

Limits to Arbitrage: Financial Crises

Small Open Economics in a Globalized World
Waterloo June 14 2008

Phelim P Boyle
Wilfrid Laurier University

Thanks to Bassam Aoun and to Feidhlim Boyle

Overview

- Introduction
- The Efficient Market Hypothesis
- Arbitrage : the classic view
- Limits to Arbitrage
- **Failure of Arbitrage**
- Leverage
- Investor sentiment

Overview

- Closed End Funds
- Merger Arbitrage Strategy
- Example
- Bubbles
- The Subprime Saga
- Twin Spirals
- The 2007 credit crunch
- Summary

The traditional view

- Market is efficient
- Investors are rational
- They make sensible decisions
- Security price is equal to its fundamental value
- The prices in the market are **right**
- M Friedman(1953). Rational traders will undue any mispricing

The process

Suppose stock price deviates from its true value. Under traditional view, rational investors will correct the mispricing.

- Assume price is too low
- Informed investors buy the security
- This will restore it to its correct price

Assumes investors are knowledgeable, have deep pockets and are patient.

Arbitrage in Action: Classic View

- Suppose current price of an asset is S_t .
- *Informed* investors know its true price is V_t
- If $S_t < V_t$ they will buy the asset
- This will drive up the price to V_t
- If $S_t > V_t$ they will sell the asset short
- This will drive down the price to V_t
- Arbitrage will force price to converge to V_t .

Brownian Bridge Construction

- Let X_t satisfy

$$dX_t = \frac{b - X_t}{T - t} dt + \sigma dW_t$$

where W_t is a Brownian motion and $X_0 = a$.

- Let

$$S_t = e^{X_t}$$

- No equivalent martingale measure in this market
- Arbitrage is possible

Basic Example: Arbitrage

- Suppose current price of a security is 95 .
- At $T = 1$ its price will be 100 *for sure*
- Assume interest rate is 5%.
- Current price is

