A Model of Monetary Exchange in Over-the-Counter Markets

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Money in financial over-the-counter markets

Broad question:
Quantity of money and performance of OTC markets

What we do:
– Build model of fiat money used as medium of exchange in OTC markets
– Study effects of monetary policy on asset prices and financial liquidity

How we do it:
Embed the OTC market structure and gains from trade in financial assets of Duffie, Gârleanu and Pedersen (2005) into the monetary framework of Lagos and Wright (2005)
Applications and results

We show that the quantity of money and market microstructure:

1. Determine asset prices and standard measures of financial liquidity (spreads, trade volume, dealer supply of immediacy)

2. Generate a speculative premium (or speculative 'bubble')

3. Explain positive correlation between real stock yield and nominal Treasury yield (the Fed Model)

4. Lead to equilibria with recurrent belief driven liquidity crises (times of sudden large increases in trading delays and spreads, and sharp persistent declines in asset prices, trade volume, and dealer participation in marketmaking)
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2. Generate a *speculative premium* (or *speculative ‘bubble’*)

3. Explain positive correlation between real stock yield and nominal Treasury yield (the *Fed Model*)

4. Lead to equilibria with recurrent belief driven *liquidity crises* (times of sudden large increases in trading delays and spreads, and sharp persistent declines in asset prices, trade volume, and dealer participation in marketmaking)
Environment

- *Time*. Discrete, infinite horizon, two subperiods per period

- *Population*. \([0, 1]\) investors, \([0, v]\) dealers (both infinitely lived)

- *Commodities*. Two divisible, nonstorable consumption goods:
  - *dividend good*
  - *general good*
Preferences

Dealers: \[ E_0 \sum_{t=0}^{\infty} \beta^t (c_{td} - h_{td}) \]

Investors: \[ E_0 \sum_{t=0}^{\infty} \beta^t (\varepsilon_{ti} y_{ti} + c_{ti} - h_{ti}) \]

- \( \beta \in (0, 1) \): discount factor
- \( c_{td}, c_{ti} \): consumption of general good
- \( h_{td}, h_{ti} \): effort to produce general good
- \( y_{ti} \): consumption of dividend good
- \( \varepsilon_{ti} \): preference shock, i.i.d. over time, cdf \( G(\cdot) \) on \( [\varepsilon_L, \varepsilon_H] \)
Endowments and production technology

First subperiod

$A^s$ productive units (trees)

- Each unit yields $y$ dividend goods at the end of the first subperiod
- Each unit permanently “fails” with probability $1 - \pi$ at the beginning of the period
- Failed units immediately replaced by new units (allocated uniformly to investors)

Second subperiod

- Linear technology allows dealers and investors to transform effort into general goods
Assets

Equity shares

- $A^s$ equity shares

- At the beginning of period $t$:
  - $(1 - \pi) A^s$ shares of failed trees disappear
  - $(1 - \pi) A^s$ shares of new trees allocated uniformly to investors

Fiat money

- Money supply: $A^m_t$ dollars

- Monetary policy: $A^m_{t+1} = \mu A^m_t$, $\mu \in \mathbb{R}_{++}$
  (implemented with lump-sum injections/withdrawals)
Market structure

First subperiod: OTC market

- money, equity (*cum dividend*)
- dealer-investor pairwise trade
- Walrasian trade between all dealers

Second subperiod: centralized market

- general good, money, equity (*ex dividend*)
- Walrasian trade between all dealers and investors

"Anonymity" \implies quid pro quo trade
\implies money serves as means of payment
OTC market structure

Investors

- Contact a dealer with probability $\delta$

Dealers

- Contact an investor with probability $\kappa \equiv \delta / \nu$
- Have access to a competitive interdealer market

Bilateral terms of trade

- Investor makes offer with probability $\theta$
- Dealer makes offer with probability $1 - \theta$
Timeline and market structure

- Depreciation shock
- Asset endowment
- Dividend is known
- Preference shock

Dividend consumption

Money injection

Interdealer Market

Centralized Market

Period $t$
Value functions

**Dealers**

\[ W^D_t (a_t) : \text{value of entering CM with } a_t \equiv (a^m_t, a^s_t) \]

\[ \hat{W}^D_t (a_t) : \text{value of rebalancing portfolio } a_t \text{ in OTCM} \]

\[ V^D_t (a_t) : \text{value of entering OTCM} \]

