Identification in Macroeconomics

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In order to recommend a course of action to achieve an objective, we must first know whether that course of action will in fact promote the objective. Positive scientific knowledge ... is clearly a prerequisite for ... normative judgment.

Milton Friedman
Nobel Lecture, 1976

STATE OF EMPIRICAL MACRO

- Key empirical questions same as 80 years ago:
  - What are the sources of business cycles?
  - How does monetary and fiscal policy affect the economy?
  - Why do some countries grow faster than others?

- Why do we not know the answers to these questions?

- Crucial reason: Identification in macro is hard

MONETARY POLICY IN THE GREAT RECESSION

- Monetary policy is endogenous
  - Not just a little endogenous
  - Fed employs hundreds of PhD economists to make policy
    as endogenous as possible
- Fed lowered rates aggressively in 2008
  - Did so for a reason! (e.g., housing collapse and financial crisis)
  - OLS regression of output on interest rates does not capture
    effects of monetary policy
  - It captures combined effects of monetary policy
    and factors causing Fed to act

STRANDS OF EMPIRICAL WORK IN MACRO

- Direct causal inference
  - Identify plausibly exogenous variation in some policy
    (i.e., a natural experiment)
  - Regress outcomes of interest on exogenous policy variation

- More structural modes of inference
  - Use a set of moments to discriminate between models
  - GMM estimation of a structural model
  - Full information DSGE estimation

DIRECT CAUSAL INFERENCE IN MACRO

Two challenges:

- Convincing natural experiments few and far between
- Rarely see exactly the experiment we want (external validity)

EXTERNAL VALIDITY IN MACRO

1. Term structure of shocks heterogeneous
   - Some only affect short run
   - Some affect short and long run
   - Some only affect longer run (e.g., when monetary policy at ZLB)
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4. Policy response depends on information content of the shock
   - Monetary surprises may convey information about other economic fundamentals

EXTERNAL VALIDITY IN MACRO

- Even very clean natural experiments only give partial answers to how future policy actions will affect economy

- One response: Gather direct evidence on every different case
  - May not be feasible
- Surely we can learn from experiments we have about other cases

THE POWER OF PORTABLE STATISTICS

- Structural inference in macro often take following form:
  - Use a set of moments to discriminate between models
  - I.e., affect posterior over space of models

- Portable statistics are particularly valuable:
  - Statistics that can be used over and over again to discipline and test different models

- Example: Equity premium
  - Mehra-Prescott 85 used it to evaluate one class of models
  - Generation of researchers has since used this same statistic to evaluated a host of new models

DIFFERENT TYPES OF MOMENTS

Several types of moments can be highly informative:

- Micro moments

- Macro moments

- Simple moments (means, variances, covariances)

- "Identified moments" (responses to structural shocks – causal effects)

MICRO MOMENTS

Examples:

- Frequency or price change and related statistics
  (Bils-Klenow 04, Nakamura-Steinsson 08, Klenow-Kryvtsov 08)
  - Informative about models of price setting
  - Indirectly informative about effectiveness of monetary and fiscal policy

- Changes in shopping time and quantity and quality of food intake
  at retirement (Aguiar-Hurst 05)
  - Informative about competing models of life-cycle consumption and savings

MACRO MOMENTS

Example:

- Real wages and hours worked
    - Past 200 years have seen substantial increases in real wages, while hours worked have been stable or fallen
    - Rules out models without income effects
    - Motivates use of "balanced-growth preferences" (King-Plosser-Rebelo 88, Boppart-Krusell 16)

SIMPLE MOMENT MATCHING IN MACRO

Rich tradition of using simple micro and macro moments:

- RBC literature (Kydland-Prescott 82, King-Rebelo 99)

- Shimer puzzle literature (Shimer 05)

- Misallocation literature (Hsieh-Klenow 09)

- Exchange rate disconnect (Meese-Rogoff 83, Itskhoki-Mukhin 17)

- "Wedges" literature (Chari-Kehoe-McGrattan 08, Shimer 09)

Simple statistics can often yield powerful inference

- Rising standards for what constitutes a credible identification strategy to estimate a causal effect (e.g., Angrist-Pischke 10)

- Increased use of:
    - Instrumental variables
    - Difference-in-difference estimation
    - Regression discontinuities
    - Randomized controlled trials

- How can these methods be used in macro?

