Comparing Different Regulatory Measures to Control Stock Market Volatility: A General Equilibrium Analysis

A. Buss
INSEAD

B. Dumas
INSEAD, CEPR, NBER

R. Uppal
Edhec, CEPR

G. Vilkov
Goethe U. Frankfurt

Journée of the Foundation BdF

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Outline

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4. Effects of Regulatory Measures
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1 Motivation, Objective, and Contribution

2 The Model
   Key Features of Our Model
   Some Details of the Model
   Calibrating the Model

3 The Real Effects of Financial Markets

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5 Conclusion
Two Major Themes of the Paper

Develop a model where financial markets influence real sector

► Specifically, can sentiment-prone investors affect real economy?
  ■ investment,
  ■ output,
  ■ consumption

► Results: We show negative externalities due to sentiment-prone investors.
Two Major Themes of the Paper

Financial Regulation

- Which policy measure is most effective for regulating financial markets and reducing its negative externalities?
  1. Tobin Tax
  2. Short-sale constraint
  3. Borrowing / Leverage constraint

- Results:
  - Tobin tax and short-sale constraint are counter-effective.
  - Borrowing / Leverage constraint seems to be promising.
Our model is related to the literature on “investor sentiment” and “behavioral equilibrium theory.”

- Non-optimizing households: Hong and Stein (1999)
- Sentiment and production: Panageas (2005)

Also, the literature on the remedies to the recent financial crisis is close to our work.

- Credit constraints: Krishnamurthy (2003).
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First Key Feature of Our Model: Investors with Heterogeneous Beliefs

- **Hansen (2007):** “While introducing heterogeneity among investors will complicate model solution, it has **intriguing possibilities.**”

- **Stiglitz (2010)** criticizes representative-investor models; states importance of heterogeneous investors as **key challenge.**

- **Sargent (2008)** in his presidential address to the American Economic Association, discusses extensively the implications of the **common beliefs** assumption for policy.
Second Key Feature of Our Model: Heterogeneous Beliefs with Endogenous Risk

- Model meets twin challenges set by Eichenbaum (2010).

- The twin challenges Eichenbaum (2010) posed are:
  1. to model heterogeneity in beliefs and persistent disagreement between investors, and
  2. financial market frictions with risk residing internally in the financial system rather than externally in the production system.

- The twin challenges are met here because in our model the heterogeneity of investor beliefs is a fluctuating, stochastic one so that it constitutes an internal source of risk:
  - sentiment is stochastic, and
  - volatility of sentiment is stochastic;
  thus, market alternates between periods of quiescence and agitation.
Third Key Feature of Our Model: Market Incompleteness and Frictions

- Typically, general-equilibrium models assume complete financial markets, which simplifies the task of solving for equilibrium.
- However, once regulatory constraints are introduced, financial markets are not complete.
- We identify the equilibrium when markets are incomplete.
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We assume that there exists a representative firm producing and paying out a single consumption good.

At each period $t$ the firm uses the capital stock $K_t$ to generate production $Y_t = K_t \times Z_t$, where $Z_t$ denotes the stochastic technology.

The capital of the firm depreciates at the periodic rate $\delta$, and after investment $I_t$ its law of motion can be described as

$$K_{t+1} = (1 - \delta)K_t + I_t$$

We assume that the change in the capital level is subject to quadratic adjustment costs $\frac{\xi}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 K_t$.
Investment $I_t$ is chosen to maximize value of firm $P_{k,t}$ for owner $k$:

$$P_{k,t}^S(K_t) = \max_{I_t, \ldots, I_{T-1}} \left\{ D_t + E_t \left[ \sum_{\tau=t+1}^{T} \frac{M_{k,\tau}}{M_{k,t}} D_{\tau} \right] \right\}$$

We assume that the value of the firm is maximized with respect to the expectations of the rational investor.

- Carceles-Poveda and Coen-Pirani (2007) show that with constant-returns-to-scale production, investors agree on investment decisions even in markets that are not complete.

