Competitiveness, Market Power and Price Stickiness: A Paradox and a Resolution

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Abstract

Are prices less sticky when markets are more competitive? Our intuition would naturally lead us to give an affirmative answer to that question. But we first show that DSGE models with staggered price or wage contracts have actually the opposite and paradoxical property, namely that price stickiness is an increasing function of competitiveness. To eliminate this paradox, we next study a model where monopolistic competitors choose prices optimally subject to a cost of changing prices as in Rotemberg (1982a,b). For a given cost function, we find the more intuitive result that more competitiveness leads to more flexible prices.

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1 Introduction

Is there a connection between competitiveness, market power and the “stickiness” of prices\textsuperscript{1}? This is an old question and, as early as 1935, Gardiner Means noted that, in the face of the general slump, prices were falling less in sectors with high market power.

Recently price or wage rigidities have been successfully introduced into dynamic stochastic general equilibrium (DSGE) models\textsuperscript{2}. The corresponding models succeed in reproducing the persistent response of output and inflation found in the data. Modelling nominal rigidities has notably taken the form of staggered wage or price contracts à la Taylor (1979, 1980) or Calvo (1983).

It is possible to answer in such a framework our question on competitiveness, since these models include a parameter which explicitly depicts the degree of competitiveness, more specifically the elasticity of substitution between goods. But the answer to our question is highly paradoxical since, as we shall see below, in models with staggered price contracts, one finds that more competitiveness leads to more sticky prices.

The intuition is easy to grasp if one goes to the extreme case of perfectly substitutable goods, corresponding to a competitive market. Consider to simplify a Taylor model with two periods contracts. In any period $t$ half of the agents renew their contract. Because of perfect substitutability these agents will have to align their price on the lowest price set in $t-1$ (which still holds, since the contracts last 2 periods). And for the same reason so will agents in period $t+1$. By that time all prices will be the same and, continuing the same reasoning, all future prices will be equal to that price also, so that prices are totally sticky irrespective of the shocks to which the economy may be subjected. So full competitiveness leads to complete stickiness of prices in that model.

Clearly this result is quite counterintuitive and our intuition would rather lead us to believe that more competitive markets should lead to more flexible, less sticky, prices.

So in a second step we want to construct a model where more competitiveness leads to more flexible prices. For that we shall use a different model

\textsuperscript{1}By more sticky prices we will mean prices that return more slowly to their market clearing value. In what follows prices will have an autoregressive root, denoted below as $\phi$, and stickiness will be measured by the size of that root.

of price stickiness proposed by Rotemberg (1982a,b), where prices are sticky because there is a cost of changing prices, measured by an explicit convex cost function. We shall show that, for a given cost function, the “flexibility” of prices increases with competitiveness.

2 The model

2.1 The agents

Households have an intertemporal utility function:

\[ U = \sum \beta^t \left[ \log C_t + \sigma \log \left( \frac{M_t}{P_t} \right) - \xi \frac{L_t}{\nu} \right] \quad \nu > 1 \]  

and are submitted in each period to a budget constraint:

\[ P_tC_t + M_t = W_tL_t + \Pi_t + \mu_tM_{t-1} \]  

where \( \mu_t \) is a multiplicative money shock à la Lucas (1972) and \( \Pi_t \) is distributed profits.

Output is produced with intermediate goods indexed by \( j \in [0,1] \) by competitive firms. They all have the same constant returns to scale production function:

\[ Y_t = \left( \int_0^1 Y_{jt}^\theta dj \right)^{1/\theta} \quad 0 < \theta \leq 1 \]  

where \( Y_t \) is the level of output and \( Y_{jt} \) the amount of intermediate good \( j \) used in production. The elasticity of substitution between intermediate goods is equal to \( 1/(1-\theta) \), so the parameter \( \theta \) is a good index of competitiveness.