$$S_0 = V_0 = 100e^{-.05} = 95.12$$

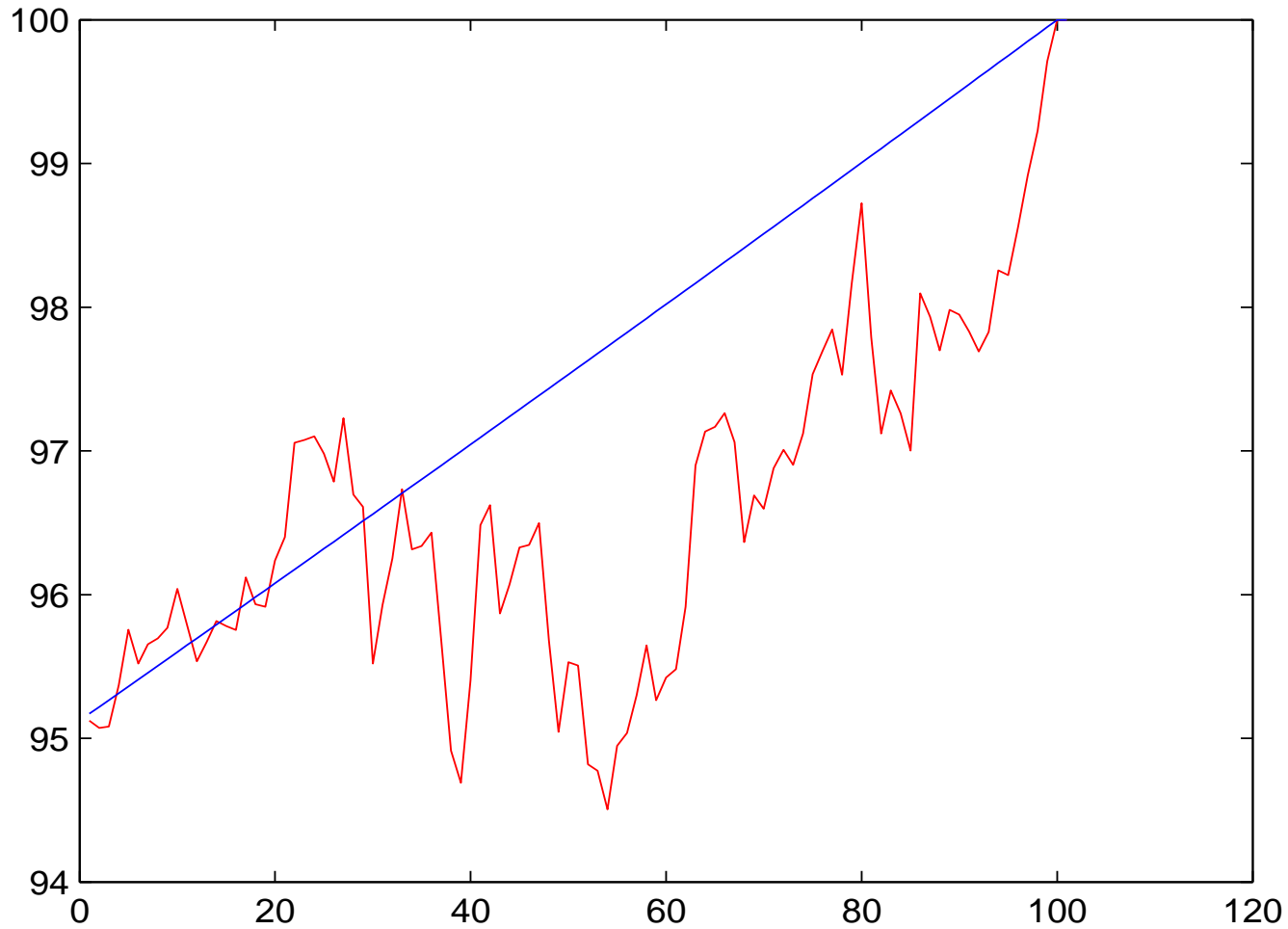
- Graph of

$$V_t = 100e^{-.05(T-t)}$$

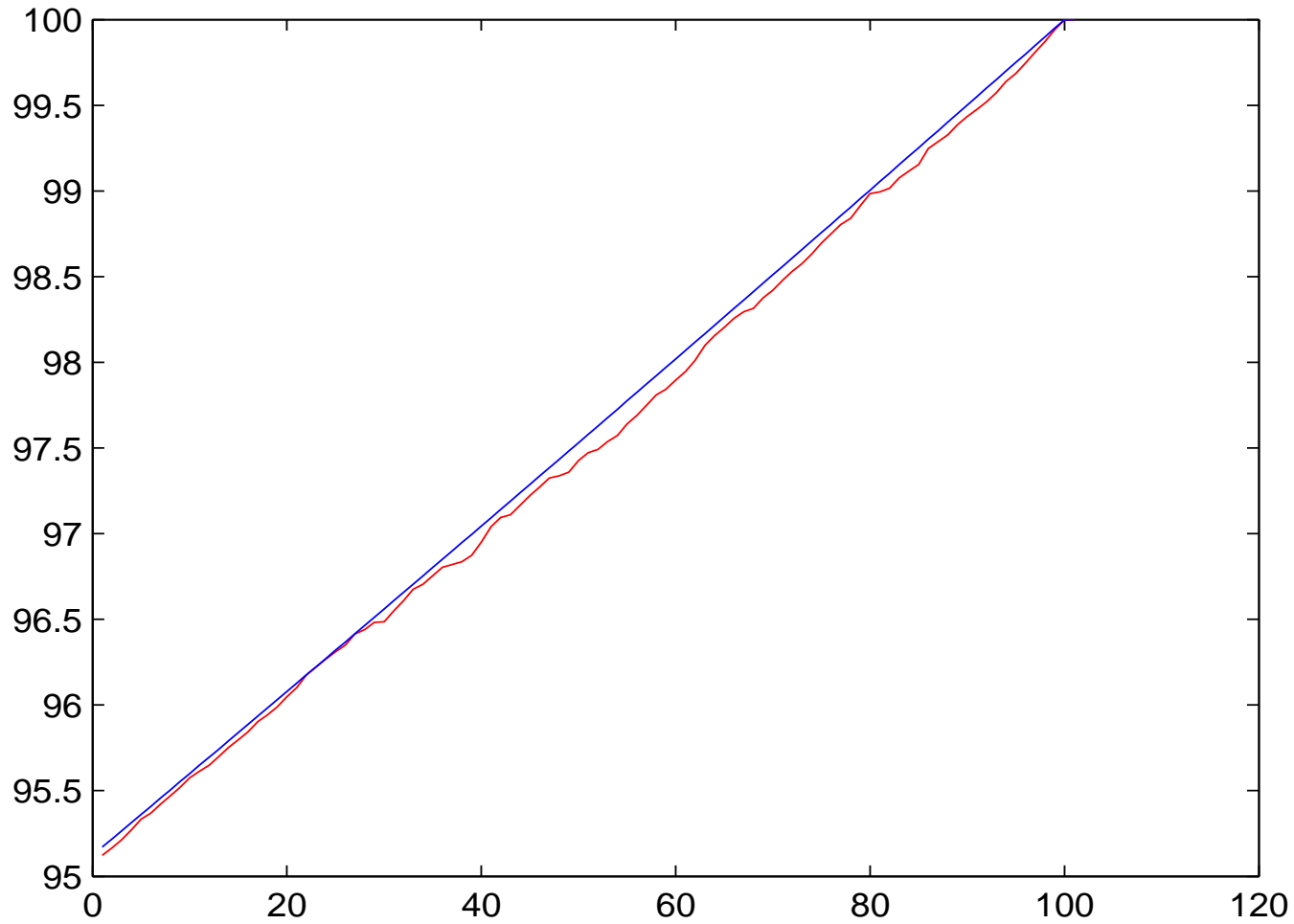
is in blue

- If market price S_t deviates from V_t .

