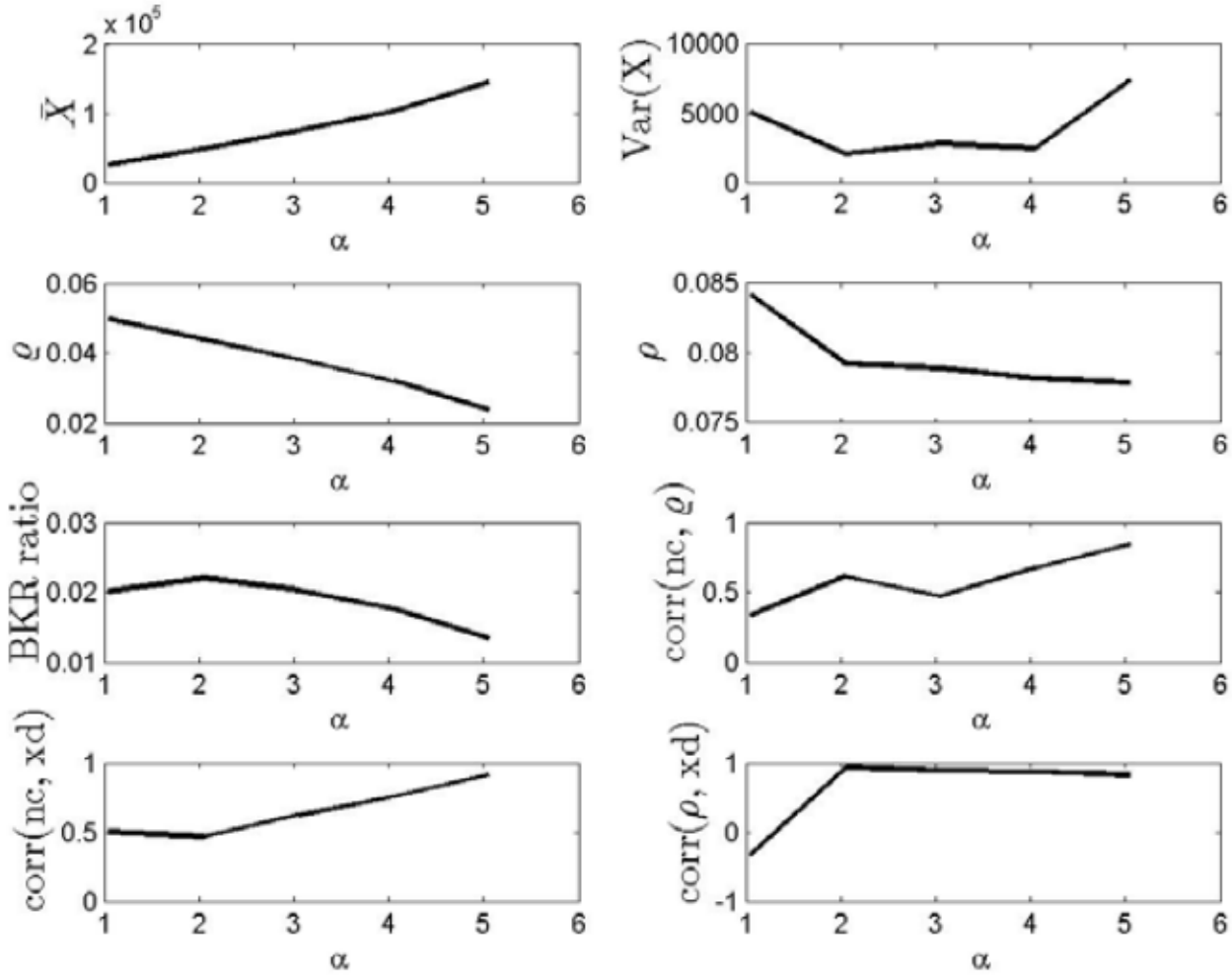
The Story in a Nutshell

Key Result:
'Search for yield' exacerbates the debt cycle

	With SFY Investors	Without SFY Investors
Duration of business cycle	$\sim$ 80 periods	$\sim$ 36 periods

