New Keynesian Phillips Curve

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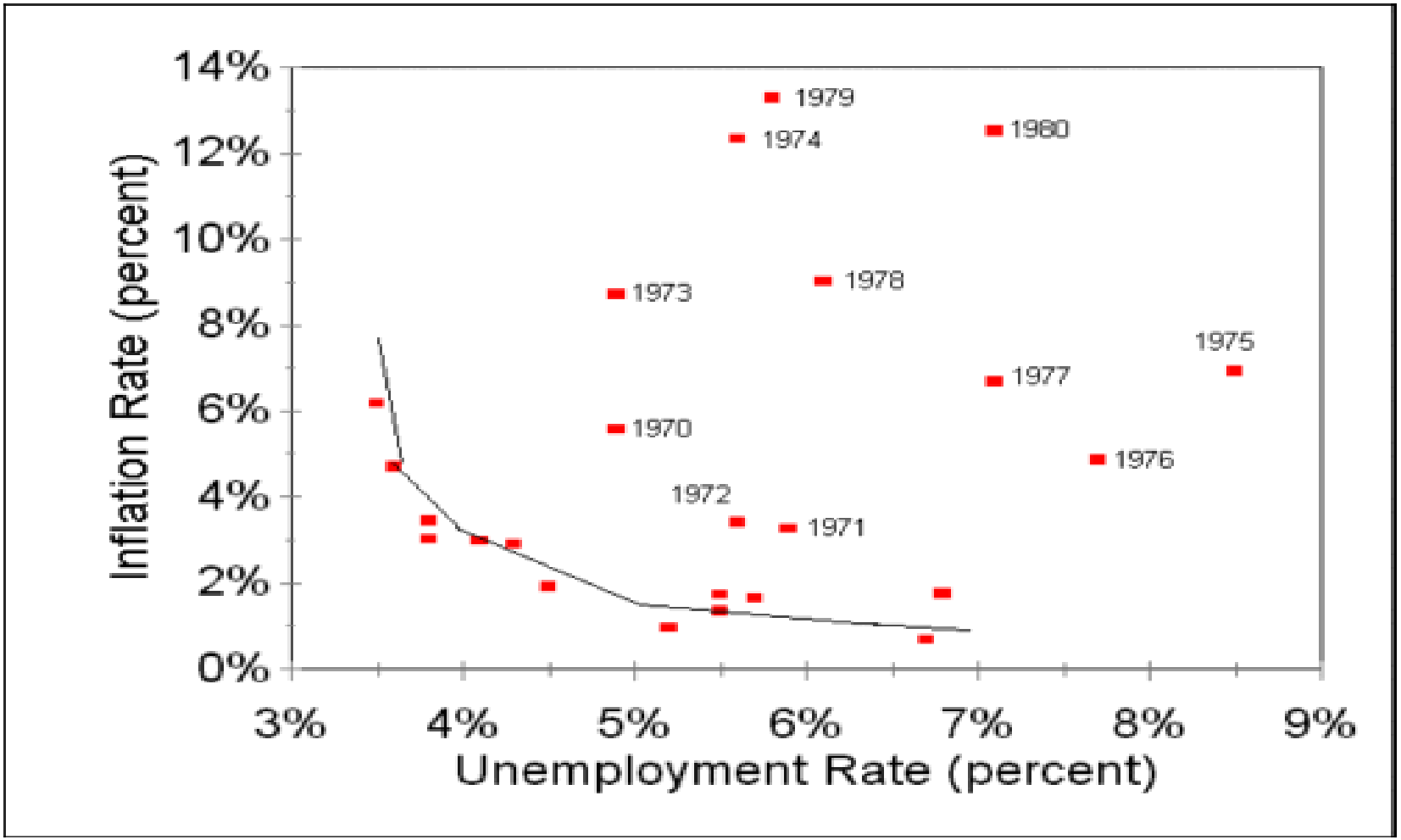
Econ 2713 Notes Week #3

