# Structural VAR

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- Perhaps the most common question that a VAR tries to figure out (though by no means the only one) is what are the effects of a monetary policy shock.
- It's no use regressing macroeconomic outcomes on shocks to interest rates, because the most obvious reason why interest rates would be tightened is that the Fed expects inflation or growth to be high in the future. Monetary policy is endogenous.
- The structural VAR though is trying to figure out the effects of exogenous monetary policy shocks—the FOMC changing monetary policy not because of differences in the outlook for growth or inflation

# Different Methods to Identify Shocks

- Cholesky Restrictions
- Long-Run Restrictions (Blanchard-Quah and others)
- Identification from heteroscedasticity
- Agnostic Identification (Faust, 1998)
- Identification from high frequency data

# Long-run restrictions (Testing long-run neutrality)

- King and Watson (1997) survey the use of bivariate SVAR models to test some simple long-run neutrality propositions in macroeconomics.
- The key feature of long-run neutrality propositions is that changes in nominal variables have no effect on real economic variables in the long-run.
- Some examples of long-run neutrality propositions are:
  - A permanent change in the nominal money stock has no long-run effect on the level of real output

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  - A permanent change in the rate of inflation has no long-run effect on unemployment (a vertical Phillips curve)
  - A permanent change in the rate of inflation has no long-run effect on real interest rates (the long-run Fisher relationship).

# Long-run restrictions (Testing long-run neutrality)

- KW show that testing long-run neutrality within a SVAR framework requires the data to be I(1). They characterize long-run neutrality of money using the SMA representation for $\Delta y_t$ written as:

Output: $\Delta y_t = \mu_y + \theta_{yy}(L)\varepsilon_{yt} + \theta_{ym}(L)\varepsilon_{mt}$
Money: $\Delta m_t = \mu_m + \theta_{my}(L)\varepsilon_{yt} + \theta_{mm}(L)\varepsilon_{mt}$

- where $\varepsilon_{yt}$ represents exogenous shocks to output that are uncorrelated with exogenous shocks to nominal money $\varepsilon_{mt}$.

# Long-run restrictions (Testing long-run neutrality)

- Long-run neutrality of money involves the answer to the question:
  - Does an unexpected and exogenous permanent change in the level of money (m) lead to a permanent change in the level of output (y)?
- If the answer is no, then money is long-run neutral towards output.
- In terms of the SMA representation, $\varepsilon_{mt}$ represents exogenous unexpected changes in money.

$\theta_{mm}(1)\varepsilon_{mt}$ = Permanent effect of $\varepsilon_{mt}$ on m.
$\theta_{ym}(1)\varepsilon_{mt}$ = Permanent effect of $\varepsilon_{mt}$ on y.