- Key challenge: Object estimated often does not correspond directly to object of interest (i.e., policy response or structural parameter)

CAUSAL EFFECTS AS IDENTIFIED MOMENTS

- Even when they don't directly answer question of interest, responses to **identified** shocks (i.e., causal effects) can be used as **moments** in structural estimation exercises to help discriminate between models

- Favored structural model then used to answer question of interest

- We use term **identified moment** as a shorthand for:
  - A target statistic (i.e., **moment**) obtained as a response to an **identified** structural shock (i.e., causal effect)

EXAMPLE: LABOR SUPPLY ELASTICITY

- In some cases, identified moments correspond directly to a deep structural parameter

- Example: Estimates of Frisch elasticity of labor supply (see, e.g., Chetty 2012, Chetty et al., 2013)

- Macroeconomists long been comfortable using such estimates to "calibrate" parameters in their models

EXAMPLE: MARGINAL PROPENSITY TO CONSUME

In other cases:

- Doesn't correspond directly to a deep structural parameter
- Yet is still a powerful diagnostic tool for important classes of models

- Example: Estimates of marginal propensity to consume
  (e.g., Johnson-Parker-Souleles 06, Parker et al. 13)
    - simple complete markets models can't match these
    - Angeletos et al. 01: adding self-control problems helps match this
    - Kaplan-Violante 14: uninsurable risk/borrowing constraints/illiquid assets
      helps match this

A MOMENT IS A MOMENT?

- If your strategy is match moments between theory and data ...

  ... why pick complicated identified moments? ...

  ... why not pick simple moments (like variances and covariances)? ...

  ... identifying structural shocks is often complicated and controversial ...

  ... why go through the bother? ...

  ... after all, a moment is a moment!

WHY USE IDENTIFIED MOMENTS?

- Unconditional moments typically sensitive to relative variance of all structural shocks in the model

- If you ignore some structural shock, estimation will be biased

- Identified moments focus on parameters having to do with a particular structural shock — particular subset of causal mechanisms

- Identified moments can be invariant to relative variance of other shocks and in some cases parameters in other "blocks" of the model (these can be treated as nuisance parameters)

EXAMPLE: HOUSING IN GREAT RECESSION

- Mian-Sufi-Rao: Cities where house prices fell more saw larger drop in consumption and non-tradable employment
  - Use Saiz 10 instrument to isolate causal effect from housing to consumption and employment
- Results informative about "consumption block" of macro models
  - Rejects simple Sinai-Souleles 05 complete markets model
  - More consistent with incomplete markets/life-cycle model (e.g., Berger et al. 17)
- Simpler alternative: Look at raw correlation between housing, consumption, etc
  - Sensitive to auxiliary assumptions (e.g., what shocks drive the cycle)

Example: Monetary Policy

Rotemberg-Woodford 97, Christiano-Eichenbaum-Evans 05:

- Use structural VAR to estimate causal effect of monetary policy on output, inflation, etc.
- Use these identified impulse responses as moments in a structural estimation exercise

- Completely different identifying assumptions from Smets-Wouter 07
- Advantage: Insensitive to many model features (e.g., what shocks drive business cycles)
- Challenge: Must argue for identification of monetary policy responses

PARTIAL IDENTIFICATION

Any given set of identified moments typically:

- Consistent with several models (but not all models)
- I.e., partially identify model space

Point-identifying correct model unrealistic:

- Several models being consistent with a statistic not grounds for throwing out statistic
- Think in reverse: If statistic provides evidence against an important class of models, statistic is useful.

CROSS-SECTIONAL IDENTIFICATION IN MACRO

- Increasingly important in macro:
    - Mian-Sufi 14, Nakamura-Steinsson 14, Autor-Dorn-Hanson 13, Baraja-Hurst-Ospina 16, Martin-Phillipon 17, ...

- Key challenge:
    - How to go from regional responses to aggregate responses
    - Cross-sectional responses don't directly answer key aggregate questions
    - GE effects absorbed by time fixed effects
    - Common to do "back-of-envelope" calculation

CROSS-SECTIONAL IDENTIFICATION IN MACRO

- Important insight:
  - Cross-sectional responses often powerful diagnostic tools to distinguish between models

- Approach:
  - Use cross-sectional responses as moments in estimation of structural models
  - Use favored structural model to answer aggregate questions

- Example: Fiscal stimulus ...