Phillips Curve for the U.S. 1960-1980

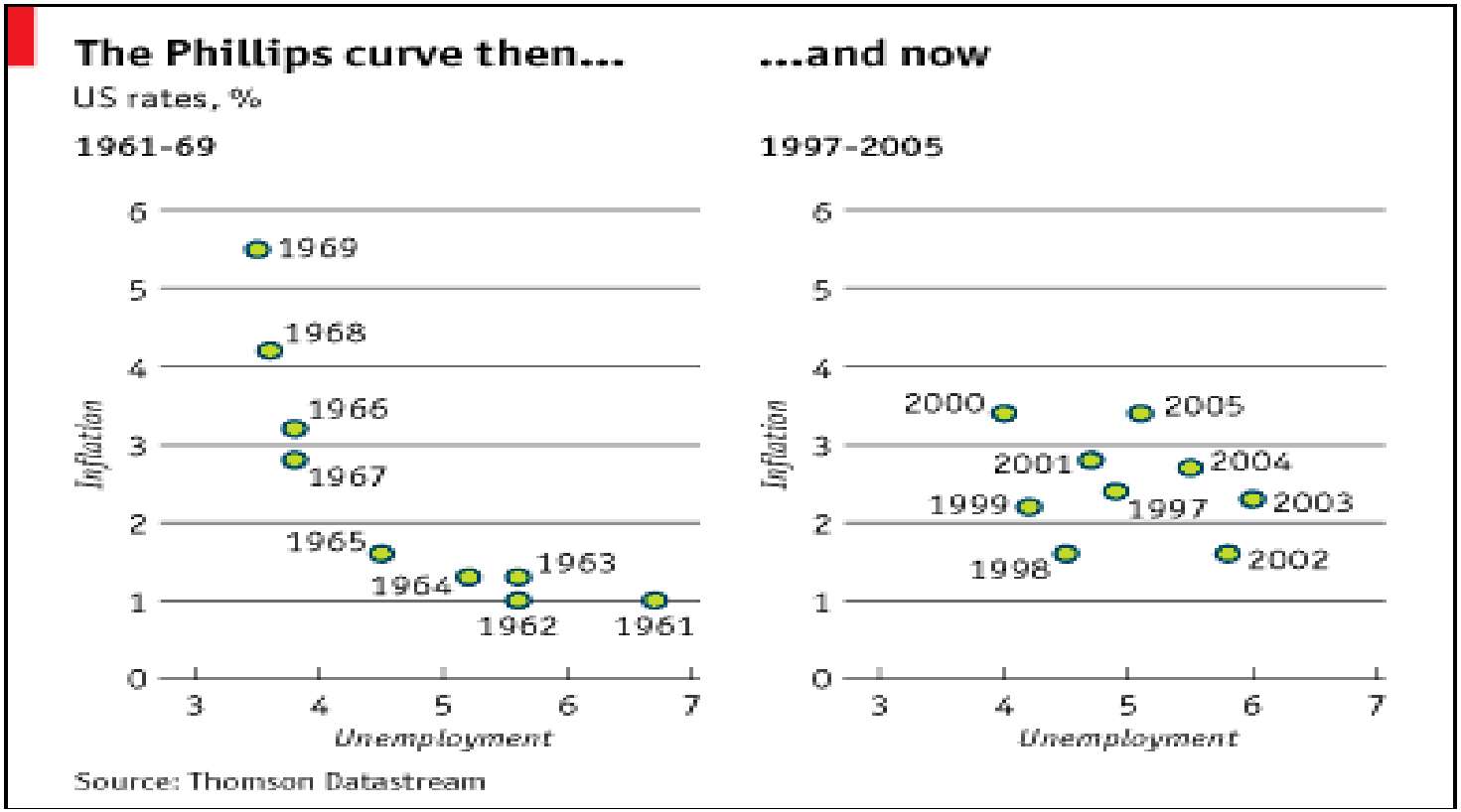


A Short-Run Inflation Output Trade-off?