Market price and true price



Classic Convergence



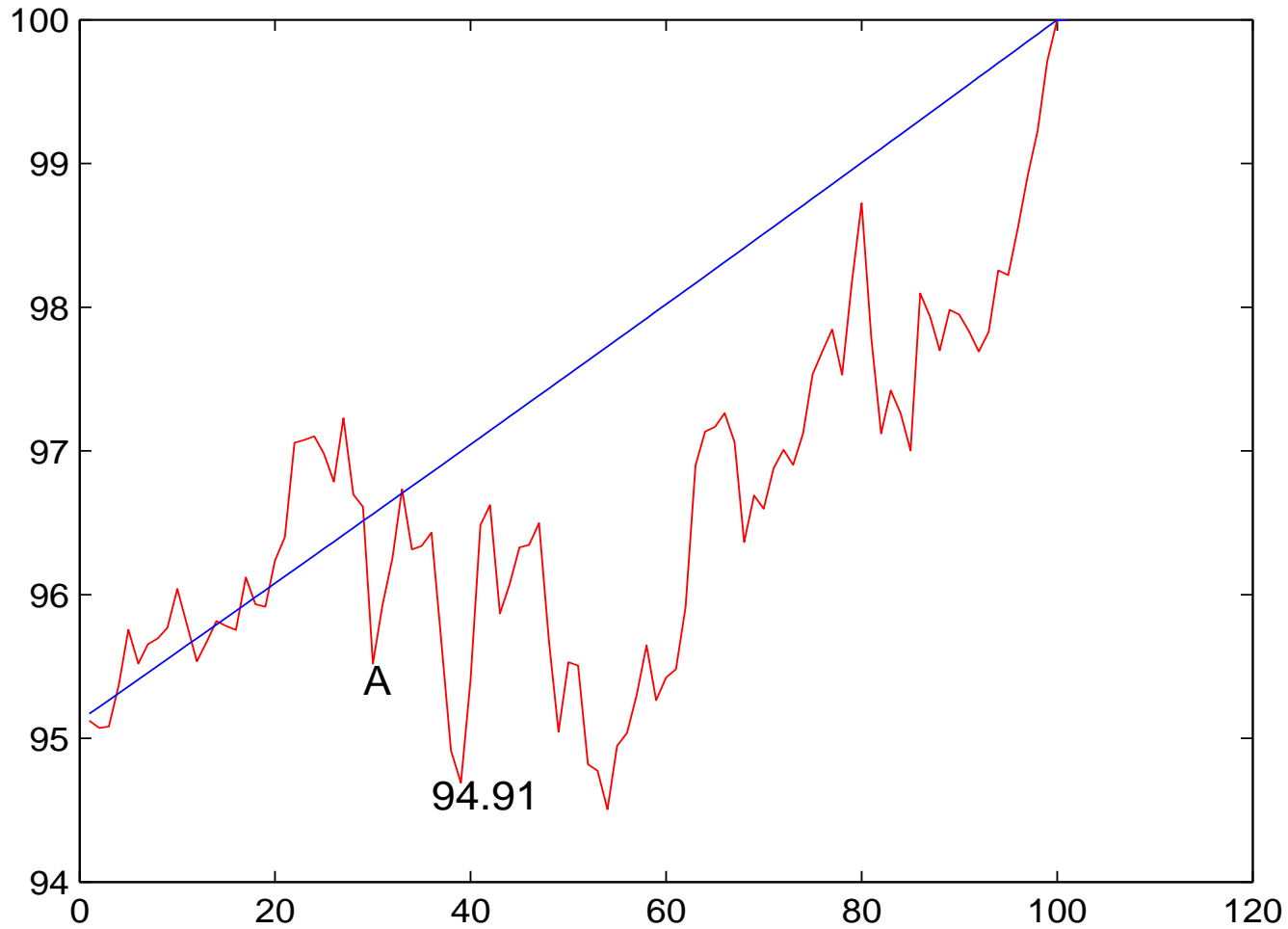
Shleifer and Vishny 1997

- Textbook arbitrage uses no capital and has no risk
- In practice, arbitrage requires capital and there is risk
- Arbitrage is a highly specialized activity
- Requires expertise and experience
- Carried out by professional investors
- Uses other people's money

Shleifer and Vishny 1997

- One reason why there are limits to arbitrage
- Assume compensation is performance based
- Arbitrageur paid on realized returns
- Suppose portfolio is marked to market
- Investors withdraw funds if returns are poor
- Fund may have to liquidate if mispricing increases.
- Simple example next

Buy security for 95.52 at A



Leverage can be Lethal

Own Money Invested	Funds Borrowed	15 day return percent	Yearly return percent
95	0	-0.64	-15.33
65	30	-0.94	-22.52
35	60	-1.74	-41.83
5	90	-12.2	-292.8

Merger Arbitrage

- Should provide an ideal situation to study arbitrage
- Based on a clearly defined corporate event
- Future value of security is specified
- Date of convergence also quite predictable
- Merger arbitrage strategy
- Used by Event Driven Hedge Funds

Merger Arbitrage

- Company B bids for Company S. B will pay C for each share of S at time T .
- Merger Arbitrage Fund buys N shares of S at t^+ and receives NC at time T if deal goes through. MAF invests

$$NS(t^+)$$

at time t^+ .

