Impact of Financial Regulation and Innovation on Bubbles and Crashes due to Limited Arbitrage: Awareness Heterogeneity

Hitoshi Matsushima

University of Tokyo, Faculty of Economics

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Bubbles may be harmful under weak regulation and high enthusiasm

Unproductive company can raise huge funds by issuing shares

Bubbles may be beneficial as collaterals, otherwise.

Regulator cannot identify whether it is productive or not.

How can we deter harmful bubbles without identification?
Naked credit default swap (naked CDS) can be an effective policy method, if we assume:

Naked CDS is designed as secured contract with reserve requirement.

*Naked CDS is a time bomb otherwise. (Warren Buffett)*

Naked CDS payments are utilized for debt obligation.
What are CDSs?

**Covered CDS**
- Insurance against own default risk
- Underlying assets required

**Naked CDS**
- Hedge against third party default risk
- No underlying assets required
Main Statements of This Paper

Without naked CDS, weak regulation on leverage fosters bubble,

With naked CDS, weak regulation on leverage deters bubble.

With weak regulation on leverage and/or with high enthusiasm, availability of naked CDSs deter (harmful) bubble,

With strong regulation on leverage and/or with low enthusiasm, availability of naked CDSs foster (beneficial) bubble.
How can we describe bubbles and crashes?

Key Concept:
Awareness Heterogeneity between arbitrageurs and positive feedback traders (PFTs)

Arbitrageurs are: (mostly) rational aware of bubbles and crashes have limited funds ex. Goldman Sachs

PFTs are: slave to euphoria unaware of bubbles and crashes have a plenty of free money ex. AIG

Related (but Different) Literatures:
Limited Arbitrage: Shleifer and Vishny (92)
Heterogeneous Beliefs: Harrison and Kreps (78)
Informational Asymmetry: Allen and Gorton (93)
Financial Interactions between Arbitrageurs and PFTs

**Debt Contracting:**

For purchasing shares, arbitrageurs borrow money from PFTs under regulation on leverage.

No premium, because of their awareness heterogeneity in bubbles.

**Naked CDS Trading:**

Arbitrageurs purchase naked CDS from PFTs.

No premium, because of their awareness heterogeneity in crashes.

Arbitrageurs expect naked CDS payment riskless.
Naked CDS is beneficial for arbitrageurs, but PFTs spend free money on shares and loan.

**Reserve for naked CDS**

\[\text{Reserve for naked CDS} = \text{PFTs’ Free Money} - \text{PFTs’ Share Value} - \text{PFTs’ Loan}\]

Greater PFTs’ share value and PFT’s loan crowd out reserve for naked CDS.

→ Arbitrageurs’ relative future benefit decreases.

→ Arbitrageurs are willing to time earlier.
How can we formulate arbitrageurs’ incentive?

Timing Game with Behavioral Types:  
Matsushima (JET 2013, Theory of Reputation)

Symmetric arbitrageurs compete with each other to win the earliest.

\( n \) players (Arbitrageurs) \( i = 1, \ldots, n \).

Each player selects time \( a_i \) in bounded time interval \([0,1]\).

Earliest to time wins: Winner payoff \( \bar{v}_i(t) \) is greater than loser payoff \( v_i(t) \).

Winner payoff is increasing in time, \( \bar{v}_i'(t) > 0 \).

Player is behavioral, i.e., never times, with tiny probability \( \varepsilon > 0 \).

Player is rational with probability \( 1 - \varepsilon > 0 \).

Strategy \( q_i : [0,1] \rightarrow [0,1] \)

Player times at or before time \( t \) with probability \( q_i(t) \).

(No-bubble is a unique NE if \( \varepsilon = 0 \))
**Bubble-Crash Strategy Profile** \( \tilde{q} \)

Arbitrageur never times before critical time \( \tilde{\tau} \).