- The Phillips curve is an empirical regularity first documented in 1958 by A.W. Phillips who showed that wage inflation and unemployment were negatively related - lower unemployment leads to higher wages.
- In the 1960s, leading economists, such as Solow and Samuelson argued that the this trade-off might be exploited; if the government wanted to lower unemployment this could be achieved at the cost of some inflation by pursuing Keynesian-type expansionary fiscal or monetary policies.
- The idea of a stable trade-off between inflation and output was discredited by Friedman (1968) and Phelps (1968) who argued that the long-run, expectations augmented Phillips curve was perfectly vertical at the natural rate of unemployment.
- The stagflation of the 1970s, in which both high inflation and high unemployment were observed simultaneously, appeared to vindicate Friedman and Phelps' view, and discussion of the Phillips curve trade-off fell into disrepute.

What Has Caused the Recent Revival in Interest in the Phillips Curve?

- Flattening out of the tradeoff?



- The desire to do monetary policy analysis? No room for this in DSGE RBC-type models!

The Old, Neoclassical Expectations Augmented Phillips Curve

- Generally written in the form:

$$\pi_t = E_{t-1}\pi_t + \alpha(y_t - \overline{y})$$

  where $\overline{y}$ is the natural rate of output, and $y_t - \overline{y}$ is the output gap.
- Only unanticipated inflation results in output fluctuations.
- In the original Phillips curve, the relationship was between wage (w) inflation $\Delta w \approx \pi$ (assuming mark-up pricing) and (under linear, labor only production) unemployment $u = -(y - \overline{y})$; there was no augmentation of expectations of wage/price inflation (no $E_{t-1}\pi_t$ term.)

New Classical Economics and Rational Expectations

- The Rational Expectations revolution led by Lucas, Sargent, Wallace and others held that agents had rational expectations of future endogenous variables; they did not make systematic forecast mistakes.
- If agents have rational expectations, the forecast error $\epsilon = E_{t-1}\pi_t - \pi_t$ should be mean zero, i.e., the unconditional expectation, $E[\epsilon] = 0$.
- In that case, output is at the natural rate and the Phillips curve is vertical at that level.

The Policy Ineffectiveness Debate (1980s)

- A consequence of Rational Expectations together with instantaneous market clearing was that government fiscal or monetary policies could have no impact on output or employment. As Lucas suggested, monetary policy could have real effects only to the extent that its impact on prices was unanticipated.
- Perfectly foreseen changes in monetary policy would induce rational wage and price setters to instantaneously adjust wages and prices proportionately so as to leave output and employment constant.
- However, this policy ineffectiveness proposition conflicts with empirical VAR evidence on the efficacy of monetary policies on real activity and indeed, with the aim of central bankers to affect economic outcomes.
- A reaction to this proposition has been the development in the 1990s-present of micro-founded "New Keynesian" models in which prices and wages do not instantaneously adjust so that there is a role of macroeconomic policies.

How to Model Sluggish Price Adjustment?

- Several approaches.
- Akerloff and Yellen (*QJE*, *AER* 1985) suppose that some monopolistically competitive firms use rule-of-thumb pricing strategies in which they keep prices constant following a demand shock; these near-rational agents's losses are small (second-order) compared with the optimal strategies (the profit function is flat in a neighborhood of the optimum own price). In the aggregate however, with lots of such monopolistically competitive firms, changes in the money supply can have large (first-order) real effects
- Taylor (1979,1980) supposes that wage/price contracts are staggered between two groups of firms, who maintain fixed wage/prices for two periods. Prices are set optimally taking into account current and expected future prices.
- Calvo (1983) proposes the simpler and more tractable assumption that each period, a certain fraction of firms is able to set its own price, which it does taking into account the expected average market price and future expected demand.

Taylor's Staggered Contracts Model

- N firms, N periods. Every period $1/N$ firms sets wages for N periods.
- Assume $N = 2$ for simplicity. Group 1 firms set wages in odd periods, group 2 in even period. Wages set at t last for two periods, t and $t + 1$
- x_t is the log of the wage rate set in period t.
- Wage setting takes account of the two period horizon over which wages will be unchangeable.

Wage Setting

- Wages depend on lagged wage rates (set by the other group) and still in effect at time t.
- It depends on expected wage rates at $t+1$, Ex_{t+t}.