- Main risk is the deal breaks. If deal goes through, target price will converge to C .

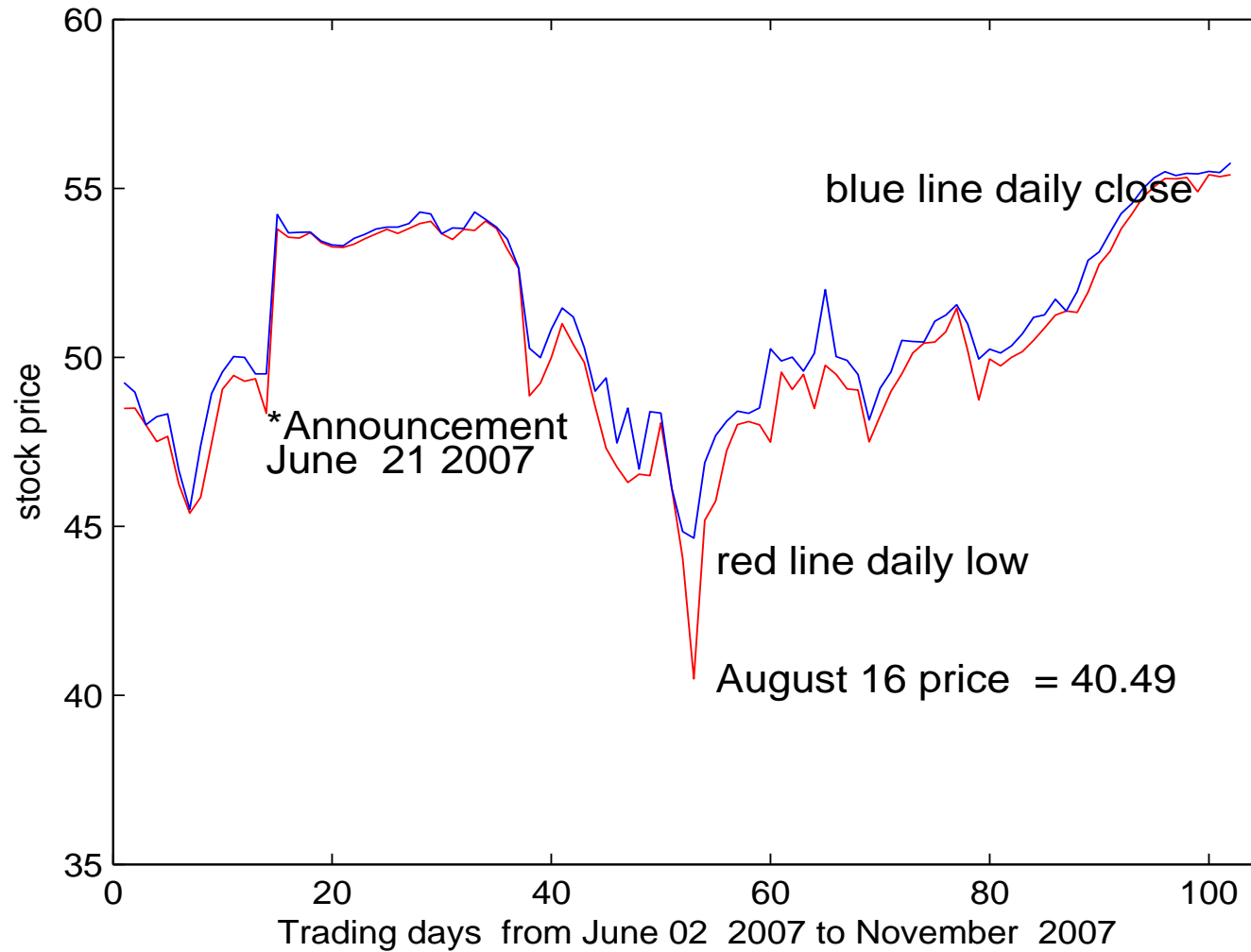
Example: Novamerican Steel Inc.

- Merger announced June 2007
- Symmetry Holdings Inc. and Novamerican Steel Inc.(Tons) announced that they entered into a definitive agreement whereby Symmetry to pay 56 dollars for each Novamerican share.
- Expected completion six months
- **Strategy:** Buy the target (Tons) shares now and get 56 on deal completion

Investment strategy

- Hedge Fund (HF) buys 10,000 shares of Tons in July at 50 per share
- Initial cost is 500,000
- HF expects to sell shares in November for 560,000
- Expected return is 12 percent in four months

Target stock price



Price history of target shares

- In November the deal closed and TONS shareholders received 56 per share.
- However on August 16 2007 shares fell to 40
- Caused by dry up of liquidity in the market
- If hedge fund sold shares then, the return would have been **minus 20 percent** in one month
- If investors judge fund on its short run performance there is pressure to liquidate early

Listening in

- Trader: there are lots of sellers - TONS is falling fast - i have never seen this action - something is wrong
- Risk Manager: we are down 20 percent on this trade. time to cut our losses? - the market is telling us the deal is broken
- Portfolio Manager: our analysis is sound - there must be forced selling or the deal is off? but the prices today are irrational - why are no merger arbs stepping in???

