Financial crises

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RISKMETRICS

Overview

- What are market crises?
- Market crises and risk models
- Expectations and market crises
- Warning signals

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- What are market crises?
- Market crises and risk models
- Expectations and market crises
- Warning signals

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What are market crises?
Crises, bubbles, and volatility

- Sharp changes in asset prices
  - Non-price impact: positions, transactions volume, expectations, real economy, financial and payments systems integrity
- What happens in a crisis?
  - Volatility spike, correlation breakdown, liquidity impasse
- Systemic risk
  - Contagion: related and unrelated markets, via sentiment, hedging, same and similar fundamentals
  - Credit contraction
  - Payment systems impaired
- Focus on two crises: one localized, one general
  - The ERM Crisis of 1992-1993
  - The Asian/Russian crisis of 1997-1998

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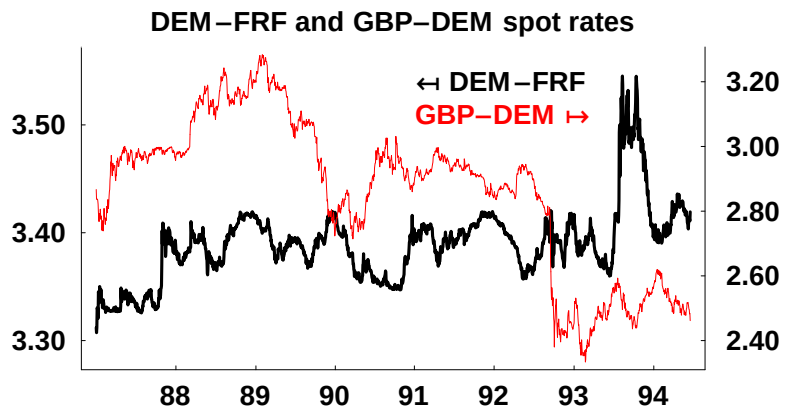
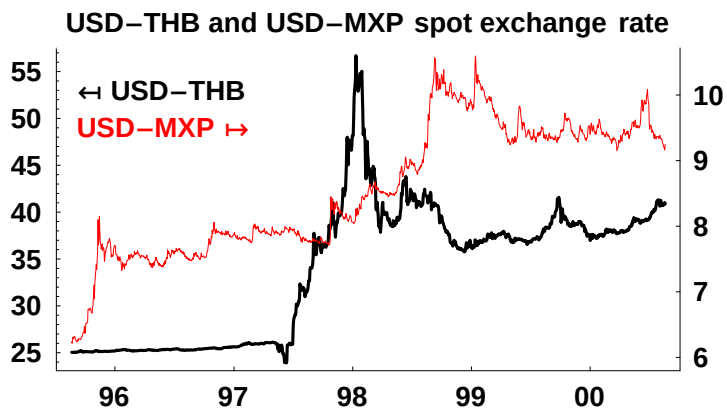
What are market crises? Currency crises

- Special role of currency crises in postwar crises
  - One of the only asset prices subjected to price controls. Other example gold until speculative run undermined Bretton Woods.
- Involve the banking system in an essential way: short-term capital inflows and outflows
- Speculative attack pattern therefore not typical for other assets
- Have shown a special tendency to impact other markets, spread out of control
  - October 1987 U.S. stock market crash may have been precipitated by currency dispute
- And today: Japanese yen, Turkish lira, Brazilian real, Argentinean peso…

What are market crises?
Brief description of the events

- "Black Wednesday"
  - Sterling leaves ERM 16 Sept. 1992
- Breaking the USD-THB peg
  - First speculative attack 14-15 May 1997
  - Float 2 July 1997
- Russia/LTCM phase 1998
  - FOMC rate cuts 29 Sept., 15 Oct.





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What are market crises? Identifying crises

- No precise way of identifying crises
  - Difficult enough to define a sharp asset price move
  - Sharp asset prices changes enough to define crisis?
    - Actually quite common
    - Not every big move is a crisis: gold in September 1999
- Changes in
  - Behavior of asset prices: volatility and liquidity
  - Relationships among asset prices: correlation and liquidity
  - Market sentiment as expressed through derivatives prices
- Basic tool is normal distribution
  - Need normal distribution to determine what is large or frequent
- Extreme value theory: tail events follow a particular class of distributions, parameters estimated from data

- What are market crises?
- Market crises and risk models
- Expectations and market crises
- Warning signals

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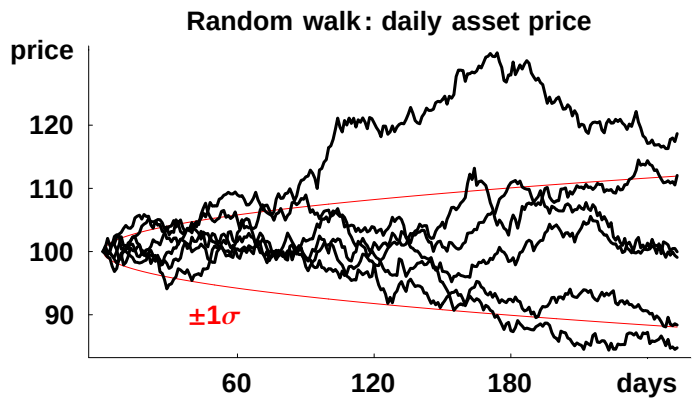
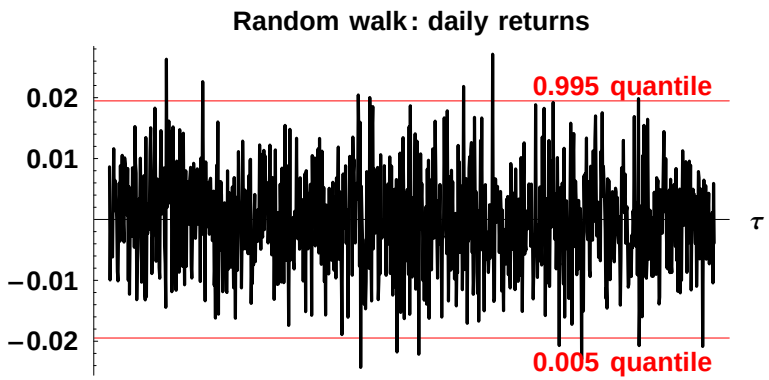
Market crises and risk models
The standard model





1 Asset price follows random walk

2 Expected asset return is zero

Some implications of the classical assumptions:

- Asset return is normally distributed
- The confidence interval widens in proportion to the square root of time.
- Return volatilities and correlations constant or change gradually
- The volatility of the random walk can be accurately estimated using the historical volatility over some recent period.