**Investors**

\[ W^I_t (a_t) : \text{value of entering CM} \]

\[ V^I_t (a_t, \epsilon_t) : \text{value of entering OTCM} \]
Centralized market

**Dealers**

\[ W_t^D (a_t) = \max_{c_t, h_t, \tilde{a}_{t+1}} \left[ c_t - h_t + \beta V_{t+1}^D (a_{t+1}) \right] \]

\[ c_t + \phi_t \tilde{a}_{t+1} \leq h_t + \phi_t a_t \]

\[ a_{t+1} = (\tilde{a}^m_{t+1}, \pi \tilde{a}^s_{t+1}) \]

**Investors**

\[ W_t^I (a_t) = \max_{c_t, h_t, \tilde{a}_{t+1}} \left[ c_t - h_t + \beta \int V_{t+1}^I (a_{t+1}, \epsilon') \, dG(\epsilon') \right] \]

\[ c_t + \phi_t \tilde{a}_{t+1} \leq h_t + \phi_t a_t + T_t \]

\[ a_{t+1} = (\tilde{a}^m_{t+1}, \pi \tilde{a}^s_{t+1} + (1 - \pi) A^s) \]
Dealer problem in OTCM

\[ V_t^D (a_{td}) = \kappa \theta \int \hat{W}_t^D (\hat{a}_{td}^m, \hat{a}_{td}^s) dH_t (a_{ti}, \varepsilon) \]

\[ + \kappa (1 - \theta) \int \hat{W}_t^D (\hat{a}_{td*}^m, \hat{a}_{td*}^s) dH_t (a_{ti}, \varepsilon) \]

\[ + (1 - \kappa) \hat{W}_t^D (a_{td}) \]

where

\[ \hat{W}_t^D (a_t) = \max_{\hat{a}_t^m, \hat{a}_t^s} W_t^D (\hat{a}_t^m, \hat{a}_t^s) \]

\[ \hat{a}_t^m + p_t \hat{a}_t^s \leq a_t^m + p_t a_t^s \]

\[ p_t : \text{nominal equity price in the OTC interdealer market} \]
Investor problem in OTCM

\[ V_t^I (a_{ti}, \epsilon_i) = \delta \theta \int \left[ \epsilon_i y \bar{a}_{ti}^s + W_t^l (\bar{a}_{ti}^m, \bar{a}_{ti}^s) \right] dF_t^D (a_{td}) + \delta (1 - \theta) \int \left[ \epsilon_i y \bar{a}_{ti}^s + W_t^l (\bar{a}_{ti}^m, \bar{a}_{ti}^s) \right] dF_t^D (a_{td}) + (1 - \delta) \left[ \epsilon_i y a_{ti}^s + W_t^l (a_{ti}) \right] \]
Trading situations in OTCM

1. Dealer with interdealer market

2. Dealer-investor trade
   - investor offers w.p. $\theta$
   - dealer offers w.p. $1 - \theta$
Dealer with interdealer market

Dealer with $a_t = (a_t^m, a_t^s)$ chooses $(\hat{a}_{td}^m, \hat{a}_{td}^s)$

$$
\hat{a}_{td}^m = \begin{cases} 
0 & \text{if } p_t \phi_t^m < \phi_t^s \\
 a_t^m + p_t a_t^s & \text{if } \phi_t^s < p_t \phi_t^m 
\end{cases}
$$

$$
\hat{a}_{td}^s = \begin{cases} 
 a_t^s + \frac{1}{p_t} a_t^m & \text{if } p_t \phi_t^m < \phi_t^s \\
 0 & \text{if } \phi_t^s < p_t \phi_t^m 
\end{cases}
$$
Dealer-investor trade: formulation

Investor with type $\varepsilon$ and $(a^m_{ti}, a^s_{ti})$ contacts dealer with $(a^m_{td}, a^s_{td})$
Dealer-investor trade: formulation

Investor with type $\varepsilon$ and $(a_{ti}^m, a_{ti}^s)$ contacts dealer with $(a_{td}^m, a_{td}^s)$