Recommendations

- Portfolio Manager: Stay the course
- Risk Manager: Sell the stock
- Trader: Buy more!

We will see later why the shares dropped

Investor Bias

Psychologists have found that people have certain biases when forming beliefs.

- **Overconfidence**: People are often overconfident in their judgements
- **Optimistic**: People often overestimate their abilities. 90% of people think they are above average drivers
- **Belief perseverance**: When people have formed an opinion they tend to hold it too tightly and for too long.

Investor Sentiment

- Investor Sentiment: Optimism or pessimism about stocks in general
- Investor Sentiment can be measured.
- It varies over time: comes in waves
- More pronounced for small, risky, non dividend paying, risky high growth stocks
- These stocks are less analyzed.

Measuring Investor Sentiment

- Investor surveys
- Retail investor trading volume
- Mutual fund flows
- Closed end fund discounts (higher when investors are bearish)
- Option implied volatility

Closed End Fund

- Shares traded on exchange
- Manager invests in traded securities stocks bonds etc
- The Net Asset Value is the value of the underlying securities
- Price of share differs from the Net Asset Value
- Difference related to investor sentiment
- Market bearish high discount.

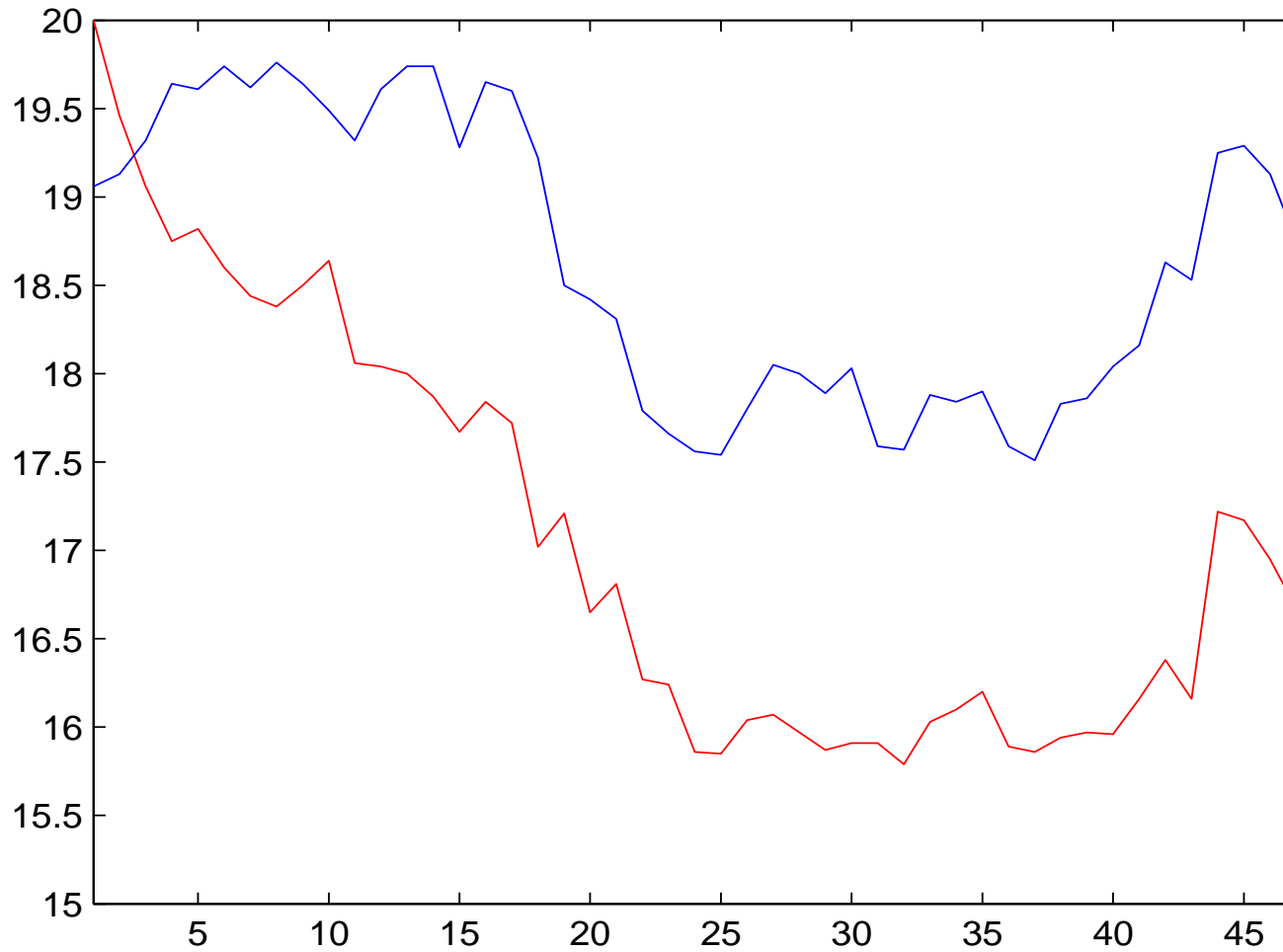
Example of Closed End Fund

Western Asset Inflation Management Fund Inc. is a non-diversified closed-end investment management company traded on the New York Stock Exchange under the symbol IMF. The Fund is advised by Legg Mason Partners Fund Advisor.

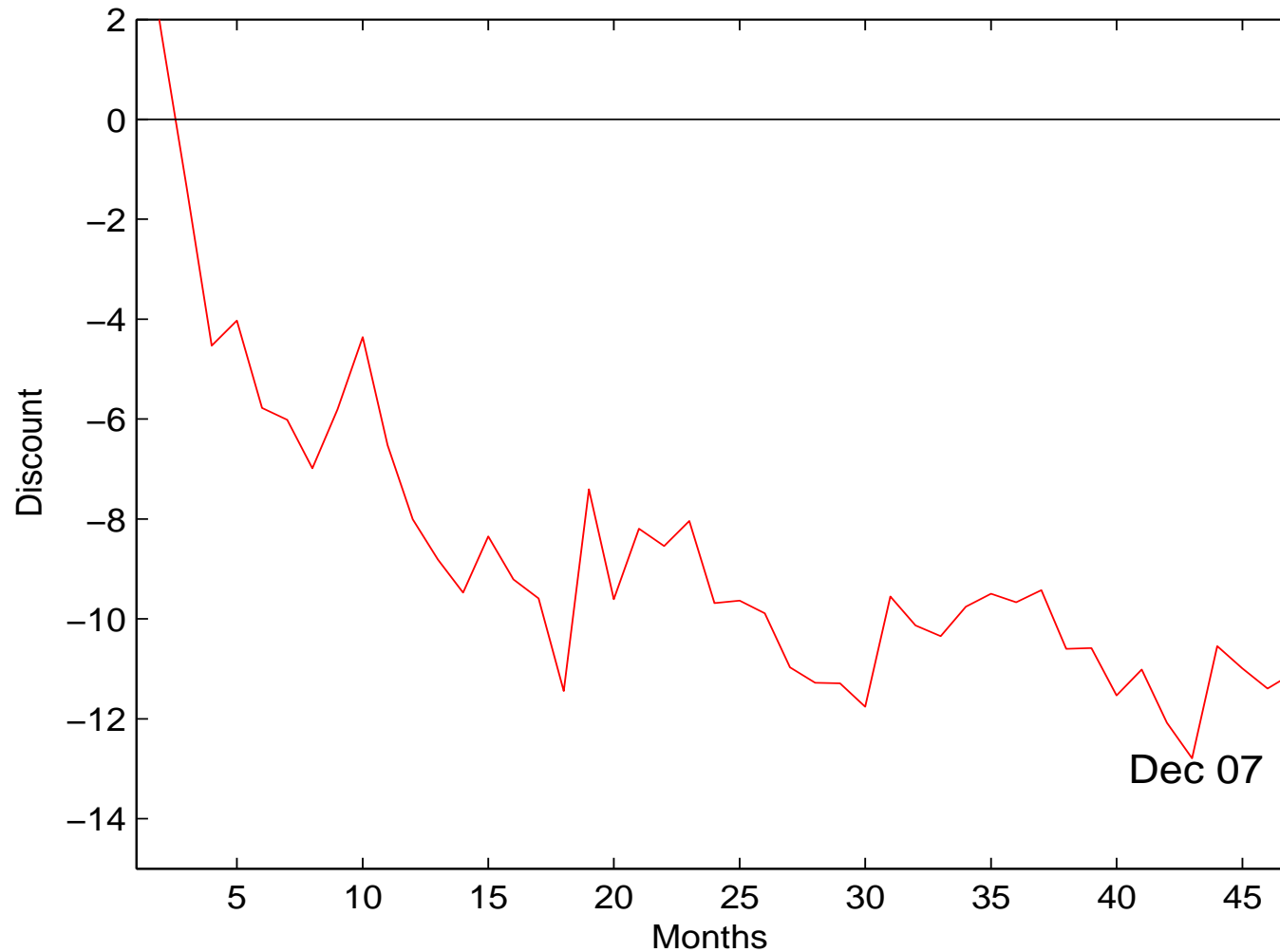
IMFs Assets

Assets	Percentage
Index-Linked US Treasury	81.8
Mortgage Backed	11.2
Investment Grade	2.9
High Yield	2.3
Emerging Market Debt	1.8
Total	100.0

IMF prices May 2004 to present



IMF closed end fund discount



Bubbles

- Periods when assets trade above intrinsic values
- Easy to recognize - **in hindsight**
- Fuelled by noise traders (and in other ways)
- They think prices will rise, they buy more and feed the bubble
- Bubbles cause misallocation of resources
- Why don't arbitrageurs take the other side?