These output firms competitively maximize profits:

\[ P_t \left( \int_0^1 Y_{jt}^\theta dj \right)^{1/\theta} - \int_0^1 P_{jt}Y_{jt} \]  

Intermediate goods themselves are produced by monopolistically competitive firms indexed by \( j \in [0,1] \). Firm \( j \) has a production function:

\[ Y_{jt} = Z_{jt}L_{jt}^{\alpha} \quad 0 < \alpha \leq 1 \]  

where \( Z_t \) is a common productivity shock.
2.2 Price rigidities

We shall consider in this article two alternative models of price rigidities:

- In the first model we shall consider, prices are set according to Calvo (1983) contracts. The probability of a price contract to continue unchanged is $\gamma$. Conversely every contract can break with probability $1 - \gamma$. If a contract breaks in firm $j$ at time $t$, this firm sets a new price $X_{jt}$, based on all information available up to time $t$.

- In the second model we shall consider, as in Rotemberg (1982a,b), a firm producing intermediate product $j$ incurs, in addition to production costs, a cost of changing prices, denoted as $\chi_{jt}$ in real terms, where:

$$
\chi_{jt} = \frac{\lambda}{2} Y_t \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 
$$

3 Common equilibrium conditions

We shall thus study two models, and begin by deriving in this section the first order and equilibrium conditions that are common to these two models.

3.1 Households

Households maximize the discounted utility (1) subject to the budget constraints (2). The Lagrangean is:

$$
\sum_t \beta^t \left[ \text{Log} C_t + \sigma \text{Log} \left( \frac{M_t}{P_t} \right) - \xi L_t^{\nu} + \zeta_t (W_t L_t + \mu_t M_{t-1} - P_t C_t - M_t) \right]
$$

and the first order conditions in $C_t$, $L_t$ and $M_t$:

$$
\zeta_t P_t = \frac{1}{C_t} 
$$

$$
\zeta_t W_t = \xi L_t^{\nu-1} 
$$

$$
\zeta_t = \frac{\sigma}{M_t} + \beta E_t \left( \zeta_{t+1} M_{t+1} \right)
$$

Combining (8) and (9) we find:

$$
\frac{W_t}{P_t C_t} = \xi L_t^{\nu-1}
$$
Now combining (8) and (10) and using $\mu_{t+1} = M_{t+1}/M_t$, we obtain:

$$\frac{M_t}{P_tC_t} = \sigma + \beta E_t \left( \frac{M_{t+1}}{P_{t+1}C_{t+1}} \right)$$

which solves as:

$$\frac{M_t}{P_tC_t} = \frac{\sigma}{1 - \beta}$$

### 3.2 Output firms

Output producing firms competitively maximize profits (eq. 4) subject to the production function (eq. 3). This yields the demand for intermediate good $j$:

$$Y_{jt} = Y_t \left( \frac{P_{jt}}{P_t} \right)^{-1/(1-\theta)}$$

The elasticity of these demand curves goes from 1 to infinity (in absolute value) when $\theta$ goes from zero to one, so again $\theta$ appears as a natural index of competitiveness.

Since the output firms are competitive, the aggregate price is equal to the usual CES index:

$$P_t = \left[ \int_0^1 P_{jt}^{-\theta/(1-\theta)} \right]^{-(1-\theta)/\theta}$$

### 4 Price dynamics under Calvo contracts

We shall now show that under Calvo contracts persistence is, quite counter-intuitively, positively related to competitiveness.

