

Monetary Economics

Sticky Wages and Prices

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February 2021

Outline

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- 2 Theories of Sticky Wages
- 3 Time and State Dependent Price Setting
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Labor Demand, Supply and Real Wages

- There is a general problem with sticky wages that must be finessed to get increases in employment
- In general, as in Friedman's model, increased employment requires that
 - ▶ Employers perceive themselves to be paying less
 - ▶ Employees perceive themselves to be receiving more
- Suppose that the price level increases and the real wage decreases from its equilibrium level
 - ▶ Both firms and households know this
 - ▶ The quantity of labor demanded increases
 - ▶ The quantity of labor supplied decreases
 - ▶ The actual quantity of labor employed will be the lesser of the quantity demanded and supplied
 - ★ This assumes that there is no forced labor
 - ▶ The actual quantity of labor employed decreases

Labor Demand, Supply and Real Wages

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 - ▶ The actual quantity of labor employed will be the lesser of the quantity demanded and supplied
 - ★ This assumes that firms are not forced to hire more workers than they want to employ
 - ▶ The actual quantity of labor employed decreases
- If the initial real wage is not consistent with the quantities of labor demanded and supplied being equal, other results are possible

Sticky Wages I

- Suppose that nominal wages are set before anything else happens in a period
- Nominal wage this period need not be consistent with other aspects of equilibrium
- The nominal wage will reflect developments through period $t - 1$
- As Walsh shows, Section 2.5.3, Appendix 2.7.1 and 2.7.2 and 7.2.1, the output and employment part of the economy can be simplified to a linear approximation of percentage deviations around the steady state

$$y_t = a (p_t - E_{t-1} p_t) + (1 + a) \varepsilon_t \quad (1)$$

- where
 - ▶ $a = \frac{1-\alpha}{\alpha}$
 - ▶ α is the share of capital in the Cobb-Douglas production function
 - ▶ variation of capital is assumed to be unimportant and investment is zero
 - ▶ government purchases are zero

Sticky Wages II

- ▶ the quantity of labor employed is determined by the quantity of labor demanded
- ▶ all variables are percentage deviations from the steady state
 - ★ Note that percentage deviations from the steady state can be approximated by log deviations from the steady state for small deviations
- ▶ y_t is the log output deviation from the steady state log output
- ▶ p_t is the log price level deviation from the steady state log price level
- ▶ ε is the unexpected productivity(TFP) shock
- The nominal part of the economy can be summarized by the quantity equation if the interest elasticity of the demand for money is zero
- The demand for money is

$$m_t - p_t = y_t$$

which has an income elasticity of the demand for money equal to one

Sticky Wages III

- The supply of money is given by

$$m_t = \rho_m m_{t-1} + s_t$$

where s_t is the surprise part of the nominal quantity of money

- The demand for money and supply of money imply

$$\begin{aligned} p_t - E_{t-1} p_t &= (m_t - y_t) - (E_{t-1} m_t - E_{t-1} y_t) \\ &= (m_t - E_{t-1} m_t) - (y_t - E_{t-1} y_t) \end{aligned}$$

- Note that $m_t - E_{t-1} m_t = s_t$ by definition and $E_{t-1} y_t = 0$ because $E_{t-1} y_t = 0$ is the log deviation from the steady state
- Therefore

$$p_t - E_{t-1} p_t = s_t - y_t$$

Sticky Wages IV

- Substituting this equation into equation (1) yields

$$y_t = a(p_t - E_{t-1} p_t) + (1 + a) \varepsilon_t$$

$$y_t = a(s_t - y_t) + (1 + a) \varepsilon_t$$

$$(1 + a) y_t = a s_t + (1 + a) \varepsilon_t$$

$$y_t = \frac{a}{1 + a} s_t + \varepsilon_t$$

- Note that $\frac{a}{1+a} = 1 - \alpha$ and we get

$$y_t = (1 - \alpha) s_t + \varepsilon_t$$

$$y_t = (1 - \alpha) (m_t - E_{t-1} m_t) + \varepsilon_t$$

- Walsh interprets the size of this coefficient as sufficiently large that sticky wages and prices are more likely than imperfect information to be consistent with actual output behavior
- The effect of a money surprise here is $(1 - \alpha)$ which is about 2/3

Sticky Wages V

- Walsh interprets a similar linearized equation with imperfect information as reflecting a small effect of imperfect information
- This may be evidence for wage stickiness but
 - ▶ the results are based on employment being determined by labor demand with suppliers providing more labor than the supply curve indicates – unless the real wage is above the equilibrium real wage