- Even though markets are not complete, the pricing kernels of the two investors are similar, and so the investment choices they make are also similar.
Model: Households/Investors

- **Additive external habit (“catching up with the Joneses”):**

\[
\max E_k \sum_{t=0}^{T} \beta_k^t \frac{(c_{k,t} - h_k \times C_t)^{1-\gamma_k}}{1 - \gamma_k}, \quad \text{where}
\]

- **\(h_k\)** is the habit factor; scaling last period’s aggregate consumption \(C_t\)
- **\(\gamma_k > 0\)** controlling the investor’s risk appetite
- **\(E_k\)** is investor \(k\)’s cond. expectation (subjective probability measure)
- **subject to budget equation**

\[
c_{k,t} + \underbrace{\theta_{k,t}^S S_{k,t}}_{\text{equity investment}} + \underbrace{\theta_{k,t}^B B_{k,t}}_{\text{risk-free investment}} = \theta_{k,t-1}^S (S_{k,t} + D_t) + \theta_{k,t-1}^B
\]
Model: Source of Uncertainty

Uncertainty in the economy is generated by a Hidden Markov Model.

**Hidden Part**

- Two unobservable fundamental states: 'Expansion' or 'Recession'.
- Transition between the unobservable states follows a Markov process.

**Observables**

While the state of the economy is unobservable for the investors, they observe

1. **productivity realization** $Z_t$: 'high' or 'low'
2. **a public signal**: 'positive' or 'negative'
We assume that

- the realized technology level provides information about the current state of the economy,
- while the signal is pure noise.

Investors use the observations to form conditional state probabilities using a nonlinear analog of the Kalman filter.

One investor ("rational") knows signal is pure noise.

The other investor ("sentiment-prone") believes incorrectly that signal also provides useful information; assigning weight $w$. 
Regulatory Measures

1. **Tobin tax** $\kappa_t$ affects the individual budget constraint:

\[
c_{k,t} + \theta^S_{k,t} S_{k,t} + \theta^B_{k,t} B_{k,t} + \kappa_t S_{k,t} \left| \theta^S_{k,t} - \theta^S_{k,t-1} \right| = \theta^S_{k,t-1} (S_{k,t} + D_t) + \theta^B_{k,t-1}
\]

Tax revenue is reimbursed to investors as a lump-sum transfer.

2. **Short-sale constraint** restricts the holdings of the risky asset to be above a predefined limit $\rho$:

\[
\theta^S_{k,t} \geq \rho, \forall k, t.
\]

3. **Leverage constraint** limits the amount of borrowing, or equivalently, investment in the risky asset, to be less than a specified level $\alpha$:

\[
\frac{\theta^S_{k,t} \times S_{k,t}}{\theta^B_{k,t} \times B_{k,t} + \theta^S_{k,t} \times S_{k,t}} \leq \alpha, \forall k, t,
\]
Equilibrium

Equilibrium in this economy is defined as

- consumption policies, $c_{k,t}$, that maximize lifetime expected utility
- portfolio policies, $\theta_{k,t}^{\{B,S\}}$, that finance the optimal portfolio policy
- investment policy, $l_t$, that maximizes the value of the firm
- price processes for the financial assets, $\{B_t, S_t\}$, such that the following markets clear at each state and date:
  - markets for the stock and bond,
  - market for consumption, and investment.
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   Some Details of the Model
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For the quantitative analysis we calibrate our model to match several stylized facts of the U.S. macroeconomy and financial markets.

For example, output and investment volatility as well as the levered equity risk premium and its volatility.

We solve model for 30 years, assuming each period in model corresponds to one year, with the last 15 years used as burn-in period.

All statistics are based on 10,000 simulated paths of economy.