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Market crises and risk models
The standard model

- Normal distribution describes asset price returns very well—up to a point
- Anomalies are small but economically important

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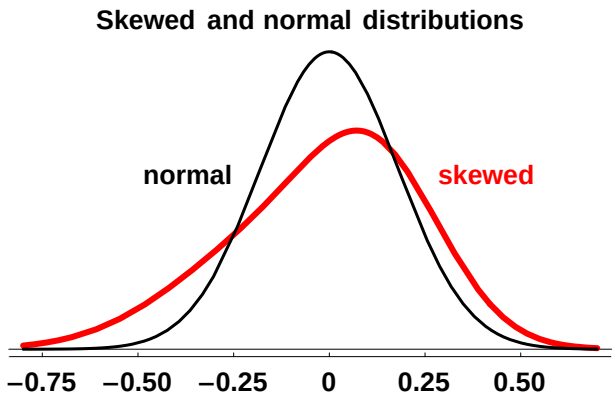
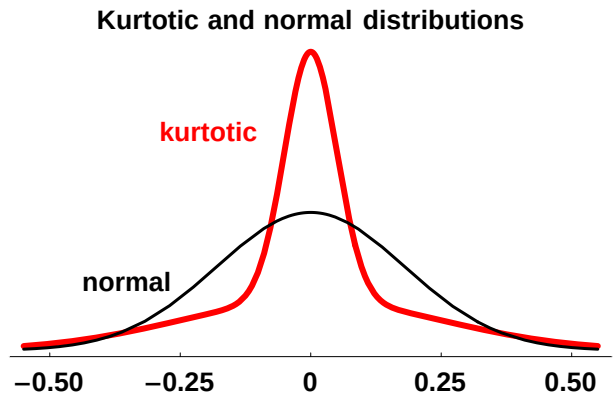
Market crises and risk models
Deviations from the standard model





- Kurtosis
  - Large moves happen more frequently than is consistent with normality
- Skewness
  - Large moves happen more frequently in one direction than the other
  - Normal distribution is symmetric
- Time-varying volatility
  - RiskMetrics EWMA approach
  - But still large changes in volatility in crises

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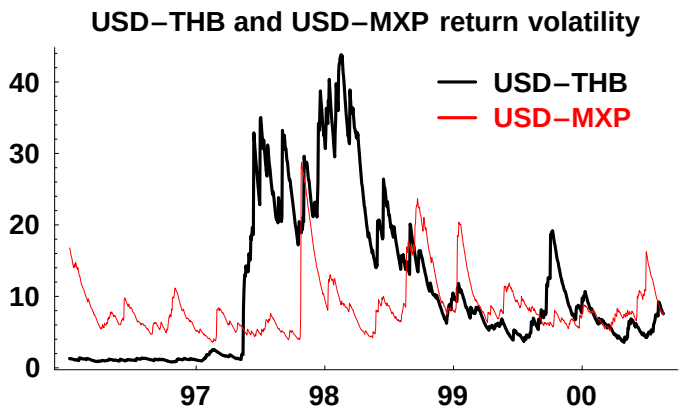
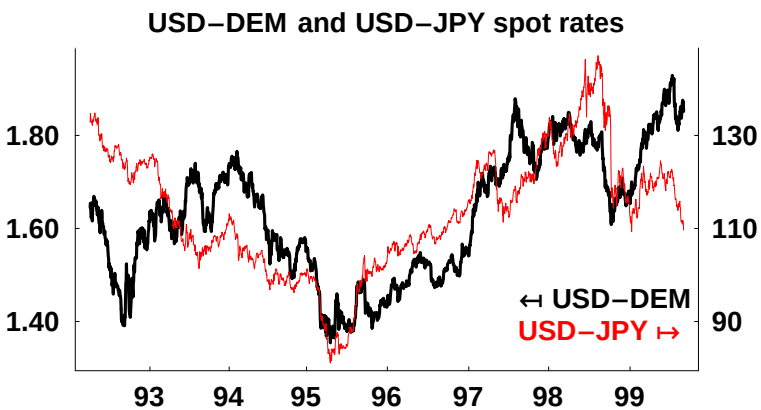
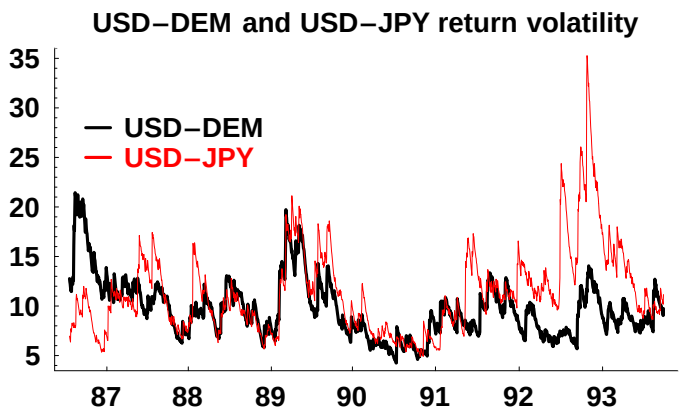
Market crises and risk models
Volatility in crises

- Sudden and very large run-up in volatility
- Volatilities go up sharply in a crisis, particularly pegged currencies
- But volatilities may go up in the absence of a crisis, or due to events in local market







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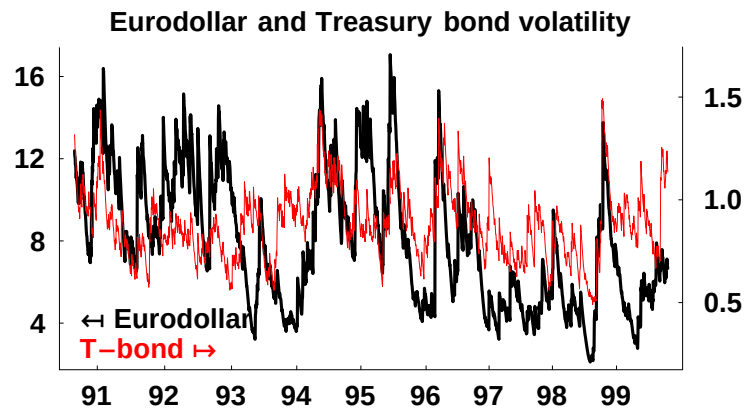
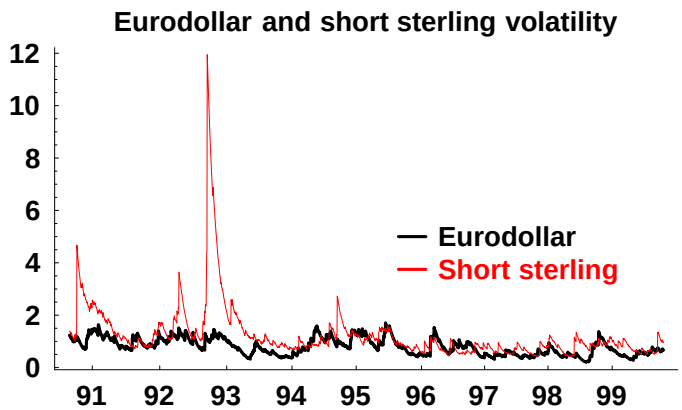
Market crises and risk models
Volatility in crises