It also depends on excess demand, which is modeled as the excess of output at time t over the full employment level, $\overline{y}$:

$$x_t = 1/2(x_{t-1} + E_t x_{t+1}) + \gamma(y_t - \overline{y}), \quad \gamma > 0. \tag{1}$$

A Short-Run Expectations Augmented Phillips Curve

- Output is produced using only labor. Full employment output $\overline{y}$.
- Firms are assumed to set prices as a mark-up over marginal costs, in this case wages, implying that the log of the price level is given by:

$$p_t = 1/2 \sum_{i=0}^{1} x_{t-i}. \tag{2}$$

- Let $\pi_t = p_t - p_{t-1}$.
- Using that definition and manipulating (1-2) we get:

$$\pi_t = E_t \pi_{t+1} + \gamma(y_t + y_{t-1} - 2\overline{y}) \tag{3}$$

which resembles a Phillips curve type trade–off. But notice: inflation depends on *expected future* inflation (not current inflation) and the output gap.

Calvo (*JME* 1983) Pricing

- Taylor's approach involves aggregation of firm pricing decisions in a deterministic fashion which can become tedious. A short-cut, introduced by Calvo (1983) is to assume that in any given period each firm has a constant probability, θ of being able to adjust its prices.
- Calvo's analysis was in continuous time. Here I present an exposition in discrete time following Roberts, *JMCB* (1995).
- Assuming a continuum of monopolistically competitive firms, θ is the fraction of firms that cannot change prices in each period.

Calvo (1983) Pricing, Continued

- The price that would maximize a firm's profit at a moment in time (its desired price) is:

$$p_t^* = p_t + \alpha \tilde{y}_t \tag{4}$$

where p_t is the overall price level and $\tilde{y}_t$ is the output gap $(y_t - \overline{y})$

- If only fraction θ firms can adjust prices each period, they take this into account. The price they set is:

$$z_t = \theta E_t \sum_{j=0}^{\infty} (1-\theta)^j p_{t+j}^* \tag{5}$$

- The overall price level p_t is assumed to be the average of all prices:

$$p_t = \theta \sum_{j=0}^{\infty} (1-\theta)^j z_{t-j} \tag{6}$$

Solving the System

- $$\begin{aligned} z_t &= \theta E_t \sum_{j=0}^{\infty} (1-\theta)^j p^*_{t+j} \\ &= \theta E_t \frac{1}{1-(1-\theta)F}(p_t + \alpha \tilde{y}_t). \end{aligned}$$

  where F is the forward operator.
- Since $z_t = E_t z_t$, we can write:

$$\begin{aligned} [1-(1-\theta)F]E_t z_t &= \theta E_t(p_t + \alpha \tilde{y}_t) \\ \text{or} \quad z_t &= \theta(p_t + \alpha \tilde{y}_t) + (1-\theta)E_t z_{t+1}. \end{aligned} \tag{7}$$

Solving the System, Continued

- Similarly,

$$\begin{aligned} p_t &= \theta \sum_{j=0}^{\infty} (1-\theta)^j z_{t-j} \\ &= \theta \frac{1}{1-(1-\theta)L} z_t, \end{aligned}$$

where L is the lag operator.

$$\begin{aligned} [1-(1-\theta)L]p_t &= \theta z_t \\ \text{or} \quad p_t &= \theta z_t + (1-\theta)p_{t-1} \end{aligned} \tag{8}$$

Another Version of the New Keynesian Phillips Curve

- Let $\pi_t = p_t - p_{t-1}$
- Using that definition and combining 7-8 yields

$$\pi_t = \beta \tilde{y}_t + E_t \pi_{t+1}$$

where $\beta = \alpha\theta^2/(1-\theta)$.

- Inflation depends positively on the output gap and future expected inflation.
- Indeed, iterating this forward, we see that inflation is a function of all future output gaps:

$$\pi_t = \beta \sum_{s=0}^{\infty} E_t \tilde{y}_{t+s}$$

Discussion

- So what's the big difference?
- Neoclassical Expectations Augmented Phillips Curve

$$\pi_t = E_{t-1}\pi_t + \alpha(y_t - \overline{y})$$

- New Keynesian Phillips Curve

$$\pi_t = E_t\pi_{t+1} + \beta(y_t - \overline{y})$$

- So the difference is just forward expectations of inflation! But this matters a lot, since, under rational expectations, π_t need not equal $E_t\pi_{t+1}$, so y_t need not equal $\overline{y}$.
- Hence, there can be a role for policy (more on this next week).

