Lecture 1
New Keynesian Models: Background and Motivation

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University of Warwick - EC956

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Disclaimer

The views expressed in this presentation, and all errors and omissions, should be regarded as those solely of the authors, and are not necessarily those of the Federal Reserve Bank of San Francisco, the Federal Reserve Board of Governors or the Federal Reserve System.

Course Admin

Course Admin

Lectures

- Tuesday: 12:00 - 14:00
- Weeks 6-10 (Feb. 12 - Mar. 12)
- Lecturer: Rhys Bidder
    - `Rhys.Bidder@gmail.com`
    - `www.frbsf.org/economic-research/economists/rhys-bidder/`

Classes

- Tuesday: 10:00 - 11:00 and 11:00 - 12:00
- TA: Emil Kostadinov
    - `Emil.Kostadinov@warwick.ac.uk`
    - `www.emilkostadinov.weebly.com/`

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Problem sets

- Similar setup to first half of the course
  - Questions for students to do in advance of seminar (answers posted)
  - Questions for Emil to go through in seminar
  - Questions for further private study
- Try to do them on your own - even if they're beyond you initially!

Interaction

- My office hour
  - Tuesday 14:30-15:30
  - Office S1.108
- Emil's office hour
  - Thursday 13:00-14:00, Friday 12:00-13:00
  - Office S2.135

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Readings

- Main textbook
  - *Monetary Policy, Inflation and the Busines Cycle* (2^{nd} ed.), Galí, PUP
  - Covering (parts of) chapters 1-5
- Additional (very occasional / background) readings
  - *Monetary Theory and Policy*, Walsh, MIT
  - *Interest and Prices*, Woodford, MIT
  - Various academic papers and the financial press

Attitude

- Be friendly, respectful and encouraging to others
- Everyone asks questions where others know (or think) the answer is obvious - no big deal...

History Lesson

Quantity theory of money

Much discussion (though not in recent years) of the effects of monetary policy began with some form of the following equation

$$M_t V_t \equiv P_t Y_t \tag{1}$$

where M_t is the quantity of money, V_t the velocity of its circulation, P_t the general price level and Y_t real output.

Equation (1) is an *identity* (always true by definition)

- Holds regardless of CB targeting interest rate, i_t, or M directly
- Uninteresting unless a theory restricts behavior of at least one variable

(Long run) 'classical dichotomy' / 'quantity theory of money'

- In the long run, Y and V are determined by non-monetary factors
- Thus, M and P move 1:1 in the long run

Quantity theory of money

Economists agree about little but...

- The *long run* classical dichotomy is arguably an exception
- Long run growth determined by 'supply' factors - not monetary
- In LR, monetary factors only influence *nominal*, but not *real* variables
- Long run correlations between M and $P \approx 1$ in the data

Almost complete consensus that *'there is no long-run trade-off between the rate of inflation and the rate of unemployment'* - Taylor (1996)

Fisher equation

Its rare nowadays for central banks to use M_t as an explicit policy tool

- Typically now set a short term nominal interest rate, i_t
- Given 'money demand', the central bank adapts money supply so market clears at desired i_t

In this context, the 'quantity equation' is less intuitive - instead the 'Fisher equation' is useful to aid understanding

$$i_t = r_t + E_t[\pi_{t+1}] \tag{2}$$

where i_t/r_t is the nominal/real interest rate and π_t is (net) inflation.

The (long run) classical dichotomy implies that r_t is unrelated to monetary factors

- i_t and inflation move 1:1, conditional on r_t
- If r_t changes without a change in i_t inflation adjusts

Effects of Monetary Policy

Interaction of real and nominal factors

In the shorter run the classical dichotomy is not broadly accepted

- Money/interest rates and output (or other measures of activity, such as unemployment) appear to co-move
- Central banks' activities are predicated on the assumption that changing i_t induces a change in r_t

Co-movements are suggestive that there is a connection between real and nominal variables (see Ch. 1 Walsh)

- Lead-lag correlations $\Rightarrow$ high M_t typically precedes high Y_t
- Cyclical movements in money track those of GDP growth fairly well until early 80s
- Short term nominal rates generally track - and somewhat precede - cyclical movements in GDP