- Interest rate volatility
  - Exceptional volatility in interest rates due to currency crises
  - Bond volatility—but not money market volatility—exceptional during LTCM crisis
  - Fixed income volatility approximately of the order of magnitude of duration

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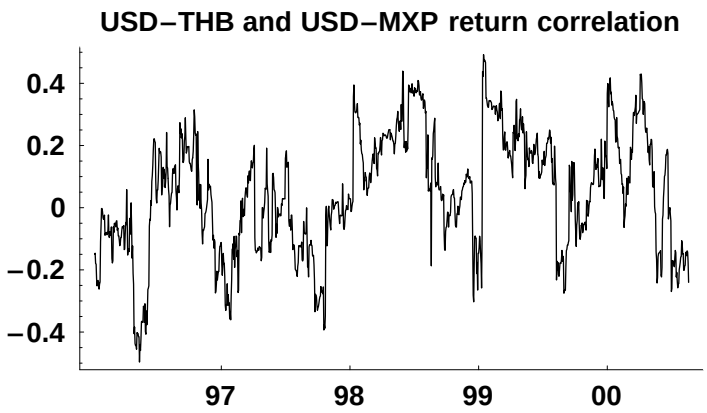
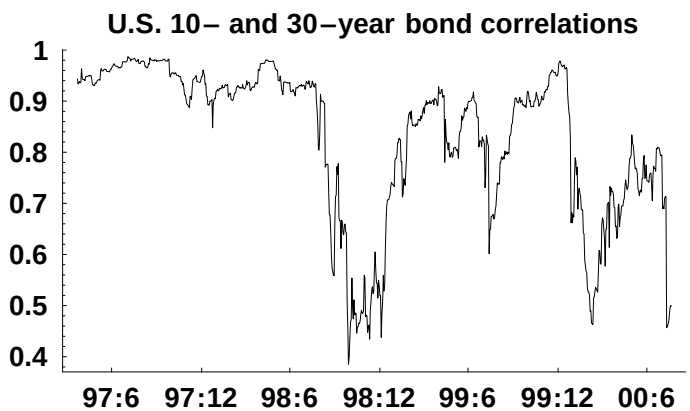
Market crises and risk models
Correlations in crises

- Correlations change all the time and can change rapidly during crises: “correlation breakdown.”
- Changes in substitutability
- Correlations can be systematically different in crises from normal periods
  - Some correlations fall precipitously: interest rates along a curve
  - Some correlations rise precipitously: interest rates or equity indexes across markets





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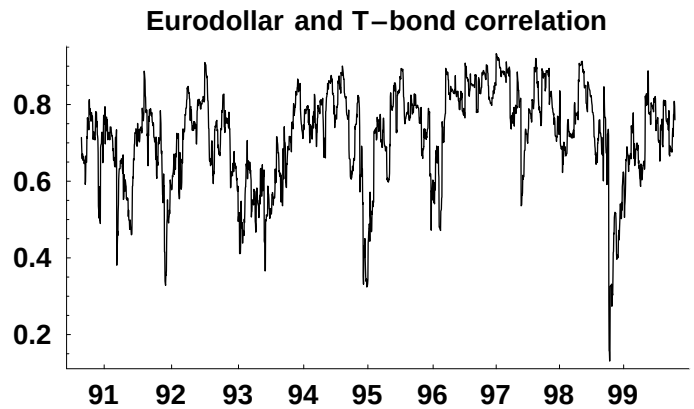
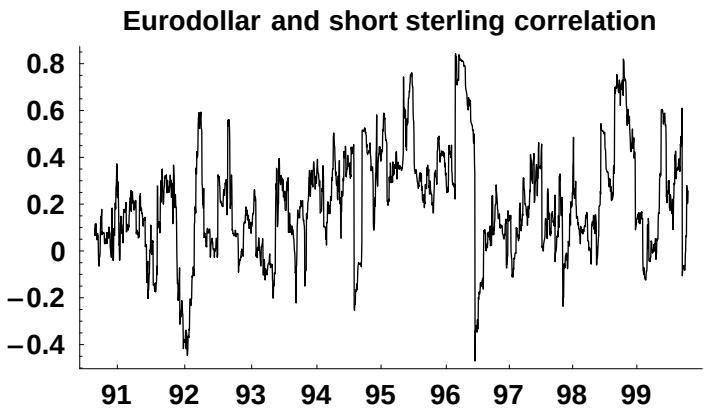
Market crises and risk models
Correlations in crises





- Liquidity impact
- High correlation of money market rates during LTCM crisis due to expectations of monetary easing

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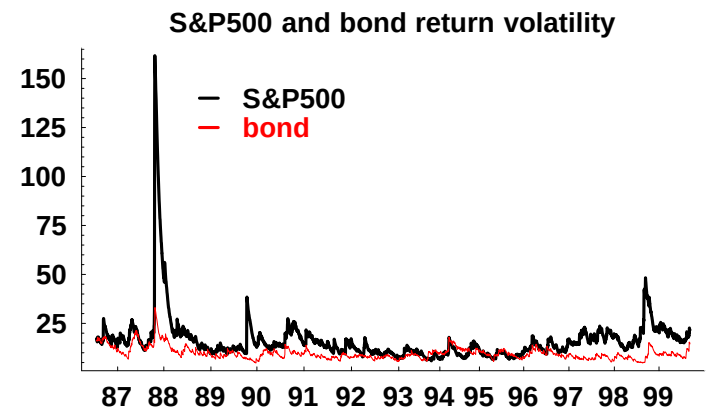
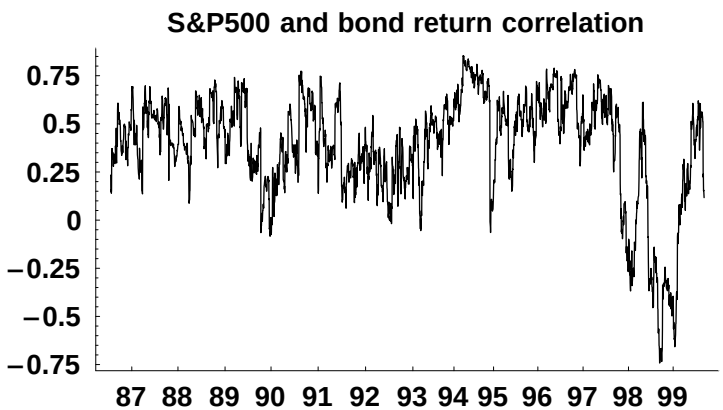
Market crises and risk models
Correlations in crises