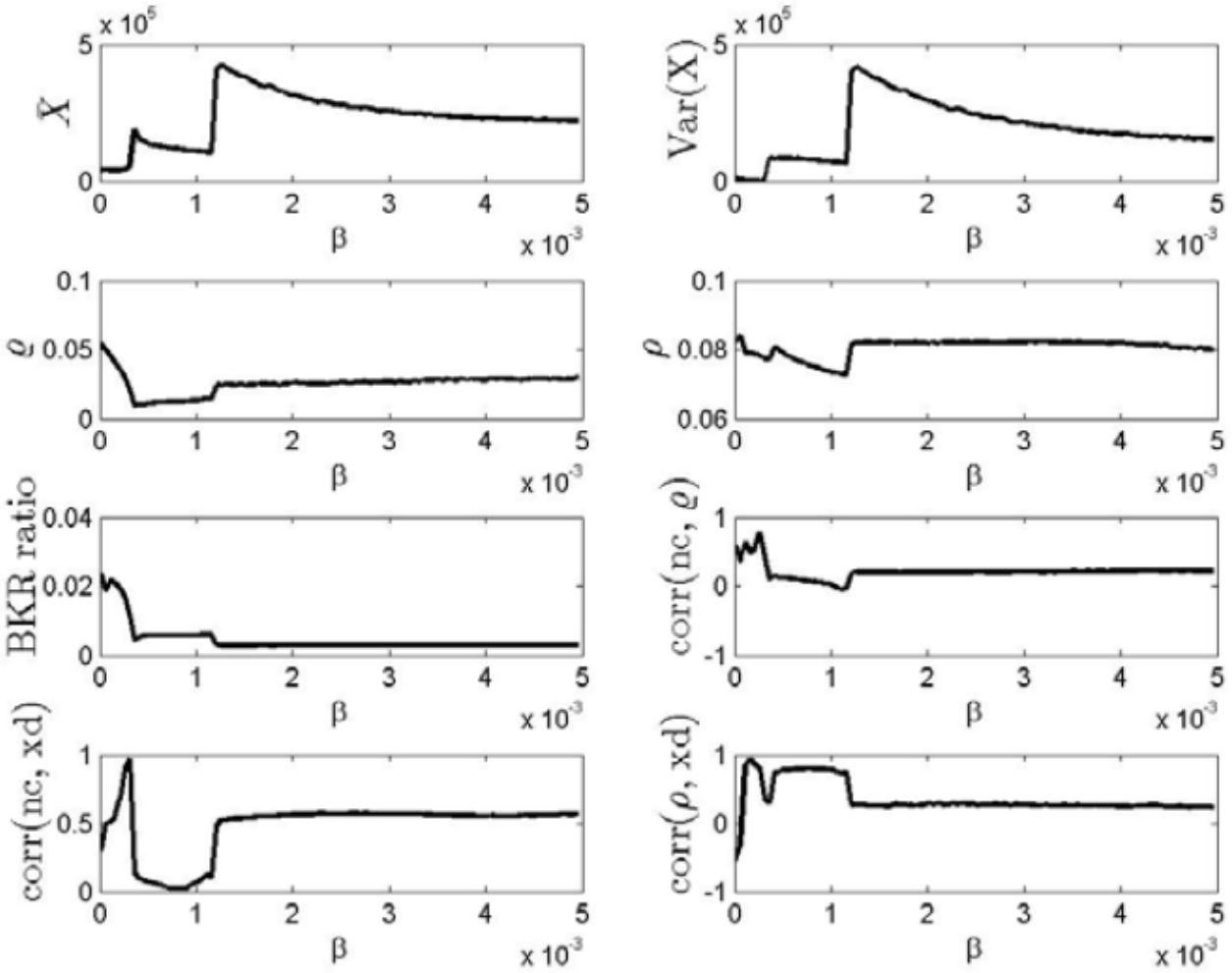
Monte Carlo Simulations

MC Simulation for α



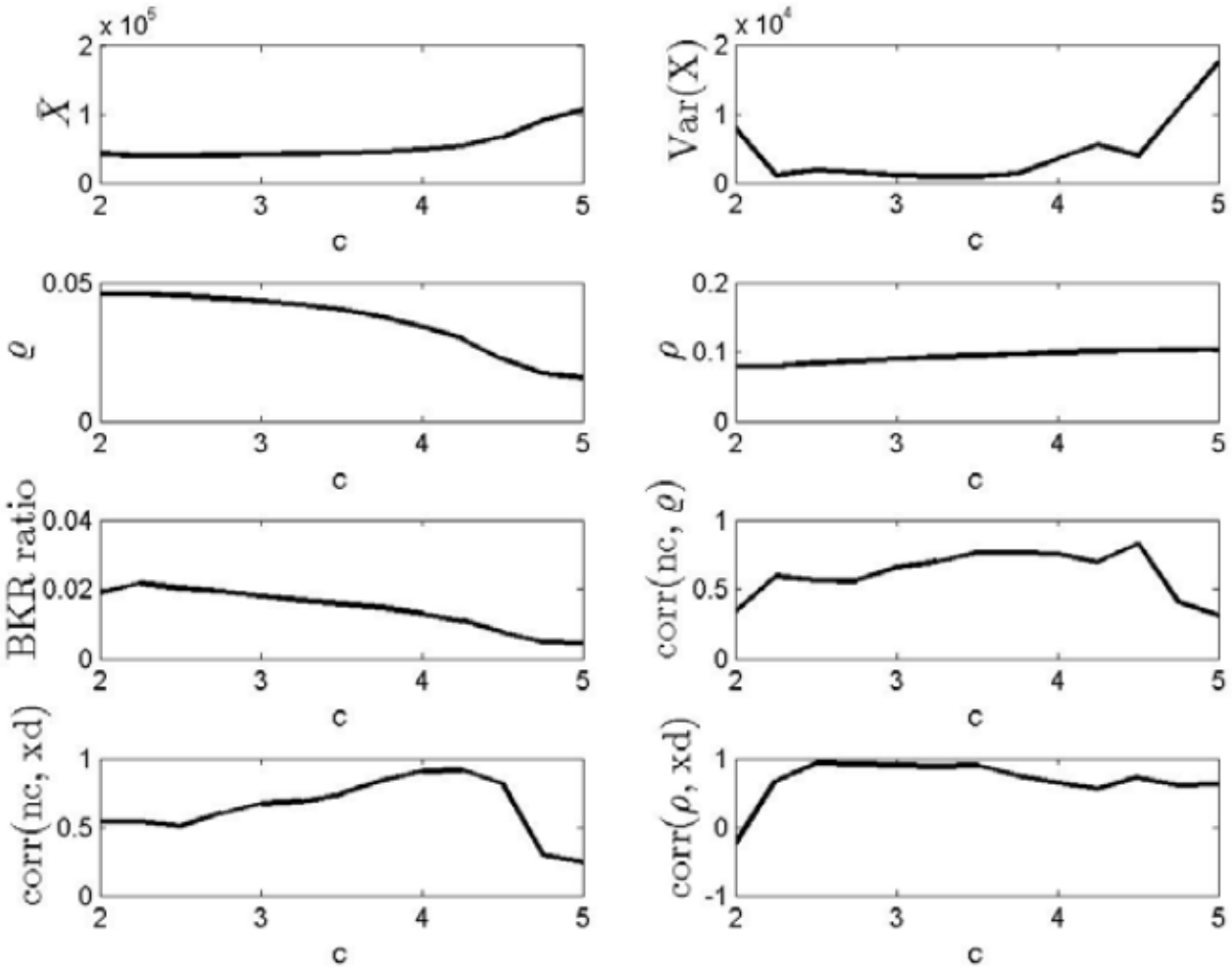
Monte Carlo Simulations Results

MC Simulation for β



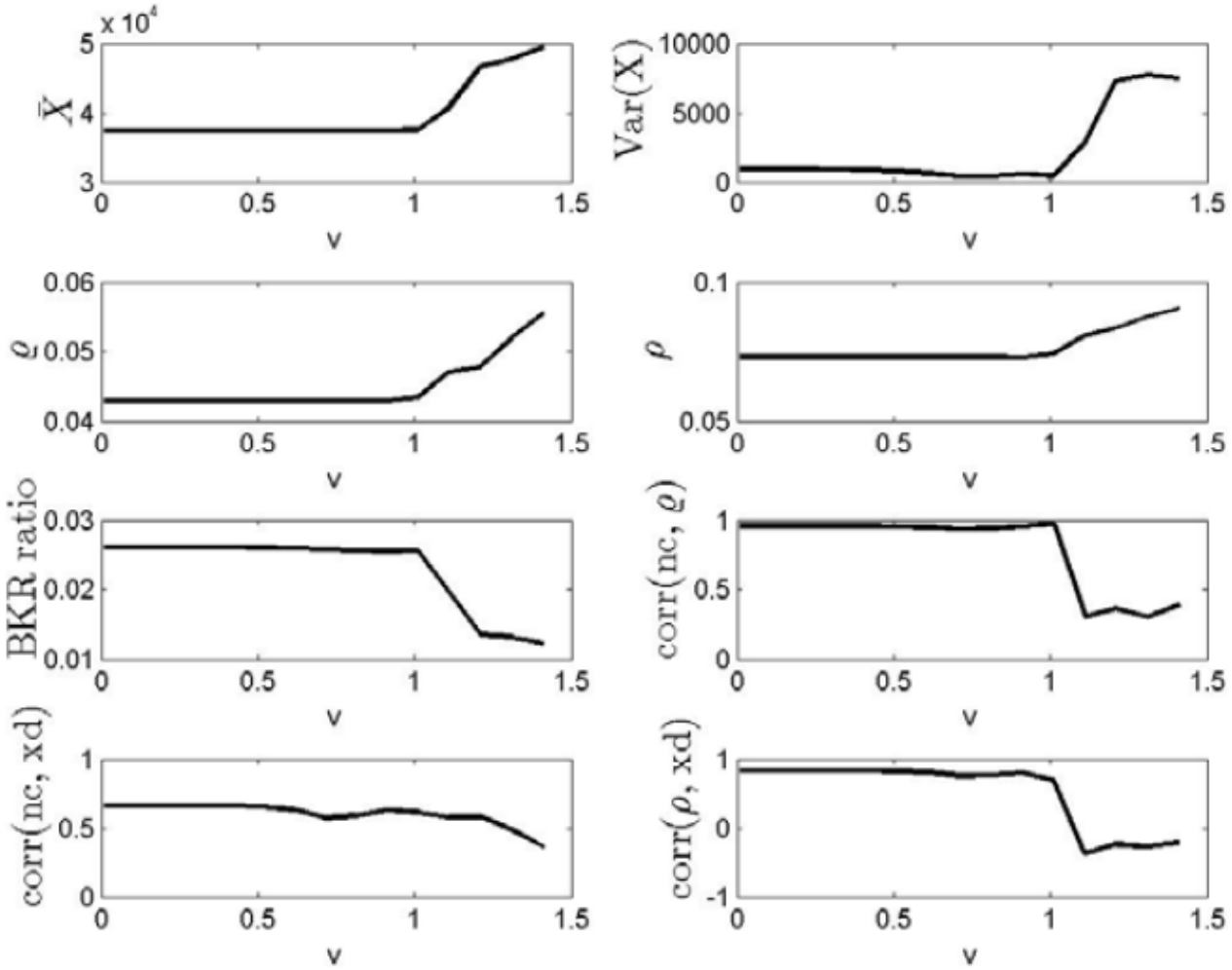
