MACROECONOMICS

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PowerPoint® Slides by Ron Cronovich

SEVENTH EDITION

CHAPTER 14

A Dynamic Model of Aggregate Demand and Aggregate Supply

In this chapter you will learn:

- how to incorporate dynamics into the AD-AS model we previously studied
- how to use the dynamic AD-AS model to illustrate long-run economic growth
- how to use the dynamic AD-AS model to trace out the effects over time of various shocks and policy changes on output, inflation, and other endogenous variables

Introduction

- The dynamic model of aggregate demand and aggregate supply is built from familiar concepts, such as:
  - the IS curve, which negatively relates the real interest rate and demand for goods & services
  - the Phillips curve, which relates inflation to the gap between output and its natural level, expected inflation, and supply shocks
  - adaptive expectations, a simple model of inflation expectations

How the dynamic AD-AS model is different from the standard model

- Instead of fixing the money supply, the central bank follows a monetary policy rule that adjusts interest rates when output or inflation change.
- The vertical axis of the DAD-DAS diagram measures the inflation rate, not the price level.
- Subsequent time periods are linked together: Changes in inflation in one period alter expectations of future inflation, which changes aggregate supply in future periods, which further alters inflation and inflation expectations.

Keeping track of time

- The subscript "t" denotes the time period, *e.g.*
  - Y_t = real GDP in period t
  - Y_{t-1} = real GDP in period $t - 1$
  - Y_{t+1} = real GDP in period $t + 1$
- We can think of time periods as years. *E.g.*, if t = 2008, then
  - $Y_t = Y_{2008}$ = real GDP in 2008
  - $Y_{t-1} = Y_{2007}$ = real GDP in 2007
  - $Y_{t+1} = Y_{2009}$ = real GDP in 2009

The model's elements

- The model has five equations and five endogenous variables: output, _____, _____, _____, and _____.
- The equations may use different notation, but they are conceptually similar to things you've already learned.
- The first equation is for output…

Output: The Demand for Goods and Services

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t$$

output — Y_t

natural level of output — $\bar{Y}_t$

real interest rate — r_t

$\alpha > 0, \ \rho > 0$

_____ relation between output and interest rate, same intuition as _____.

Output: The Demand for Goods and Services

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t$$

measures the interest-rate sensitivity of demand — α

"natural rate of interest" – in absence of demand shocks, $Y_t = \bar{Y}_t$ *when* $r_t = \rho$ — ρ

demand shock, random and zero on average — ε_t

The Real Interest Rate: The Fisher Equation

$$r_t = i_t - E_t \pi_{t+1}$$

ex ante (i.e. expected) real interest rate — r_t

nominal interest rate — i_t

expected inflation rate — $E_t \pi_{t+1}$

π_{t+1} = increase in price level from period t to $t+1$, not known in period t

$E_t \pi_{t+1}$ = _____, formed in period t, of inflation from t to $t+1$

Inflation: The Phillips Curve

$$\pi_t = E_{t-1}\pi_t + \phi(Y_t - \bar{Y}_t) + \nu_t$$

- π_t: *current inflation*
- $E_{t-1}\pi_t$: *previously expected inflation*
- $\phi(Y_t - \bar{Y}_t)$: $\phi > 0$ *indicates how much inflation responds when output fluctuates around its natural level*
- ν_t: *supply shock, random and zero on average*

Expected Inflation: _____ Expectations

$$E_t \pi_{t+1} = \pi_t$$

For simplicity, we assume people expect prices to continue rising at the current inflation rate.

The Nominal Interest Rate: The _____

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t)$$

- i_t: *nominal interest rate, set each period by the central bank*
- ρ: *natural rate of interest*
- π_t^*: *central bank's inflation target*

$\theta_\pi > 0, \ \theta_Y > 0$

The Nominal Interest Rate: The Monetary-Policy Rule

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t)$$

measures how much the central bank adjusts the interest rate when _____ deviates from its target

measures how much the central bank adjusts the interest rate when _____deviates from its natural rate