Interaction of real and nominal factors

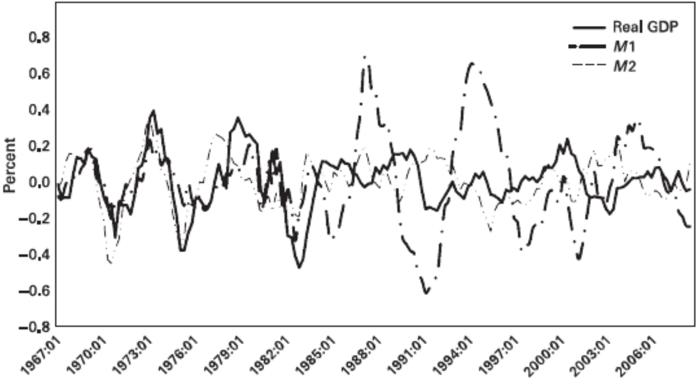

Figure 1.6
Detrended money and real GDP, 1967:1–2008:2.

De-trended money and output (from Walsh Ch.1)

Interaction of real and nominal factors

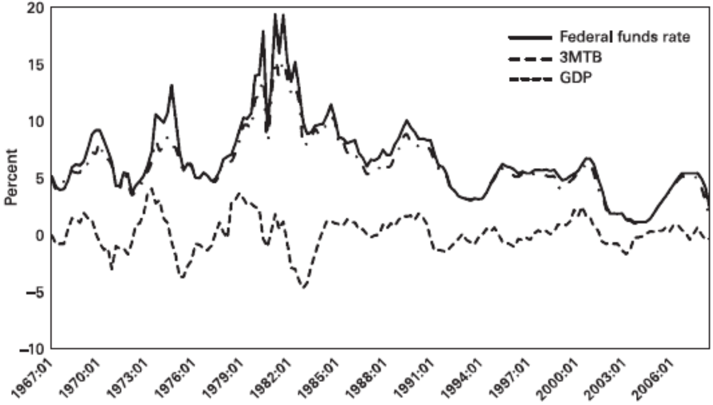

Figure 1.7
Interest rates and detrended real GDP, 1967:1–2008:2.

Short rate and de-trended output (from Walsh Ch.1)

Interaction of real and nominal factors

Difficult to disentangle direction of causality

- Are these movements *induced* by monetary policy or is policy *responding* to the economy?
- Even if policy variable appears to lead activity, we face the *post hoc ergo propter hoc* fallacy

Want to examine periods after an unanticipated 'shock' from policymakers

- Derives purely from policymaker - not economy - and thus closer to a 'natural experiment'
- Then estimate propagation of shock through economy
  - If M_t is the tool, does it affect M/P and real activity, rather than passing 1:1 into prices? - Recall 'quantity theory'
  - If i_t is the tool, does it affect r_t and real activity, rather than passing 1:1 into $E_t[\pi_{t+1}]$? - Recall Fisher equation

Identifying monetary policy shocks and their effects

Friedman and Schwarz (1963) and narrative approaches

- Seminal work on influence of monetary policy in the U.S. (most notably in the Great Depression)
  - Documentary evidence to isolate ΔM unrelated to economic conditions
  - Suggests that fluctuations in money supply led to those in real activity
  - Related to case study analyses of disinflationary policy (Sargent (1986))
- Influential - but problematic elements in empirical approach
  - Later support from Romer and Romer (1989) in a more modern form
  - Further strengthened by Romer and Romer (2004)

Other recent work on obtaining measures of policy surprises

- Nakamura and Steinsson (2013) and Gertler Karadi (2015) use ‘high frequency information’
- Look at asset price movements in short intervals around FOMC announcements to identify ‘surprises’

Identifying monetary policy shocks and their effects

On three occasions the System deliberately took policy steps of major magnitude which cannot be regarded as necessary or inevitable economic consequences of contemporary changes in money income and prices. Like the crucial experiments of the physical scientist, the results are so consistent and sharp as to leave little doubt about their interpretation. The dates are January-June 1920, October 1931, and June 1936-January 1937

- Friedman and Schwarz, 1963, p.688

Identifying monetary policy shocks and their effects

There was another major anti-inflationary shock to monetary policy on October 6, 1979. In effect, the Federal Reserve decided that its measures over the previous year had been unsuccessful in reducing inflation and that much stronger measures were needed. Although the shift in policy was to some extent presented as a technical change, the fact that it was intended to lead to considerably higher interest rates and lower money growth was clear. For example, "the Committee anticipated that the shift . . . would result in ... a prompt increase ... in the federal funds rate"

- Romer and Romer, 1989, p.142

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Vector Autoregressions

Another powerful approach to assessing the impact of monetary policy shocks is Vector Autoregression (VAR) analysis (see Walsh Ch. 1 for this example)

$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} = A(L) \begin{pmatrix} y_{t-1} \\ x_{t-1} \end{pmatrix} + \begin{pmatrix} u_{yt} \\ u_{xt} \end{pmatrix}$$

where A(L) is a 2×2 matrix polynomial in the lag operator and u_{it} is the time t serially inependent innovation (or 'forecast error') to variable i.