- w.p. $\theta$ investor offers $\langle (\bar{a}_{ti*}^m, \bar{a}_{ti*}^s), (\bar{a}_{td}^m, \bar{a}_{td}^s) \rangle$, solves:

$$\max_{\bar{a}_{ti*}^m, \bar{a}_{ti*}^s, \bar{a}_{td}^m, \bar{a}_{td}^s} \left[ \varepsilon y \bar{a}_{ti*}^s + W_t^l (\bar{a}_{ti*}^m, \bar{a}_{ti*}^s) \right]$$

$$\bar{a}_{ti*}^m + \bar{a}_{td}^m + p_t (\bar{a}_{ti*}^s + \bar{a}_{td}^s) \leq a_{ti}^m + a_{td}^m + p_t (a_{ti}^s + a_{td}^s)$$

$$\hat{W}_t^D (\bar{a}_{td}^m, \bar{a}_{td}^s) \geq \hat{W}_t^D (a_{td}^m, a_{td}^s)$$
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$$\bar{a}_{ti}^m + \bar{a}_{td}^m + p_t(\bar{a}_{ti}^s + \bar{a}_{td}^s) \leq a_{ti}^m + a_{td}^m + p_t(a_{ti}^s + a_{td}^s)$$

$$\hat{W}^D_t (\bar{a}_{td}^m, \bar{a}_{td}^s) \geq \hat{W}^D_t (a_{td}^m, a_{td}^s)$$

- w.p. $1 - \theta$ dealer offers $\langle (\bar{a}_{ti}^m, \bar{a}_{ti}^s), (\bar{a}_{td}^m, \bar{a}_{td}^s) \rangle$, solves:

$$\max_{\bar{a}_{ti}^m, \bar{a}_{ti}^s, \bar{a}_{td}^m, \bar{a}_{td}^s} \hat{W}^D_t (\bar{a}_{td}^m, \bar{a}_{td}^s)$$

$$\bar{a}_{ti}^m + \bar{a}_{td}^m + p_t(\bar{a}_{ti}^s + \bar{a}_{td}^s) \leq a_{ti}^m + a_{td}^m + p_t(a_{ti}^s + a_{td}^s)$$

$$\varepsilon y \bar{a}_{ti}^s + W_t^l (\bar{a}_{ti}^m, \bar{a}_{ti}^s) \geq \varepsilon y a_{ti}^s + W_t^l (a_{ti}^m, a_{ti}^s)$$
Dealer-investor trade: solution when investor offers

\[ \bar{a}_{ti}^m = \begin{cases} 0 & \text{if } \varepsilon^*_t < \varepsilon \\ a_{ti}^m + p_t a_{ti}^s & \text{if } \varepsilon < \varepsilon_t^* \end{cases} \]

\[ \bar{a}_{ti}^s = \begin{cases} a_{ti}^s + \frac{1}{p_t} a_{ti}^m & \text{if } \varepsilon^*_t < \varepsilon \\ 0 & \text{if } \varepsilon < \varepsilon_t^* \end{cases} \]

where

\[ \varepsilon_t^* = \frac{p_t \phi_t^m - \phi_t^s}{y} \]
Dealer-investor trade: solution when dealer offers

\[
\overline{a}^m_{ti} = \begin{cases} 
0 & \text{if } \varepsilon_t^* < \varepsilon \\
 a^m_{ti} + p^o_t(\varepsilon) a^s_{ti} & \text{if } \varepsilon < \varepsilon_t^* 
\end{cases}
\]

\[
\overline{a}^s_{ti} = \begin{cases} 
 a^s_{ti} + \frac{1}{p^o_t(\varepsilon)} a^m_{ti} & \text{if } \varepsilon_t^* < \varepsilon \\
0 & \text{if } \varepsilon < \varepsilon_t^* 
\end{cases}
\]

where

\[
p^o_t(\varepsilon) \equiv \left( \frac{\varepsilon y + \phi^s_t}{\varepsilon_t^* y + \phi^s_t} \right) p_t
\]
Euler equations: dealers

\[ \phi_t^m \geq \beta \max (\phi_{t+1}^m, \phi_{t+1}^s / p_{t+1}) \]

\[ \phi_t^s \geq \beta \pi \max (p_{t+1} \phi_{t+1}^m, \phi_{t+1}^s) \]
Euler equations: investors

\[
\phi_t^m \geq \beta \left[ \phi_{t+1}^m + \delta \theta \int_{\epsilon^{*}_{t+1}}^{\epsilon_H} \left( \frac{\epsilon_i y + \phi_s^{t+1}}{p_{t+1}} - \phi_{t+1}^m \right) dG(\epsilon_i) \right]
\]
Euler equations: investors

\[
\phi_t^m \geq \beta \left[ \phi_{t+1}^m + \delta \theta \int_{\varepsilon_t}^{\varepsilon_H} \left( \frac{\varepsilon_i y + \phi_{t+1}^s}{p_{t+1}} - \phi_{t+1}^m \right) dG(\varepsilon_i) \right]
\]

\[
\phi_t^s \geq \beta \pi \left[ \bar{\varepsilon} y + \phi_{t+1}^s + \delta \theta \int_{\varepsilon_l}^{\varepsilon_t} \left[ p_{t+1} \phi_{t+1}^m - (\varepsilon_i y + \phi_{t+1}^s) \right] dG(\varepsilon_i) \right]
\]
Nonmonetary equilibrium