Critiques

- Several critiques of the New Keynesian Phillips Curve have been made and are summarized in Mankiw's (2001) paper.
- Perverse dynamics: Inflation is expected to go down in a boom (Ball 1994). Suppose $\tilde{y}_t > 0$, so output is above trend. Then we must have $\pi_t > E_t \pi_{t+1}$. But this is of course inconsistent with the natural rate of unemployment a.k.a. the non-accelerating inflation rate of unemployment.
- Another view of Ball's argument (Mankiw 2001) Interest rate hikes by the central bank are expansionary. If credible, they would imply $E_t \pi_{t+1} < \pi_t$, which can only occur if $\tilde{y}_t > 0$.

More critiques

- Lack of persistence: The NK Phillips curve,

$$\pi_t = \beta \tilde{y}_t + E_t \pi_{t+1}$$

does not involve lagged inflation π_{t-1} so the only persistence in inflation comes via output, $\tilde{y}_t$. But this is inconsistent with the degree of autocorrelation in inflation processes as shown by Fuherer and Moore (1995).

- In particular, let $\epsilon_t = \pi_t - E_{t-1}\pi_t$. We can rewrite the NK Phillips curve as

$$\pi_t = \pi_{t-1} - \beta \tilde{y}_{t-1} + \epsilon_t$$

which implies a *negative* correlation between the rate of change in inflation and the lagged output gap. But as Fuherer and Moore (1995), Gali and Gertler (*JME* 1999) show, this correlation is in fact positive in the data.

- From Gali and Gertler (1999): $\pi_t = 0.081(.040)\tilde{y}_{t-1} + \pi_{t-1} + \epsilon_t$.

Hybrid versions may fit the data better

- Many have considered a simple-fix hybrid model:

$$\pi_t = \phi\pi_{t-1} + (1-\phi)E_t\pi_{t+1} + \gamma\tilde{y}_t$$

though it does not fit the data much better.

- May be due to mis-measurement of the output gap. Standard assumption is that equilibrium real marginal cost to a firm (reciprocal of the mark-up) is stationary; in log-terms

$$mc_t = \kappa\tilde{y}_t$$

- The marginal cost version of the NK Phillips curve is:

$$\pi_t = E_t\pi_{t+1} + \lambda mc_t.$$

- If movements in marginal cost lag movements in output, an extra real rigidity comes into play that may cause problems.
- Gali and Gertler estimate the marginal cost version and get an estimate of λ that is significantly positive, consistent with the NK theory.

The Persistence Puzzle??

- Still unsolved.
- Promising avenue: real rigidities (as in Gali an Gertler (1999), Ireland (2003), others)
- For instance, a firm that raises its price lowers the demand it faces, and there may be persistence to this demand reduction in the form of a lowered market share in future periods when prices cannot be adjusted.
- Other approaches: limits to agents' information absorption capabilities (Amato and Shin (2003), Woodford (2003); coordination problems (Driscoll and Holden (2003)).

Failure of the Natural Rate Hypothesis

- The natural rate hypothesis is that the output gap is, on average, zero:

$$E[y - \overline{y}] = 0$$

  Real business cycle models satisfy this assumption as markets clear instantaneously every period.

- By contrast, consider the specification of the New Keynesian Phillips Curve:

$$\pi_t = bE_t\pi_{t+1} + \lambda\tilde{y}_t$$

  In a steady state, $E[\tilde{y}] = \frac{1-b}{\lambda}\overline{\pi}$.

- It follows that the output gap will vary directly with the stationary level $\overline{\pi}$ of the inflation rate in violation of the natural rate hypothesis.

Indexation as a Solution?

- A slightly different version of Calvo pricing (Yun (1996)) has all prices indexed to the steady state inflation rate.

$$\pi_t = b_0 + b_1 E_t \pi_{t+1} + \lambda \tilde{y}_t$$

- In a steady state,

$$E[\tilde{y}] = \frac{1}{\lambda}(-b_0 + (1 - b_1)\overline{\pi})$$

- But setting $b_o = (1 - b_1)\overline{\pi}$ indexation to steady state inflation appears to restore the natural rate hypothesis.
- But, this is a rather static assumption.