Rational arbitrageur randomly times according to hazard rate \( \theta(t) \) after \( \tilde{\tau} \).

\[
\tilde{q}_i(\tilde{\tau}) = 0.
\]

\[
\tilde{q}_i(t) = \frac{1 - \exp\left(-\frac{1}{n} \int_{\tau=\tilde{\tau}}^t \theta(\tau) d\tau\right)}{1 - \varepsilon} \text{ for all } t > \tilde{\tau},
\]

Critical time \( \tilde{\tau} > 0 \):

\[
\varepsilon = \exp\left[-\frac{1}{n} \int_{\tau=\tilde{\tau}}^1 \theta(\tau) d\tau\right]
\]

Hazard rate

\[
\theta(t) = \frac{n}{n - 1} \frac{\bar{v}'(t)}{v_1(t) - v_j(t)}
\]

**No-Bubble Strategy Profile** \( q^* \)

Rational arbitrageur times at initial time 0 with certainty.

\[
q^*_i(0) = 1
\]
Characterization Theorems

**Theorem 1**: Bubble-Crash $\tilde{q}$ is NE if and only if

$$I_1 \equiv \exp\left[-\frac{1}{n}\int_{\tau=0}^{1} \theta(\tau)d\tau\right] \leq \varepsilon.$$  

It is a unique NE if and only if $I_1 < \varepsilon$.

**Theorem 2**: No-Bubble strategy profile $q^*$ is NE if and only if

$$I_2 \equiv \frac{\tilde{v}_1(0) - \sigma(0)}{\tilde{v}_1(1) - \tilde{v}_1(0)} \geq \sum_{l=0}^{n-1} \frac{(n-1)!}{l!(n-1-l)!} \left(\frac{1-\varepsilon}{\varepsilon}\right)^l \frac{1}{l+1}.$$  

Indices $I_1$ and $I_2$ imply (inverse of) relative future benefit for arbitrageur.  

[Greater $I_1$, greater $I_2$, smaller $\tilde{\tau}$, smaller $\theta(t)$] $\Rightarrow$ [Bubble is less likely to persist]
Stock Market Formulation

Company’s total share, $S(t)$, increases in time.
Arbitrageur’s shareholdings, $S_i(t) = S_i(t)$.
Bubble crashes once arbitrageurs’ shareholdings become less than $n\phi \times 100$ %.
Company issue shares as much as possible, $S_i(t) = \phi S(t)$.

PFTs have sufficient free money, $B(t)$.
Arbitrageurs borrow money from PFTs through short-term non-recourse debt contracts with leverage ratio $L > 0$.

PFTs perceive share price $P(t)$ as unchanged over time, but
PFTs unconsciously reinforce price perception, $P'(t) > 0$.

Exogenous Bubble Price Path, Endogenous Crash Time
Arbitrageur’s debt obligation

$$\frac{L-1}{L} P(t)S_i(t)$$

Arbitrageur’s Personal Capital:

$$W_i(t) = \frac{P(t)S_i(t)}{L}$$

$$\therefore \quad W_i'(t) = \frac{P(t)S_i'(t) + P'(t)S_i(t)}{L} \quad \text{............................. (A)}$$

Arbitrageur earns capital gain $$S_i(t)\{P(t + \Delta) - P(t)\}$$ from $$t$$ to $$t + \Delta$$:

$$\therefore \quad W_i'(t) = S_i(t)P'(t) \quad \text{............................................... (B)}$$

From (A) and (B), we can derive:

Total Share:

$$S(t) = S(0)(\frac{P(t)}{P(0)})^{L-1}$$

Arbitrageur’s Share:

$$S_i(t) = \phi S(0)(\frac{P(t)}{P(0)})^{L-1}$$

Arbitrageur’s Personal Capital:

$$W_i(t) = \frac{P(t)S_i(t)}{L} = \frac{\phi}{L} P(0)S(0)(\frac{P(t)}{P(0)})^L$$
Incorporation of Stock Market into Timing Game

Specification of winner and loser payoffs depends on whether CDSs are available.

1) Basic Model: No CDS available

2) Covered CDS Model

3) Naked CDS Model
1) Basic Model: No CDS Available

Winner payoff: $\bar{v}_i(t) = W_i(t)$
Loser Payoff $v_i(t) = 0$ \[\therefore\text{Non-Recourse}\]
Hazard rate \( \theta^*(t, L) = L \frac{n}{n-1} \frac{P'(t)}{P(t)} \) is increasing in \( L \) and \( \frac{P'(t)}{P(t)} \).

Index \( I_1^*(L) = \left( \frac{P(0)}{P(1)} \right)^{L/n-1} \) is decreasing in \( L \) and \( \frac{P(1)}{P(0)} \).

