OPTIMAL MARKET TIMING

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University of Colorado at Boulder, April 2006
Can the observed cross-sectional associations between stock returns and financing decisions be explained within efficient markets?

Yes! And quantitatively.
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Outline

1. Stylized Facts
2. Model
3. Quantitative Results
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1. Stylized Facts
2. Model
3. Quantitative Results
Stylized Facts
Return-related evidence on behavioral underreaction to market timing

1. Equity issuance waves (Choe, Masulis, and Nanda 1993)
2. Stock market predictability associated with the new equity share (Baker and Wurgler 2000)
3. Underperformance following SEOs, increases with volume (Loughran and Ritter 1995; Spiess and Afflect-Graves 1995)
4. Deteriorating profitability of issuers (Loughran and Ritter 1997)
5. Overperformance following cash distribution, stronger in value firms (Ikenberry et al. 1995; Michaely et al. 1995)
6. Mean-reverting profitability of cash-distributing firms (Lie 2005)
7. Negative associations between capital investment and average returns (Titman et al. 2004; Xing 2005)
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Outline

1. Stylized Facts
2. Model
3. Quantitative Results
Model

Technology

Production

\[ y_{it} = e^{x_t + z_{jt}} \]

Operating profits

Productivity

\[ k_{jt}^\alpha - f \]

Capital stock

Fixed costs of production

Shocks

\[ x_{t+1} = \bar{x}(1 - \rho_x) + \rho_x x_t + \sigma_x \epsilon_{t+1}^x \]

Aggregate productivity

\[ z_{jt+1} = \rho_z z_{jt} + \sigma_z \epsilon_{jt+1}^z \]

Idiosyncratic productivity

Li, Livdan, and Zhang (2006)

Optimal Market Timing

UC-Boulder
Model

Technology

- Production

\[ y_{it} = e^{x_t + z_{jt}} - k_{jt} - f \]

- Operating profits

- Productivity

- Fixed costs of production

- Capital stock

- Shocks

\[ x_{t+1} = \bar{x}(1 - \rho_x) + \rho_x x_t + \sigma_x \epsilon_{x_{t+1}} \]

- Aggregate productivity

\[ z_{jt+1} = \rho_z z_{jt} + \sigma_z \epsilon_{z_{jt+1}} \]

- Idiosyncratic productivity

Li, Livdan, and Zhang (2006)
Model

Corporate investment

- Capital accumulation:

\[ k_{jt+1} = \frac{i_{jt}}{\kappa} + (1 - \delta)k_{jt} \]

- Capital investment

- Capital adjustment costs:

\[ c_{jt} = a \left( \frac{i_{jt}}{k_{jt}} \right)^2 k_{jt}, \quad a > 0 \]

- Adjustment costs
Model

Corporate investment

- Capital accumulation:
  \[ k_{jt+1} = i_{jt} + (1 - \delta)k_{jt} \]

- Capital adjustment costs:
  \[ c_{jt} = \frac{a}{2} \left( \frac{i_{jt}}{k_{jt}} \right)^2 k_{jt} \quad a > 0 \]
External equity:

\[ e_{jt} = \max \left\{ 0, \left( i_{jt} + c_{jt} \right) - y_{jt} \right\} \]

The uses of funds - Internal funds

Costs of raising equity:

\[ \lambda_{jt} = \lambda_0 1_{\{e_{jt} > 0\}} + \lambda_1 e_{jt} \]

Fixed costs of raising equity + Proportional flow costs
External equity:

\[ e_{jt} = \max \left\{ 0, \left( i_{jt} + c_{jt} \right) - y_{jt} \right\} \]

The uses of funds - Internal funds

Costs of raising equity:

\[ \lambda_{jt} = \lambda_0 \mathbf{1}\{e_{jt}>0\} \quad + \quad \lambda_1 e_{jt} \]

Fixed costs of raising equity + Proportional flow costs
Payout

\[ d_{jt} = \max \left\{ 0, \frac{y_{jt}}{\text{Internal funds}} - \frac{(i_{jt} + c_{jt})}{\text{The uses of funds}} \right\} \]