Monte Carlo Simulations Results

MC Simulation for c



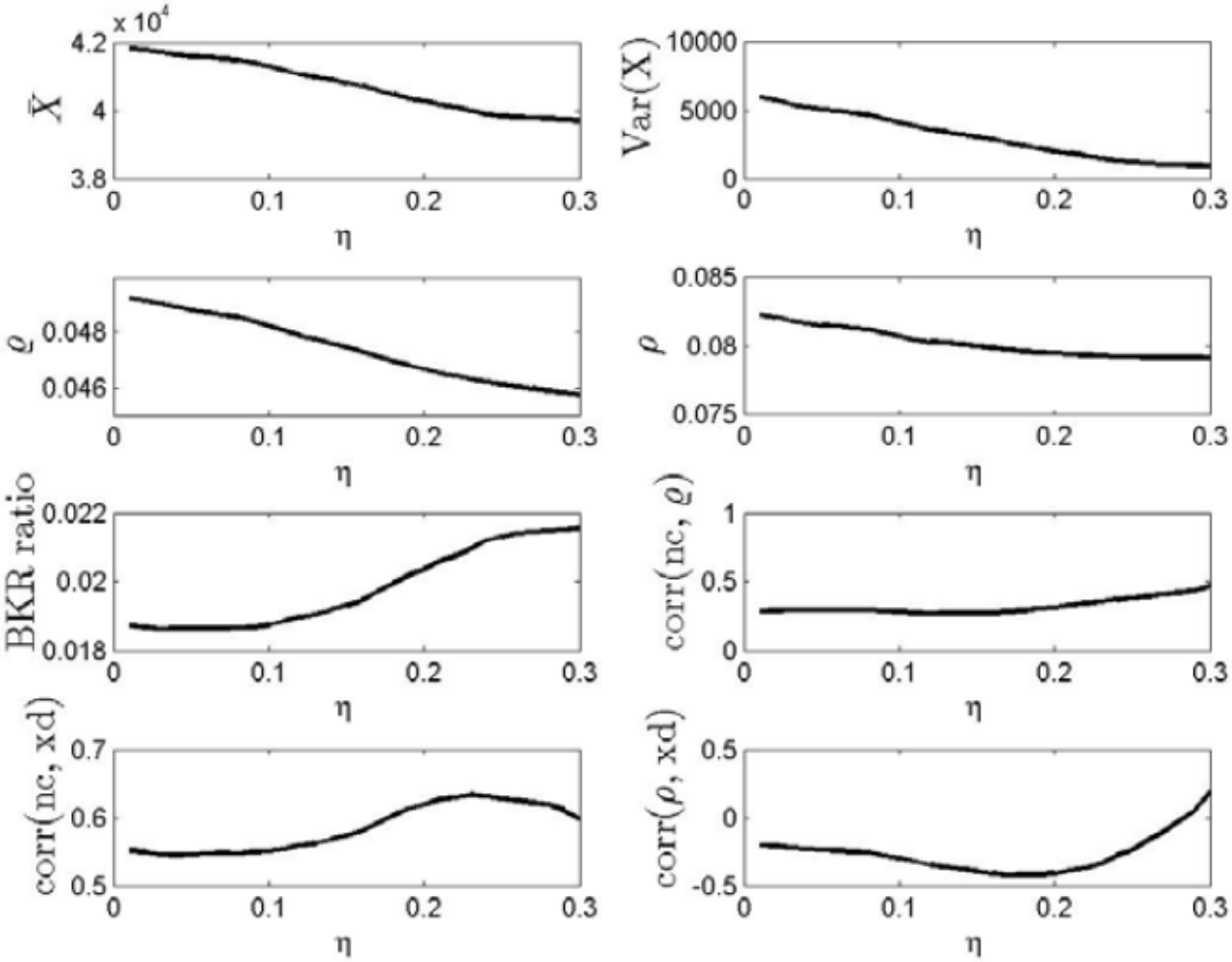
Monte Carlo Simulations Results

MC Simulation for $\overline{v}$



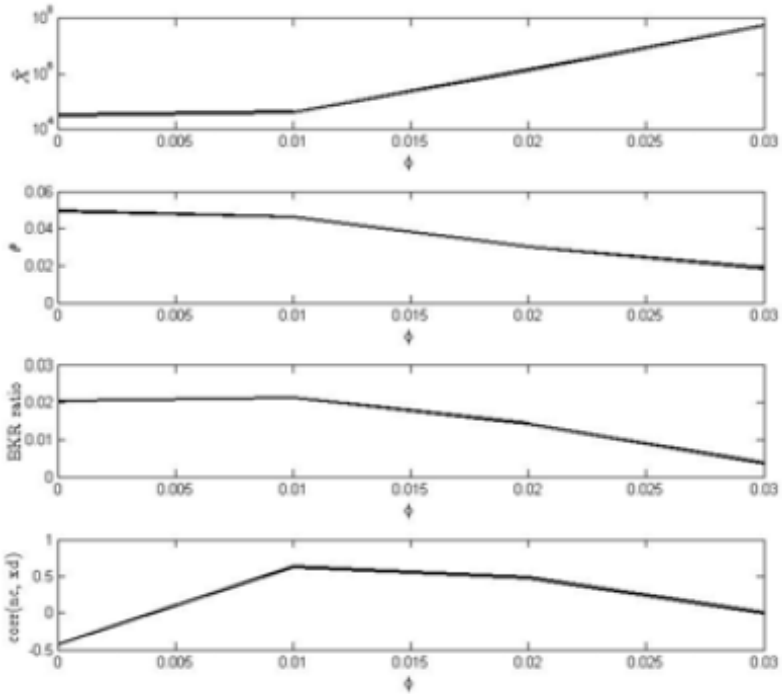