Proposition

(i) A nonmonetary equilibrium exists for any parametrization.

(ii) In the nonmonetary equilibrium:

- there is no trade in the OTC market
- $A^s_i = A^s - A^s_D = A^s$ (only investors hold equity shares)
- the equity price is:

$$\phi^s = \frac{\beta \pi}{1 - \beta \pi} \bar{\xi} y.$$
Proposition

(i) If $\mu \in (\beta, \bar{\mu})$, there is one stationary monetary equilibrium.

(ii) For any $\mu \in (\beta, \bar{\mu})$, $\varepsilon^* \in (\varepsilon_L, \varepsilon_H)$ is the unique solution to

$$\frac{(1 - \beta \pi) \int_{\varepsilon^*}^{\varepsilon_H} [1 - G(\varepsilon)] \, d\varepsilon}{\varepsilon^* + \beta \pi \left[ \bar{\varepsilon} - \varepsilon^* + \delta \theta \int_{\varepsilon_L}^{\varepsilon^*} G(\varepsilon) \, d\varepsilon \right] \mathbb{I}_{\{\hat{\mu} < \mu\}}} - \frac{\mu - \beta}{\beta \delta \theta} = 0.$$

(iii) As $\mu \to \bar{\mu}$, $\varepsilon^* \to \varepsilon_L$ and $\phi^s \to \frac{\beta \pi}{1 - \beta \pi} \bar{\varepsilon} y$.

(iv) As $\mu \to \beta$, $\varepsilon^* \to \varepsilon_H$ and $\phi^s \to \frac{\beta \pi}{1 - \beta \pi} \varepsilon_H y$. 
Stationary monetary equilibrium

\[
\begin{align*}
\text{Low Inflation} & \quad \text{High Inflation} \\
A_D^s &= \pi A^s & A_D^s &= 0 \\
A_I^s &= (1 - \pi) A^s & A_I^s &= A^s \\
A_l^m &= A_l^m & A_l^m &= A_l^m \\
\phi^s &= \frac{\beta \pi}{1 - \beta \pi} \varepsilon^* y & \geq \phi^s &= \frac{\beta \pi}{1 - \beta \pi} \left( \varepsilon + \delta \theta \int_{\varepsilon_L}^{\varepsilon^*} G(\varepsilon) d\varepsilon \right) \\
Z &= \frac{A_D^s + \delta G(\varepsilon^*) A_I^s}{\delta \theta [1 - G(\varepsilon^*)] \frac{1}{\varepsilon^* y + \phi^s} + \delta (1 - \theta) \int_{\varepsilon^*}^{\varepsilon_H} \frac{1}{\varepsilon y + \phi^s} dG(\varepsilon)}
\end{align*}
\]
Asset prices and inflation

**Proposition**

*In the stationary monetary equilibrium: \( \partial \phi^s / \partial \mu < 0 \)
Asset prices and inflation: equity

Equity prices (ex dividend, daily)

$\mu = \bar{\beta}$

$\mu = \hat{\mu}$
Proposition

In the stationary monetary equilibrium:

(i) $\frac{\partial \phi^s}{\partial (\delta \theta)} > 0$

(ii) $\frac{\partial Z}{\partial \delta} > 0$, for $\mu \in (\hat{\mu}, \bar{\mu})$
Asset prices and OTC frictions: equity

Equity prices (ex dividend, daily)

\[ \delta = 0.18 \]

\[ \delta = 0.83 \]
Asset prices and OTC frictions: real balances

Real balances

\[ \phi_t^m A_t \]

\( t \) (years)

\[ 0 \rightarrow 100 \]

\( \delta = 0.59 \)

