Market Tranquility and Turbulence

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Introduction and Motivation

Economic Model I: One-period Decisions

Economic Model II: Multi-period Outcomes

Model Estimation

Empirical Illustration

Conclusions and Further Research
Introduction and Motivation

- Market risk under coordination effects: Exogenous risk magnified by traders’ actions
  ⇒ Extreme events have a nonnegligible probability in many asset returns.

- Examples: Many traders with similar positions at beginning of turbulence
  ▶ October 1987: Portfolio insurance.
  ▶ LTCM: Arbitrage strategies.

- Economics: Coordination games help to understand financial crises (currency attacks, bank runs, debt crises) and market risk
Table 3: Some Simulation Results,
MC sample statistics from simulated model with parameter estimates from Table 2, and 100,000 simulations.

<table>
<thead>
<tr>
<th>$c^+$</th>
<th>$c^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>with covariates</strong></td>
<td><strong>without covariates</strong></td>
</tr>
<tr>
<td>$1 \times \sigma$</td>
<td>$1 \times \sigma$</td>
</tr>
<tr>
<td>10.71%</td>
<td>9.88%</td>
</tr>
<tr>
<td>$2 \times \sigma$</td>
<td>$2 \times \sigma$</td>
</tr>
<tr>
<td>2.50%</td>
<td>2.49%</td>
</tr>
<tr>
<td>$3 \times \sigma$</td>
<td>$3 \times \sigma$</td>
</tr>
<tr>
<td>0.37%</td>
<td>0.42%</td>
</tr>
<tr>
<td>$4 \times \sigma$</td>
<td>$4 \times \sigma$</td>
</tr>
<tr>
<td>0.00%</td>
<td>0.04%</td>
</tr>
<tr>
<td>$5 \times \sigma$</td>
<td>$5 \times \sigma$</td>
</tr>
<tr>
<td>0%</td>
<td>0.00%</td>
</tr>
<tr>
<td>$6 \times \sigma$</td>
<td>$6 \times \sigma$</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Figure 1: Yen–Dollar 1997–1999

![Yen–Dollar 1997–1999 Graph](image-url)
- Econometrics?⇒Contribution of this paper:

We develop a quantitative methodology to study market risk dynamics under coordination effects ⇒General model that links time series econometrics and global games theory.

▷ Economics: Simple extension of a standard global game for implementation in a time series context ⇒Multi-period model with tranquil and turbulent times.

▷ Econometrics: Extension of financial returns models ⇒Economic discipline in the modelling of extreme events.
Related literature

• Previous attempts to bring coordination games to the data, mainly in the context of currency crises: Jeanne and Masson (2000) ⇒ 2nd generation models with multiple equilibria and sunspots.


• Our approach:
  ▶ Develop a general methodology for the structural estimation of a global game.
  ▶ Not the estimation of a reduced-form model that is consistent with the global game.
Economic Model I: One-period Decisions

• Global game of market risk in the spirit of Morris and Shin (1999, 2000)
  ⇒ Empirical implementation in a time series context.

• Let us think of the market of a particular financial asset.

• Apart from other market participants, there is a continuum of strategic traders that
  ▶ decide going long or short in the asset under study
  ▶ taking into account their price impact as a group.

⇒ They are the players of the following game.
**Asset return decomposition**

Observed return =
Fundamental return + Strategic return,

\[ r = v + \left[ c^+ (1 - \lambda) - c^- \lambda \right]. \]

- **Fundamental return:**
  \( v_t \) is *fundamental return*
  \( \Rightarrow \) Exogenous to the model, driven by economic fundamentals.
  \[ v \sim N \left( m, \alpha^{-1} \right). \]

- **Strategic return:**
  \( \lambda \in [0, 1] \) is percentage of strategic traders with short position.
  \( \Rightarrow \) \( c^+ \geq 0 \) and \( c^- \geq 0 \) are *price impacts*.

- **Global game** \( \Rightarrow \) Unique \( \lambda^e \): Equilibrium value of \( \lambda \) as a function of parameters.
Trading decisions

- Decision of trader $i$ is going long on the asset under study if

$$E\left[ r \mid I^i \right] > 0$$

and going short otherwise, where $I^i$ is her information set.

$\Rightarrow$ Mutually reinforcing nature of trading actions.

- Information set of strategic trader $i$:
  - Fundamental mean and uncertainty $(m, \alpha)$.
  - Signal on fundamental return with precision $\beta$.
  - Price impacts $(c^+, c^-)$.

$$I^i = (m^i, \alpha, \beta, c^+, c^-).$$

- If there is asymmetric information, but not too high $\left(\beta \geq \bar{\beta}\right)$

$\Rightarrow$ There is a unique (symmetric) equilibrium.
Market equilibrium under unbounded signal’s precision

- Let us assume that information asymmetry is arbitrarily small ($\beta \to \infty$).

- Global game $\Rightarrow$ Returns in equilibrium

$$r = v + c^+ (1 - \lambda^e) - c^- \lambda^e,$$

$$\lambda^e = I \left[ v < 0.5 \left( c^- - c^+ \right) \right],$$

where $I [\cdot]$ is the indicator function.