# Long-run restrictions (Testing long-run neutrality)

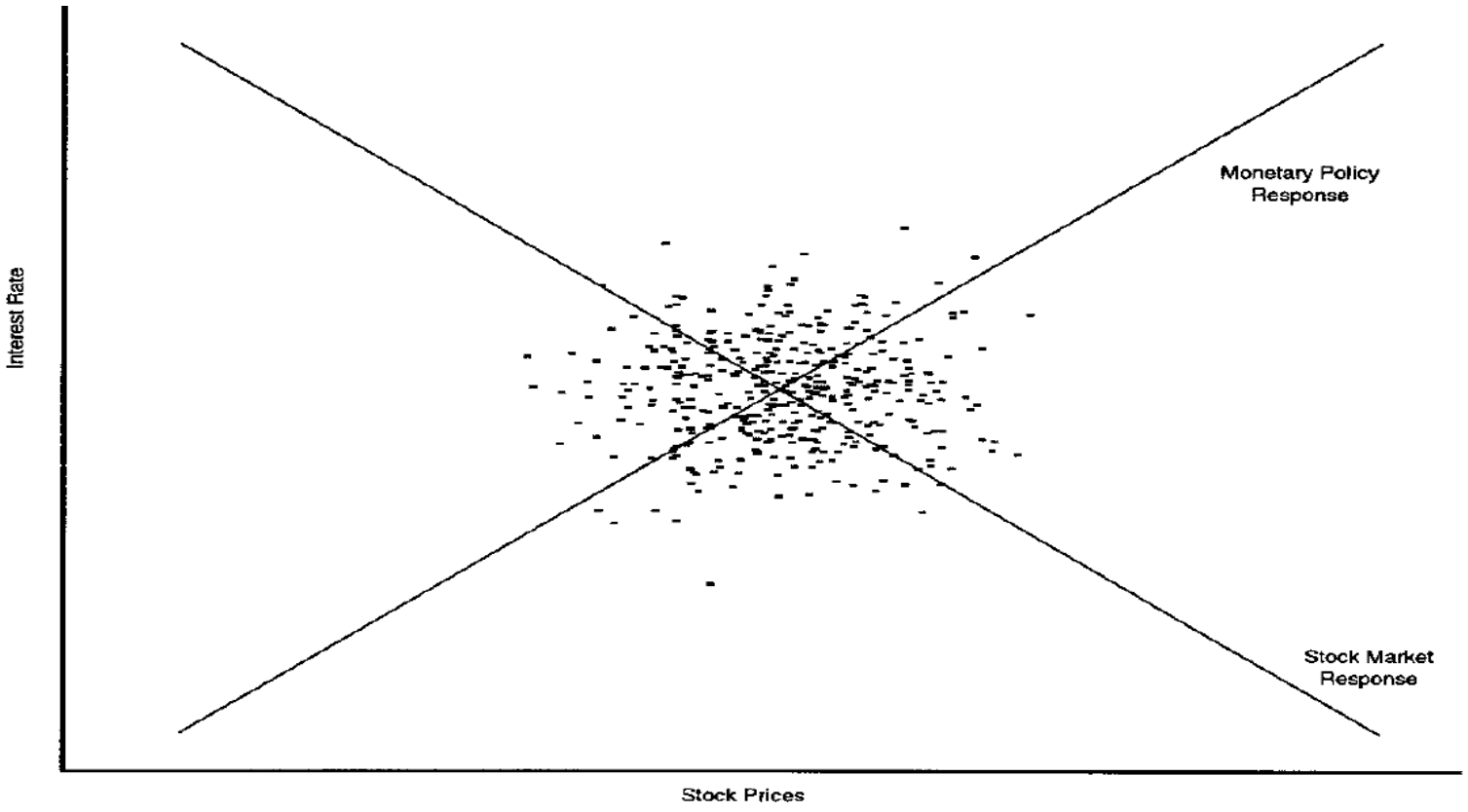
- With the data in logs, the long-run elasticity of output with respect to permanent changes in money is:

$$\gamma_{ym} = \frac{\theta_{ym}(1)}{\theta_{mm}(1)}$$

- Result: money is neutral in the long-run when $\theta_{ym}(1) = 0$, or $\gamma_{ym} = 0$