Taylor's Theory of Staggered Nominal Wage Adjustment I

- Wages are set by contracts for two periods, half of possible contracts set each period
- The wage set in period t is x_t
- The wage set in period $t - 1$ is x_{t-1}
- The average wage faced by firms is $w_t = (1/2) (x_t + x_{t-1})$
- To get a connection to the price level, suppose that

$$p_t = w_t + \mu$$

$$\mu = 0$$

- Changes in the price level and the nominal wage are proportional
- Sometimes said that the “markup” of prices over wages is a constant proportion
- $\mu = 0$ is just a normalization

Taylor's Theory of Staggered Nominal Wage Adjustment II

- Taylor assumed that

$$x_t = \frac{1}{2} (p_t + E_t p_{t+1}) + ky_t$$

where k is a positive parameter and it is assumed that the wage set in period t increases with the level of output

- The price level is

$$\begin{aligned} p_t &= w_t \\ &= \frac{1}{2} (x_t + x_{t-1}) \\ &= \frac{1}{2} \left[\frac{1}{2} (p_t + E_t p_{t+1}) + ky_t + \frac{1}{2} (p_{t-1} + E_{t-1} p_t) + ky_{t-1} \right] \\ &= \frac{1}{4} [2p_t + E_t p_{t+1} + p_{t-1} + \eta_t] + \frac{k}{2} (y_t + y_{t-1}) \end{aligned}$$

where $\eta_t = E_{t-1} p_t - p_t$

Taylor's Theory of Staggered Nominal Wage Adjustment III

- and

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

- In terms of inflation $\pi_t = p_t - p_{t-1}$,

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

- The price level has persistence but the inflation rate depends on expected inflation

Costs of Price Changes I

- “Menu” costs are an example and a common term
- It costs something to change prices
- The general consensus seems to be that these costs are not high enough to explain observed price changes

Not-perfect Competition and Price Determination I

- Kenneth Arrow wrote a paper – “Toward a Theory of Price Adjustment” arguing that prices have to be set somehow
- If prices are not set in an auction of one sort or another by an auctioneer or auction rules, the buyer or seller has to set the price
- Implication: Industry cannot have perfect competition if firms are not price takers
- Arrow may well have not been the first to make this point
- Firms are price setters
- Armen Alchian created the term “price searchers” for firms that set prices, possibly with a large number of other firms producing the same product in similar circumstances
 - ▶ A firm is not certain about the right price
 - ▶ A firm can have costs of changing prices

Monopolistic Competition I

- Use imperfect competition as a way to introduce price setting
- By itself, this will not introduce real effects of monetary policy
- Prices are not equal to marginal cost but that is true no matter what monetary policy is
 - ▶ If output were produced by a monopoly producer, marginal revenue would equal marginal cost and an increase in the price level would be the same thing as an increase in the price of the product
 - ▶ Nominal wages would adjust and marginal revenue would equal marginal cost at the same quantity produced
- Monopolistic competition with sticky prices for intermediate goods allows for sticky prices and still allows for a single price for output
- So we introduce monopolistic competition among producers of intermediate goods
- Let Y_t be the output of the final good
- Let $Y_t(i)$ be the input of the intermediate good to produce the final good

Monopolistic Competition II

- The final good is produced by intermediate goods as in

$$Y_t = \left[\int_0^1 Y_t(i)^q di \right]^{\frac{1}{q}} \quad 0 < q \leq 1$$

- The market for the final good is perfectly competitive
- Firms maximize profits $P_t Y_t - \int P_t(i) Y_t(i) di$
- Standard manipulations generate a demand for each intermediate good given by

$$Y_t^d(i) = \left[\frac{P_t}{P_t(i)} \right]^{\frac{1}{1-q}} Y_t$$

- and the zero-profit condition for the firms producing final goods implies

$$P_t = \left[\int P_t(i)^{\frac{q}{q-1}} di \right]^{\frac{q-1}{q}}$$

Monopolistic Competition III

- Each intermediate good is produced by labor $L_t(i)$ and capital $K_t(i)$ with

$$Y_t(i) = K_t(i)^\alpha L_t(i)^{1-\alpha}$$

- The profits of each monopolistically competitive firm are given by

$$\Pi_t(i) = P_t(i)Y_t(i) - r_tK_t(i) - W_tL_t(i)$$

where r_t is the rental rate on capital and W_t is the nominal wage and can be rewritten as

$$\Pi_t(i) = [P_t(i) - P_t V_t] \left[\frac{P_t}{P_t(i)} \right]^{\frac{1}{1-q}} Y_t$$

where V_t is minimized unit cost of production

Monopolistic Competition IV

- The value of the price $P_t(i)$ that maximizes profits can be written

$$P_t(i) = \frac{P_t V_t}{q}$$

where $1/q$ is a constant "markup" over unit cost $P_t V_t$, $1/q > 1$

- The demand for labor by each intermediate goods producer is given by

$$\frac{W_t}{P_t(i)} = q \left[\frac{(1 - \alpha) Y_t(i)}{L_t(i)} \right]$$

where $\frac{(1-\alpha)Y_t(i)}{L_t(i)}$ is the marginal product of labor

- A symmetric equilibrium, roughly speaking, is one in which all similarly situated parties receive the same payoffs and behave similarly