FISCAL STIMULUS: AGGREGATE EVIDENCE

- Barro-Redlick 11 use evidence from wars:
  - Government purchases multiplier of 0.6-0.7
  - Most identification from WWI, WWII, Korean War
  - Conceptually: Use wars as instrument for spending
  - Potential violations of exclusion restriction: patriotism, rationing, etc.

- Blanchard-Perotti 02 use SVAR:
  - Peak output response of 1.3 after 15 quarters
  - Very large standard errors
  - Highly sensitive to sample period, controls
    (see, e.g., Gali et al. 07, Ramey 11, 16)

FISCAL STIMULUS: AGGREGATE EVIDENCE

- Additional weakness of evidence:
  - Highly sensitive to monetary reaction

- Monetary reaction to fiscal shock:
  - Normal time: "leans against the wind"
  - At ZLB: Not able to lean against the wind

- Aggregate multiplier may be very different at ZLB
  (See Ramey-Zubairy 17, Miyamoto et al. 17 for direct evidence)

- Telling apart RBC model and NK model crucial
  - Both can yield multipliers around 0.7 in normal times
  - But NK model implies much bigger multipliers at ZLB

FISCAL STIMULUS: CROSS-SECTIONAL EVIDENCE

- Explosion of work post Great Recession:
  - Chodorow-Reich et al. 12, Wilson 12, Shoag 15, Nakamura-Steinsson 14, Acconcia et al. 14, Dupor-Mehkari 16, etc.
- Survey by Chodorow-Reich 17
- Estimates of local fiscal multiplier cluster at 1.5-2.0

- Regress output growth on change in military spending
  at state level the U.S.

$$\left(\frac{Y_{it} - Y_{it-2}}{Y_{it-2}}\right) = \alpha_i + \gamma_t + \beta\left(\frac{G_{it} - G_{it-2}}{Y_{it-2}}\right) + \Gamma X_{it} + \epsilon_{it}$$

- Basic idea for identification:
    - National military buildups exogenous to **relative conditions** in states
      receiving disproportionate procurement spending
- Instrument: Fitted value of state spending on national spending
  allowing different sensitivity for each state
- Year fixed effects (controls for all aggregate shocks)
- State fixed effects (state specific trends)
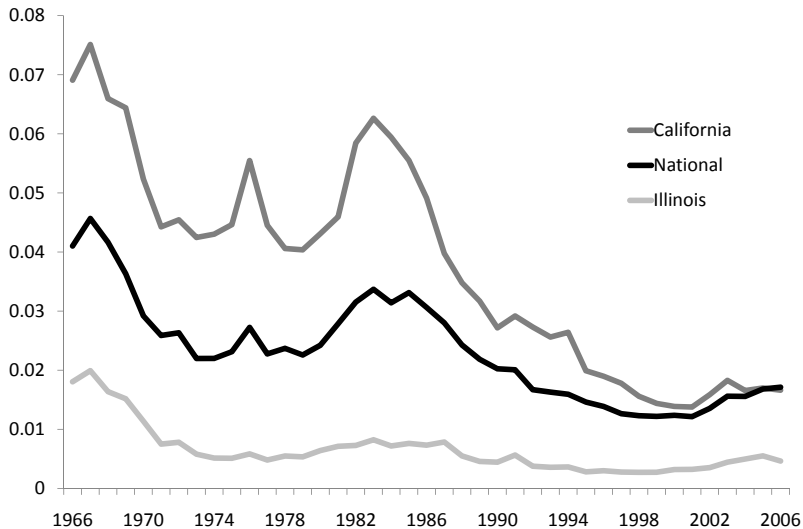
Figure: Prime Military Contracts as a Fraction of State GDP

TABLE I
The Effects of Military Spending

	Output		Output defl. state CPI		Employment		CPI		Pop.
	State	Region	State	Region	State	Region	State	Region	State
Prime Military Contracts	1.43	1.85	1.35	1.91	1.28	1.76	0.03	-0.26	-0.10
	(0.36)	(0.58)	(0.36)	(0.65)	(0.29)	(0.62)	(0.18)	(0.45)	(0.17)
Num. Obs.	1989	390	1989	390	1989	390	1785	350	1989

WHAT DO WE LEARN?