- That is, money is neutral in the long-run when the exogenous shocks that permanently alter money, $\varepsilon_{mt}$, have no permanent effect on output.

# Identification from Heteroskedasticity

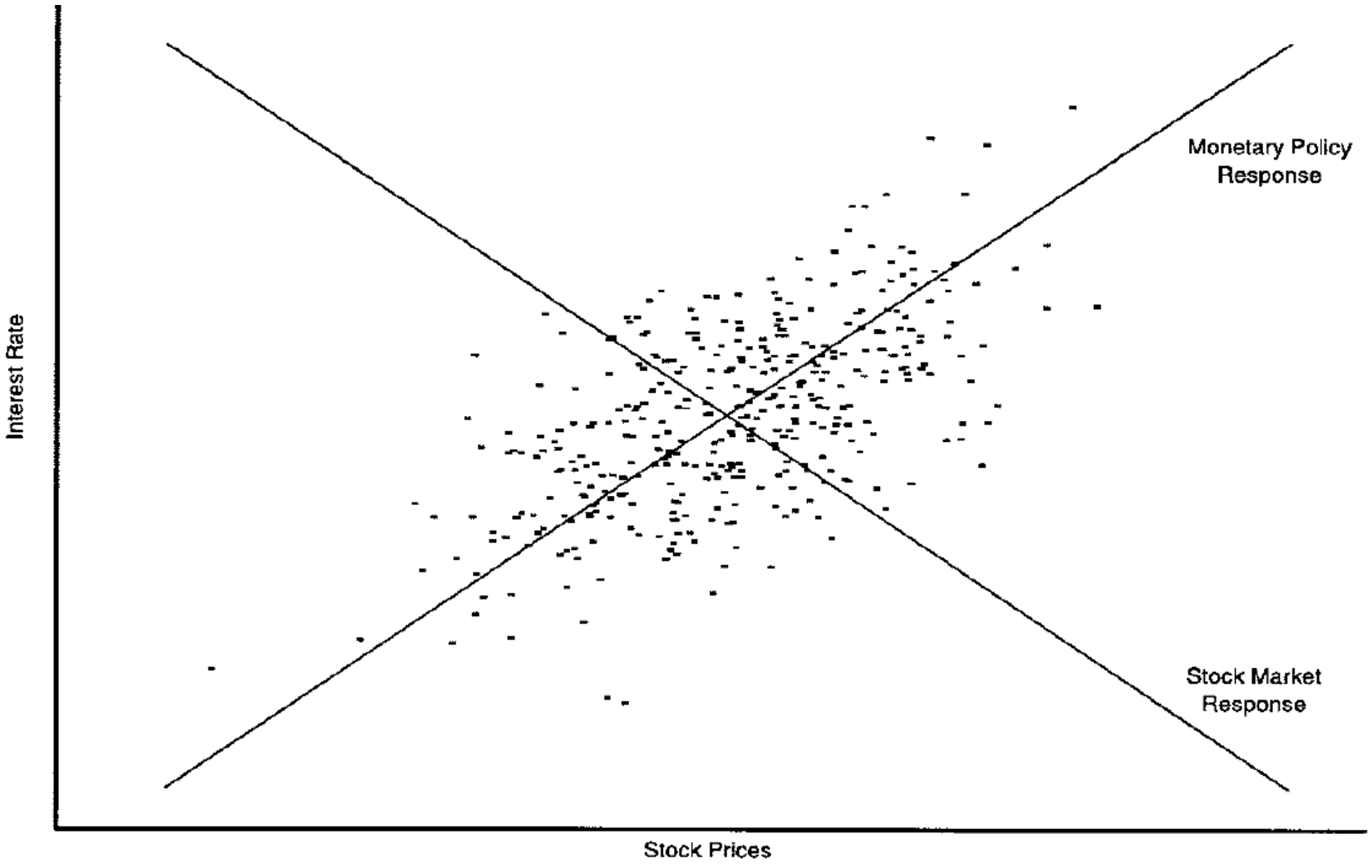
- Suppose we want to identify the response of monetary policy to stock market
- Problem: identification