- Stock and bond correlation
- Generally positive
  - Drops to near zero during stress periods
  - During Asian and LTCM crises sharply negative
- Some correlations may rise

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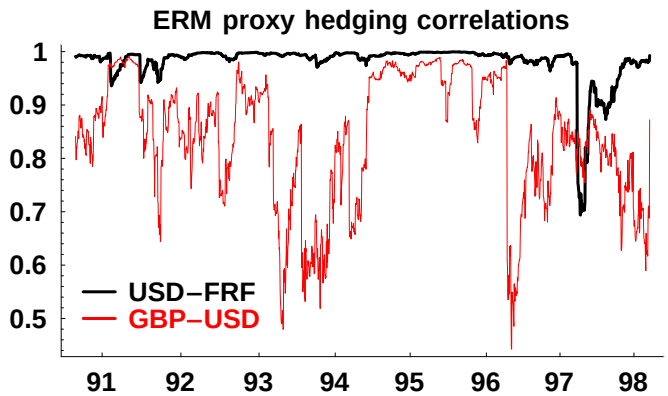
Market crises and risk models
Correlations in crises



- Proxy hedging
  - Hedge in an asset that is highly correlated with the exposure but has a deeper market or lower financing rate.

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Market crises and risk models
Liquidity in crises

- Flight to liquidity
  - Need to meet margin and collateral requirements
  - Expression of general anxiety: everyone want to know they can get into cash at low cost
  - Many market participants have similar trades on at any point in time
    - Primarily “carry trades,” dependent on exit timing to avoid loss
    - Convergence trades, yen carry trade, repo-financed trades
  - “I’m unwinding this position, I can always put it back on later.”

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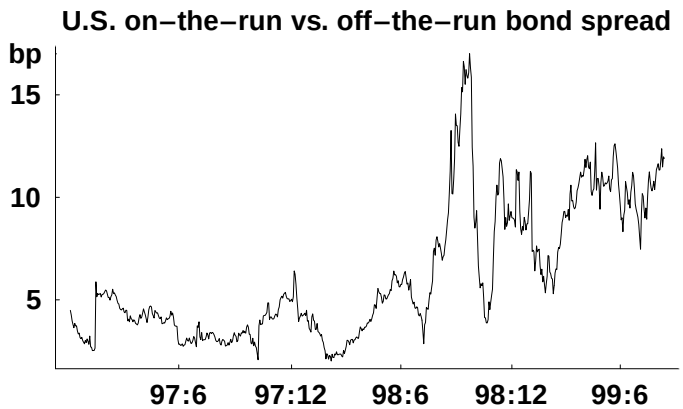
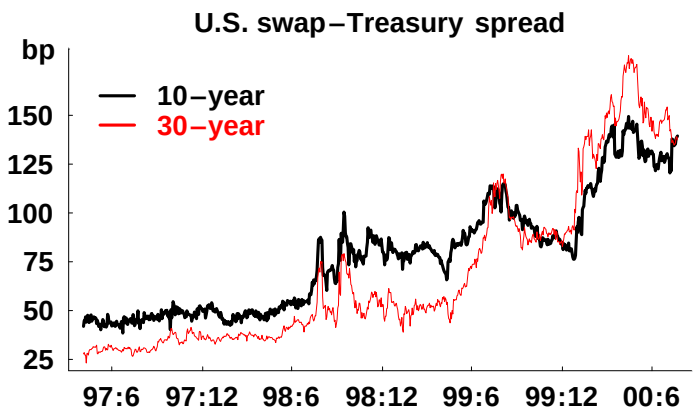
Market crises and risk models
Liquidity in crises

- Measuring liquidity
  - OFF vs. OTR
  - Bid-ask spreads
  - Average distance of prices from a fitted curve
  - Term structure of open interest on exchanges
  - Ratio of front to back OI
  - Short-term options, risk reversals
  - Vol of vol
  - Swap spreads





spreads in basis points

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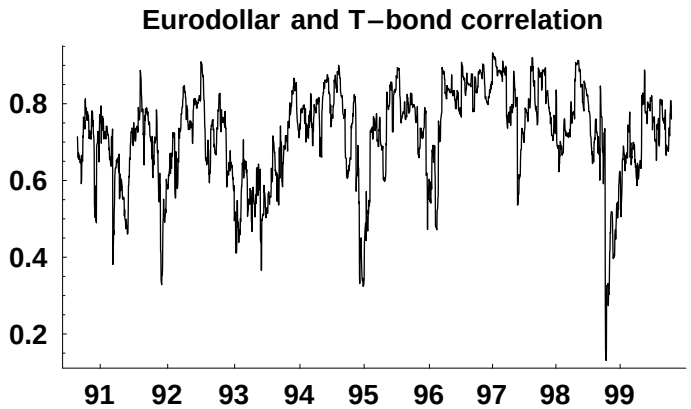
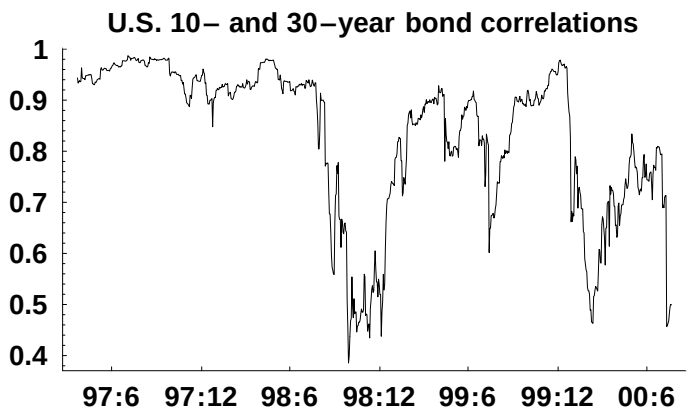
Market crises and risk models
Liquidity and correlation

- Liquidity can influence correlations among assets
- Futures not subject to squeezing or liquidity impasses





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Market crises and risk models
Credit spreads

- Credit spreads rise sharply in crises
- Measuring market perceptions of credit risk
  - Spreads between risk free (government) and credit risky instruments
  - Spreads between commercial paper and Treasury bill rates
  - Japan premium
- Move together with liquidity indicators

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- What are market crises?
- Market crises and risk models
- Expectations and market crises
- Warning signals