The effective cash-flow accrued to the shareholders

\[ \tilde{d}_{jt} = d_{jt} - e_{jt} - \lambda_{jt} \]
Model

Payout

- Payout

\[
d_{jt} = \max \left\{ 0, \underbrace{y_{jt}}_{\text{Internal funds}} - \underbrace{(i_{jt} + c_{jt})}_{\text{The uses of funds}} \right\}
\]

- The effective cash-flow accrued to the shareholders

\[
\tilde{d}_{jt} = d_{jt} - e_{jt} - \lambda_{jt}
\]

Model

Value maximization

Stochastic discount factor:

\[ m_{t+1} = \eta e^{\gamma_t (x_t - x_{t+1})} \]

Stochastic discount factor

\[ \gamma_t = \gamma_0 + \gamma_1 (x_t - \bar{x}), \quad \gamma_1 < 0 \]

Value maximization

\[ v(k_{jt}, x_t, z_{jt}) = \max_{\{i_{jt}\}} \left\{ \tilde{\sigma}_{jt} + E_t [m_{t+1} v(k_{jt+1}, x_{t+1}, z_{jt+1})] \right\} \]

subject to capital accumulation
Model

Value maximization

- Stochastic discount factor:
  \[ m_{t+1} = \eta e^{\gamma_t (x_t - x_{t+1})} \]

  Stochastic discount factor
  \[ \gamma_t = \gamma_0 + \gamma_1 (x_t - \bar{x}), \quad \gamma_1 < 0 \]

- Value maximization
  \[ v(k_{jt}, x_t, z_{jt}) = \max_{\{i_{jt}\}} \left\{ d_{jt} + E_t [m_{t+1} v(k_{jt+1}, x_{t+1}, z_{jt+1})] \right\} \]

  subject to capital accumulation
Evaluating the value function at the optimum yields:

\[ v_{jt} = \tilde{d}_{jt} + \mathbb{E}_t[m_{t+1} v_{jt+1}] \iff 1 = \mathbb{E}_t[m_{t+1} r_{jt+1}] \]

where \( r_{jt+1} \equiv v_{jt+1}/(v_{jt} - \tilde{d}_{jt}) \)

\[ \mathbb{E}_t[r_{jt+1}] = \underbrace{r_{ft}}_{\text{real interest rate}} + \beta_{jt} \lambda_{mt} \]

where \( \beta_{jt} \equiv -\frac{\text{Cov}_t[r_{jt+1},m_{t+1}]}{\text{Var}_t[m_{t+1}]} \) and \( \lambda_{mt} \equiv \frac{\text{Var}_t[m_{t+1}]}{\mathbb{E}_t[m_{t+1}]} \)
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Outline

1. Stylized Facts
2. Model
3. Quantitative Results
Calibrate the model in monthly frequency:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.70</td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>$-3.751$</td>
</tr>
<tr>
<td>$\rho_x$</td>
<td>$\sqrt[3]{0.95}$</td>
</tr>
<tr>
<td>$\sigma_x$</td>
<td>$0.007/3$</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>0.965</td>
</tr>
<tr>
<td>$\sigma_z$</td>
<td>0.100</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.994</td>
</tr>
<tr>
<td>$\gamma_0$</td>
<td>50</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>$-1000$</td>
</tr>
<tr>
<td>$f$</td>
<td>0.005</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.01</td>
</tr>
<tr>
<td>$a$</td>
<td>15</td>
</tr>
<tr>
<td>$\lambda_0$</td>
<td>0.08</td>
</tr>
<tr>
<td>$\lambda_1$</td>
<td>0.025</td>
</tr>
</tbody>
</table>

Similar to previous studies such as Gomes (2001) and Zhang (2005)
Quantitative Results

The value function

![Graph showing the value function with respect to k.](image-url)
Quantitative Results

The optimal investment policy

Li, Livdan, and Zhang (2006)
Quantitative Results

The optimal financing policy

\[ \frac{e}{k} \]

\[ k \]
Quantitative Results

The optimal payout policy

Li, Livdan, and Zhang (2006)
Quantitative Results

Design: applying the Kydland-Prescott (1982) quantitative-theory approach

1. Simulate 100 artificial samples of 5000 firms and 480 months
2. Replicate empirical studies on the artificial samples
3. Report the cross-simulation averaged statistics
4. Compare the model-implied moments with data moments

Overidentification: 14 parameters vs. 424 moments!
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Quantitative Results