CASE STUDY
The Taylor Rule

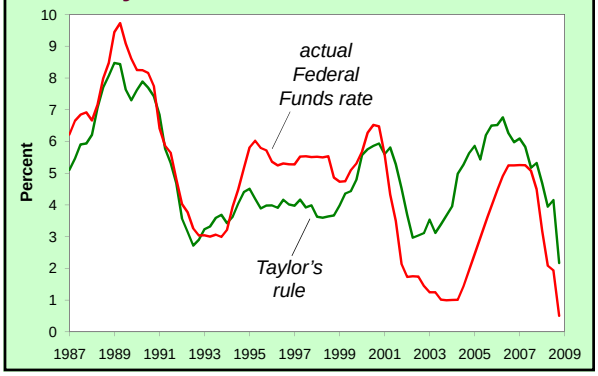
- Economist John Taylor proposed a monetary policy rule very similar to ours:

  $i_{ff} = \pi + 2 + 0.5(\pi - 2) - 0.5(\text{GDP gap})$

  where
  - i_{ff} = nominal federal funds rate target
  - GDP gap = 100 x $\frac{\bar{Y} - Y}{\bar{Y}}$

    = percent by which real GDP is below its natural rate
- The Taylor Rule matches Fed policy fairly well.…

CASE STUDY
The Taylor Rule



The model's variables and parameters

- Endogenous variables:

Y_t = Output

π_t = Inflation

r_t = Real interest rate

i_t = Nominal interest rate

$E_t \pi_{t+1}$ = Expected inflation

The model's variables and parameters

- Exogenous variables:

$\bar{Y}_t$ = Natural level of output

π_t^* = Central bank's target inflation rate

ε_t = Demand shock

v_t = Supply shock

- Predetermined variable:

π_{t-1} = Previous period's inflation

The model's variables and parameters

- Parameters:

α = Responsiveness of demand to the real interest rate

ρ = Natural rate of interest

ϕ = Responsiveness of inflation to output in the Phillips Curve

θ_π = Responsiveness of i to inflation in the monetary-policy rule

θ_Y = Responsiveness of i to output in the monetary-policy rule

The model's long-run equilibrium

- The normal state around which the economy fluctuates.
- Two conditions required for long-run equilibrium:
  - There are _____: $\varepsilon_t = \nu_t = 0$
  - Inflation is _____: $\pi_{t-1} = \pi_t$

The model's long-run equilibrium

- Plugging the preceding conditions into the model's five equations and using algebra yields these long-run values:

$$Y_t = \bar{Y}_t$$
$$r_t = \rho$$
$$\pi_t = \pi_t^*$$
$$E_t \pi_{t+1} = \pi_t^*$$
$$i_t = \rho + \pi_t^*$$

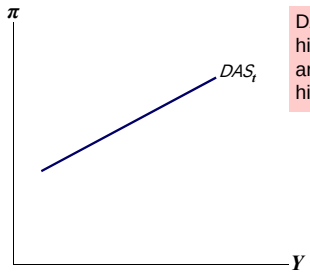
The Dynamic Aggregate Supply Curve

- The DAS curve shows a relation between output and inflation that comes from the Phillips Curve and Adaptive Expectations:

$\pi_t =$ _____ (*DAS*)

The Dynamic Aggregate Supply Curve

$$\pi_t = \pi_{t-1} + \phi(Y_t - \bar{Y}_t) + \nu_t$$



DAS slopes _____: high levels of output are associated with high inflation.

DAS ____ in response to changes in the natural level of output, previous inflation, and supply shocks.

The Dynamic Aggregate _____ Curve

- To derive the DAD curve, we will combine four equations and then eliminate all the endogenous variables other than output and inflation.

Start with the demand for goods and services:

$$Y_t = \bar{Y}_t - \alpha(r_t - \rho) + \varepsilon_t$$

using the Fisher eq'n

$$Y_t = \bar{Y}_t - \alpha(i_t - E_t\pi_{t+1} - \rho) + \varepsilon_t$$

The Dynamic Aggregate Demand Curve

result from previous slide

$$Y_t = \bar{Y}_t - \alpha(i_t - E_t\pi_{t+1} - \rho) + \varepsilon_t$$

using the expectations eq'n

$$Y_t = \bar{Y}_t - \alpha(i_t - \pi_t - \rho) + \varepsilon_t$$

using monetary policy rule

$$Y_t = \bar{Y}_t - \alpha[\pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t) - \pi_t - \rho] + \varepsilon_t$$

$$Y_t = \bar{Y}_t - \alpha[\theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t)] + \varepsilon_t$$