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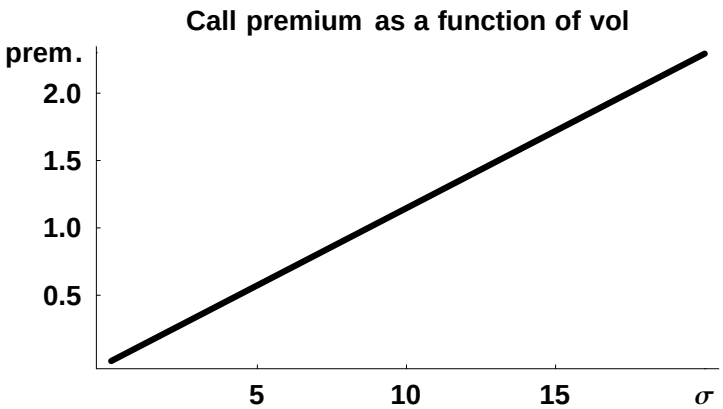
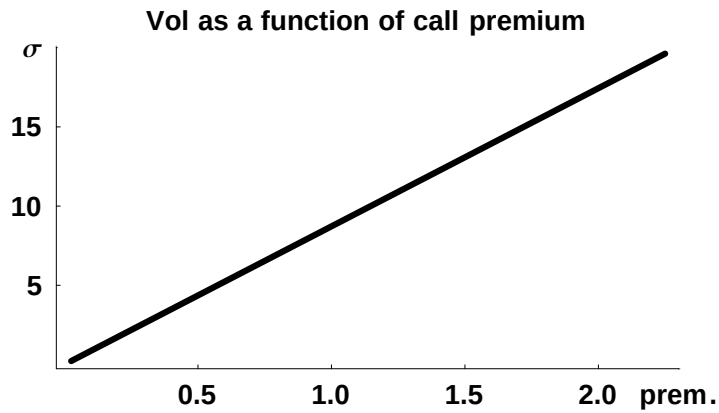
Expectations in market crises
Expectations and market prices

- Market expectations play crucial role in crises
  - Market participants try to anticipate events, position themselves for future
- Market expectation embedded in prices: efficient markets theory
- Even in efficient markets, entanglement of expectations with
  - Risk premiums
  - Liquidity
- How are expectations expressed?
  - Spot/cash prices
  - Forward prices equal to expected future spot prices
    - Forwards poor predictors of future prices, but everything else as bad
    - Predictive performance even worse for large moves
  - Interest rate and futures term structures and spreads
  - Option implied volatilities and volatility surfaces

Expectations in market crises
Implied volatility: background





- A measure of how much asset prices move around
- A measure of option prices themselves
  - Option markets can be viewed as markets for the “commodity” asset price volatility
  - Exposures to volatility are traded and volatility price discovery occur in option markets

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Expectations in market crises
Implied volatility and future volatility

- Theory: implied volatility equal to expected future volatility
- Predictive performance not bad, and seems to have some value for predicting large moves
- Correlations between IV and spot important for hedging
- Self-insurance properties can disappear in crises

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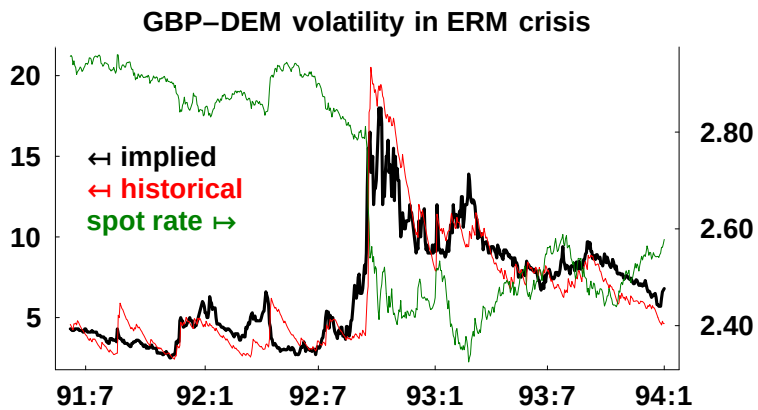
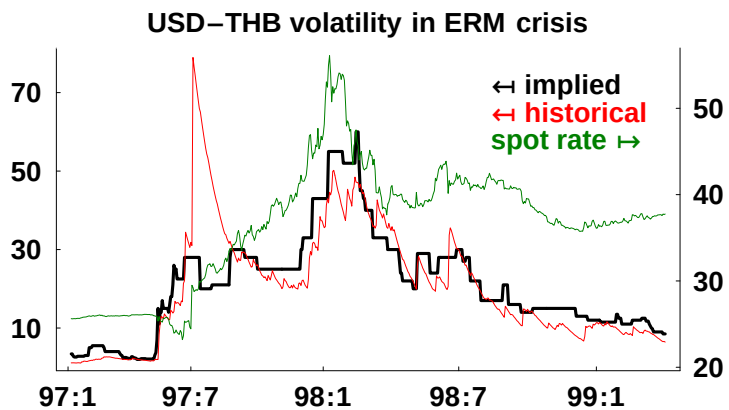
Expectations in market crises
Implied volatility behavior in crises

- Charts display historical EWMA volatility (RiskMetrics methodology) and 1-month implied volatility
- Implied typically mean-reverting, not far from historical
- In crises IV anticipatory:
  - Historical lags implied slightly
  - Historical then spikes much higher than implied, but decays rapidly
  - Implied continues to rise, then decays slowly





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Expectations in market crises
The volatility smile: Black-Scholes "anomalies"

In the *Black-Scholes world*, each asset has a unique, unchanging implied volatility:

1. Implied volatility for options on a given underlying would remain constant over time.
2. One implied volatility for on a given underlying, regardless of moneyness (delta) and regardless of whether they are puts or calls.
3. One implied volatility for options on a given underlying, regardless of maturity.

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Expectations in market crises
The volatility smile: Black-Scholes "anomalies"

In the *real world*

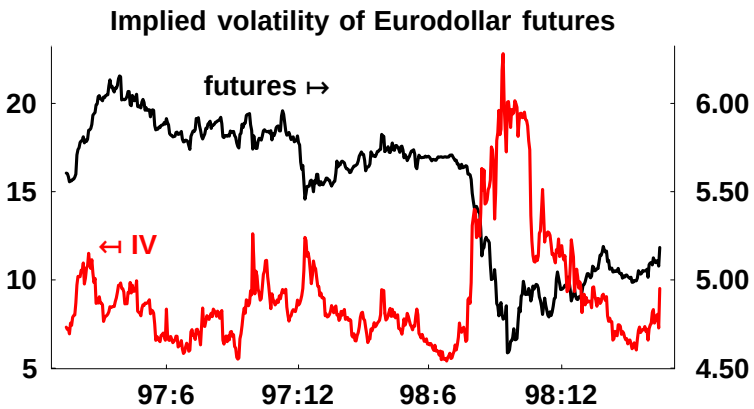
1 Implied vols always changing.