- Local multiplier not the same as aggregate multiplier:
  - States don't have to pay for spending (financed federally)
  - Spillovers to other states
  - Monetary policy doesn't respond in cross-section

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      (which is aggregate multiplier)

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    (which is aggregate multiplier)
- Different reaction:
  - Perhaps relative multiplier is a powerful statistic in distinguishing between competing models (e.g., RBC vs. New Keynesian)
  - Aggregate multiplier is actually not very strong on that front

TABLE 6—GOVERNMENT SPENDING MULTIPLIER IN SEPARABLE PREFERENCES MODEL

	Closed economy aggregate multiplier	Open economy relative multiplier
Panel A. Sticky prices		
Volcker-Greenspan monetary policy	0.20	0.83
Constant real rate	1.00	0.83
Constant nominal rate	∞	0.83
Constant nominal rate ($\rho_g = 0.85$)	1.70	0.90
Panel B. Flexible prices		
Constant income tax rates	0.39	0.43
Balanced budget	0.32	0.43

Notes: The table reports the government spending multiplier for output deflated by the regional CPI for the model presented in the text with the separable preferences specification. Panel A presents results for the model with sticky prices, while panel B presents results for the model with flexible prices. The first three rows differ only in the monetary policy being assumed. The fourth row varies the persistence of the government spending shock relative to the baseline parameter values. The fifth and sixth rows differ only in the tax policy being assumed.

TABLE 7–GOVERNMENT SPENDING MULTIPLIER IN GHH MODEL

	Closed economy aggregate multiplier	Open economy relative multiplier
Panel A. Sticky prices		
Volcker-Greenspan monetary policy	0.12	1.42
Constant real rate	7.00	1.42
Constant nominal rate	∞	1.42
Constant nominal rate ($\rho_g = 0.50$)	8.73	2.04
Panel B. Flexible prices		
Constant income tax rates	0.00	0.30
Balanced budget	-0.18	0.30

Notes: The table reports the government spending multiplier for output deflated by the regional CPI for the model presented in the text with the GHH preferences specification. Panel A presents results for the model with sticky prices, while panel B presents results for the model with flexible prices. The first three rows differ only in the monetary policy being assumed. The fourth row varies the persistence of the government spending shock relative to the baseline parameter values. The fifth and sixth rows differ only in the tax policy being assumed.

WHAT DO WE LEARN?

- Plain vanilla RBC model inconsistent with regional multiplier
- Plain vanilla NK model inconsistent with regional multiplier
- "Ultra Keynesian" model consistent with regional multiplier

- "Ultra Keynesian" model implies large aggregate effects of fiscal stimulus when monetary policy is constrained

MONETARY POLICY:
WHAT IS THE BEST EVIDENCE WE HAVE?

When we ask prominent macroeconomists, most common answers are:[1]

- Friedman and Schwartz 63

- Volcker disinflation

- Mussa 86

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[1] Of course, a significant fraction say something along the lines of "I know it in my bones that monetary policy has no effect on output."

FRIEDMAN-SCHWARTZ 63

Three policy actions that were:

1. "Of major magnitude"

2. "Cannot be regarded as necessary or inevitable economic consequences of contemporary changes in money income and prices."

These were:

1. January - June 1920

2. October 1931

3. July 1936 - January 1937

We focus on second two – which were during the Great Depression
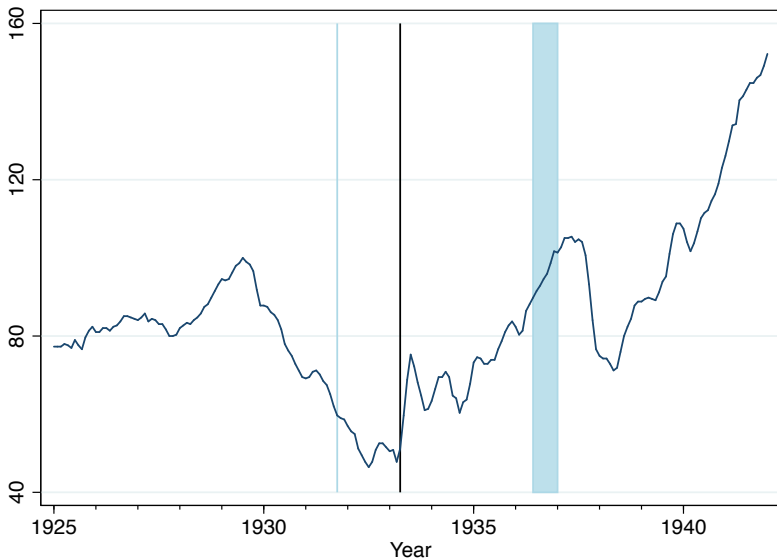
- Fed raised rediscount rate from 1.5% to 3.5%
  - Seeking to arrest speculative attack on US dollar

