More on price setting, and policy implications.

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*14.452. Spring 2002. Topic 8. Due to time, these notes are even more sketchy than for the previous topics.

1 Staggering of price decisions, and inflation

The model we saw in topic 7 captured the fact that prices are typically set for some time. But it dit not capture the fact that prices are unlikely to be all set at the same time.

Staggering of price (and wage) decisions is important. If a price setter does not want to move his relative price very much, then, when it is his turn to change the price, he will change it only by a small amount. By symmetry, so will everybody else, when their turn comes. The price level will adjust slowly.

Given time constraints, I shall not cover these issues in much detail. Read my Handbook chapter, or sections 8-2 and 10-5 in BF. (Relative to BF, there has been substantial progress in solving for the behavior of the price level with state contingent rules. See the work by Ricardo Caballero).

Let me just derive the Calvo specification here:

1.1 Price setting

Start from the basic equation for the relative price chosen by price setter i in the models of topic 7:

$$\frac{P_i}{P} = Y^a$$

(In the model of topic 7, $a \equiv (\beta - 1)/(1 + \sigma(\beta - 1))$. So, the closer β is to 1, the closer a is to zero.)

Take logs, use lower case letters, so:

$$p_i = p + ay$$

This gives the desired (log) price. Suppose however that, every period, only a proportion $1 - \delta$ of price setters is allowed to change their price, and the price remains in effect with probability δ every period.

(This simple "Poisson" assumption may not be very realistic. But it captures the notion that prices are adjusted at different times, and allows for simple aggregation).

For notational convenience, denote by q_t the (log) nominal prices set in period t, and by p_t the (log) price level. Then, assume the behavior of q_t and p_t is characterized by:

$$q_t = (1 - \delta\beta) \sum_0^{\infty} \beta^k \gamma^k \ (Ep_{t+k} + aEy_{t+k})$$

$$p_t = (1 - \delta) \sum_0^{\infty} \delta^k \ q_{t-k}$$

- The price chosen in period t depends on all future expected desired prices, with weights corresponding to the probability that the price is still in place at each future date, and a discount rate, γ.
- The price level is then a weighted average of current and past individual prices, still in place today.
- The interpretation of y_t is as the proportional deviation of output from its flex price natural level this period.

You can give different interpretations to q. Sometimes, it can be interpreted as the wage chosen by unions, and each price is then a markup on that wage.

How would the two equations look like if derived from an optimization problem of firms? More complicated, but not very different. Discounting a the proper interest rate. And various covariances. (See Michael Woodford, Chapter 3-2).

1.2 The behavior of the price level and inflation

To solve, rewrite the two equations as:

$$q_t = (1 - \delta\gamma)(p_t + ay_t) + \delta\gamma E q_{t+1}$$

$$p_t = (1 - \delta)q_t + \delta p_{t-1}$$

Subtract p_{t-1} from both sides in the second equation:

$$(p_t - p_{t-1}) = (1 - \delta)(q_t - p_{t-1})$$

Subtract p_{t-1} from both sides in the first equation and rearrange:

$$(q_t - p_{t-1}) = (p_t - p_{t-1}) + (1 - \delta\gamma)ay_t + \delta\gamma(Eq_{t+1} - p_t)$$

Using the previous equation to eliminate $q_t - p_{t-1}$ and $Eq_{t+1} - p_t$ and rearranging:

$$(p_t - p_{t-1}) = \frac{(1 - \delta)(1 - \delta\gamma)}{\delta} ay_t + \gamma(Ep_{t+1} - p_t)$$

Or, defining $\pi_t = p_t - p_{t-1}$:

$$\pi_t = \frac{(1 - \delta)(1 - \delta\gamma)}{\delta} ay_t + \gamma E\pi_{t+1}$$

This says that inflation depends on the current output gap, and expected inflation. Note some implications:

- Staggering leads to **price stickiness**. This is clear from the next to last equation, in which the price level at time t depends on the price level at time $t - 1$, and the expected price level at time $t + 1$, with roughly equal weigths.

- The smaller a, the more slowly prices adjust. This is known in the literature as "real rigidities". A small desired response of the relative price implies a slow adjustment of the price level.

(A follow up on the discussion in class. If we think of a as coming from from the slope of the marginal utility of leisure, a is likely to be quite big, and therefore to lead to rapid price adjustment. To get slow adjustment of prices, we require a low value of a. This has led a number of researchers to explore alternative descriptions of the labor market. More on this in 14.454.)

- There is however no stickiness in inflation. Inflation is fully forward looking. Indeed, can solve it to get:

$$\pi_t = \frac{(1-\delta)(1-\delta\gamma)}{\delta} \sum_0^{\infty} E y_{t+i}$$

  Inflation depends on current and expected output gaps, not (directly) on the past.