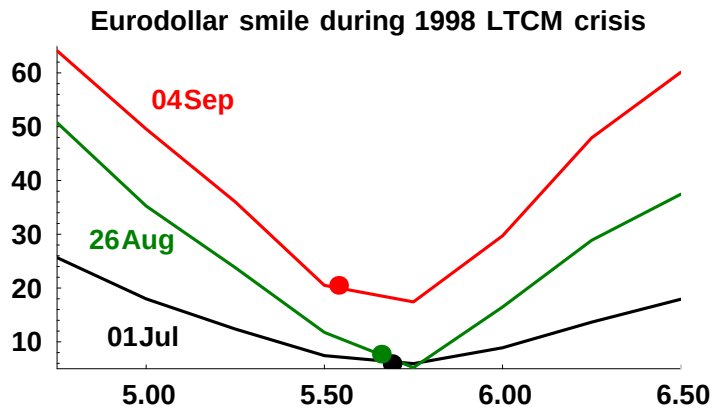
2 The **volatility smile**.

- Out-of-the-money options tend to have higher volatilities than at-the-money.
- Equally out-of-the-money puts and calls often have different volatilities.

3 Implied volatilities for options with different maturities are usually different. This is called the **term structure of volatility**.

Expectations in market crises
Behavior of the volatility smile





- Increase in curvature and skewness toward lower rate
- Accompanied by sharp rise in level of implied volatility

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Expectations in market crises
Implied probability distributions

Risk neutral distributions implied by derivatives prices

- Expectations and risk premiums jointly determine asset prices. Can be disentangled only with a model.
- **Risk neutral probabilities:** probabilities of future prices that are embedded in asset prices as they now stand
  - Example: odds at the racetrack are risk neutral, don't necessarily coincide with anyone's personal views
  - Incorporate risk preferences $\Rightarrow$ risk neutral probabilities will fluctuate as risk aversion fluctuates, even with expectations stable
- Risk neutral probabilities can be extracted from current forward-looking asset prices, I.e. forwards, futures and options.

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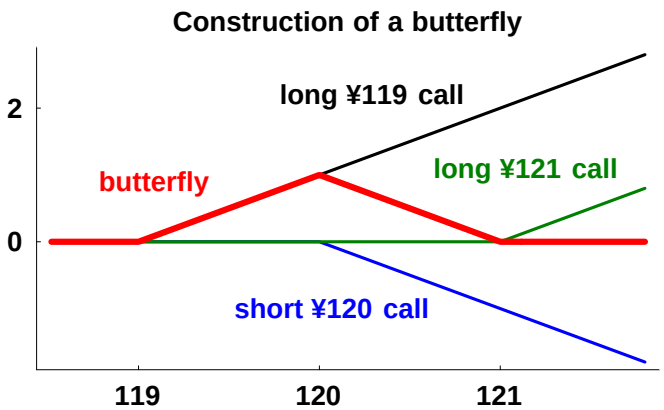
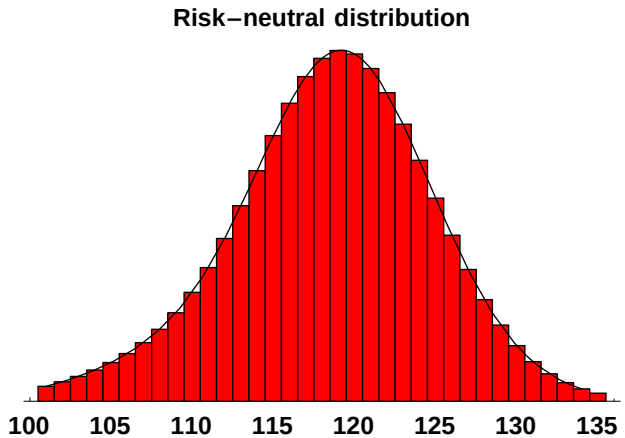
Expectations in market crises
Implied probability distributions





The Breeden-Litzenberger result

- Second difference of the call price with respect to the exercise price equals the risk neutral density (easy, huh?)
  - That means the curvature of the call function

⇒ With a nice dense set of options with different exercise prices but same maturity, just trace out risk neutral density mechanically

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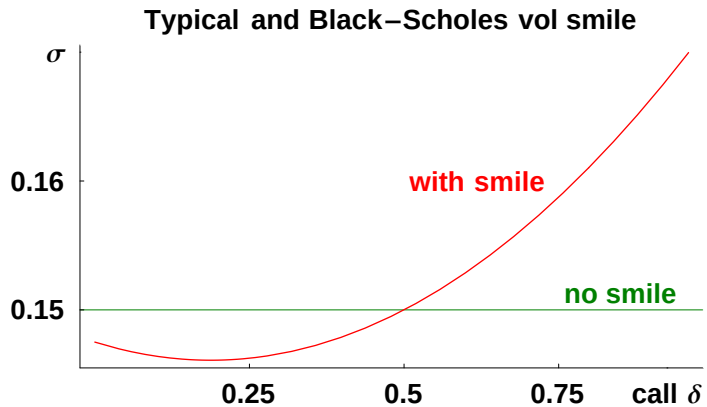
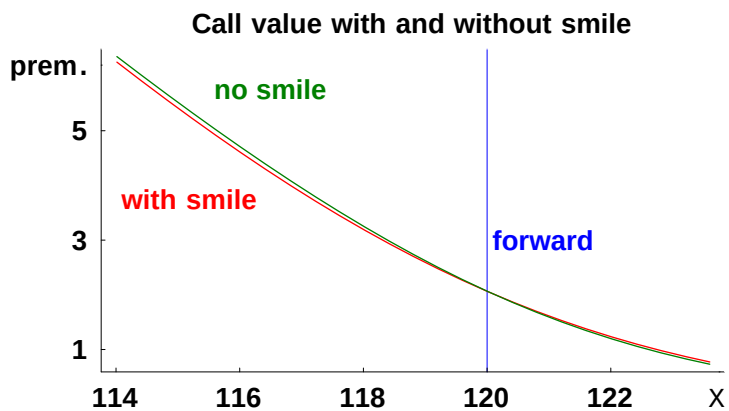
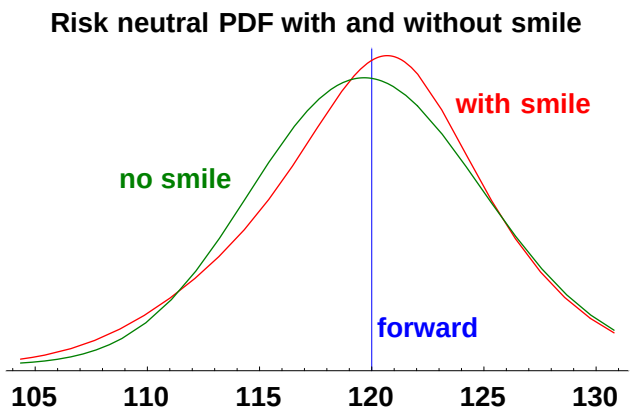
Expectations in market crises
Implied probability distributions