\( \delta = 0.67 \)
Measures of financial liquidity

- Trade volume
- Bid-ask spreads
- Liquidity provision by dealers
Define the **speculative premium** as

\[ P = \phi^s - \frac{\beta \pi}{1 - \beta \pi} \tilde{\epsilon} y \]
The "Fed Model"
Log dividend yield in the nonmonetary equilibrium:

\[
\log \bar{D}_{t+1} - \log \phi_t^s = \log [(1 + r) - \bar{\gamma} \pi]
\]

where \( D_t = \bar{\varepsilon} y_t \) and \( \bar{D}_{t+1} \equiv \bar{\gamma} \pi D_t \)
Log **dividend yield** in the nonmonetary equilibrium:

$$\log \bar{D}_{t+1} - \log \phi_t^s = \log [(1 + r) - \bar{\gamma}\pi]$$

Modigliani-Cohn hypothesis:

$$\log \bar{D}_{t+1} - \log \phi_t^s = \log [(1 + \iota) - \bar{\gamma}\pi]$$

"Explanation" of positive relation between **nominal bond yield** $\iota = (\mu - \beta\bar{\gamma}) / \beta\bar{\gamma}$ and **dividend yield**
- Log dividend yield in the nonmonetary equilibrium:

\[ \log \tilde{D}_{t+1} - \log \phi_t^s = \log [(1 + r) - \tilde{\gamma} \pi] \]

- Modigliani-Cohn hypothesis:

\[ \log \tilde{D}_{t+1} - \log \phi_t^s = \log [(1 + \iota) - \tilde{\gamma} \pi] \]

- Liquidity/monetary considerations + resale option:

\[ \log \tilde{D}_{t+1} - \log \phi_t^s = \log [(1 + r) - \tilde{\gamma} \pi] - \log \epsilon(\iota) \]
Log dividend yield in the nonmonetary equilibrium:

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Liquidity/monetary considerations + resale option:

$$\log \tilde{D}_{t+1} - \log \phi_t^s = \log [(1 + r) - \tilde{\gamma} \pi] - \log \epsilon (\iota)$$

$$\epsilon (\iota) \equiv \max \left\{ \epsilon^*, \bar{\epsilon} + \delta \theta \int_{\epsilon_L}^{\epsilon^*} G (\epsilon) \, d\epsilon \right\} \quad \text{with } \epsilon' (\iota) < 0$$
Endogenous trading delays: dealer entry

- $\delta(v)$: probability investor contacts a dealer
- $\kappa(v) \equiv \frac{\delta(v)}{v}$: probability dealer contacts an investor
- $\kappa'(v) < 0 < \delta'(v)$
- Free entry: to participate in OTCM of $t+1$ dealer must pay $k > 0$ general goods in the CM of $t$
Free-entry equilibrium

Equilibrium conditions as before, plus the free-entry condition

\[ \Phi_{t+1} - k \leq 0, \text{ with } "\ = \ " \text{ if } v_{t+1} > 0 \]

where

\[ \Phi_{t+1} = \beta \kappa \left( v_{t+1} \right) \left( 1 - \theta \right) \left\{ G \left( \epsilon_{t+1}^* \right) S_{t+1}^b + \left[ 1 - G \left( \epsilon_{t+1}^* \right) \right] S_{t+1}^a \right\} \tilde{\phi}_{t+1} \]

\[ S_{t+1}^b \equiv \int_{\epsilon_L}^{\epsilon_{t+1}^*} \left[ p_{t+1} - p_{t+1}^o \left( \epsilon \right) \right] A \left[ \frac{dG \left( \epsilon \right)}{G \left( \epsilon_{t+1}^* \right)} \right] \]

\[ S_{t+1}^a \equiv \int_{\epsilon_{t+1}^*}^{\epsilon_H} \left[ p_{t+1}^o \left( \epsilon \right) - p_{t+1} \right] \frac{A^m_{it+1}}{p_{t+1}^o \left( \epsilon \right)} \frac{dG \left( \epsilon \right)}{1 - G \left( \epsilon_{t+1}^* \right)} \]

\[ \tilde{\phi}_{t+1} \equiv \max \left( \phi_{t+1}^m, \phi_{t+1}^s / p_{t+1} \right) \]
Sunspots

\[ \sigma_{ij} \equiv \Pr (S_{t+1} = S_j | S_t = S_i) \quad \text{(} S_i \text{ is a sunspot)} \]