- Economic discipline: $\lambda^e$ as a function of $v$ and $(c^+, c^-)$

$\Rightarrow$ High sensitivity of $\lambda^e$ to small changes of $v$ around $0.5 \left( c^- - c^+ \right)$. 
Economic Model II: Multi-period Outcomes

- Multi-period model: Sequence of one-period games
  \[ r_t = (v_t + c_t^+) - (c_t^- + c_t^+) I [v_t < 0.5 (c_t^- - c_t^+)] , \]
  \[ v_t \mid (m_t, \alpha_t) \sim N (m_t, \alpha_t^{-1}) . \]

  **Fundamental mean and uncertainty**

- Fundamental mean: Proxy \( f \) of economic fundamentals (beta, duration, interest rate differential)
  \[ m_t = \gamma_0 f_{t-1} . \]

- Fundamental uncertainty: Stochastic volatility
  \[ -\ln \alpha_t - \gamma_1 = \gamma_2 (-\ln \alpha_{t-1} - \gamma_1) + \gamma_3 u_t , \]
  \[ u_t \sim N (0, 1) . \]
Price impacts and speculative capital

We expect \((c^+_t, c^-_t)\)
▷ to be high when the relative size of strategic traders with respect to the total market is high (turbulent times)
▷ to be low otherwise (tranquil times).

⇒ We will capture this feature by a single index \(c_t\) that drives both \((c^+_t, c^-_t)\) and is called speculative capital.

• Asymmetry in Buy and Sell Side:

Nondecreasing positive functions of \(c_t\) that might be 0 for some periods
⇒ Tranquil vs. turbulent times.

\[c^+_t = \max(c_t, 0),\]
\[c^-_t = \max(c_t - \xi_1, 0)^{\xi_2} .\]
• Dynamics of Speculative Capital:

Not derived endogenously through an explicit model
⇒ Approximation by linear link to local and global uncertainty, \( \left( \alpha_t^{-1}, \sigma_t^2 \right) \).

\[
c_t = \phi_0 + \phi_1 z_t^L + \phi_2 z_t^G,
\]

\[
z_t^L = \frac{-\ln \alpha_t - \gamma_1}{\left[ \gamma_3^2 / (1 - \gamma_2^2) \right]^{1/2}}, \quad z_t^G = \frac{\ln \sigma_t^2 - E \left( \ln \sigma_t^2 \right)}{\left[ Var \left( \ln \sigma_t^2 \right) \right]^{1/2}}.
\]

For instance, we can proxy \( \sigma_t^2 \) by means of

\[
\sigma_t^2 = g_{t-1}^2,
\]

where \( g \) is the return from some global index (MSCI).
Understanding the model

- A simple version of our model is

\[ r_t = (v_t + c_t^+) - (c_t^- + c_t^+) I [v_t < 0.5 (c_t^- - c_t^+)] , \]
\[ v_t \mid (m_t, \alpha_t) \sim N (m_t, \alpha_t^{-1}) , \]
\[ m_t = 0 , \]
\[ -\ln \alpha_t - \gamma_1 = \gamma_2 (-\ln \alpha_{t-1} - \gamma_1) + \gamma_3 u_t , \]
\[ u_t \sim N (0, 1) , \]
\[ c_t^+ = \max (c_t, 0) , \]
\[ c_t^- = \max (c_t - \xi_1, 0) \xi_2 , \]
\[ c_t = \phi_0 + \phi_1 z_t^L + \phi_2 z_t^G , \]
\[ z_t^L = \frac{-\ln \alpha_t - \gamma_1}{\left[ \gamma_3^2 / (1 - \gamma_2^2) \right]^{1/2}} , \]
\[ z_t^G \sim N (0, 1) . \]

- We can enrich the model with proxies for \((m_t, z_t^G)\).
Figure 8: Some Scenarios of Strategic Trader Impact

(a) Up by escalator–down by elevator
(b) Up and down by escalator
(c) Repeated down by elevator
(d) Up and down by elevator
(e) Occasional extreme volatility
Model Estimation

• Previous simple model has 8 unknown parameters to estimate \( (\gamma_1, \gamma_2, \gamma_3, \phi_0, \phi_1, \phi_2, \xi_1, \xi_2) \).

• Our model characterizes implicitly the likelihood of return data, but there is not an analytical likelihood ⇒ Maximum likelihood is not feasible.

• General estimation procedure ⇒ Indirect inference: Match features of an auxiliary model, which is easier to handle.

▷ We use Efficient Method of Moments (EMM) as proposed by Gallant and Tauchen (1996). ⇒ Nearly as efficient as (unfeasible) maximum likelihood.

▷ EMM is implemented by means of the Markov chain Monte Carlo (MCMC) approach of Chernozhukov and Hong (2003).
Empirical Illustration


- Yen-carry trades: Borrow in Yen at low interest rate and invest in Dollars at high interest rate ⇒ Profit from both Dollar appreciation and interest rate differential.
  - Many highly leveraged traders with similar positions at beginning of turbulence ⇒ Coordination risk.
  - Change in market conditions (Russian default, steeper yield curves outside Japan,...) ⇒ Those traders wanted to unwind positions: Sharp dollar depreciation.