Monte Carlo Simulations Results

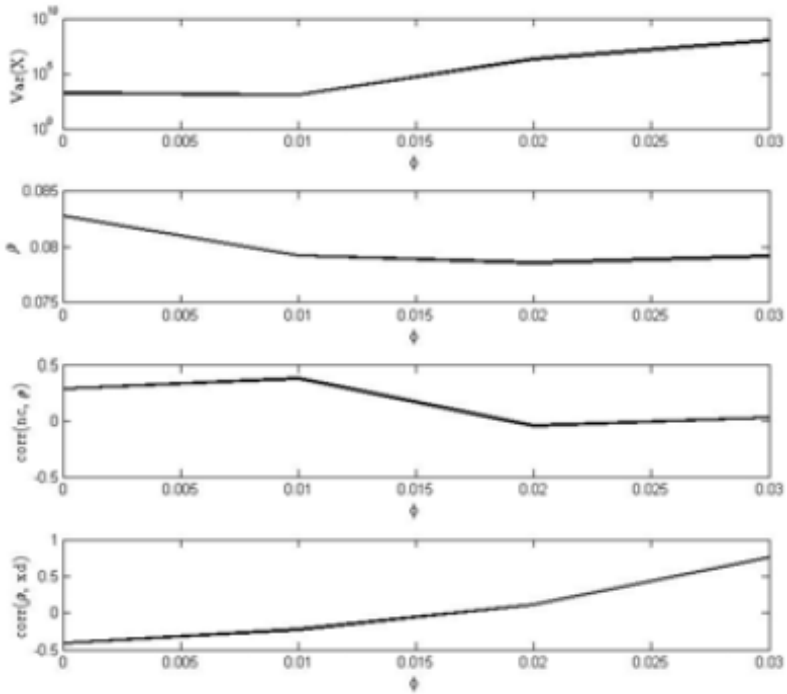
MC Simulation for η



Monte Carlo Simulations Results

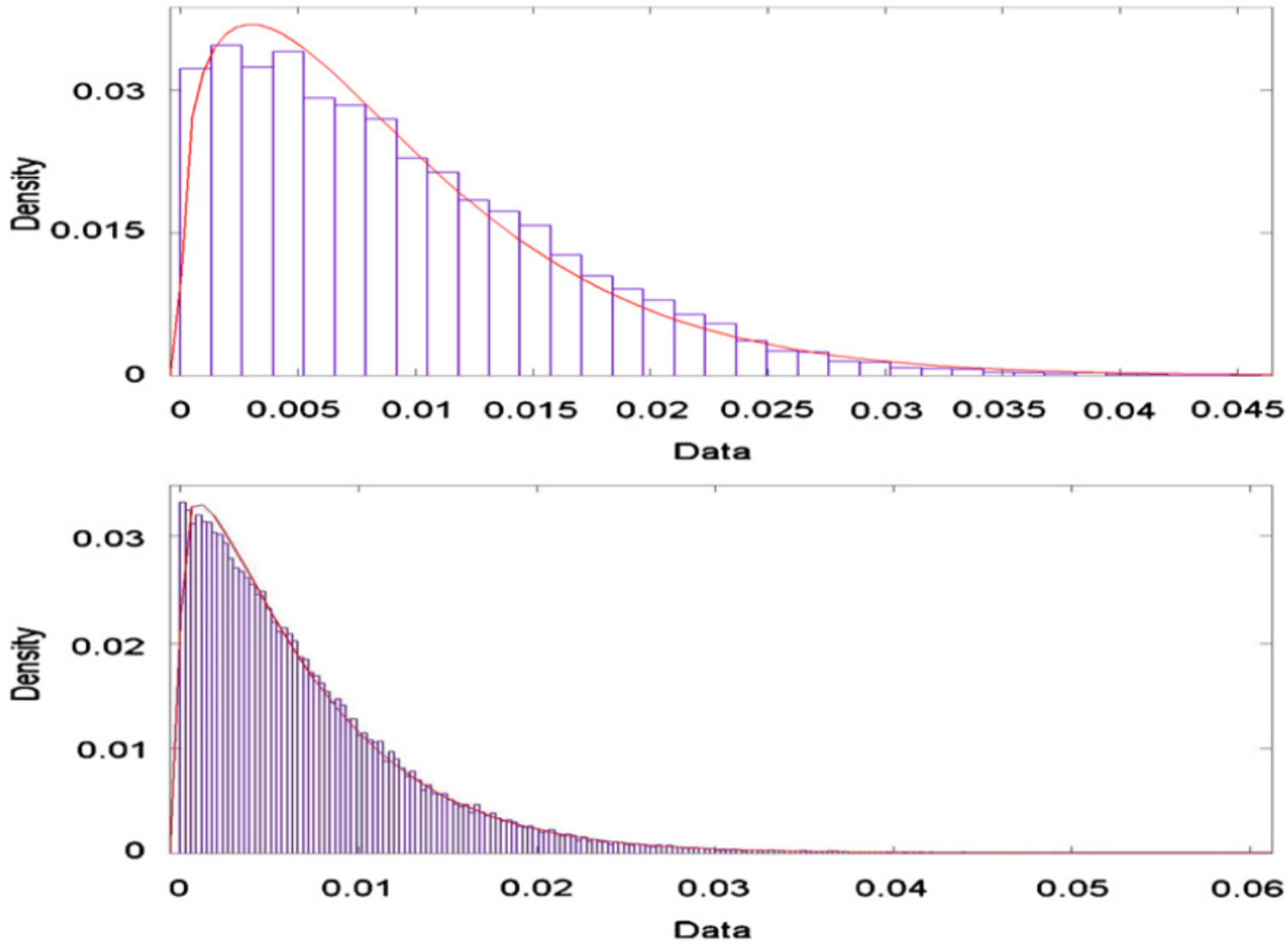
MC Simulation for ϕ