Equity issuance waves

Expansions: \( x_t > \bar{x} + \frac{\sigma_x}{\sqrt{1-\rho_x^2}} \); contractions: \( x_t < \bar{x} - \frac{\sigma_x}{\sqrt{1-\rho_x^2}} \)

<table>
<thead>
<tr>
<th></th>
<th>The frequency of equity issuance</th>
<th>The aggregate equity-financing rate</th>
<th>The new equity share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansions</td>
<td>( \frac{\sum_{j=1}^{N} 1{e_{jt}&lt;0}}{N} )</td>
<td>( \frac{\sum_{j=1}^{N} e_{jt}}{\sum_{j=1}^{N} k_{jt}} )</td>
<td>( \frac{\sum_{j=1}^{N} e_{jt}}{\sum_{j=1}^{N} (e_{jt}+y_{jt})} )</td>
</tr>
<tr>
<td>Contractions</td>
<td>0.825</td>
<td>0.030</td>
<td>0.526</td>
</tr>
<tr>
<td></td>
<td>0.015</td>
<td>0.002</td>
<td>0.036</td>
</tr>
</tbody>
</table>

**Quantitative Results**

Predictive regressions of one-year-ahead stock market returns

Data: Baker and Wurgler (2000)

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$b$</td>
<td>$t(b)$</td>
</tr>
<tr>
<td>Value-weighted</td>
<td>$-7.42$</td>
<td>$(-3.86)$</td>
</tr>
<tr>
<td>Equal-weighted</td>
<td>$-13.12$</td>
<td>$(-3.64)$</td>
</tr>
</tbody>
</table>
Quantitative Results

Intuition: equity issuance waves and predictability associated with the new equity share

\[ x_t \uparrow \Rightarrow \]

Expected profitability \( \uparrow \)

Aggregate expected return \( \downarrow \)

\[ \Rightarrow \]

Capital investment \( \uparrow \)

\[ \Rightarrow \]

New equity share \( \uparrow \)
Quantitative Results

The empirical associations between corporate investment and average returns

Data: Titman, Wei, and Xie (2004); 

\[ CI_{jt} \equiv \frac{i_{jt}/y_{jt}}{(1/3)\sum_{s=1}^{3} i_{jt-s}/y_{jt-s}} - 1 \]

<table>
<thead>
<tr>
<th>CI Portfolio</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest 3</td>
<td>0.042</td>
<td>0.066</td>
</tr>
<tr>
<td>Highest</td>
<td>−0.127</td>
<td>−0.040</td>
</tr>
<tr>
<td>CI-spread</td>
<td>0.169</td>
<td>0.106</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CI \times DCF</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>−0.79</td>
<td>−0.61</td>
</tr>
<tr>
<td>(−2.80)</td>
<td>(−3.65)</td>
<td></td>
</tr>
</tbody>
</table>
Quantitative Results
Monthly cross-sectional regressions of percentage stock returns

Data: Loughran and Ritter (1995)

<table>
<thead>
<tr>
<th>Sample</th>
<th>log(ME)</th>
<th>log(BM)</th>
<th>ISSUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data Model</td>
<td>Data Model</td>
<td>Data Model</td>
</tr>
<tr>
<td>All months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.49 (−3.98)</td>
<td>0.99 (−3.87)</td>
<td></td>
</tr>
<tr>
<td>All months</td>
<td>−0.05 (−0.91)</td>
<td>0.67 (4.52)</td>
<td>0.30 (4.57)</td>
</tr>
<tr>
<td>Periods following light volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>−0.26 (−3.12)</td>
<td>0.31 (2.28)</td>
<td>0.20 (1.80)</td>
</tr>
<tr>
<td>Periods following heavy volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.16 (2.11)</td>
<td>1.03 (6.16)</td>
<td>0.39 (6.30)</td>
</tr>
</tbody>
</table>
Quantitative Results

Positive long-term stock price drift following open market share repurchases

Data: Ikenberry, Lakonishok, and Vermaelen (1995)