- Collapse of Dollar vs. Yen in October 1998 (up by escalator, down by elevator) shows that even highly liquid markets are vulnerable to coordination risk.
Table 3: Some Simulation Results,
MC sample statistics from simulated model with parameter estimates from Table 2, and 100,000 simulations.

<table>
<thead>
<tr>
<th>c+</th>
<th>frequency</th>
<th>mean</th>
<th>c-</th>
<th>frequency</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with covariates</td>
<td></td>
<td></td>
<td>without covariates</td>
<td></td>
</tr>
<tr>
<td>1 × σ</td>
<td>10.71%</td>
<td>1.2</td>
<td>8.45%</td>
<td>1.2</td>
<td>8.47%</td>
</tr>
<tr>
<td>2 × σ</td>
<td>2.50%</td>
<td>1.8</td>
<td>3.23%</td>
<td>1.8</td>
<td>3.35%</td>
</tr>
<tr>
<td>3 × σ</td>
<td>0.37%</td>
<td>2.3</td>
<td>1.32%</td>
<td>2.3</td>
<td>1.31%</td>
</tr>
<tr>
<td>4 × σ</td>
<td>0.00%</td>
<td>2.9</td>
<td>0.52%</td>
<td>2.9</td>
<td>0.50%</td>
</tr>
<tr>
<td>5 × σ</td>
<td>0%</td>
<td>N/A</td>
<td>0.17%</td>
<td>N/A</td>
<td>0.20%</td>
</tr>
<tr>
<td>6 × σ</td>
<td>0%</td>
<td>N/A</td>
<td>0.03%</td>
<td>N/A</td>
<td>0.06%</td>
</tr>
</tbody>
</table>

Figure 1: Yen–Dollar 1997–1999
Figure 5: MSCI Index Volatility 1990–2004

Figure 6: Distribution of $c^+$ and $c^-$ with covariates

MC sample statistics from simulated model with parameter estimates from Table 2, and 100,000 simulations.

Figure 7: Distribution of $c^+$ and $c^-$ without covariates

MC sample statistics from simulated model with parameter estimates from Table 2, and 100,000 simulations.
B Tables and Figures

Table 1: Summary statistics daily yen–dollar exchange rate returns (percentages) and covariates

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Yen return %</th>
<th>MSCI</th>
<th>Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean:</td>
<td>-0.01</td>
<td>0.00</td>
<td>-0.03</td>
</tr>
<tr>
<td>Std</td>
<td>0.70</td>
<td>1.00</td>
<td>0.02</td>
</tr>
<tr>
<td>Skewness:</td>
<td>-0.50</td>
<td>-1.07</td>
<td>0.18</td>
</tr>
<tr>
<td>Kurtosis:</td>
<td>3.98</td>
<td>2.03</td>
<td>-1.31</td>
</tr>
<tr>
<td>Min:</td>
<td>-5.63</td>
<td>-4.84</td>
<td>-0.06</td>
</tr>
<tr>
<td>Max:</td>
<td>3.24</td>
<td>2.28</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 2: Estimation results

Standard errors in parenthesis.

<table>
<thead>
<tr>
<th></th>
<th>No covariates</th>
<th>With covariates</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_0$</td>
<td>-1.624</td>
<td>(0.042)</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.991</td>
<td>(0.001)</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>0.016</td>
<td>(0.020)</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>-0.698</td>
<td>(0.065)</td>
</tr>
<tr>
<td>$\phi_0$</td>
<td>-0.640</td>
<td>(0.011)</td>
</tr>
<tr>
<td>$\phi_1$</td>
<td>1.567</td>
<td>(0.066)</td>
</tr>
<tr>
<td>$\phi_{2a}$</td>
<td>0.864</td>
<td>(0.032)</td>
</tr>
<tr>
<td>$\phi_{2b}$</td>
<td>0.008</td>
<td>(0.020)</td>
</tr>
<tr>
<td>$\xi_1$</td>
<td>1.456</td>
<td>(0.070)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>Unbounded</td>
<td>Unbounded</td>
</tr>
</tbody>
</table>
Conclusions and Further Research

• Recent experiences of market risk under coordination effects: Qualitative understanding with economic theory
  ⇒ Econometrics?: Contribution of this paper

• We develop a quantitative methodology to study market risk dynamics under coordination effects
  ⇒ Helpful for both portfolio/risk managers and policy makers.

▷ Economics: Simple extension of a standard global game for implementation in a time series context
  ⇒ Multi-period model with tranquil and turbulent times.

▷ Econometrics: Extension of financial returns models
  ⇒ Economic discipline in the modelling of extreme events.
Further research:

- The informational content of prices: Endogenous public information
  ⇒ Angeletos and Werning (2005), Hellwig et al. (2006), and Tarashev (2003).

- Richer dynamics: Learning, herding, etc.
  ⇒ Abreu and Brunnermeier (2003), Angeletos et al. (2006), and Dasgupta (2003).

- Contagion: Interaction between markets