Empirical Measures of the Effects of Monetary Policy

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1. Monetary Policy in the Short-Run

Brief overview of models in which money matters in the short-run (see MPT Chapter 5)

1.1. Flexible Price Models

• In MIU and CIA models, anticipated money growth affects expectations on future inflation. Hence, substitution effects between present and future expectations have real effects
• However, unexpected money growth shocks have no real effects because they do not affect expectations. Hence, money is neutral in the short-run.

• To reconcile long-run neutrality with short-run real effects of money in a flexible price environment, we rely on informational frictions
Imperfect Information and the Lucas Island Model

- **Basic idea**: Agents face a signal extraction problem: prices have changed but they do not know whether this is a change in relative prices or a generalized price increase.

- **Set-up**: Agents are randomly allocated among islands after each period. Hence they care about prices in the island they currently occupy but also on prices at islands they may be reassigned to.
• Individuals have imperfect information about aggregate economic variables, such as money supply and the price level.

• When prices change in the agent’s island, he must decide whether they reflect purely nominal changes in aggregate variables or island-specific relative price-changes.
Implications:

- Agents face a signal-extraction problem
- Testable implications:
  ii. Signal-extraction problem: short-run relation between output and inflation will depend on the relative variance of real and nominal shocks. A
rise in aggregate volatility will mean that a price increase is more likely to be interpreted as arising from an aggregate price increase. Hence, there will be a smaller real response and thus aggregate shocks will have smaller real effects: SVAR-GARCH iii. Sargent and Wallace (1975): policy ineffectiveness proposition. If money only has real effects when it is unanticipated then systematic monetary policy is ineffective.
Empirical Findings

Policy ineffectiveness does not seem to hold: systematic monetary policy appears to have real effects in the short-run.
Limited Participation Models

The first link in the monetary transmission mechanism requires that the central bank be able to control short-term interest rates with the growth rate of money.

**Mechanism:** certain sectors of the economy face restrictions in financial intermediation.
• A monetary injection affects different agents differently: some agents are left with higher money holdings than desired while other agents are left with lower balances than desired

• Fuerst (1992), Christiano and Eichenbaum (1992) introduce a liquidity effect in a CIA model by distinguishing 3 sectors: households, firms, and financial intermediaries
• Households allocate between money and bank deposits
• Intermediaries lend out deposits to firms to finance their wage bill
• After households make their deposits, intermediaries receive a lump-sum monetary injection.
• However, the household is not allowed to reoptimize its deposit allocation
• Hence intermediaries wish to lend the excess cash for which they lower interest rates.
• This generates a liquidity effect
• The firms’ effective wage bill declines with the interest rate, thus lowering the marginal cost of labor. Hence, equilibrium employment and output increase.
Empirical Evidence

• LP models are successful in generating liquidity effects and in explaining some features of the term structure

• However, LP models require a high labor supply elasticity to match the effects of monetary shocks on output, real wages, and profits

• Financial frictions maybe appropriate for the very short-run but not for the medium- and long-run
1.2. Nominal Rigidities

General idea: wages and/or prices are fixed for some period of time (usually require more than one-period).

- Price stickiness, Calvo (1983)
- Monopolistic competition: create an optimizing environment for sticky pricing.
One-period wage rigidity in a MIU model

• Under flexible prices, a positive disturbance to money growth would raise the expected rate of inflation.
• Hence, an increase in the nominal interest affects labor supply and output as long as utility is non-separable.
Example: The Sidrauski Model (Chapter 2)

Assumptions:

• Utility is separable in consumption and money holdings – money has no effect on output with flexible prices

• The capital stock is fixed and investment is zero (McCallum and Nelson, 1999)
**Equilibrium**

1. \( y_t = (1 - \alpha) n_t + e_t \)  
   \( \text{Production function} \)

2. \( y_t = c_t \)  
   \( \text{Resource constraint} \)

3. \( y_t - n_t = w_t - p_t \)  
   \( \text{Labor demand} \)

4. \( \Phi E_t (c_{t+1} - c_t) - r_t = 0 \)  
   \( \text{f.o.c. for consumption,} \)

5. \( \eta \left( \frac{n^{ss}}{1 - n^{ss}} \right) n_t + \Phi c_t = w_t - p_t \)  
   \( \text{leisure, and money} \)

   \( \text{holdings} \)

6. \( m_t - p_t = c_t - \frac{1}{b} i_t \)
(7) \[ i_t = r_t + E_t p_{t+1} - p_t \] \hspace{1cm} \text{Fisher relation}

(8) \[ m_t = \gamma m_{t-1} + s_t \] \hspace{1cm} \text{Money growth process}

**Remarks**

- With flexible prices, equations 1-5 can be solved for the equilibrium path of output, labor, consumption, the real wage, and the real interest rate w/o \( s_t \)
• This is the classical dichotomy: real variables are determined independently of money supply and money demand factors.