The Dynamic Aggregate Demand Curve

result from previous slide

$$Y_t = \bar{Y}_t - \alpha[\theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t)] + \varepsilon_t$$

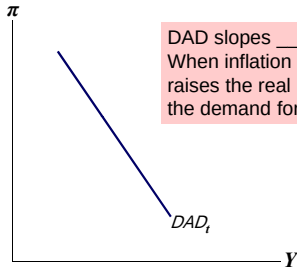
combine like terms, solve for Y

$$Y_t = \bar{Y}_t - \mathrm{A}(\pi_t - \pi_t^*) + \mathrm{B}\varepsilon_t, \qquad (DAD)$$

where $\mathrm{A} = \dfrac{\alpha\theta_\pi}{1+\alpha\theta_Y} > 0, \quad \mathrm{B} = \dfrac{1}{1+\alpha\theta_Y} > 0$

The Dynamic Aggregate Demand Curve

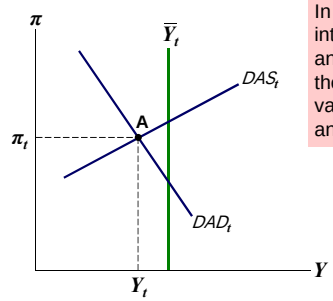
$$Y_t = \bar{Y}_t - \mathrm{A}(\pi_t - \pi_t^*) + \mathrm{B}\varepsilon_t$$



DAD slopes _____:
When inflation rises, the central bank raises the real interest rate, reducing the demand for goods & services.

DAD shifts in response to changes in the natural level of output, the inflation target, and demand shocks.

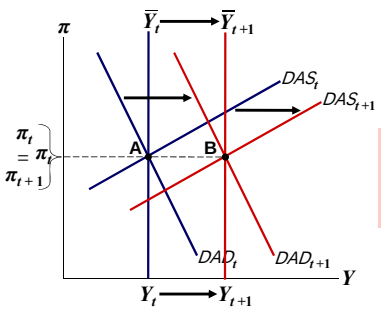
The short-run equilibrium



In each period, the intersection of DAD and DAS determines the short-run eq'm values of inflation and output.

In the eq'm shown here at **A**, output is below its natural level.

Long-run growth

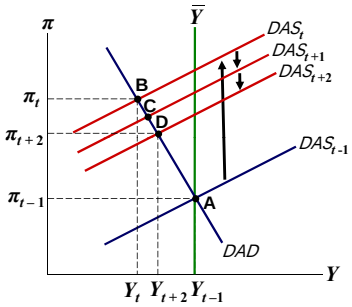


Per DAS shifts initi because economy can produce more g&s

New eq'm at **B**, income grows but inflation remains stable.

demand for g&s

A shock to aggregate supply



Period $t + 2$:
As inflation falls, inflation expectations fall, DAS moves downward, output rises.
This process continues until output returns to its natural rate.
LR eq'm at **A**.

Parameter values for simulations

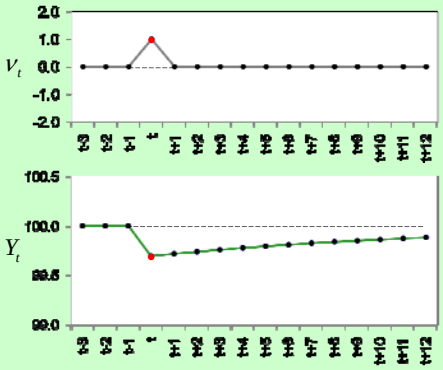
$\bar{Y}_t = 100$
$\pi_t^* = 2.0$
$\alpha = 1.0$
$\rho = 2.0$
$\phi = 0.25$
$\theta_\pi = 0.5$
$\theta_Y = 0.5$

Thus, we can interpret $Y_t - \bar{Y}_t$
Central bank's inflation ion of

The following graphs are called ***impulse response functions***. They show the "response" of the endogenous variables to the "impulse," *i.e.* the shock.