The impact of the smile

- Puts skewness and kurtosis into risk neutral distribution
- Slight alteration in option price, big alteration in curvature







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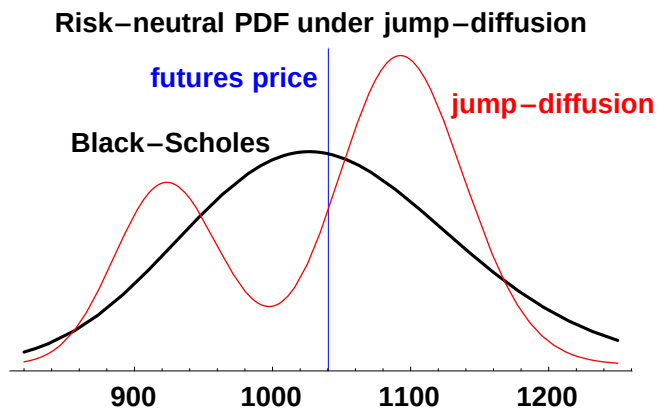
Expectations in market crises
Implied probability distributions

Jump-diffusions

- Combines random walk (diffusion) with jump process
  - Jump timing: Poisson-distributed ⇒ jump probability
  - Jump size: random or deterministic
- Use option prices to estimate jump probability = probability something bad occurs
- Estimates for S&P 500
  - 1-month options on 14Sep98
  - 3 parameters to estimate:
    - diffusion vol = 14%
    - jump probability= 32%
    - jump size = -0.15%



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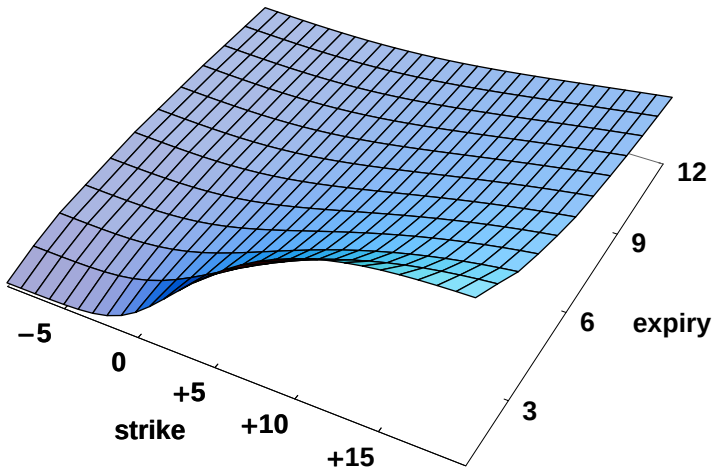
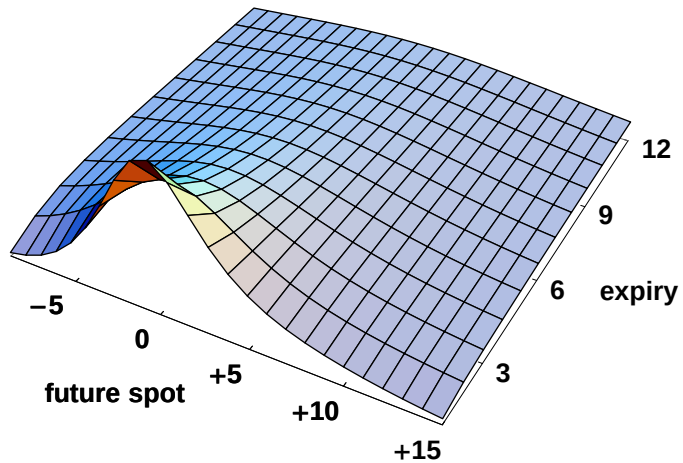
Expectations in market crises
Implied probability distributions

USD–JPY implied volatility surface



USD–JPY risk–neutral PDF



Risk neutral distribution over a range of horizons

- Vol surface → concise view of market expectations over the next year
  - Skew toward strong yen, dissipates for longer horizons
  - Variance increasing over time, as square-root-of-time rule would suggest
- Example USD-JPY 11Nov99
  - Forecast horizons from 1 month to 1 year

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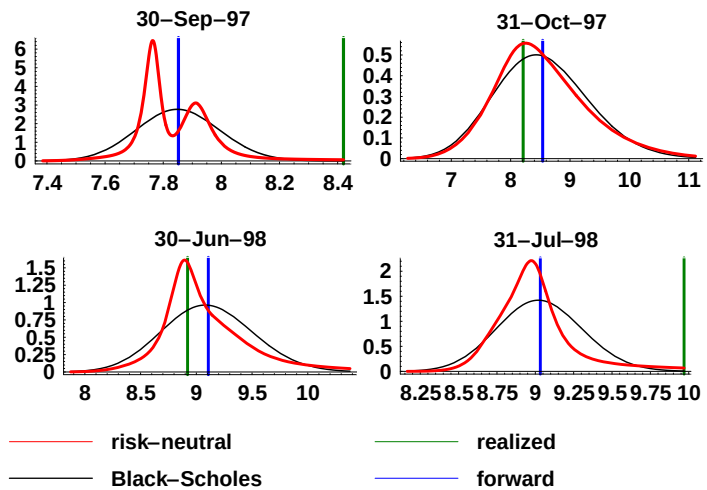
Expectations in market crises
Implied probability distributions

Option-based model using interpolation technique

- Bimodal distribution typical of jump-diffusion
- High variance can swamp kurtosis and skewness
- Poor forecasting by forwards in jump environment



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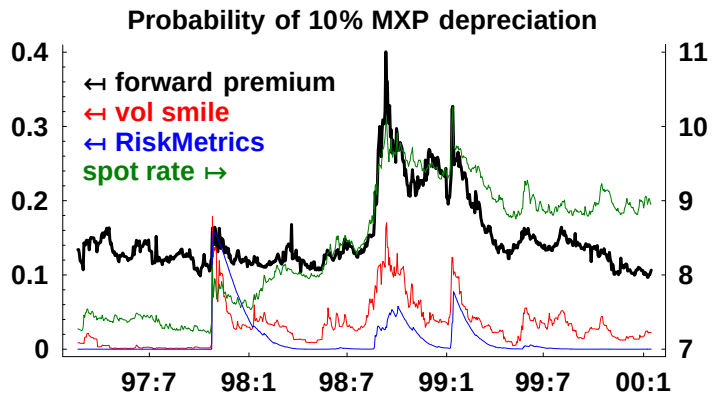
Expectations in market crises
Implied probability distributions

- Comparison of forecasts
  - Forward premium: assume depreciation of 10%
  - Volatility smile: implied PDF
  - RiskMetrics EWMA volatility
- Forwards consistently display high probability
- RiskMetrics tracks implied volatility closely but collapses to zero more often



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- What are market crises?
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Warning signals
Is there any hope for warning?