- Industrial production plunged sharply afterwards
  - But had also been in free fall before

- Clean exogenous monetary shock

- But what is counterfactual?

- Fed announced doubling of reserve requirements and Treasury sterilized gold inflows

- Strong growth before, sharp plunge afterwards

- Confounding factors?
  - Fiscal policy was tight in 1937
    (end or veteran's bonuses and first collection of social security tax)
  - Great deal of labor unrest in 1937

FRIEDMAN-SCHWARTZ 63 AND GREAT DEPRESSION

- More general argument that Fed caused the Depression by failing to act

- Eichengreen 92 argues policy was constrained by gold standard

- Roosevelt took US off gold standard in April 1933
  (black line in figure above)
    - Timing suggests that something Roosevelt did mattered
    - But Roosevelt did several things

VOLCKER DISINFLATION
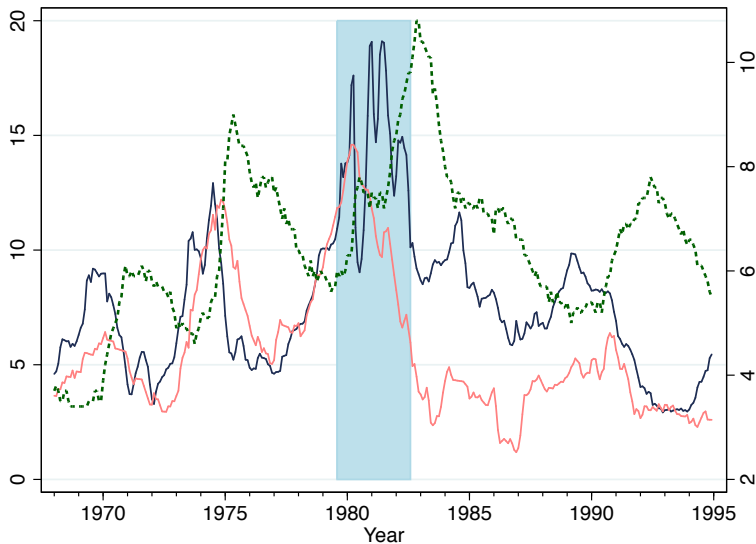
Blue: Fed funds rate. Red: 12-month inflation. Green: Unemployment.

VOLCKER DISINFLATION

- Volatile and rising inflation in the 1970s
  - "Stop-go" policy (e.g., Goodfriend 07)

- August 79, Paul Volcker takes over as Chair of Fed:
  - Oct 79 - Mar 80: Very tight policy
  - Apr 80 - Nov 80: Loose policy
  - Nov 80 - Late 82: Very tight policy

- Economy swings with monetary policy:
  - Spring-Summer 80: Output fell dramatically
  - Late 80: Output rebounds, inflation still high (stop-go)
  - 1981-1982: Output falls, large recession, inflation down
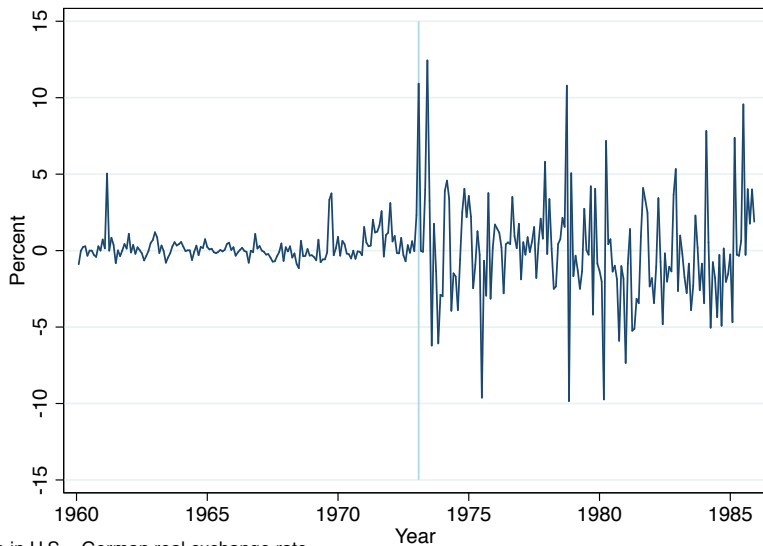
Change in U.S. - German real exchange rate.