Popping Bubbles

- Not easy in practice
- Suppose an arbitrageur takes a short position and prices continue to rise
- Needs very deep pockets and patience
- Arbitrageur knows there will be a collapse but not **when**?
- **Delicate, difficult and dangerous timing game**
- Gives an incentive to ride the bubble

Julian Robertson

- Internet Bubble late 1990s
- Julian Robertson (*Tiger Fund*) refused to invest in internet stocks
- JR closed fund in 2000.

JR *retired* to New Zealand bought a golf course. Now invests his own money. Bought CDS on subprime securities.

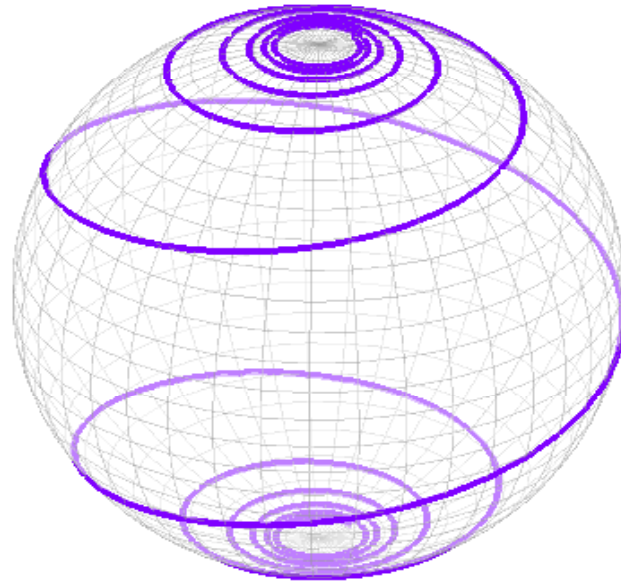
Comments on current credit crisis

- Turmoil in financial markets
- Sources of the problem
- House price rise
- Era of easy credit
- Subprime mortgages
- Fall in house prices
- Huge impact on credit markets
- Transmission and amplification

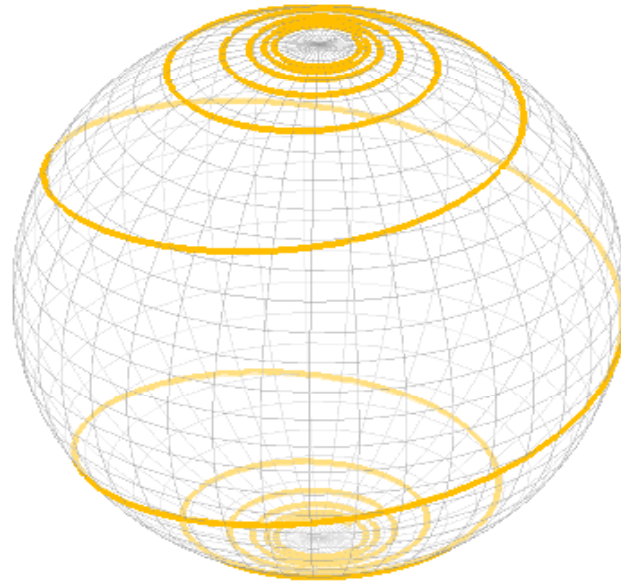
Evidence

- Drop in liquidity and tightening of credit
- Banks taking massive write downs
- Many seeking new capital
- UK Northern Rock: run on the bank by the little guys
- Bear Stearns collapse: run on the bank by the big guys
- Quant hedge funds tremble

The Double Spiral



The Double Spiral



The Liquidity Spiral

- Arises from deterioration in borrowers' balance sheets
- Asset prices fall and liquidity drops
- This leads to higher margins
- Institutions cut back on leverage
- In turn causes further fall in asset prices
- Related to maturity mismatch

Liquidity

Market Liquidity

- Ease with which one can raise money by selling an asset

Funding Liquidity

- Ease with which one can raise money by borrowing using asset as collateral

Interactions Brunnermeier(2007)

- Market prices fall
- Collateral value declines
- Margins may be increased
- Effect magnified if levered position
- Increased downward pressure on market prices
- The spiral continues

Liquidity Spiral

In times of crisis reductions in market liquidity and funding liquidity are *mutually reinforcing*. Brunnermeier et al (2007) model predicts that liquidity

- can suddenly dry up
- has commonality across securities
- is related to volatility
- experiences *flight to quality* events

Simple Example

Assume Financial Institution (FI) aims at a leverage ratio of 10. Its current balance sheet is

Assets	Liabilities
Securities 100	Equity 10 Debt 90

Suppose market price of securities rises to 101

Maintaining Leverage

New balance sheet is

Assets	Liabilities
Securities 101	Equity 11 Debt 90

Leverage is now 9.18. To restore original leverage ratio, FI buys securities worth 9.