- Suddenness of crises
- Macroeconomic predictors
  - Budget deficits, trade and capital flow data
  - Mixed record and long lead times
- Signaling ability of asset prices
  - Most analysis focuses on prediction of future levels or volatilities
  - Reactivity also important: what are the most sensitive indicators?

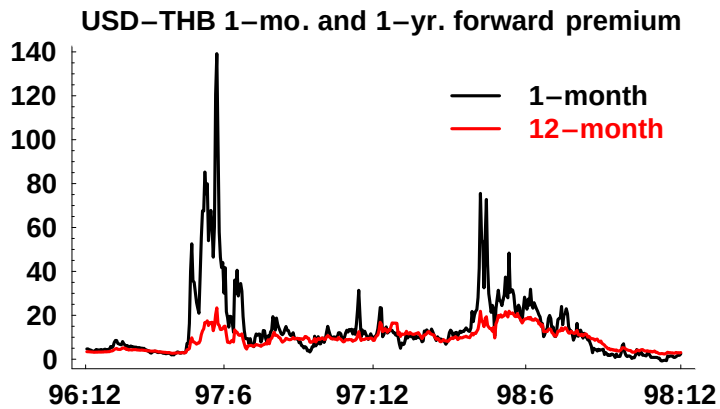
RISKMETRICS

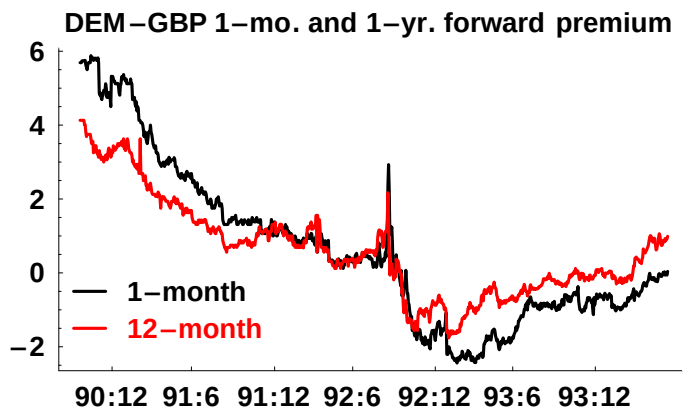
Warning signals
Options versus futures

- Option implied volatility potentially more powerful than forward rates
- Numerical example: assume forward price equal to mean future price, implied volatility equal to return standard deviation.
  - Scenario A: 2 outcomes. Future asset price $0.90 or $1.10 (probability 1/2 each). Forward = $1.00, implied volatility = 10%.
  - Scenario B: 3 outcomes. Future asset price $0.90 or $1.10 (probability 45%), or $0.50 (probability 10%). Forward price = $0.95, implied volatility = 17.75%.

Warning signals
Behavior of forward foreign exchange

- Common features
  - Forwards indicate imperfect credibility of peg
  - But subdued until crisis begins
  - Sharp increase immediately prior to collapse of peg
- Differences
  - Sterling crisis: breaking of peg leads to rapid drop in premium
  - Thai baht: premium rises to wild levels after peg broken

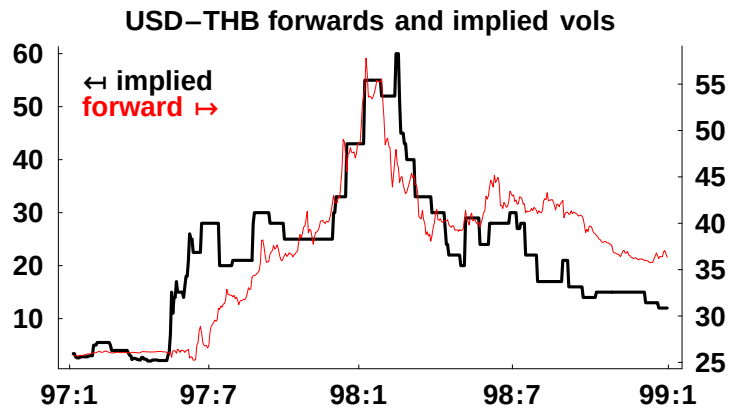


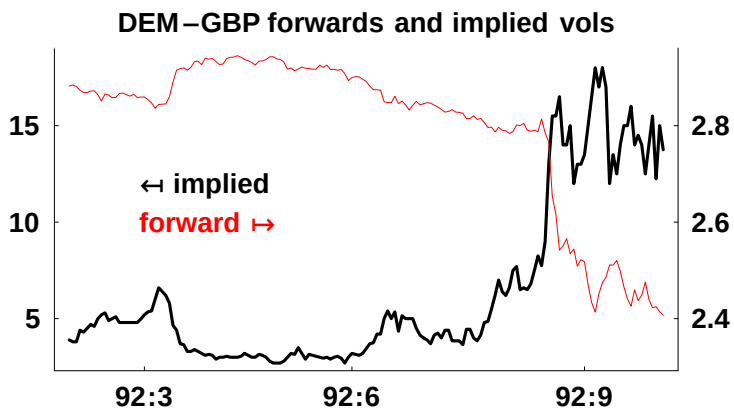


RISKMETRICS

Warning signals
Currency options and forwards

- Further reason options more sensitive: options less influenced by official intervention
  - Exchange intervention spot (sterling crisis) and forward (Thai baht)
  - Capital controls and informal restrictions on domestic rates
- Implied vols provide a few extra days of warning





RISKMETRICS

Warning signals
Some statistical results

- Study of 11 different assets: FX, fixed income, commodities, equity indexes
- Signal: implied volatility high and rising (high vol of vol)
- Measures of signaling ability
  - Predictive test (Granger causality)
  - True versus false signal (hypergeometric distribution)
- Comparison among
  - Implied volatility
  - unweighted historical volatility
  - RiskMetrics (EWMA) volatility
- Implied superior to both, RiskMetrics superior to unweighted historical

RISKMETRICS