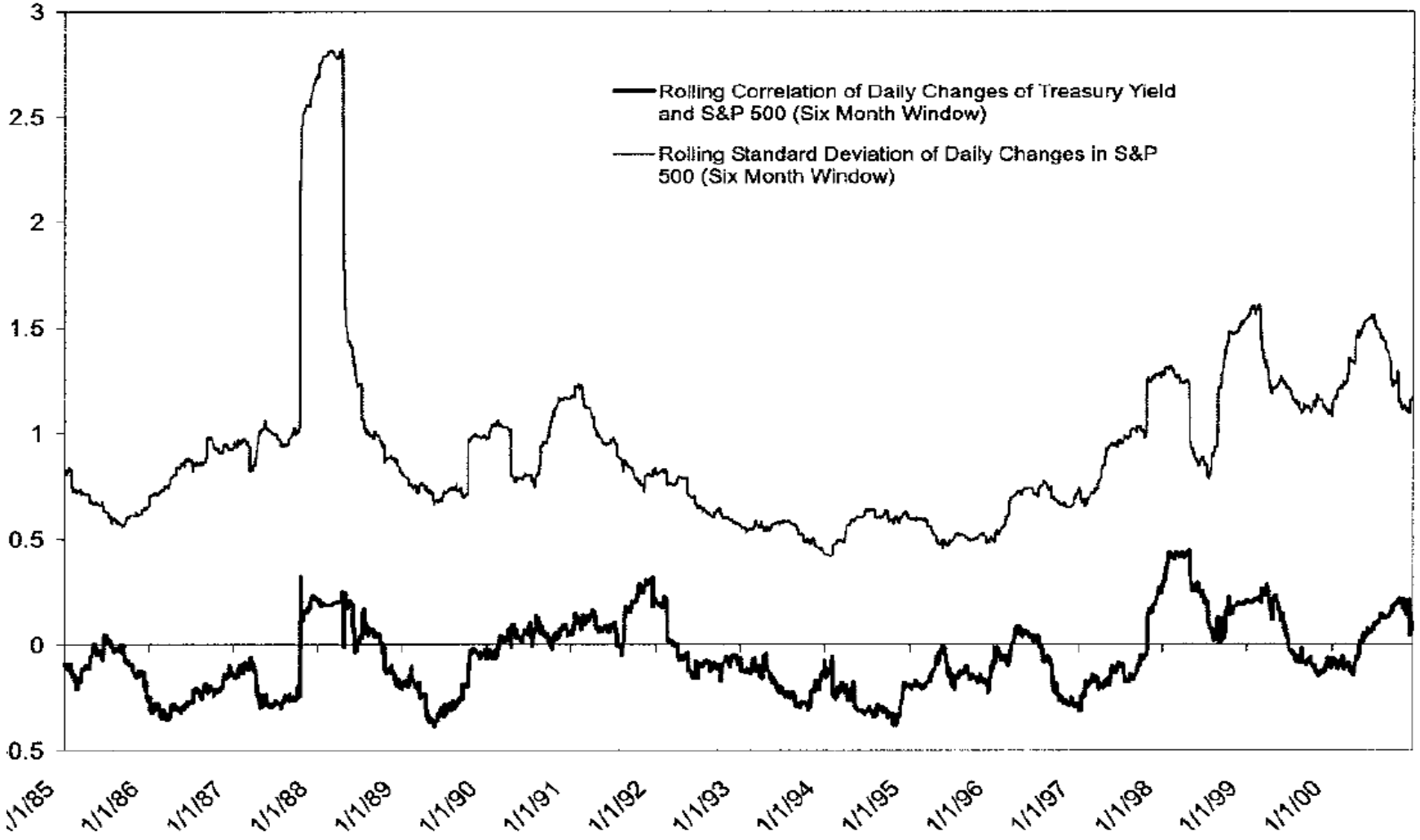
# Identification

- Consider what happens if the variance of the stock market shocks rises while the variance of the monetary policy shocks remains unchanged. Such a shift causes the realizations of stock market returns and interest rates to more closely trace out the policy reaction function than before.
- The disturbances are distributed around an ellipse that enlarges along the policy reaction function when the shocks to the stock market are more volatile.
- Thus, we are able to identify the slope of the policy reaction function based on changes in the covariance of interest rate and stock market movements across periods when the variance of their shocks shifts.

# Identification



# Evidence


Rolling Correlation of Daily Changes of Treasury Yield and S&P 500 (Six Month Window)
Rolling Standard Deviation of Daily Changes in S&P 500 (Six Month Window)
3
2.5
2
1.5
1
0.5
0
-0.5
1/1/85
1/1/86
1/1/87
1/1/88
1/1/89
1/1/90
1/1/91
1/1/92
1/1/93
1/1/94
1/1/95
1/1/96
1/1/97
1/1/98
1/1/99
1/1/00

# Identification from Heteroskedasticity

- Suppose that there are two regimes in which the structural errors have variance $\Sigma_{\varepsilon_1}$ and $\Sigma_{\varepsilon_2}$
- Let R=$B^{-1}$, and normalize R to have 1s on the diagonal.
- Then the variance-covariance matrix of reduced form errors is $R\Sigma_{\varepsilon_1}R'$ in the first regime and $R\Sigma_{\varepsilon_2}R'$ in the second regime
- This scheme gives us one way to solve the identification problem
- Two problems:
  - What if R changes across regimes?

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- This scheme gives us one way to solve the identification problem
- Two problems:
  - What if R changes across regimes?
  - What if the variance-covariance matrix of the structural errors does not change (much) across regimes?

# Identification from Heteroskedasticity

- Rigobon and Sack (2003) estimate the effects of monetary policy shocks on asset prices in this way in a VAR with stock prices and short-term interest rates.
- The two regimes are (i) days of FOMC announcements and monetary policy testimonies and (ii) all other days.
- It seems reasonable to suppose that the variance of structural monetary policy shocks is greater in the first regime than the second.
- They estimate the effects of a surprise tightening in monetary policy on stock price; a 25 basis point monetary policy surprise lowers stock prices by about 2 percentage points.

# Agnostic Identification (Faust, 1998)

- The restriction that $\Sigma = RR'$, coupled with restrictions on the signs of the contemporaneous impulse responses (e.g. a monetary policy tightening does not increase inflation this period) isn't enough to identify a unique R , but it is enough to identify a set of possible values of R .
- We say that R is set-identified, not point-identified.

# Identification from high frequency data

- Suppose that we have federal funds futures, and we treat these as expectation of the future federal funds rate.
- Around the time of an FOMC announcement, we can run the regression

$$\Delta ff_{t,h} = \beta_h MPS_t + \varepsilon_t$$

- where $\Delta ff_{t,h}$ denotes the change in the h -month ahead federal funds futures contract from just before the FOMC announcement to just after and $MPS_t$ is the difference between the FOMC's actual policy decision and the ex-ante expectation.
- If we assume that the unexpected component of the FOMC decision is a monetary policy shock, then $\beta_h$ measures the impulse response of a monetary policy shock on interest rates h months later. .

# Identification from high frequency data

- This gives us restrictions on the impulse responses estimated at lower frequency.
- Given the combination of our estimate of $\Theta(L)$ and elements of $\Psi(L)$ we can in principle back out R and hence other impulse responses.
- This was done in Faust, Swanson and Wright (2003).
- The confidence intervals for the impulse responses are wide, but avoid the "price puzzle".