Index \( I_2^*(L) = \frac{1}{\left( \frac{P(1)}{P(0)} \right)^L - 1} \) is decreasing in \( L \) and \( \frac{P(1)}{P(0)} \).

Critical time \( \tilde{\tau}^* \) is increasing in \( L \) and \( \frac{\tilde{P}'(t)}{\tilde{P}(t)} \).

[Greater leverage ratio, greater enthusiasm]
\Rightarrow [Bubble is more likely to persist]
2) Covered CDS Model
Only losers receive CDS payment \( Z_i(t) \), but have debt obligation \((L - 1)W_i(t)\).

\[
\begin{align*}
\text{Winner payoff:} & \quad \bar{v}_i(t) = W_i(t) \\
\text{Loser Payoff} & \quad v_i(t) = Z_i(t) - (L - 1)W_i(t) = W_i(t) = \bar{v}_i(t): \text{ Full Insurance}
\end{align*}
\]

No-Crash Bubble is unique NE, because of full insurance.
3) Naked CDS Model
Both winner and losers receive CDS payment $Z_i(t)$.

Payment reserve for naked CDS = PFTs’ Personal Capital – PFTs’ Share Value – PFTs’ Loan

$nZ_1(t) = B(t) - (1 - n\phi)P(t)S(t) - \frac{L-1}{L}n\phi P(t)S(t)$

Winner Payoff: $\bar{v}_i(t) = W_i(t) + Z_i(t) = \frac{1}{n}B(t) - \left(\frac{1}{n} - \frac{2\phi}{L}\right)P(0)S(0)\left(\frac{P(t)}{P(0)}\right)^L$

Loser Payoff: $v_i(t) = Z_i(t) - (L-1)W_i(t) = \frac{1}{n}B(t) - \left\{\frac{1}{n} + \frac{(L-2)\phi}{L}\right\}P(0)S(0)\left(\frac{P(t)}{P(0)}\right)^L$
Instantaneous gain is greater in naked CDS model than in basic model, because both winner and losers receive CDS payments and both have debt obligations in naked CDS model, while loser is exempted from debt obligation in basic model.

Naked CDS is more beneficial than shareholdings
Expansion of PFTs’ share value and loan is necessary for bubble persistence. High leverage and great enthusiasm need large expansions. Large expansions crowd out reserve for naked CDS.
Theorem 3:
Under high leverage ratio and high enthusiasm, naked CDS deters bubble:

If \( Z_1'(t) < (L - 1)W_1'(t) \) for all \( t \in [0,1] \), then

\[
\tilde{\tau}**(L) < \tilde{\tau}^*(L), \quad \theta**(t,L) < \theta^*(t,L), \quad I_1**(L) > I_1^*(L), \quad I_2**(L) > I_2^*(L).
\]

Under low leverage ratio and low enthusiasm, naked CDS fosters bubble:
If \( Z_1'(t) > (L - 1)W_1'(t) \) for all \( t \in [0,1] \), then

\[
\tilde{\tau}**(L) > \tilde{\tau}^*(L), \quad \theta**(t,L) > \theta^*(t,L), \quad I_1**(L) < I_1^*(L), \quad I_2**(L) < I_2^*(L).
\]

Theorem 4:
Suppose \( L > 2n\phi \). Then, high leverage ratio deters bubble:

\[
\frac{\partial}{\partial L} \tilde{\tau}**(L) < 0, \quad \frac{\partial}{\partial L} \theta**(t,L) < 0, \quad \frac{\partial}{\partial L} I_1**(L) > 0, \quad \text{and} \quad \frac{\partial}{\partial L} I_2**(L) > 0.
\]
Conclusion

Naked CDS is an effective policy method for deterring harmful bubbles, if it is well secured and utilized for debt obligation

High leverage ratio deters bubbles:

It crowds out reserve for naked CDS, lowering arbitrageurs’ future benefit. Regulator should keep weak regulation on leverage irrespective of whether company is productive or not.

Under high leverage ratio and high enthusiasm, naked CDS deters harmful bubbles:

Even losers are not exempted from debt obligation.

Under low leverage ratio and low enthusiasm, naked CDS fosters beneficial bubbles:

Naked CDS increases arbitrageurs’ absolute future benefit.