Consider y_t as a measure of real activity and x_t a measure of policy (interest rate or money, say)

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$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} = \overbrace{A(L)}^{What?} \begin{pmatrix} y_{t-1} \\ x_{t-1} \end{pmatrix} + \begin{pmatrix} u_{yt} \\ u_{xt} \end{pmatrix}$$

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Consider y_t as a measure of real activity and x_t a measure of policy (interest rate or money, say)

Vector Autoregressions

Consider a special case

$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} = \begin{pmatrix} a_1 & a_2 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} y_{t-1} \\ x_{t-1} \end{pmatrix} + \begin{pmatrix} u_{yt} \\ u_{xt} \end{pmatrix}$$

Thus we have

$$\begin{aligned} y_t &= a_1 y_{t-1} + a_2 x_{t-1} + u_{yt} \\ x_t &= u_{xt} \end{aligned}$$

Let us now consider the 'forecast errors', u_{yt} and u_{xt}...

Vector Autoregressions

x_t may not be what was expected at $t-1$ because

- the policymaker responded to surprises elsewhere in the economy in t
- the policymaker did something unexpected in a way unrelated to the broader economy (e.g. unexpected change in the voting patterns of a policy committee after new appointments)

We are interested in the effect of a *policy surprise* (i.e. originating with the policymaker) rather than a surprise to the policy instrument, *per se*

- **But** without further assumptions u_{xt} could be a combination of the desired 'policy shock' and an 'output shock' (such as a random loss in confidence by consumers, say)

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Vector Autoregressions

We can think of the forecast errors as being a linear combination of 'structural' shocks, e_{yt} and e_{xt} where the latter is the 'policy shock'

$$\begin{pmatrix} u_{yt} \\ u_{xt} \end{pmatrix} = \begin{pmatrix} e_{yt} + \theta e_{xt} \\ \phi e_{yt} + e_{xt} \end{pmatrix} = \begin{pmatrix} 1 & \theta \\ \phi & 1 \end{pmatrix} \begin{pmatrix} e_{yt} \\ e_{xt} \end{pmatrix} \equiv B \begin{pmatrix} e_{yt} \\ e_{xt} \end{pmatrix}$$

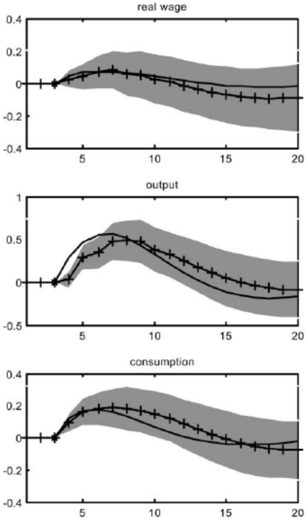
Without assumptions on B (i.e. on θ and ϕ in this example) we cannot 'pull apart' the forecast errors (u_{it}) and separately **identify** the effect of the structural shocks (e_{it})

- Example 1: Assume $\phi = 0$
  - Policy variable does not respond contemporaneously to 'output shocks'
- Example 2: Assume $\theta = 0$
  - Policy only affects output with a lag
- Many identification schemes have been proposed (see Christiano *et al* (1999) and Ramey (2016))

While researchers have disagreed on the best means of identifying policy shocks, there has been a surprising consensus on the general nature of the economic responses to monetary policy shocks. A variety of VARs estimated for a number of countries all indicate that, in response to a policy shocks, output follows a hump-shaped pattern in which the peak impact occurs several quarters after the initial shock.

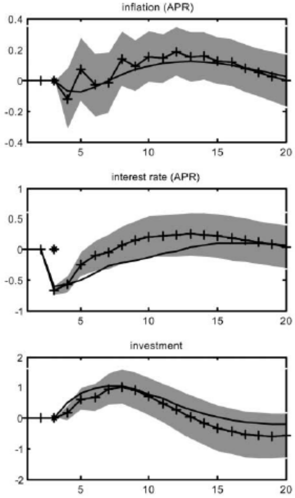
- Walsh, 1998, p.31

Vector Autoregressions



Subset of IRFs from CEE (2005)

Vector Autoregressions



Subset of IRFs from CEE (2005)

Vector Autoregressions

VAR approach useful but not without flaws/critics. . .