Evidence on Price Adjustment

- How frequently do firms adjust prices?
- In the Calvo set-up, fraction θ of firms get to reset their prices each period. Since the probability of re-setting prices is i.i.d for each firm, the average number of periods between price changes is $1/\theta$.
- Initial estimates, e.g. as reported in Taylor (1999) assumed this frequency to be equal to one year based on some early studies. This implies that in a model using quarterly data prices are adjusted on average every four periods so $\theta = .25$.
- Sbordone (JME 2002) seeks to fit an estimated version of a New Keynesian model to aggregate data and shows that this implies a θ of .33, or an adjustment every 3 quarters.
- More recent micro-level BLS data, (Bills and Klenow (2004) however, suggests that price adjustment is even more frequent, every 4.3 months, implying that in a quarterly model, we should have $\theta = .70$. This is much closer to the fully flexible pricing model, $\theta = 1$!

Inflation Persistence in the Micro Data

- Bils and Klenow (*JPE* 2004) consider inflation persistence at the micro-level data.
- If the average log price of good i is given by:

$$p_i t = (1-\theta) p_{i,t-1} + \theta mc_{i,t}$$

The implied inflation process is:

$$\pi_i t = (1-\theta) \pi_{i,t-1} + \theta \epsilon_{i,t}$$

where $\epsilon_{i,t}$ is the growth rate of the marginal cost of good i, taken to be a random walk.

- If price changes are highly infrequent, so that θ is near 0, then there should be high persistence in inflation of good i.
- Their empirical strategy is to compare frequency of price adjustments with inflation persistance ρ measured via an AR(1) model for the hundreds of goods in their sample.

Findings

- Correlation between frequency of price adjustments θ (λ in their paper) and inflation persistence ρ is significantly positive in one subsample, counter to Calvo/Taylor pricing model predictions.

TABLE 4
AGGREGATE AND SECTORAL MONTHLY INFLATION RATES

Variable	Short Sample (January 1995 to June 2000) (1)	Long Sample (January 1959 to June 2000) (2)
	A. Aggregate of 123 Sectors	
ρ	.20 (.13)	.63 (.03)
σ_ϵ	.22	.22
	B. Across $i = 1, \ldots, 123$ Sectors	
Mean ρ_i	−.05 (.02)	.26 (.02)
Mean $\sigma_{\epsilon,i}$	.83 (.08)	.91 (.07)
Correlation between ρ_i and λ_i	.26 (.09)	−.06 (.09)
Correlation between $\sigma_{\epsilon,i}$ and λ_i	.68 (.07)	.52 (.08)

NOTE.—dp_t is the first difference of p_t, where p_t is the log of the price deflator. $dp_t = \rho dp_{t-1} + \epsilon_t$, where ϵ_t is i.i.d. with standard deviation σ_ϵ; so the standard deviation of dp_t is $[\sigma_\epsilon^2/(1-\rho^2)]^{1/2}$, which equals 0.19 for the short sample and inflation and 0.27 for the long sample. $dp_{it} = \rho_i dp_{it-1} + \epsilon_{it}$, where ϵ_{it} is i.i.d. with standard deviation $\sigma_{\epsilon,i}$; so the standard deviation of dp_{it} is $[\sigma_{\epsilon,i}^2/(1-\rho_i^2)]^{1/2}$. The 123 sectors represent 68.3 percent of the 1995 consumer expenditures, and each sector is weighted by its expenditure share. Standard errors are in parentheses.

Summary:

- Phillips curve - the New Keynesian version - is back in vogue.
- It differs from the Expectations augmented Phillips curve in having forward expectations.
- It can be rationalized by a microfounded model in which firms adjust prices only infrequently.
- It allows for sluggish price adjustments and thus a role for policy.
- However, some of its predictions seem pathological.
- Furthermore, empirical support for it seems weak at both the macro and micro data levels.
- Next week we will combine the New Keynesian Phillips curve (supply side) with an intertemporal IS curve that determines the output gap (demand side).