Monopolistic Competition V

- In this context, a symmetric equilibrium implies

$$P_t(i) = P_t(j) \quad \forall i \text{ and } j$$

$$P_t(i) = P_t \quad \forall i$$

$$L_t = \frac{q(1-\alpha)Y_t}{W_t/P_t}$$

where $P_t(i) = P_t$ because output is just the combination of intermediate goods with no additional labor and capital

- This model implies that the marginal product of labor is greater than the real wage
- This model says nothing about sticky prices
- There is an issue with the underlying model, which has firms selling different products with no difference in inputs or marginal cost
 - ▶ Have to think of it as costless variation in the product
 - ▶ This issue applies to monopolistic competition generally

Time Dependent Setting of Prices – Calvo model I

- Taylor's model of price setting is an example of time-dependent setting of prices
- Half of firms adjust wage every period
- Each firm adjusts wages every other period
- The model most commonly used is the Calvo (1983) model
- Calvo assumes that firms do not adjust their prices continuously
- Each period there is a constant probability $1 - \omega$ that the firm can adjust its price
- The expected time between price changes is $1/(1 - \omega)$
- The interval between price changes for any individual firm is a random variable
- All firms that adjust their prices this period set the price P_t
- All firms that do not adjust are a random sample of all firms and their average price is P_{t-1}
 - ▶ The aggregate of all firms had a price P_{t-1} last period

Time Dependent Setting of Prices – Calvo model II

- ▶ Therefore the infinite number of randomly selected firms that do not adjust have a price P_{t-1} this period
- The price level this period will be

$$P_t = (1 - \omega)P_t^* + \omega P_{t-1}$$

where P_t^* is the optimal price set this period

- This equation does not directly include any expectations of future prices
- The optimal price does depend on expectations of future prices because there is a probability distribution of how many periods before the firm will be changing its price
- The inflation equation implied by Calvo pricing shows the dependence on the future more

Time Dependent Setting of Prices – Calvo model III

- Deviations of inflation from zero average inflation in a steady-state equilibrium are given by

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \hat{v}_t$$

where β is firms' common discount factor, $\kappa = \frac{(1-\omega)(1-\beta\omega)}{\omega}$ and \hat{v}_t is proportional deviations of real marginal cost around its steady state value

State Dependent Setting of Prices I

- Time dependent setting of prices is not obviously consistent with incentives firms have
- Tractable but incomplete
- If there is a bigger change in demand, the firm has a bigger incentive to change its price
- State-dependent models of price setting can be related to (S, s) models of inventory adjustment
- Below the upper boundary S and above the lower boundary s , no adjustment occurs
- Outside these boundaries, adjustments occur
- The failure to do anything within the boundaries reflects fixed costs of adjustment
 - ▶ Fixed costs in this context are costs that always exist if prices are changed and are independent of the size of the price change
- State-dependent models of price setting are more complicated than the Calvo model and therefore the Calvo model seems to be the model most commonly used in general equilibrium models with sticky prices

Summary I

- Prices have to be set somehow in an economy
- Price setting by buyers or sellers is the solution in some markets
- This does not necessarily imply that the firms are monopolies
- Relatively simple theories of price setting with tractable algebra are necessary for general equilibrium models of the economy
- Several tractable models have been proposed
- Many models of sticky nominal wages imply that increases in the price level and lower real wages increase employment even if quantity demanded equaled quantity supplied before
 - ▶ Can get around this by assuming that the real wage is above the equilibrium level
 - ▶ This is not very credible in the aggregate
- Taylor gets around it by having two-period contracts
- It is hard to have perfect competition and price setting in markets without auctions

Summary II

- ▶ Auctions do not characterize markets for most final goods and services, or even intermediate goods
- ▶ Monopolistic competition is a way to introduce price setting by firms without assuming that all firms are monopolies
- ▶ By itself, this does not introduce real effects of monetary policy
- The Calvo model – time dependent setting of prices by firms – does introduce real effects of monetary policy without multi-period contracts
 - ▶ A constant fraction of firms is randomly chosen to change prices each period but other firms do not change their prices
 - ▶ There is no economic explanation of why this price-setting mechanism exists