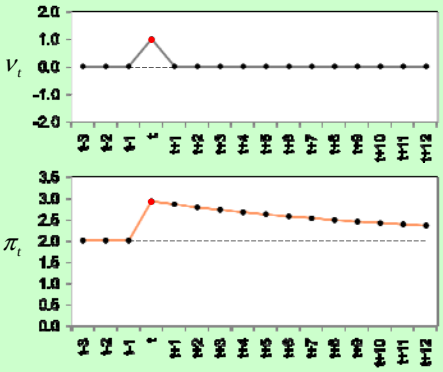
These values are from the Taylor Rule, which approximates the actual behavior of the Federal Reserve.

The dynamic response to a supply shock



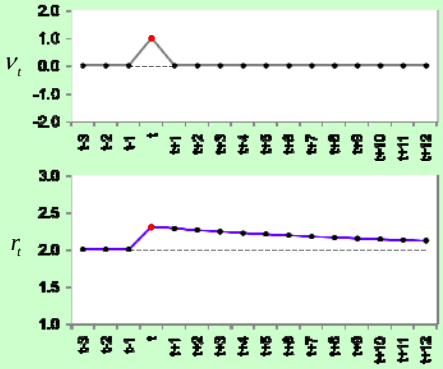
A one-period supply shock affects output for many periods.

The dynamic response to a supply shock



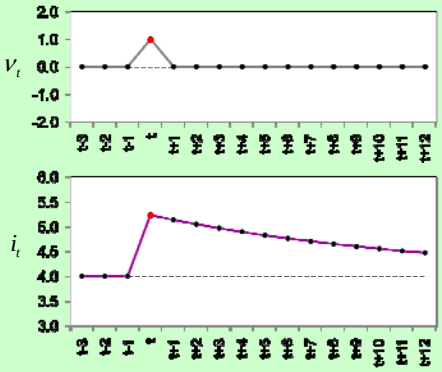
Because inflation expect-ations adjust slowly, actual inflation remains high for many periods.

The dynamic response to a supply shock



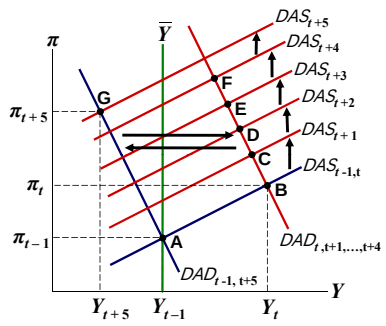
The real interest rate takes many periods to return to its natural rate.

The dynamic response to a supply shock



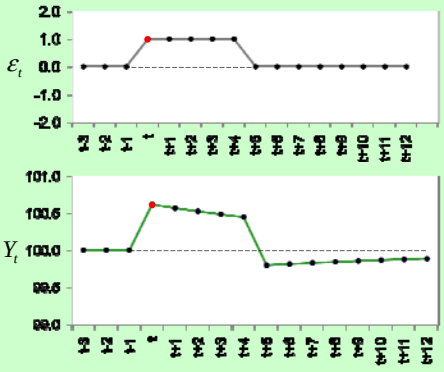
The behavior of the nominal interest rate depends on that of the inflation and real interest rates.

A shock to aggregate demand



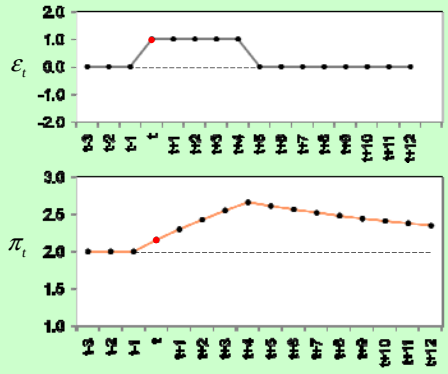
Periods $t + 6$ and higher: DAS gradually shifts down as inflation and inflation expectations fall, economy gradually recovers until reaching LR eq'm at **A**.