\[ \tilde{Z}_i = \frac{\beta \bar{\gamma}}{\mu} \sum_j \sigma_{ij} \left[ 1 + \delta \theta \int_{\varepsilon_j^* \epsilon_j^*} \frac{\varepsilon - \varepsilon_j^*}{\varepsilon_j^* + \bar{\phi}_j^s} dG(\varepsilon) \right] \tilde{Z}_j \]

\[ \bar{\phi}_i^s = \beta \bar{\gamma} \pi \sum_j \sigma_{ij} \left[ \bar{\phi}_j^s + \max \left( \varepsilon_j^*, \bar{\varepsilon} + \delta \theta \int_{\varepsilon_j^* L} \varepsilon_j^* - \varepsilon \right) \right] \]

\[ k = (1 - \theta) \beta \bar{\gamma} \frac{\delta (v_j)}{v_j} \left[ A_{lj}^s \int_{\varepsilon_L}^{\varepsilon_j^*} (\varepsilon_j^* - \varepsilon) dG(\varepsilon) + \tilde{Z}_j \int_{\varepsilon_j^*}^{\varepsilon_H} \frac{\varepsilon - \varepsilon_j^*}{\varepsilon_j^* + \bar{\phi}_j^s} dG(\varepsilon) \right] \]

\[ A_{lj}^s = A^s \text{ if } \varepsilon_j^* < \bar{\varepsilon} + \delta \theta \int_{\varepsilon_L}^{\varepsilon_j^*} (\varepsilon_j^* - \varepsilon) dG(\varepsilon) \quad ( = (1 - \pi) A^s \text{ otherwise}) \]

\[ \tilde{Z}_j = \frac{A_{Dlj}^s + \delta (v_j) G(\varepsilon_j^*) A_{lj}^s}{\delta (v_j) \theta [1 - G(\varepsilon_j^*)]} \left[ \frac{1}{\varepsilon_j^* + \bar{\phi}_j^s} + \delta (v_j) (1 - \theta) \int_{\varepsilon_j^*}^{\varepsilon_H} \frac{1}{\varepsilon_j^* + \bar{\phi}_j^s} dG(\varepsilon) \right] \]
Summary

- A model of monetary exchange in OTC markets
- Liquidity and asset prices in OTC markets
  - Inflation:
    - distorts the asset allocation across investors
    - reduces trade volume
    - reduces dealers’ incentives to provide liquidity
    - increases ask-spreads
  - Asset prices contain a *speculative premium* that:
    - decreases with inflation
    - decreases with OTC frictions (trading delays, power of dealers)
Dynamic stochastic equilibria with episodes that resemble crises:

- **speculative premium “bursts”**
  - sudden, sharp decline in asset price

- **liquidity “dries up”**
  - sudden, sharp decline in marketmaking and trade volume
  - sudden, sharp increase in trading delays and spreads per share
Summary

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- *liquidity* “dries up”
  - sudden, sharp decline in marketmaking and trade volume
  - sudden, sharp increase in trading delays and spreads per share
end.
Sunspots example

\[ \beta = (0.99)^{1/365} \]
\[ \varepsilon \sim U[0.01, 20] \]
\[ \delta(v) = 1 - e^{-(0.1)v} \]
\[ k = 0.1 \]
\[ y_{t+1} = \tilde{\mu}e^{x_{t+1}}y_t \]
\[ x_{t+1} \sim \mathcal{N}(-\Sigma^2/2, \Sigma^2) \]
\[ \bar{\gamma} = E\left(\frac{y_{t+1}}{y_t}\right) = (1.04)^{1/365} \]
\[ \Sigma = SD\left(\frac{y_{t+1}-y_t}{y_t}\right) = \frac{0.12}{\sqrt{365}} \]
\[ \pi = (0.9)^{1/365} \]
\[ \theta = 0.5 \]
\[ \mu = (1.03)^{1/365} \]
\[ \sigma_{00} = (0.996)^{1/365}; \sigma_{11} \approx 1 \]

<table>
<thead>
<tr>
<th>( \phi^s_0 / \phi^s_1 )</th>
<th>( \delta(v_0) )</th>
<th>( \delta(v_1) )</th>
<th>( Z_0 / Z_1 )</th>
<th>( \varepsilon^<em>_0 / \varepsilon^</em>_1 )</th>
<th>( A^s_{D0} )</th>
<th>( A^s_{D1} )</th>
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<tr>
<td>1.17</td>
<td>0.87</td>
<td>0.04</td>
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