#### 4.1 Optimal price setting

We shall first derive optimal price setting by intermediate firms under Calvo price contracts. Consider a firm $j$ which has to decide in period $t$ its “new price” $X_{jt}$. If that contract is still in effect in period $s \geq t$ (with probability $\gamma^{s-t}$), the corresponding real profit in period $s$ will be:

$$\frac{\Pi_{js}}{P_s} = X_{jt}Y_{js} - W_sL_{js} = \frac{X_{jt}Y_{js}}{P_s} - \frac{W_s}{P_s} \left( \frac{Y_{js}}{Z_s} \right)^{1/\alpha}$$

5
Firm $j$ maximizes expected discounted real profits, multiplied by the marginal utility of consumption. Since utility (1) is logarithmic in consumption, this marginal utility is equal to $1/C_s = 1/Y_s$. So firm $j$ maximizes the expected value of the following criterion, where the term $\gamma^{s-t}$ represents the probability that the price contract $X_{jt}$ signed in $t$ is still in effect at time $s$:

$$\sum_{s \geq t} \beta^{s-t} \gamma^{s-t} \frac{P_{js}}{P_s Y_s} = \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} \left[ \frac{X_{jt} Y_s}{P_s Y_s} - \frac{W_s}{P_s Y_s} \left( \frac{Y_s}{Z_s} \right)^{1/\alpha} \right]$$  \hspace{1cm} (17)

Now inserting (5) and (14) (with $P_{js} = X_{jt}$, since we are dealing with the contract signed in $t$) into (17), we obtain the maximand:

$$E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} \left[ \left( \frac{X_{jt}}{P_s} \right)^{-\theta/(1-\theta)} - \frac{W_s}{P_s Y_s} \left( \frac{Y_s}{Z_s} \right)^{1/\alpha} \left( \frac{X_{jt}}{P_s} \right)^{-1/(\alpha(1-\theta))} \right]$$  \hspace{1cm} (18)

Let us differentiate with respect to $X_{jt}$. We obtain the first-order condition:

$$X_{jt}^{(1-\alpha \theta)/(\alpha(1-\theta))} E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} P_s^\theta/(1-\theta) =$$

$$\frac{1}{\alpha \theta} E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} \left( \frac{W_s}{P_s Y_s} \left( \frac{Y_s}{Z_s} \right)^{1/\alpha} \right) P_s^{1/(\alpha(1-\theta))}$$  \hspace{1cm} (19)

We see that $X_{jt}$ is actually independent of $j$. All firms changing their price choose the same price, given by (19), which we shall denote as $X_t$. We finally use $C_s = Y_s$ and replace in (19) $W_s$ by the value given by formula (11) to obtain the final value of $X_t$:

$$X_t^{(1-\alpha \theta)/(\alpha(1-\theta))} = \frac{\xi}{\alpha \theta} \frac{E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} \left( \frac{Y_s}{Z_s} \right)^{\nu/\alpha} P_s^{1/(\alpha(1-\theta))}}{E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} P_s^\theta/(1-\theta)}$$  \hspace{1cm} (20)

### 4.2 Price dynamics

Let us start with newly set prices and loglinearize eq. (20). We obtain, omitting constant terms\(^3\):

$$\frac{1 - \alpha \theta}{\alpha (1 - \theta)} x_t + (1 - \beta \gamma) \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} E_t \frac{\theta}{1 - \theta} P_s$$

\(^3\)Lowercase letters represent the logarithms of the corresponding uppercase letters.
We have from (13) \( y_t = c_t = m_t - p_t \), so that (21) is rewritten:

\[
x_t = (1 - \beta \gamma) \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} E_t \left[ \frac{\nu}{\alpha} (y_s - z_s) + \frac{1}{\alpha (1 - \theta)} p_s \right]
\]  

(21)

We have from (13) \( y_t = c_t = m_t - p_t \), so that (21) is rewritten:

\[
x_t = (1 - \beta \gamma) \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} E_t \left[ (1 - \delta) (m_s - z_s) + \delta p_s \right]
\]  

(22)

with:

\[
\delta = \frac{1 - \alpha \theta - \nu + \theta \nu}{1 - \alpha \theta} = 1 - \frac{\nu (1 - \theta)}{1 - \alpha \theta}
\]  

(23)