The dynamic response to a demand shock



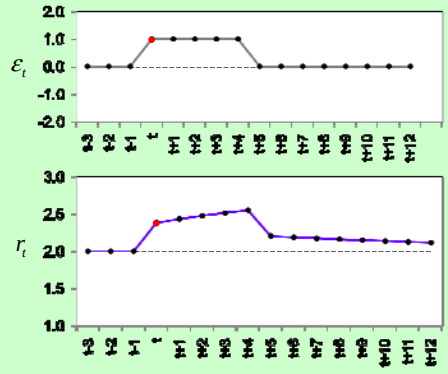
The demand shock raises output for five periods. When the shock ends, output falls below its natural level, and recovers gradually.

The dynamic response to a demand shock



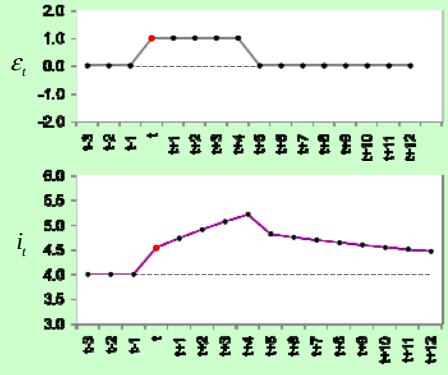
The demand shock causes inflation to rise. When the shock ends, inflation gradually falls toward its initial level.

The dynamic response to a demand shock



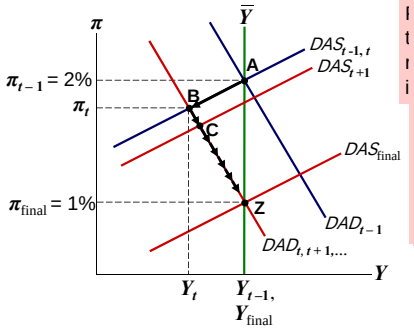
The demand shock raises the real interest rate. After the shock ends, the real interest rate falls and approaches its initial level.

The dynamic response to a demand shock



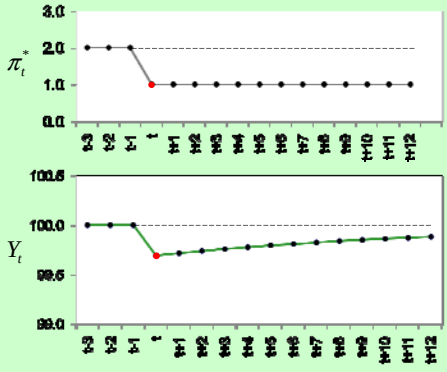
The behavior of the nominal interest rate depends on that of the inflation and real interest rates.

A shift in monetary policy



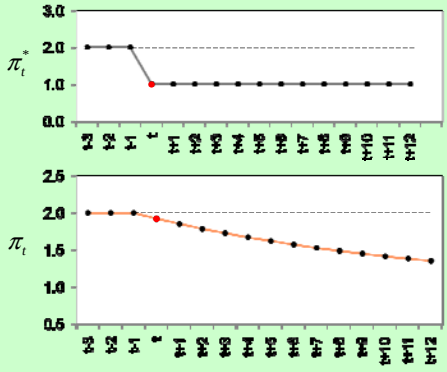
Subsequent periods: This process continues until output returns to its natural rate and inflation reaches its new target.

The dynamic response to a reduction in target inflation



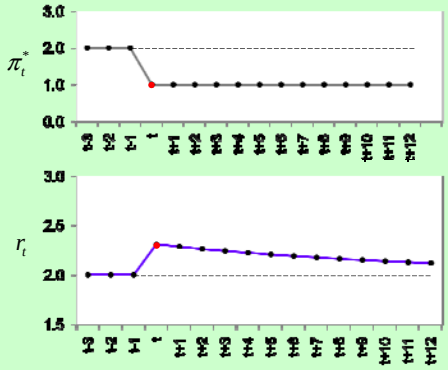
Reducing the target inflation rate causes output to fall below its natural level for a while. Output recovers gradually.

The dynamic response to a reduction in target inflation



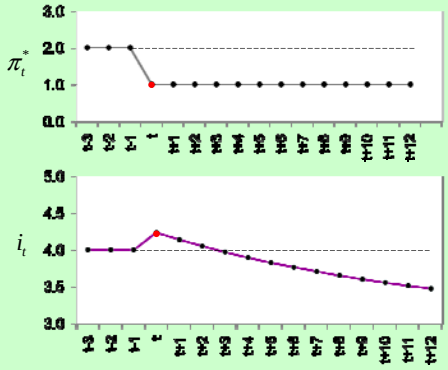
Because expect-ations adjust slowly, it takes many periods for inflation to reach the new target.