We assume the two investors have homogeneous preferences.
## Parameter Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hidden Markov Chain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autocorrelation hidden states</td>
<td>$A_{1,1}, A_{2,2}$</td>
<td>0.95</td>
</tr>
<tr>
<td>Precision of technology</td>
<td>$B_{1,1} + B_{1,2}, B_{2,3} + B_{2,4}$</td>
<td>0.95</td>
</tr>
<tr>
<td>Probability of the initial state</td>
<td>$\pi_k$</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Preferences and Beliefs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentiment of irrational Agent</td>
<td>$w$</td>
<td>0.9</td>
</tr>
<tr>
<td>Subject time preference</td>
<td>$\rho_k$</td>
<td>0.9606</td>
</tr>
<tr>
<td>Risk aversion</td>
<td>$\gamma_k$</td>
<td>3</td>
</tr>
<tr>
<td>Habit parameter</td>
<td>$h_k$</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>$\delta$</td>
<td>0.08</td>
</tr>
<tr>
<td>Volatility of technology</td>
<td>$\sigma_T$</td>
<td>4.90%</td>
</tr>
<tr>
<td>Technology growth</td>
<td>$d_T$</td>
<td>0.60%</td>
</tr>
<tr>
<td>Adjustment costs</td>
<td>$\xi$</td>
<td>13</td>
</tr>
</tbody>
</table>
## Financial and Business Cycle Statistics: Model vs. U.S. Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Variable</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macroeconomic variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output volatility</td>
<td>$\sigma(Y)$</td>
<td>3.99%</td>
<td>3.78%</td>
</tr>
<tr>
<td>Normalized investment volatility</td>
<td>$\sigma(I)$</td>
<td>2.67%</td>
<td>2.39%</td>
</tr>
<tr>
<td>Normalized consumption volatility</td>
<td>$\sigma(C)$</td>
<td>0.93%</td>
<td>0.40%</td>
</tr>
<tr>
<td>Correlation between investment &amp; output</td>
<td>$Cor(I, Y)$</td>
<td>0.82</td>
<td>0.96</td>
</tr>
<tr>
<td>Correlation between consumption &amp; output</td>
<td>$Cor(C, Y)$</td>
<td>0.95</td>
<td>0.76</td>
</tr>
<tr>
<td><strong>Financial variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk-free rate</td>
<td>$r_f$</td>
<td>2.30%</td>
<td>1.94%</td>
</tr>
<tr>
<td>Interest rate volatility</td>
<td>$\sigma(r_f)$</td>
<td>8.30%</td>
<td>5.44%</td>
</tr>
<tr>
<td>Equity premium</td>
<td>$E[R^{ep}]$</td>
<td>3.30%</td>
<td>6.17%</td>
</tr>
<tr>
<td>Equity premium volatility</td>
<td>$\sigma(R^{ep})$</td>
<td>21.70%</td>
<td>19.40%</td>
</tr>
<tr>
<td>Sharpe ratio</td>
<td>$E[R^{ep}]/\sigma(R^{ep})$</td>
<td>15%</td>
<td>32%</td>
</tr>
</tbody>
</table>
Effect of Sentiment on Financial Variables

Sentiment is measured by weight put on uninformative signal by “sentiment-prone” investor.

Volatility of Stock Returns

Results for interest rate volatility are comparable.
Effect of Sentiment on Investment Growth

Investment Growth

Sentiment

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Financial Regulation

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Effect of Sentiment on Investment Growth

Volatility of Investment Growth Rate

Results for output / consumption are comparable.
Motivation, Objective, and Contribution

The Model
- Key Features of Our Model
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The Real Effects of Financial Markets

Effects of Regulatory Measures

Conclusion
We illustrate the effects of regulatory measures using figures.

Each plot has three lines:

- The red line depicts case when both investors learn rationally;
- The black line depicts case of excessive volatility due to “sentiment-prone” trading but without regulations;
- The blue line depicts case with a particular regulatory measure in the economy with excessive volatility.
Volatility of Stock Returns

Red: Both rational;  Black: One sentiment-prone, no regulation;  Blue: With regulation

![Graphs showing the effect of Tobin tax, short-sale constraint, and leverage constraint on volatility.](image)
Red: Both rational;  Black: One sentiment-prone, no regulation;  Blue: With regulation
Investment Growth Volatility

Red: Both rational; Black: One sentiment-prone, no regulation; Blue: With regulation

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Graphs showing the impact of Tobin tax, short-sale constraint, and leverage constraint on investment growth volatility.
### Summary of Findings

**Code:**
- **Blue** indicates positive effect (good)
- **Red** indicates negative effect (bad)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Tobin Tax</th>
<th>Short-sale Constraint</th>
<th>Leverage Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial Markets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financing costs</td>
<td>Lower</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>Volatility</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment and output</td>
<td>Reduced</td>
<td>Reduced</td>
<td>Increased</td>
</tr>
<tr>
<td>Volatility</td>
<td>Increased</td>
<td>Increased</td>
<td>Mixed</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td>Lower</td>
<td>Lower</td>
<td>Much higher</td>
</tr>
<tr>
<td>Volatility</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower</td>
</tr>
</tbody>
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Real Effects of Financial Markets

- Study the impact of sentiment-prone investors on the real sector.
- Results: We demonstrate **negative externalities** due to sentiment-prone investors.

Financial Regulation

- We quantitatively assess the effectiveness of regulatory measures:
  - Tobin financial transaction tax: Mostly negative ...
  - Short-sale constraint: Mostly negative ...
  - Leverage constraint: Promising ...
References


Eichenbaum, M., 2010, “What Shortcomings in Macroeconomic Theory and Modelling have been Revealed by the Financial Crisis and how should they be Addressed in the Future?,” *Comments from an ECB panel*, http://faculty.wcas.northwestern.edu/ yona/research.html.