<table>
<thead>
<tr>
<th>Year</th>
<th>Repurchase Data</th>
<th>Repurchase Model</th>
<th>Reference Data</th>
<th>Reference Model</th>
<th>Difference Data</th>
<th>Difference Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.8</td>
<td>10.6</td>
<td>18.8</td>
<td>9.8</td>
<td>2.04</td>
<td>0.74</td>
</tr>
<tr>
<td>2</td>
<td>18.1</td>
<td>8.9</td>
<td>15.8</td>
<td>8.7</td>
<td>2.31</td>
<td>0.22</td>
</tr>
<tr>
<td>3</td>
<td>21.8</td>
<td>8.3</td>
<td>17.2</td>
<td>8.1</td>
<td>4.59</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>8.6</td>
<td>7.9</td>
<td>9.5</td>
<td>7.8</td>
<td>−0.96</td>
<td>0.10</td>
</tr>
</tbody>
</table>

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Optimal Market Timing
Quantitative Results

Intuition: investment policy and expected return

Expected return

Low investment-to-asset firms

High investment-to-asset firms

Investment-to-asset
Quantitative Results

Intuition: financing policy and expected return

Expected return

Investment-to-asset

Low investment-to-asset firms
Nonissuing firms

Issuing firms
High investment-to-asset firms

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Quantitative Results

Intuition: payout policy and expected return

Low investment-to-asset firms
Nonissuing firms
High payout firms

High investment-to-asset firms
Issuing firms

Expected return

Investment-to-asset

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Quantitative Results

Intuition: book-to-market and expected return

- Investment-to-asset
- Expected return

- Low investment-to-asset firms
  - Nonissuing firms
  - High payout firms
  - Value firms

- Growth firms
- Low payout firms
- Issuing firms
- High investment-to-asset firms

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## Quantitative Results

Operating performance of issuers and nonissuers (data: Loughran and Ritter 1997)

<table>
<thead>
<tr>
<th>Event year</th>
<th>Cash flow-to-asset</th>
<th>Investment-to-asset</th>
<th>Market-to-book</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Model</td>
<td>Data</td>
</tr>
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<td></td>
<td>Data</td>
<td>Model</td>
<td>Data</td>
</tr>
<tr>
<td></td>
<td>Data</td>
<td>Model</td>
<td>Data</td>
</tr>
<tr>
<td>−4</td>
<td>16.1%</td>
<td>26.0%</td>
<td>8.2%</td>
</tr>
<tr>
<td>−1</td>
<td>17.0%</td>
<td>30.1%</td>
<td>10.2%</td>
</tr>
<tr>
<td>0</td>
<td>15.8%</td>
<td>27.8%</td>
<td>10.0%</td>
</tr>
<tr>
<td>+1</td>
<td>14.2%</td>
<td>25.8%</td>
<td>10.6%</td>
</tr>
<tr>
<td>+4</td>
<td>12.1%</td>
<td>23.0%</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

**Panel B: Nonissuer medians**

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<tr>
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<th>Market-to-book</th>
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<td></td>
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<td>Data</td>
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<tr>
<td></td>
<td>Data</td>
<td>Model</td>
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<td>−4</td>
<td>16.4%</td>
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<td>5.0%</td>
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<tr>
<td>−1</td>
<td>15.1%</td>
<td>27.0%</td>
<td>5.7%</td>
</tr>
<tr>
<td>0</td>
<td>15.8%</td>
<td>27.8%</td>
<td>5.9%</td>
</tr>
<tr>
<td>+1</td>
<td>15.2%</td>
<td>26.8%</td>
<td>6.5%</td>
</tr>
<tr>
<td>+4</td>
<td>13.5%</td>
<td>24.2%</td>
<td>6.6%</td>
</tr>
</tbody>
</table>
## Quantitative Results

Quarterly operating performance around cash distribution (data: Lie 2005)

<table>
<thead>
<tr>
<th></th>
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<td>Panel A: Levels of operating performance</td>
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<td>0.0354</td>
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<td>Panel B: Changes in operating performance</td>
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<tr>
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Quantitative Results

Intuition: Deteriorating accounting performance

- Firm-level profitability is mean-reverting in the model as well as in the data (Fama and French 1995, 2000, 2006)
- Ex-post, firms that issue equity and distribute cash have recently experienced positive firm-specific profitability shocks
- Going forward, these firms face the same distribution of shocks as other firms

Looking back at historical data, econometricians observe deteriorating accounting performance of equity-issuing and cash-distributing firms

Li, Livdan, and Zhang (2006)
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A neoclassical model can quantitatively explain the return-related evidence often interpreted as behavioral market timing.