MONETARY POLICY AND RELATIVE PRICES

- Strong evidence for effects of monetary policy on relative prices
  - Can be assessed using discontinuity-based identification

- Bretton Woods system of fixed exchange rates breaks down in Feb 73
  - This is a pure high-frequency change in monetary policy
  - Sharp break in volatility of **real** exchange rate

- High-frequency evidence on **real** interest rates
  - Look at narrow time windows around FOMC announcements
  - Measure real interest rate using yields on TIPS
  - Nominal and real rates respond roughly one-for-one
    several years into term structure
    (see, e.g., Nakamura-Steinsson 17, Hansen-Stein 15)

HIGH-FREQUENCY EVIDENCE ON OUTPUT?

- Much weaker!

  (e.g., Cochrane-Piazzesi 02, Angrist et al. 17)

    - High-frequency monetary shocks are small
    - Output not observed at high frequency
    - Too many other shocks occur over several quarters
    - Not enough statistical power to estimate effects on output
      using this method

- Effect on relative prices is key empirical issue

    - Relative prices affect output in all models
    - Monetary and non-monetary models (e.g., NK versus RBC) differ sharply
      on whether monetary policy can affect relative prices

Romer-Romer 89:

- Fed records can be used to identify natural experiments
- Specifically: "Episodes in which the Federal Reserve attempted to exert a contractionary influence on the economy in order to reduce inflation."
- Six episodes (Romer-Romer 94 added a seventh)
- After each one, unemployment rises sharply
- Strong evidence for substantial real effects of monetary policy
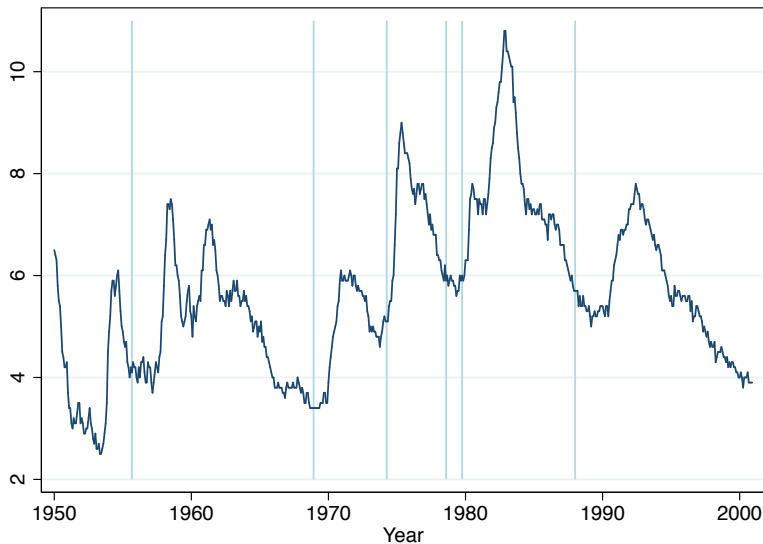
Unemployment rate. Vertical lines are Romer-Romer 89 dates.

ROMER-ROMER 89 – CRITIQUES

- Inherent opacity of the process of selecting the shock dates
  - High cost of replication
  - Similar critique applies to many complex econometric methods

- Few data points
  - May happen to be correlated with other shocks
  - Hoover-Perez 94 point out high correlation with oil shocks

- Shocks predictable suggesting endogeneity
  - Difficult to establish convincingly due to overfitting concerns
  - Cumulative number of predictability regressions run hard to know

CONTROLLING FOR CONFOUNDING FACTORS

- Common approach to identification in VAR literature:
  - Regress fed funds rate on output, inflation, etc. + a few lags of fed funds rate, output, inflation, etc.
  - View residual as exogenous variation in monetary policy

- Often described as involving "minimal identifying assumptions"

- In our view, these are strong identifying assumptions

CONTROLLING FOR CONFOUNDING FACTORS

- Fed bases policy on huge amount of data
  - Banking sector, stock market, foreign developments, commodity prices, terrorist attacks, temporary investment tax credit, Y2K, etc., etc.