We now add a nominal friction: the nominal wage is set prior to the start of the period.

Firms will demand labor according to the realized real wage
Let
\[ w_t^c = E_{t-1} w_t^* + E_{t-1} p_t \]
where \( w_t^* \) is the equilibrium nominal wage with flexible prices.

From expression (3), actual employment is determined by
\[ n_t = y_t - (w_t^c - p_t) = y_t - E_{t-1} w_t^* + (p_t - E_{t-1} p_t) \]

After some manipulation and plugging into the production function…
\[ y_t - E_{t-1} y_t^* = \alpha(p_t - E_{t-1} p_t) + (1 + \alpha)e_t; \quad a = \frac{\alpha}{1 - \alpha} \]

Assuming serially uncorrelated disturbances

\[
\begin{cases}
  y_t = \alpha(p_t - E_{t-1} p_t) + (1 + \alpha)e_t \\
  m_t - p_t = y_t
\end{cases}
\]

\[ y_t = \left( \frac{a}{1 + a} \right) s_t + \left( \frac{1 + a}{1 + a} \right) e_t = (1 - \alpha)s_t + e_t \]
Remarks

• The dynamics of consumption smoothing and capital accumulation are insufficient to produce the output persistence revealed by the data. Hence, RBC models usually include serially correlated shocks.

• With one-period fixed wages the effects of a monetary shock only lasts one period, also insufficient to generate output persistence.

• We need more persistence!
Imperfect Competition and Price Stickiness

• Main virtue: makes explicit price-setting behavior
• Imperfect competition alone does not resolve monetary non-neutrality – still need stickiness.

Basics of the model

• Intermediate goods producer w/ monopolistic competition and multi-period staggered price-setting
\[ p_t(i) = \frac{p_t V_t}{q} \]

The price of intermediate good \( i \) is set as a constant mark-up \( 1/q \) over unit nominal costs, \( pV \)

\[ n_t = \frac{q(1-\alpha)y_t}{w_t/p_t} \]

Labor demand from all intermediate producers and the final goods producer
Introducing price stickiness

• Taylor-type staggered wage contracts: a portion of contracts/prices is renegotiated each period. This generates output persistence

• e.g. intermediate good price-setting: firms set prices of intermediate goods for two periods, half in one period, half in the other.

The implied behavior for aggregate deviation of price from ss is…
\[
\bar{p}_t = \frac{1}{2} \left( \frac{1 - \gamma}{1 + \gamma} \right) (\bar{p}_{t-1} + E_t \bar{p}_{t+1}) + \left( \frac{\gamma}{1 + \gamma} \right) (m_t + E_t m_{t+1})
\]

Remarks

• prices are backward and forward looking
• prices depend on the path of nominal money supply over 2 periods
• the model is able to reproduce persistent output movements but requires high labor-supply elasticity
Inflation Persistence

Inflation can be persistent because:

a. Money Growth Rates are persistent

b. Even with serially uncorrelated money growth, mechanisms in the economy generate persistence.

Two basic models and a refinement:

- Taylor staggered wage contracts
- Calvo pricing
- Fuhrer and Moore refinement of Taylor
Taylor’s Model

- Prices are assumed to be a constant markup above wages
- Wages are set for two periods

\[ x_t \equiv \log \text{contract wage set at time } t \]

The average wage faced by the firm is: \( w_t = \frac{(x_t + x_{t-1})}{2} \)

The workers expected real wage over the life of the contract is:
\[
\frac{1}{2} \left[ x_t = p_t + \left( x_t - E_t p_{t+1} \right) \right] = x_t - \frac{1}{2} \left( p_t + E_t p_{t+1} \right)
\]

Assuming the contract is increasing in the level of output, then

\[
x_t = \frac{1}{2} \left( p_t + E_t p_{t+1} \right) + k y_t
\]

\[
p_t = \frac{1}{2} p_{t-1} + \frac{1}{2} E_t p_{t+1} + k (y_t + y_{t-1}) + \frac{1}{2} \eta_t
\]
Rearranging and expressing in terms of inflation:

\[ \pi_t = E_t \pi_{t+1} + 2k(y_t + y_{t-1}) + \eta_t \]

key: while prices display inertia, the rate of inflation does not – a change in the level of inflation has no impact on the behavior of output. Hence

inflation can be costlessly reduced!
Calvo Pricing

- Assume prices are adjusted infrequently by firms and that the arrival of price adjustments is given by a Poisson process.
- Each period, the probability that the firm will adjust its price is $q$. Hence the expected time between adjustments is $1/q$. 
• Assume the firm minimizes the quadratic adjustment cost of changing its price, given by…

\[ q(p_{it} - p_t^*)^2 + (1-q)\beta E_t (p_{it+1} - p_{t+1}^*)^2 + (1-q)^2 \beta^2 E_t (p_{it+2} - p_{t+2}^*)^2 + ... \]