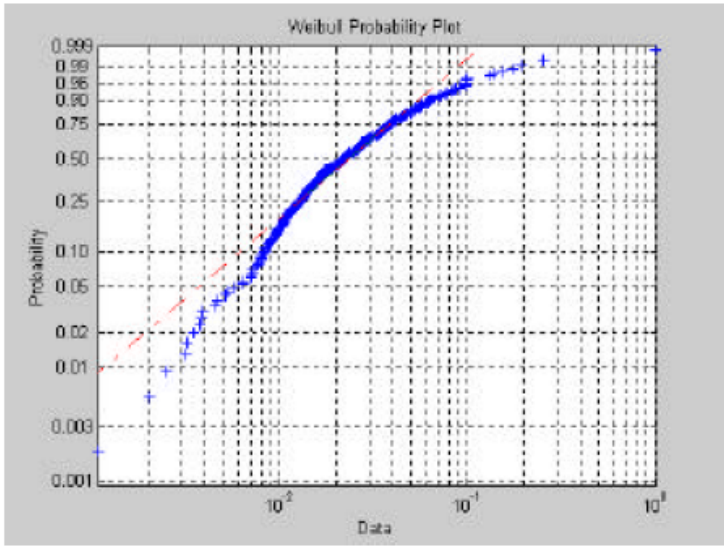
Some Empirical Validation

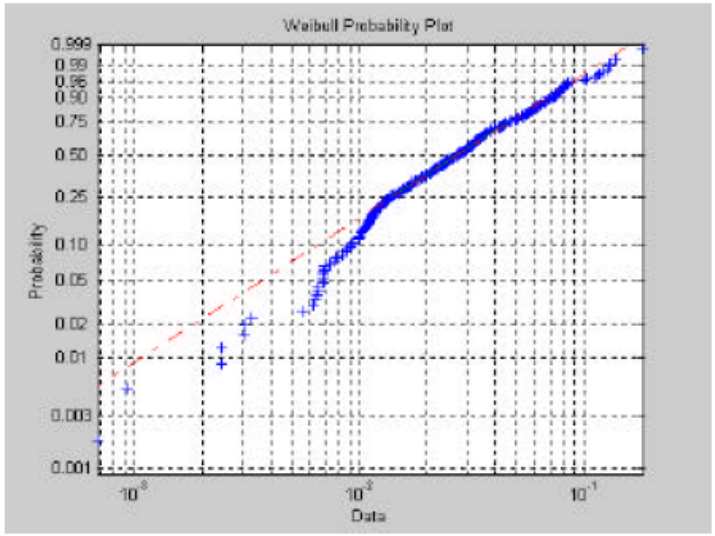
Frequency Distribution of Positive and Negative Variations in Aggregate Output and Weibull fit:



Some Empirical Validation

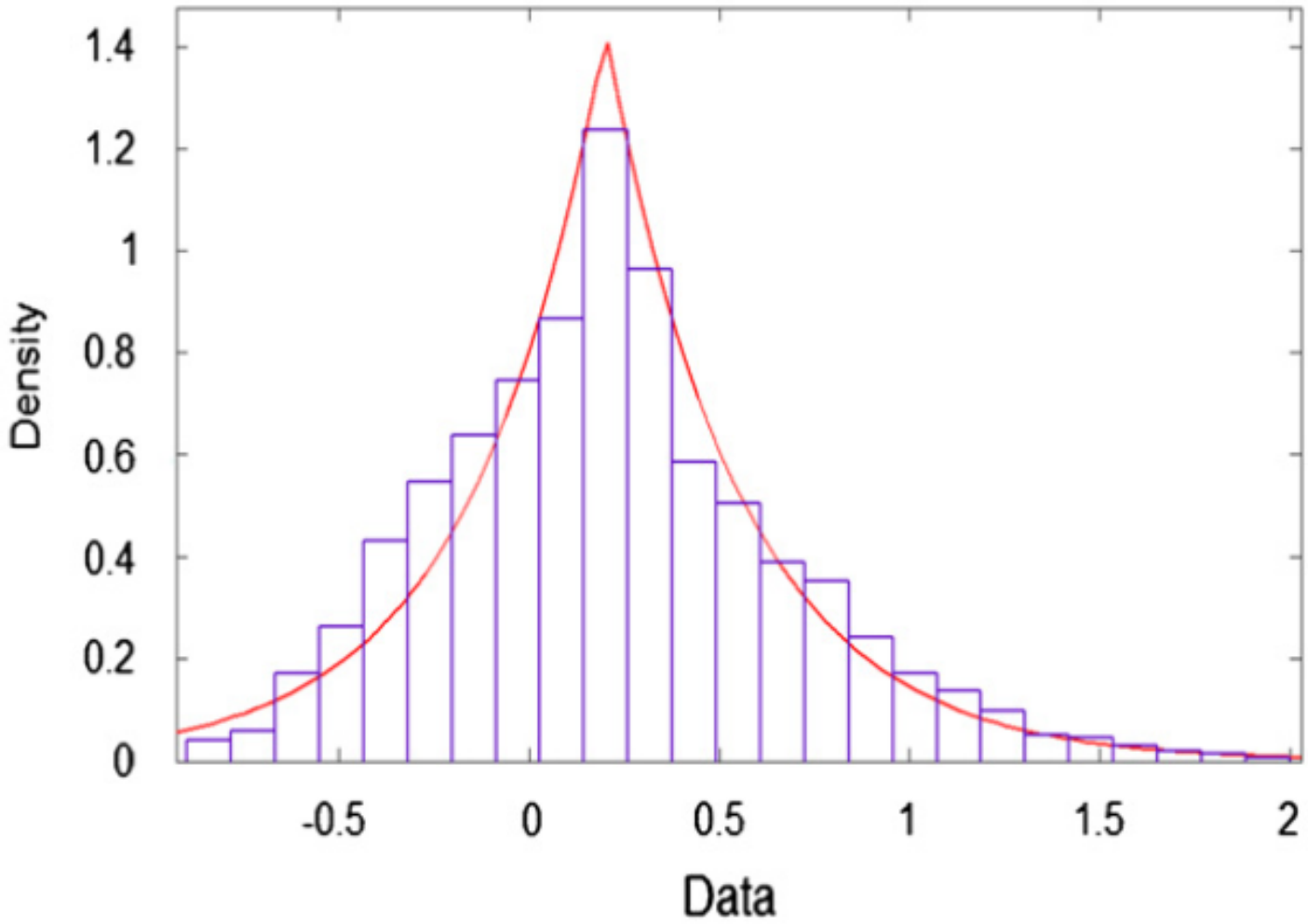
Data (Di Guilmi et al., IJAEQS, 2005):