- Both a very nice and a rather unpleasant result. Unpleasant because it does not fit the facts. The evidence:

  The Phillips curve today in the U.S:

$$\pi_t = \pi_{t-1} - \alpha(u_t - u_n)$$

  Very backward looking. Inertia. Dispositive? No. Past inflation could proxy for future inflation. u_n difficult to measure.

  More convincing: The reaction to a monetary contraction. Inflation should decrease in advance of the output gaps. The evidence is that we see first the decline in output/increase in unemployment, then the decrease in inflation. (Mankiw Reis)

- How to reconcile?

  More complex/realistic staggering? Not obvious that it can work.

  Non rational expectations? Information lags? Mankiw Reis.

- For the time being, the equation above has become a work horse, but be aware that it appears not to fit the data in important dimensions.

  The New Keynesian model:

$$y_t = -a(i_{t+1} - E\pi_{t+1}) + Ey_{t+1}$$

$$m_{t+1} - p_t = by_t - ci_{t+1}$$

$$\pi_t = dy_t + \gamma E\pi_{t+1}$$

2 The liquidity trap

Output Growth, Unemployment, Inflation, and the Nominal Interest Rate, Japan, 1990–2001

Year	Output Growth Rate (%)	Unemployment Rate (%)	Inflation Rate (%)	Short term Rate
1990	5.3	2.1	2.4	7.7
1991	3.1	2.1	3.0	7.4
1992	0.9	2.2	1.7	4.5
1993	0.4	2.5	0.6	3.0
1994	1.0	2.9	0.1	2.2
1995	1.6	3.1	–0.4	1.2
1996	3.5	3.4	–0.8	0.6
1997	1.8	3.4	0.4	0.6
1998	–1.1	3.4	–0.1	0.7
1999	0.8	4.1	–1.4	0.2
2000	1.5	4.7	–1.6	0.2
2001	–0.7	5.0	–1.6	0.1

Source: OECD Economic Outlook, December 2001.

An increase in nominal money has essentially no effect on the short term nominal interest rate. Can monetary policy be used? Depends on the behavior of inflation.

- The liquidity trap view. Put i_t equal to zero (cannot go lower), and use a backward looking Phillips curve:

$$y_t = aE\pi_{t+1}) + Ey_{t+1}$$

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

The properties of this system are strange. Get a better sense by dropping the expectation of future output in the IS relation: Then, get:

$$\pi_{+1} = \frac{1}{1 - ad}\pi_t$$

When deflation comes, output goes down, leading to more deflation, and so on.

- The forward looking view. Create expected inflation, through a commitment to higher money growth. (Or through the nominal exchange rate).

  Not obvious. Take our system again, this time under rational expectations, and $i_t = 0$, so:

$$y_t = aE\pi_{t+1} + Ey_{t+1}$$

$$\pi_t = dy_t + \gamma E\pi_{t+1}$$

  Drop again future output from the first equation, and replace in the second equation:

$$\pi_t = (ad + \gamma)E\pi_{t+1}$$

  This is also not good news. If $ad + \gamma > 1$ (which is likely given γ is close to one), then any initial inflation rate is now a solution....

  No connection to money growth... Is there another equilibrium? where money growth leads to expected inflation, so to higher output, so to a positive nominal interest rate, and so we are out of the liquidity trap?

  In practice, need to shape expectations. (If there is an exchange rate, more room, but still an indeterminacy issue. The route that Japan appears to be taking).

3 Inflation targeting

How to think of it? Why it makes sense even if one cares primarily about output.

Back to the price equation, allowing for movements in the flex price, or **natural level of output**:

$$\pi_t = d(y_t - y_{nt}) + \gamma E\pi_{t+1}$$

Note that, in this class of models (and probably in the real world, judging from the experience of Europe), y_{nt} need not be constant, or even slow moving.

This relation has a number of important implications.

- Suppose monetary policy is designed to achieve $\pi_t = \pi^*$. Then, $E\pi_{t+1} = \pi^*$, and successful inflation targeting leads to $y_t = y_{nt}$. So, inflation targeting is equivalent to trying to keep output at its (changing) natural level.

  So, in fact, if done right, very much output oriented. But with a nominal anchor.

- Obvious that the target should be the natural level of output? Not necessarily. For example, if a shock leads to a larger distortion and so a larger distance between the first best and the natural levels of output, then it may be worth trying to achieve a higher level of output this period.

- If the equation is instead given by:

$$\pi_t = d(y_t - y_{nt}) + \gamma E\pi_{t+1} + \epsilon_t$$

Then, there is clearly a trade-off between trying to stabilize inflation and keeping output close to the natural rate.

These shocks play an important role in the discussion of optimal monetary policy. See for example the survey by Clarida, Gali and Gertler on the reading list.

But what are these shocks? Shocks to the price of oil for example will show up as a change in y_{nt}, not as a shock to ϵ_t. In effect, they have to be pricing "mistakes.". Not obvious how important they are.