The dynamic response to a reduction in target inflation



To reduce inflation, the central bank raises the real interest rate to reduce aggregate demand. The real interest rate gradually returns to its natural rate.

The dynamic response to a reduction in target inflation



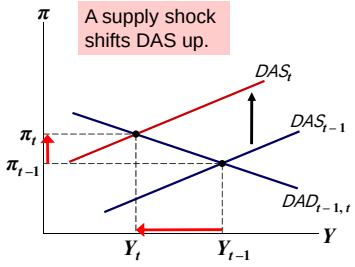
The initial increase in the real interest rate raises the nominal interest rate. As the inflation and real interest rates fall, the nominal rate falls.

APPLICATION:
Output variability vs. inflation variability

- A supply shock reduces output (bad) and raises inflation (also bad).
- The central bank faces a tradeoff between these "bads" – it can reduce the effect on output, but only by tolerating an increase in the effect on inflation….

APPLICATION:
Output variability vs. inflation variability

CASE 1: θ_π is large, θ_Y is small



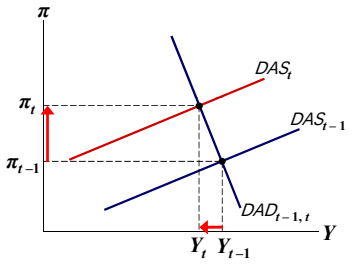
A supply shock shifts DAS up.

In this case, a small change in inflation has a large effect on output, so DAD is relatively flat.

The shock has a large effect on output, but a small effect on inflation.

APPLICATION:
Output variability vs. inflation variability

CASE 2: θ_π is small, θ_Y is large



In this case, a large change in inflation has only a small effect on output, so DAD is relatively steep.

Now, the shock has only a small effect on output, but a big effect on inflation.

APPLICATION:
The Taylor Principle

- **The Taylor Principle** (named after John Taylor): The proposition that a central bank should respond to an increase in inflation with an even greater increase in the nominal interest rate (so that the real interest rate rises).

  I.e., central bank should set $\theta_\pi > 0$.

- Otherwise, DAD will slope upward, economy may be unstable, and inflation may spiral out of control.

APPLICATION:
The Taylor Principle

$$Y_t = \bar{Y}_t - \frac{\alpha\theta_\pi}{1+\alpha\theta_Y}(\pi_t - \pi_t^*) + \frac{1}{1+\alpha\theta_Y}\varepsilon_t \qquad (DAD)$$

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t) \qquad (MP\ rule)$$

If $\theta_\pi > 0$:

- When inflation rises, the central bank increases the nominal interest rate even more, which increases the real interest rate and reduces the demand for goods & services.
- DAD has a negative slope.

APPLICATION:
The Taylor Principle

$$Y_t = \bar{Y}_t - \frac{\alpha\theta_\pi}{1+\alpha\theta_Y}(\pi_t - \pi_t^*) + \frac{1}{1+\alpha\theta_Y}\varepsilon_t \qquad (DAD)$$

$$i_t = \pi_t + \rho + \theta_\pi(\pi_t - \pi_t^*) + \theta_Y(Y_t - \bar{Y}_t) \qquad (MP\ rule)$$

If $\theta_\pi < 0$:

- When inflation rises, the central bank increases the nominal interest rate by a smaller amount. The real interest rate falls, which increases the demand for goods & services.
- DAD has a positive slope.

APPLICATION:
The Taylor Principle

- If DAD is upward-sloping and steeper than DAS, then the economy is unstable: output will not return to its natural level, and inflation will spiral upward (for positive demand shocks) or downward (for negative ones).
- Estimates of θ_π from published research:
  - θ_π = –0.14 from 1960-78, before Paul Volcker became Fed chairman. Inflation was high during this time, especially during the 1970s.
  - θ_π = 0.72 during the Volcker and Greenspan years. Inflation was much lower during these years.