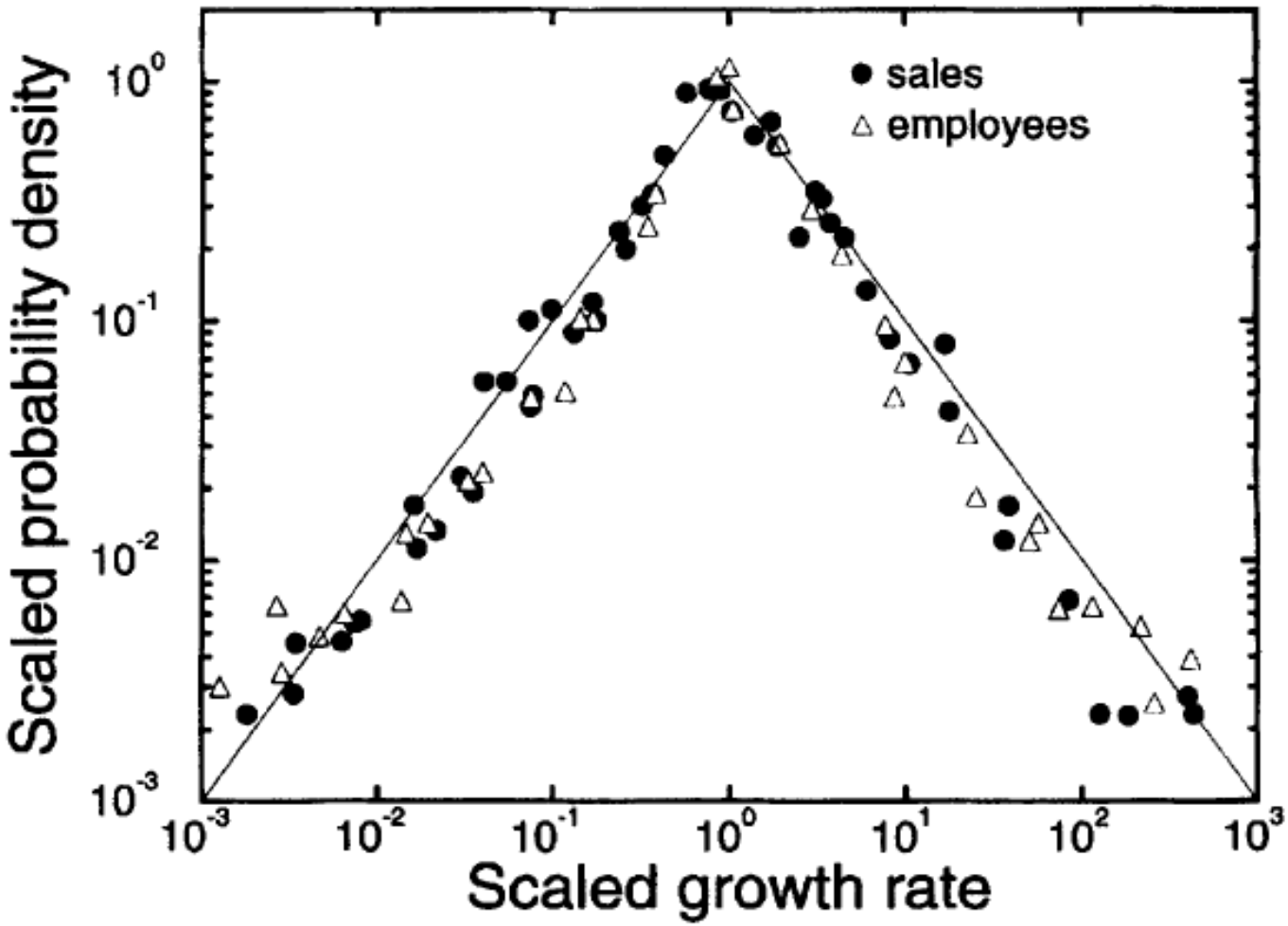
Some Empirical Validation

Frequency Distribution of Rates of Variations of Firms' Profits and Laplace Fit:



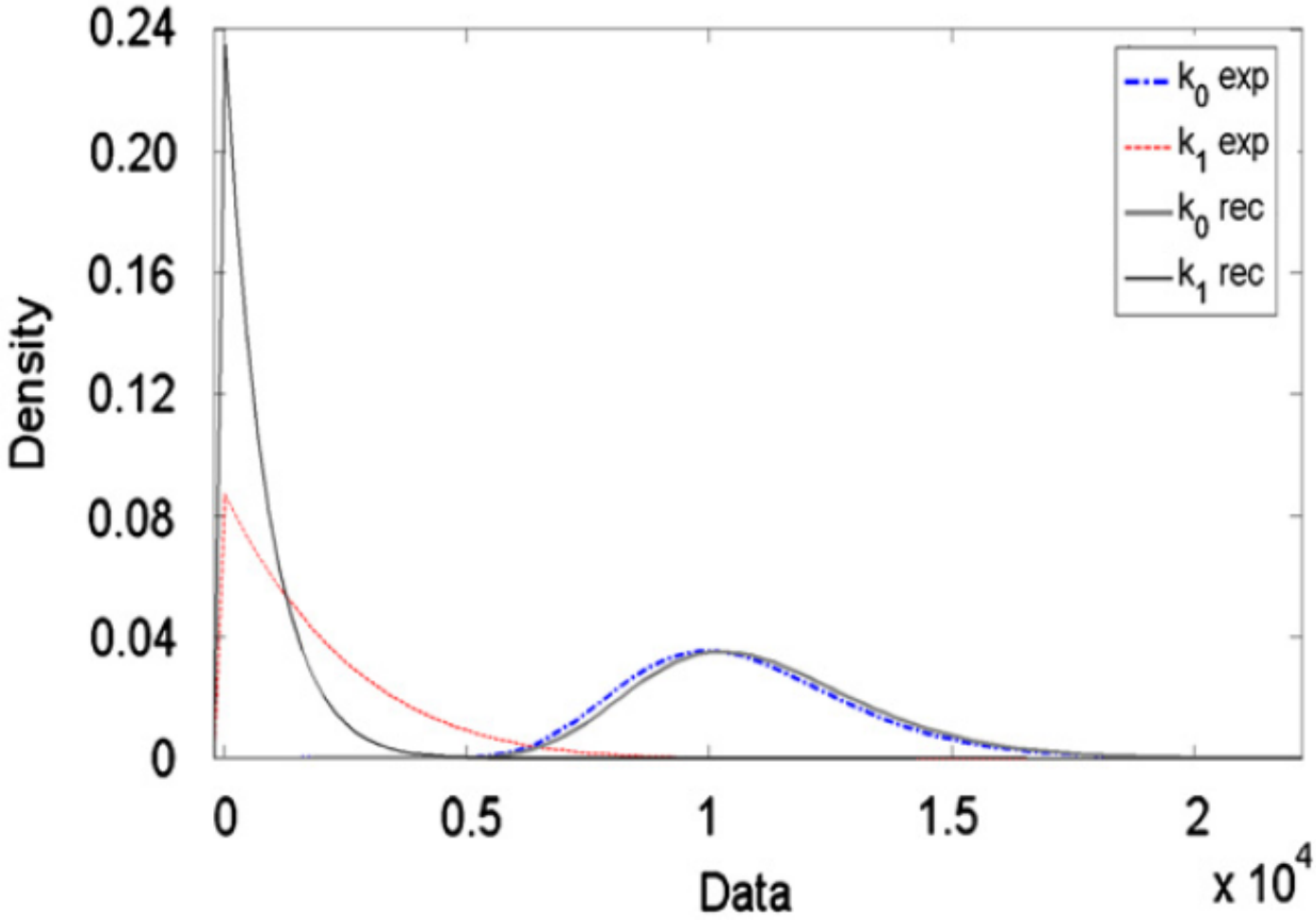
Some Empirical Validation

Data (Stanley et al., Nature, 1996):



Simulation Results

Size of risky and safe firms:



Summary

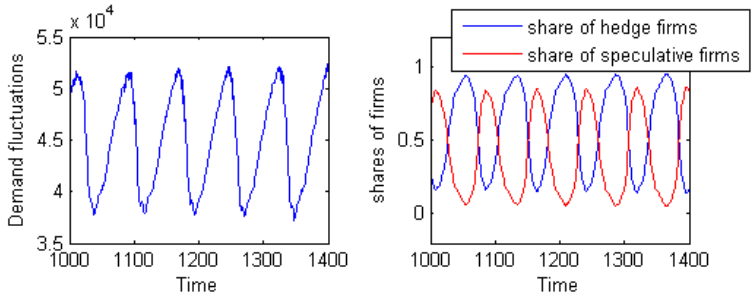
- An early attempt to think about the interactions between the real and financial sector and their dynamic implications
- Model generates endogenous boom-bust business cycles
- Model exhibits compression of interest rates due to 'search for yield'
- Can think about some simple policy implications

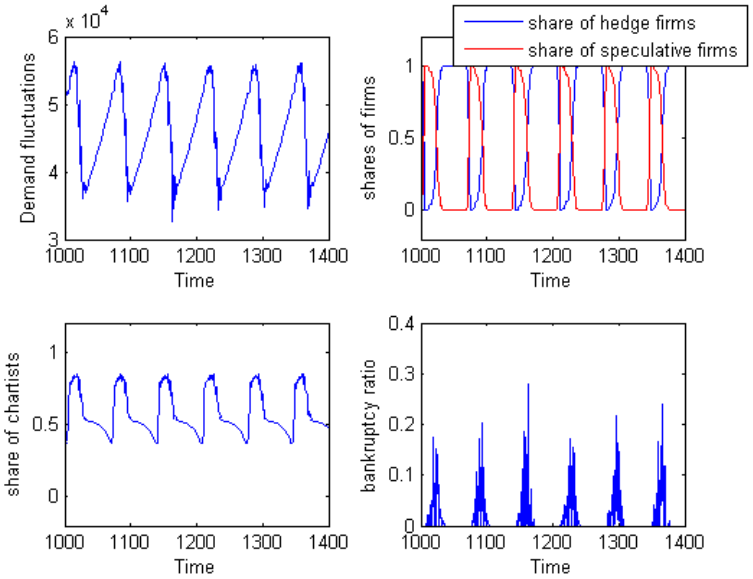
Extensions

Example: Active Monetary Policy

$$
\begin{aligned}
r_t &= (1+h)\, r_t^{CB} \\
r_t^{CB} &= \bar{r}^{CB} + \theta_X \left(X_t^d - X_t^* \right)
\end{aligned}
$$

Extensions


x 10^4
Demand fluctuations
Time
share of hedge firms
share of speculative firms
shares of firms
share of chartists
bankruptcy ratio


x 10^4
Demand fluctuations
Time
share of hedge firms
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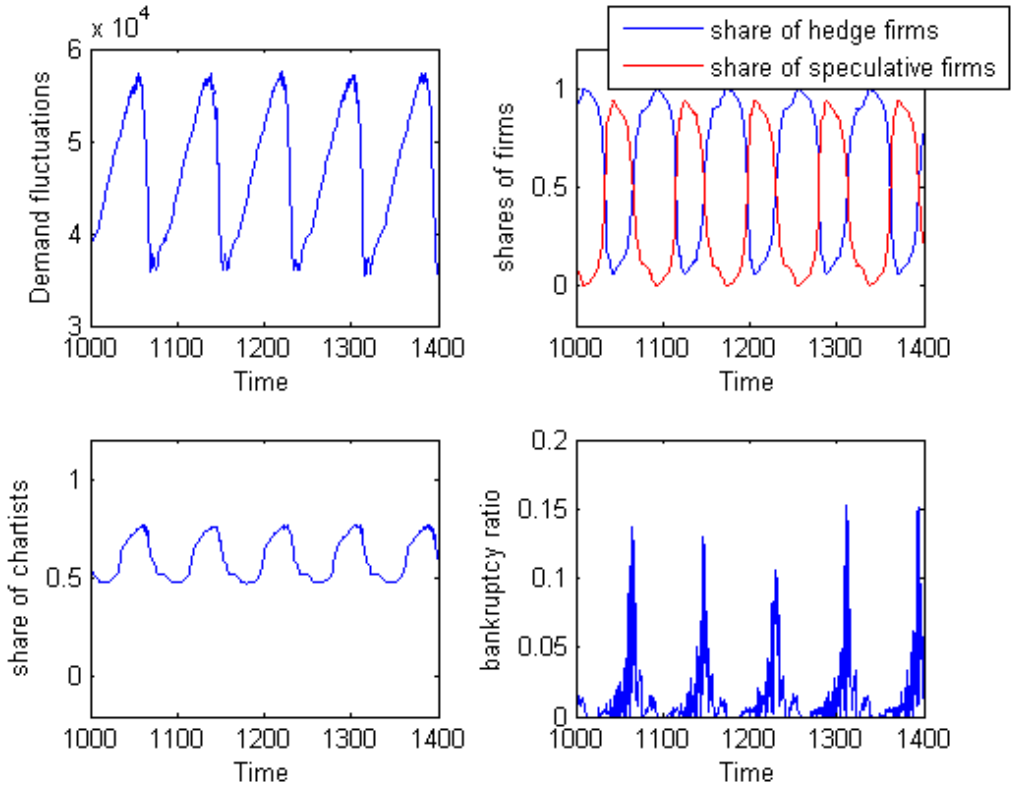
Extensions

Moderate monetary policy



Deficiencies / Possible Improvements

- Certain specifications, such as firms' investment functions, *ad hoc*
- No modelling of deleveraging process (See Koo (2009))
- No household sector, no modeling of labor market
- No credit rationing

Deficiencies / Possible Improvements

- Asset price effects on firms' balance sheets not captured
- No interlinkages among firms or among investors, thus no systemic network effects
- Debt only form of external finance
- Investors' 'search for yield' imposed rather than derived
- More careful calibration required to match data

Thank You!