Econ 314

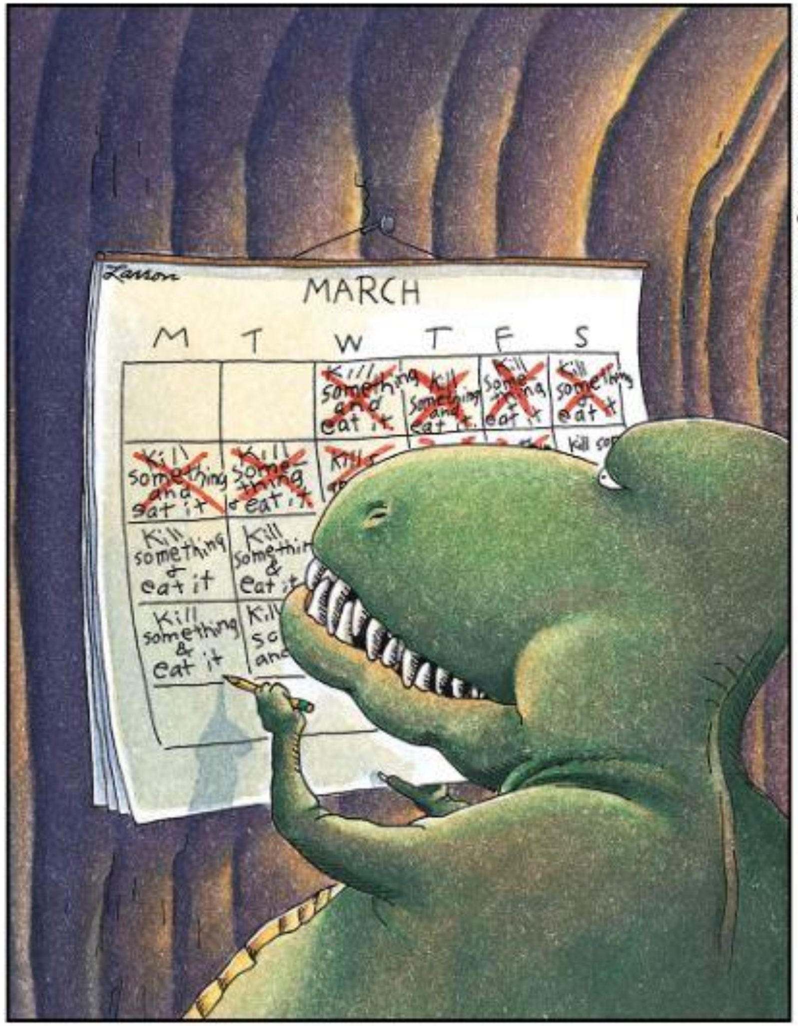
Friday, April 10
Taylor and Calvo Models of Price Adjustment

Reading: Romer’s Section 7.3 and 7.4

Coursebook: Chapter 12 (relevant sections)

Class notes: Pages 126 - 129

Today’s Far Side offering



Jurassic calendars

My calendar has a lot less on it these days, but it’s not *quite* this boring!

Context and overview

- **Fischer's predetermined-price model** showed that monetary policy could help stabilize economy even with rational expectations
- **Taylor's fixed-price model** also has two-period overlapping contracts, but same price must be set for both periods
  - Dynamics are more complex
  - Unexpected monetary shocks have long-lasting effects on output, dying away slowly
- **Calvo's probabilistic price adjustment model** is simpler to solve, has implications that seem realistic, and is now most commonly used

What are the costs of price adjustment

- If costs relate to how often prices are **set**, Fischer model is appropriate: two-period contracts avoids frequent price setting
    - Example: setting wages in union contracts with possibility of damaging strike if negotiations break down
- If costs relate to how often prices **change**, then Taylor model is more appropriate: two-period contracts with **same price** avoids menu costs
- Taylor framework: **Same price** $x_t = p_t^1 = p_{t+1}^2$ for both periods

Pricing dynamics in Taylor model

t	1	2	3	4	5	6
Group A	x_1	x_1	x_3	x_3	x_5	x_5
Group B	x_0	x_2	x_2	x_4	x_4	x_6
p_t	$\frac{x_0 + x_1}{2}$	$\frac{x_1 + x_2}{2}$	$\frac{x_2 + x_3}{2}$	$\frac{x_3 + x_4}{2}$	$\frac{x_4 + x_5}{2}$	$\frac{x_5 + x_6}{2}$

- Different information assumption: **Agents know m_t before setting x_t**
- In terms of dynamic pricing model: $q_0 = 1, q_1 = 1$ and $\omega_0 = \omega_1 = \frac{1}{2}$
- Optimal price setting: $x_t = \frac{1}{2}\left(p_t^* + E_t p_{t+1}^*\right)$

Substituting …

- **Optimal price** for each period is again $p_t^* = \phi m_t + (1-\phi)p_t$
- Substituting gives

$$x_t = \tfrac{1}{2}\left[\left(\phi m_t + (1-\phi)p_t\right) + \left(\phi E_t m_{t+1} + (1-\phi)E_t p_{t+1}\right)\right]$$

- Let ***m_t* be a random walk** with white-noise shock u_t:

$$m_t = m_{t-1} + u_t \text{ and } E_t m_{t+1} = m_t \text{ because } E_{t-1}u_t = 0$$

- Leads to solution

$$x_t = \frac{2\phi}{1+\phi} m_t + \tfrac{1}{2}\frac{1-\phi}{1+\phi}\left(x_{t-1} + E_t x_{t+1}\right)$$