• Let \( x_t \) be the price set by all firms adjusting their price at time \( t \).
The f.o.c. of the quadratic minimization problem suggest:

\[ x_t = [1 - (1 - q)\beta] p_t^* + (1 - q)\beta E_t x_{t+1} \]

Assume \( p_t^* = p_t + \gamma y_t + \varepsilon_t \)

As the number of firms increases, a fraction \( q \) adjusts each period and the aggregate price level is:

\[ p_t = qx_t + (1 - q)p_{t-1} \]
Combining terms:

\[ x_t = [1 - (1 - q)\beta](p_t + \gamma y_t + \epsilon_t) + (1 - q)\beta E_t x_{t+1} \]

\[ p_t = qx_t + (1 - q)p_{t-1} \]

Solving these two expressions:

\[ \pi_t = \beta E_t \pi_{t+1} + q \frac{(1 - (1 - q)\beta)}{1 - q} (\gamma y_t + \epsilon_t) \]
Remarks:

- current inflation depends on future inflation and current output
- expected future inflation has a coefficient equal to the discount factor
- the coefficient of output in the inflation equation is a function of how frequently prices are adjusted.
The p-bar model

McCallum has criticized these inflation equations because the violate the “natural rate hypothesis”

NRH: monetary policy cannot be used to keep output permanently about the value it would assume if all prices and wages were perfectly flexible.
If $\bar{y}$ is the deviation from s-s of the natural rate of output and $\bar{p}$ is the price level consistent with $y_t = \bar{y} = 0$, then

$$p_t - p_{t-1} = \gamma (y_{t-1} - \bar{y}_{t-1}) + E_{t-1} (\bar{p}_t - \bar{p}_{t-1})$$

Manipulating this expression with the equations that describe aggregate demand,

$$\pi_t = kE_{t-1} \pi_{t+1} + (1-k)E_{t-1} \Delta m_t + \gamma y_{t-1} + \varepsilon_t$$
Remarks:

• inflation is directly a function of the money growth rate

• However, unlike Taylor and Calvo, prices are sticky but inflation is not.
Fuhrer and Moore

Disinflations are costly in terms of lost output. Hence, the inflation rate and not just prices are persistent.

Assume wage negotiations are in terms of the wage relative to an average of real contract wages in effect over the life of the contract.
\[ x_t - p_t \equiv \psi_t \quad \text{Real value of contracts negotiated at time } t \]

\[ \nu_t \equiv \frac{1}{2}(\psi_t + \psi_{t-1}) \quad \text{Index of average “real” contract wages still in effect at time } t \]

Assume:

- In setting \( x_t \), agents attempt to achieve a current real contract price equal to the expected average of the real
contract index over the 2-period life of the contract:

\[
\frac{1}{2} (\nu_t + \nu_{t+1})
\]

- The contracted real price can deviate from this average. The expected index is designed to reflect the current state of the business cycle, \( ky_t \)

Hence:

\[
x_t - p_t = \frac{1}{2} (x_{t-1} - p_{t-1} + E_t (x_{t+1} - p_{t+1})) + 2ky_t
\]

\[
\Delta x_t = \frac{1}{2} (\pi_t + E_t \pi_{t+1}) + 2ky_t
\]
With the price level equal to $\frac{1}{2}(x_t + x_{t-1})$ then

$$\pi_t \frac{1}{2}(\Delta x_t + \Delta x_{t-1})$$

and

$$\pi_t = \frac{1}{2}(\pi_{t-1} + E_t \pi_{t+1}) + 2k(y_t + y_{t-1}) + \frac{1}{2} \eta_t$$

$$\eta_t = -[\pi_t - E_{t-1} \pi_t]$$

Remarks:

- Inflation dynamics have backward and forward looking expectations: (1) current and future
monetary policy affects expectations of future inflation; (2) reductions in money growth are costly in terms of lost output.

- Disinflations must create recessions if inflation is sticky. This is true when there is price-level stickiness only if the policy lacks credibility.