Leverage Restored

After the purchase the balance sheet is

Assets	Liabilities
Securities 110	Equity 11 Debt 99

The leverage is back to 10.

Note this action amplifies demand for the security. If widespread, price will increase.

Drop in prices

Assume instead market price of securities drops to 99. New balance sheet is

Assets	Liabilities
Securities 99	Equity 9
	Debt 90

Leverage is now too high (11). To restore original leverage ratio FI sells securities worth 9.

Leverage Restored

After the sale the balance sheet is

Assets	Liabilities
Securities 90	Equity 9
	Debt 81

The leverage is back to 10.

Note this action puts downward pressure on the price.

DeLevering

If there is a period of stress all FIs may reduce leverage ratio from 10 to 9. In this case FI will sell more of its securities

Assets	Liabilities
Securities 81	Equity 9 Debt 72

These two effects will reinforce one another. The spiral continues.

Subprime Saga

- Easy credit conditions
- Banks had surplus capital
- Incentive to take on assets
- Subprime mortgages with poor or no underwriting
- Funded with short term borrowing

Growth of Subprime

1. Prime mortgage market, dominated by Fannie and Freddie, became saturated.
2. Strong US housing market during 1995-2005
3. Low interest rates
4. Very relaxed underwriting
5. New products with teaser rates
6. Securitization of loans
7. Risks packaged and tranced and rated

Default risk depends on

1. Loan to value ratio
2. Type of mortgage FRM v ARM
3. Borrower's credit (FICO score)
4. Age of mortgage
5. Mortgage coupon rates
6. House price changes
7. Loan documentation

Securitization

1. Mortgages originally securitized to increase flow of mortgage finance
2. Two risks if bank owns a mortgage
 - (a) Prepayment risk
 - (b) Default risk
3. First risk used to be biggest worry.
4. Early MBS were insured against default
5. Subprime loans not insured. Carry higher interest rates

The Players

- Mortgagor
- Originator
- Arranger
- Warehouse lender
- Credit rating agency
- Asset manager
- Servicer
- Investor

The run up

- Securitization, Pooling and Tranching. Create AAA grade out of risky loans
- Shortening the maturity structure: Asset Liability mismatch
- Pressure on rating agencies. Rosy models all round. Assumed low regional correlation
- Cheap credit and housing boom
- Subprime loans securitized and sold to investors worldwide

The trouble begins

Date	Event
End 2006	Sub prime defaults start to rise
March 2007	Shares in New Century suspended
May 4 2007	UBS closes its hedge fund
May 2007	Moody's subprime alert
June 2007	Bear Stearns rescues its 2 HFs
June 2007	Corporate spreads widen
July 2007	Trouble in ABCP market

and continues

August 2007

- August 2007 problem in credit markets
- ECB injects 95 billion Euros
- Fed injects 25 billion USD
- ABCP market dries up
- 50 basis points spike in LIBOR
- General market began to worry about credit
- Downward spirals continue

The sequence of steps

- Credit bubble
- Sustained by chain of *smart* players
- Hard to arbitrage bubble before its time
- When problems start, crisis in one market quickly transfers to other markets
- Current financial architecture makes transfer very rapid
- Contagion across institutions and countries
- Leverage exacerbates the problems

Why don't arbitrageurs step in

- Lack of expertise and market frictions
- Caballero and Krishnamurthy (2008) have another story
- In times of crisis, agents have trouble assigning probabilities
- They are averse to Knightian uncertainty
- Reduce risk taking: set tighter VaR limits
- May make things worse
- Role for central bank

Ed Clark TD Bank

I'm an old-school banker, I don't think you should do something you don't understand, hoping there's somebody in the organization who does.

Clark met with experts with doctorates in math for several hours each week to educate him on the banks complex derivative products. He decided the business was too risky.

The whole thing didn't make common sense to me, 'You're going to get all your money back, or you're going to get none of your money back. If this ever went against us, we could take some serious losses here.

Summary

In the run up things are too rosy

- Prices escalate
- Leverage rises
- Lending standards lax

Bubble is pricked: crisis ensues

- Prices tank
- Leverage reduced
- Credit dries up
- Arbitrage becomes much harder

Comments on models

Models

- Quantitative models
- Handle with care. They can be fragile
- Need to appreciate the wider context
- Connections across markets
- Market phenomena are endogenous
- When will models break down?
- When does a bridge break down?

References

- Markus Brummermeier (2008). "Deciphering the 2007-08 Liquidity and Credit Crunch," forthcoming *Journal of Economic Perspectives*.
- Ricardo J. Caballero and Arvind Krishnamurthy,(2008). "Collective Risk Management in a Flight to Quality Episode," forthcoming *Journal of Finance*.

References

- David Greenlaw, Jan Hatzius, Anil K Kashyap, Hyun Song Shin. (2008) "Leveraged Losses: Lessons from the Mortgage Market Meltdown", US Monetary Conference Forum Conference 2008.