- **Second-order difference equation** in x, plus expectation

Intuition of solution

- Key difference from Fischer model: **x_t competes with both x_{t-1} and x_{t+1}**
- Dynamics will be both **forward-looking and backward-looking**
- AD shock at $t = 1$: x_1 will not fully adjust to compete with x_0
- x_2 will not fully adjust to compete with x_1; x_3 will not fully adjust to compete with x_2; and so on

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p_t	$\frac{x_0 + x_1}{2}$	$\frac{x_1 + x_2}{2}$	$\frac{x_2 + x_3}{2}$	$\frac{x_3 + x_4}{2}$	$\frac{x_4 + x_5}{2}$	$\frac{x_5 + x_6}{2}$

Long-lasting effects of AD shocks

- Unlike Fischer model, real effects of **AD shock last longer** than the longest contract
- Formal solution:

$$y_t = \lambda y_{t-1} + \tfrac{1}{2}(1+\lambda)u_t \text{ with } \lambda = \frac{1-\sqrt{\phi}}{1+\sqrt{\phi}} < 1$$

- No real rigidity → $\phi = 1$ and $\lambda = 0$ → immediate adjustment to u
- More real rigidity → smaller ϕ, larger λ and more persistence in y
- Taylor model implies that real effects of AD shocks have long tails, **dying out exponentially over** time

Calvo model of probabilistic price adjustment

- No fixed-length contracts
- **Randomly selected fraction α of firms reset** prices each period; others keep previous price
- Those setting prices **set x_t by similar rule** as in Taylor model
- Price is weighted average of those changing and those not:

$$p_t = \alpha x_t + (1-\alpha)\, p_{t-1}$$

- The simplicity of this equation is what makes this model easy

Setting x_t

- Romer brings back discount factor β because of possible long duration of prices
- Probability that today's price lasts t periods: $q_t = (1-\alpha)^t$
- Weights now reflect β: $\omega_t = \dfrac{\beta^t q_t}{\sum_{\tau=0}^{\infty} \beta^\tau q_\tau}$
- Denominator is $\sum_{\tau=0}^{\infty} \beta^\tau q_\tau = \sum_{\tau=0}^{\infty} [\beta(1-\alpha)]^\tau = \dfrac{1}{1-[\beta(1-\alpha)]}$ so $\omega_t = [1-\beta(1-\alpha)]\beta^t (1-\alpha)^t$
- **Optimal price** to set is $x_t = \sum_{\tau=0}^{\infty} \omega_\tau E_t p^*_{t+\tau} = [1-\beta(1-\alpha)] \sum_{\tau=0}^{\infty} [\beta(1-\alpha)]^\tau E_t p^*_{t+\tau}$

Solution

- Details are in Romer and on pp 128-129 of notes
- Substitution gives $x_t = \left[1-\beta(1-\alpha)\right]p_t^* + \beta(1-\alpha)E_t x_{t+1}$
  - Today's dynamic optimal price to set is weighted average between today's static optimal *p* and next period's dynamic optimal *x*
  - Higher α or lower β increases weight attached to current period
- Putting this in terms of the inflation rate,

$$\pi_t \equiv p_t - p_{t-1} = \alpha x_t + (1-\alpha)p_{t-1} - p_{t-1} = \alpha\left(x_t - p_{t-1}\right)$$

- Substituting and algebra give us

$$\pi_t = \frac{\alpha}{1-\alpha}\left[1-\beta(1-\alpha)\right]\phi y_t + \beta E_t \pi_{t+1} \equiv \kappa y_t + \beta E_t \pi_{t+1}$$

New Keynesian Phillips curve

$$\pi_t = \kappa y_t + \beta E_t \pi_{t+1}$$

- Can be thought of as **Phillips curve or SRAS curve**
- $\kappa = \frac{\alpha}{1-\alpha}\left[1-\beta\left(1-\alpha\right)\right]\phi y_t > 0$ so inflation is increasing in output
- If $\beta \approx 1$, then expected inflation leads to one-for-one increase in actual inflation
  - Note that this is forward-looking inflation expectation, not backward
  - This is different from contract models that had $E_{t-1}p_t$
- Otherwise similar to Lucas, Friedman-Phelps Phillips curve, and contract models: $y > 0$ when $p > E(p)$

State-dependent pricing

- Romer discusses two models of **state-dependent pricing** in Section 7.5
- Decision to change price depends on current p vs. p^* rather than fixed timing or random chance
  - Firms whose price is far from current optimal price are more likely to adjust
- Perhaps more realistic, but definitely analytically more difficult
- We don't have time to discuss in detail
  - **Caplin-Spulber model** describes world on ongoing, smooth inflation
  - **Danziger-Golosov-Lucas model** has richer set of shocks

Review and summary

- In **Taylor fixed-price model**, firms set same price for both periods of contract
  - Unanticipated AD shocks have real effects that die away slowly
  - Correspondingly, price adjustment is gradual
- In **Calvo model**, a share α of (randomly selected) adjust price each period
  - Leads to new Keynesian Phillips curve with inflation depending on output and expected future inflation
- **State-dependent pricing models** allow the decision to adjust price to depend on how far price is from optimal price

Know your professor?

Which one of the following statements is true?

a. I played in a rock band in high school.
b. I have webbed toes.
c. My wife was 14 when we started dating.
d. I have performed in both New York's Macy's Thanksgiving Parade and Pasadena's Tournament of Roses Parade.
e. My first car had 3 cylinders.
f. All of the above are true.

What's next?

- We now have several models of dynamic price-setting with predictions about effects of AD shocks on output and prices
- In the next class (April 13) we consider the phenomenon of **inflation inertia**, which is not well explained by any of these models
- We will introduce two variations on the Calvo model that can explain why inflation has inertia
  - **Christiano, Eichenbaum, and Evans**
  - **Mankiw and Reis**
- We will also briefly discuss new Keynesian DSGE models