- Too many variables to include in regression!

- Any information used by Fed and not sufficiently controlled for by included controls will result in endogenous variation being viewed as exogenous
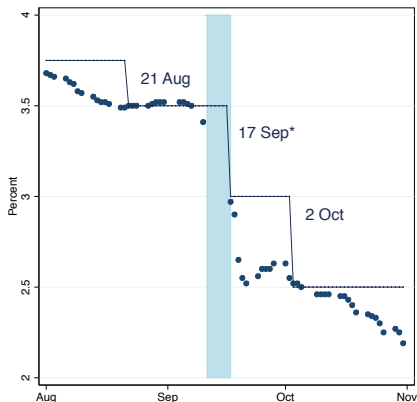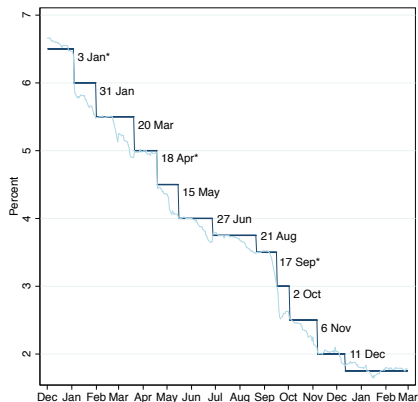
Dark line: Fed funds target. Light line/dots: 1-month eurodollar rate. * indicates unscheduled meeting.
Sample period: Dec 2000 - Feb 2002.

WAS 9/11 A MONETARY SHOCK?

- According to structural VARs: Yes!?!
  - Nothing had yet happened to controls in VAR
  - Drop in rates cannot be explained, therefore an exogenous shock

- In reality: Obviously not!
  - Fed dropped rates in Sept 2001 in response to terrorist attack, which affected Fed's assessment of future output growth and inflation

- Any unusual (from perspective of VAR) weakness in output growth after 9/11, perversely, attributed to exogenous easing of monetary policy

- Highly problematic

IDENTIFYING ASSUMPTIONS IN SVARS

- "The" identifying assumption in a monetary VAR often described as:
  - Fed funds rate does not affect output, inflation, etc. contemporaneously

- Seems like magic:
  - You make one relatively innocuous assumption
  - Violá: You can estimate dynamic causal effects of monetary policy

- Is there perhaps something more to it?

- Timing assumption not only identifying assumption being made

- Timing assumption rules out reverse causality
  - Contemporaneous correlation assumed to go from output to interest rates
  - Not other way around

- Bigger concern: Omitted variables bias
  - Monetary policy and output may be reacting to some other shock
  - If not sufficiently proxied by included controls, this shock will cause omitted variables bias (e.g., 9/11)

ROMER-ROMER 04

- Hopeless to control individually for everything in Feds information set

- Alternative approach:
  - Control for Fed's own forecasts (Greenbook forecasts)

- Key idea:
  - Endogeneity of monetary policy comes from **one thing only**:
    What Fed thinks will happen to the economy
  - Controlling for this is sufficient

ROMER-ROMER 04: WHAT IS A MONETARY SHOCK?

- Fed does not roll dice.

- Every movement in intended fed funds rate is a response to something

- Some are responses to something that directly affects outcome variable of interest
  - These are endogenous

- Others are responses to other things:
  - Time variation in policy makers' preferences
  - Time variation in policy makers' beliefs about how economy works
  - Political influences on the Fed
  - Pursuit of other objectives (e.g., exchange rate stability)

WHAT DO WE DO WITH THESE SHOCKS?