- Monetary policy shocks are now likely rare/small (Ramey (2016))
  - Makes it more difficult to use *policy* shocks to estimate impact of policy
  - Can still estimate role of policy but need *other* shocks **and** a model
- Changes in underlying parameters (Lucas critique and Rational Expectations)
  - Response to shocks depends on parameters describing policymakers' approach **and** all other parameters in the economy (e.g. regulation, preferences. . .)
  - If they change, previous estimates may become obsolete
- Responses may not be accurately recovered even from data generated by a model (Chari *et al* (2008))
  - Can still use, but in a 'moment matching' exercise *involving a model*
  - VARs on actual data and on data from model - minimize discrepancy

More problems with VAR analysis. . .

- Unhelpful for welfare analysis
  - Knowing that policy affects activity is one thing. . .
  - . . . but knowing *how it should try to affect it* is another
  - Agent's optimization problems must be explicit for micro-founded welfare analysis
  - VARs are silent on this
- Story telling / incorporation of microeconomic evidence
  - Policymakers like to understand/explain transmission mechanism
  - Elements of models (such as, say, household risk aversion) can be pinned down by evidence from experiments/more granular research
  - Not possible with VARs (or very difficult)

A lot of these 'problems' can be addressed by using a model. . .

DSGE Models

Role of monetary policy - DSGE models

Dynamic Stochastic General Equilibrium (DSGE) models feature:

- Multiple periods (D)
  - Agents form dynamic plans taking future into account
- Random shocks continually hitting the economy (S)
  - From monetary policy and other sources (e.g. technology)
- Optimzation problems of individual agents (GE)
  - Preferences/profit maximization with budget/technological constraints
- Feasibility of optimal behavior in the aggregate (GE)
  - Aggregation of individuals' decisions respects resource constraints
- Consistency of beliefs with the induced path of the economy (GE)
  - Typically impose Rational Expectations requirement

Role of monetary policy - DSGE models

DSGE models initially associated with the 'Real Business Cycle' literature

- Seminal work of Kydland and Prescott (1982) and Prescott (1986)
- No (or minor) distortions $\Rightarrow$ despite fluctuations (the 'business cycle') the economy is always efficient
- Limited role of monetary policy - main shocks were 'real' (technology)

Beautiful models - but unsatisfactory in various dimensions

- If monetary policy was included, optimal policy looked nothing like real world practice
- Effects of policy shocks often counterfactual (recall evidence discussed above)
- Hard to reconcile dominant role of technology shocks with...
    - *Unconditional* positive comovement of employment and output in data
    - Empirical studies $\Rightarrow$ *technology* shocks move them in opposite direction

Role of monetary policy - DSGE models

The challenge:

- Keep the ‘good’ aspects of RBC models...
- ...while enhancing ability to explain and justify monetary policy

Role of monetary policy - DSGE models

New Keynesian modeling was a response to this challenge

- Interpret as a **micro-founded** formalization of 'Keynesian' ideas
  - IS-LM analysis 'much less careful' - rather *ad hoc*
  - 'We are an equation short' (Keynes) - price setting not modeled
- Emphasis on **nominal rigidities** as a reason for fluctuations
  - Empirical evidence of significant price (incl. wage) stickiness
  - Taylor (1999), Bewley (1999), Dhyne *et al* (2006), Nakamura and Steinsson (2008)...
- (Very) loosely - sticky prices $\Rightarrow$ **Classical Dichotomy broken**
  - ΔM_t shock doesn't *immediately* pass 1:1 to prices
  - Δi_t shock doesn't *immediately* pass 1:1 to $E_t[\pi_{t+1}]$ - thus r_t changes
- Explicit distortions from **imperfect competition** and sticky prices implies **economy not fully efficient**
  - Scope for policy to be welfare-enhancing

Road Map

Road Map

Classical monetary model (Galí - Ch.2)

- Essentially a simple RBC model with a trivial monetary block
- Fix notation and concepts shared with New Keynesian model

Basic NK model (Galí - Ch.3)

- Very simple version of NK framework
- Basic intuition holds in more complicated NK models
- Still guides thinking in central banks (+ many academic departments)

Monetary policy in NK model (Galí - Parts of Ch.4/5)

- Properties of (theoretically) optimal policy
- 'Simple' policy rules
- Policy trade-offs (between price stability and real volatility)