- Dynamic causal inference involves two steps:
    1. Identifying exogenous variation in policy (the shocks)
    2. Estimating an impulse response given the shocks

- One way to estimate an impulse response:
    - Regress variable of interest (e.g., $\Delta^j y_{t+j}$) directly on shock (perhaps including some pre-treatment controls)
    - This imposes minimal structure (other than linearity)
    - Specification advocated by Jorda 05

VAR IMPULSE RESPONSES

- VARs construct impulse response by iterating forward entire estimated VAR system

- Embeds whole new set of strong identifying assumptions
  - Not only interest rate equation that must be correctly specified
  - Entire system must be correct representation of dynamics of all variables in the system
  - I.e., whole model must be correctly specified (including number of shocks)

VAR IMPULSE RESPONSES

- Solution to any linear rational expectations model is a VAR
  - This is usual defense regarding VAR impulse response construction

- However, to estimate true VAR, all state variables must be observable

- Suppose some state variable is not observed
  - Can iteratively solve out for it
  - But this typically transforms VAR(p) into VARMA(∞,∞)

- Estimation of VARs therefore relies on assumption that true VARMA(∞,∞) in observed variables can be approximated by VAR(p)

  (See footnote 36 of the paper for an example you can work through.)
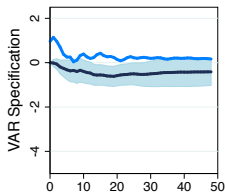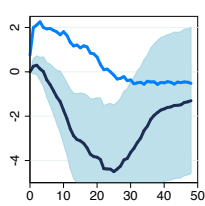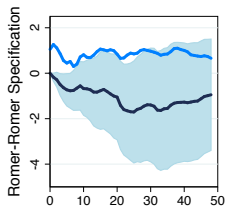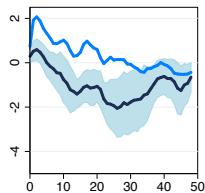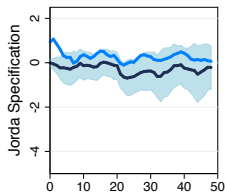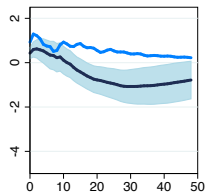
Black line: Industrial production. Blue line: Real interest rate

EXTERNAL INSTRUMENTS IN VARS

- Gertler-Karadi 15 use external instruments in VAR to estimate effects of monetary policy

- External instrument: Surprise movement in 3-month ahead fed funds future in 30-minute window around FOMC meetings

- Method:
  - Run monthly VAR
  - Regress reduced form residuals on external instrument to get contemporaneous responses
  - Iterate forward estimate VAR system to get dynamic responses

External Instrument
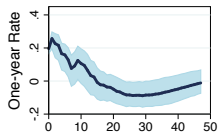
Cholesky
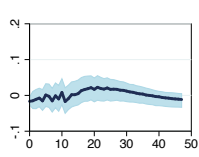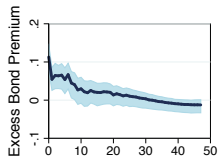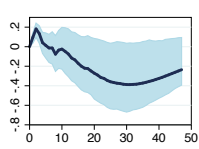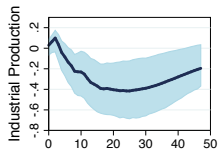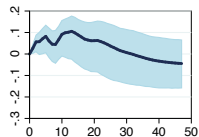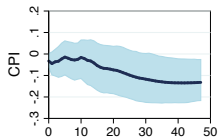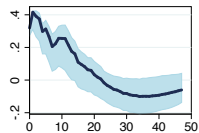
- Possible to include fast-moving financial variables

- With standard Cholesky assumptions one must make a choice:
  - Financial variables don't affect fed funds rate contemporaneously
  - Fed funds rate doesn't affects financial variables contemporaneously
  - Neither assumption palatable

- External instrument gets away from this dichotomy

- Do not relax assumptions embedded in construction of
  VAR impulse responses

- Still must assume that VAR system is a correct representation of
  dynamics off all included variables

- Since contemporaneous response on output are small,
  dynamic responses rely heavily on these assumptions

MACROECONOMICS AND METEOROLOGY

- Similar in certain ways:
    - Deal with highly complex general equilibrium systems
    - Trouble making long-term predictions

- Meteorology:
    - Olden days: People prayed to the rain gods
    - Today: People watch the weather channel

- Macroeconomics:
    - Today: Policy discussions highly ideological since evidence is not convincing
    - Future (hopefully): Solid empirical knowledge will lead policy discussions to be based on evidence rather than faith