Note that \( \delta = 1 \) when \( \theta = 1 \), i.e. when we are in the competitive case. If \( \theta < 1 \), then \( \delta < 1 \). Differentiating (23) we find:

\[
\frac{\partial \delta}{\partial \theta} = \frac{\nu (1 - \alpha)}{(1 - \alpha \theta)^2} > 0
\]  

(24)

Let us now turn to aggregate prices, which are given by eq. (15) above. In view of the “demographics” of price contracts, a fraction \( (1 - \gamma) \gamma^i \) of price contracts comes from period \( t - i, i = 0, 1, ..., \infty \), so that (15) is rewritten:

\[
P_t = \left[ (1 - \gamma) \sum_{i=0}^{\infty} \gamma^i x_{t-i}^{1/(1-\theta)} \right]^{-(1-\theta)/\theta}
\]  

(25)

which yields after loglinearization:

\[
p_t = (1 - \gamma) \sum_{i=0}^{\infty} \gamma^i x_{t-i} = \frac{1 - \gamma}{1 - \gamma L} x_t
\]  

(26)

### 4.3 Resolution

The dynamic system consists of Eqs. (22) and (26) above. Let us forward (22) one period and take the expectation as of period \( t \):

\[
E_t x_{t+1} = (1 - \beta \gamma) \sum_{s \geq t+1} \beta^{s-t-1} \gamma^{s-t-1} E_t \left[ (1 - \delta) (m_s - z_s) + \delta p_s \right]
\]  

(27)

Combining with (22) we obtain:

\[
x_t = \beta \gamma E_t x_{t+1} + (1 - \beta \gamma) \left[ (1 - \delta) (m_t - z_t) + \delta p_t \right]
\]  

(28)
Now (26) can be written:

\[ p_t - \gamma p_{t-1} = (1 - \gamma) x_t \]  

(29)

Forwarding one period and taking the expectation as of \( t \) yields:

\[ E_t p_{t+1} - \gamma p_t = (1 - \gamma) E_t x_{t+1} \]  

(30)

Let us insert into (28) the values of \( x_t \) and \( E_t x_{t+1} \) given by eqs. (29) and (30). We obtain:

\[(1 - \delta) (1 - \gamma) (1 - \beta \gamma) (p_t - m_t + z_t) + \gamma (p_t - p_{t-1}) + \beta \gamma (p_t - E_t p_{t+1}) = 0\]  

(31)

This equation is of the form:

\[ a (p_t - m_t + z_t) + b (p_t - p_{t-1}) + c (p_t - E_t p_{t+1}) = 0 \]  

(32)

with:

\[ a = (1 - \delta) (1 - \gamma) (1 - \beta \gamma) \quad b = \gamma \quad c = \beta \gamma \]  

(33)

This solves as (see the appendix):

\[ p_t = \phi p_{t-1} + \sum_{j=0}^{\infty} \kappa_j E_t (m_{t+j} - z_{t+j}) \]  

(34)

where:

\[ \kappa_0 = \frac{a}{a + b + c (1 - \phi)} \quad \kappa_j = \frac{c}{a + b + c (1 - \phi)} \kappa_{j-1} \]  

(35)

and the autoregressive root \( \phi \) is solution of the characteristic equation:

\[ \Phi(\phi) = c \phi^2 - (a + b + c) \phi + b = 0 \]  

(36)

### 4.4 Competitiveness and Price Stickiness

We shall study how the response of prices to monetary and technology shocks depends on competitiveness. Let us define the composite shock \( \omega_t \):

\[ \omega_t = m_t - z_t \]  

(37)

Now let us first consider as our “benchmark” the case where all prices are reset every period, i.e. where \( \gamma = 0 \). In that case (31) immediately yields:

\[ ... \]
\[ p_t = m_t - z_t = \omega_t \] (38)

We shall now consider the case \( \gamma \neq 0 \), and see that the parameter \( \phi \) in eq. (34) will appear as a natural measure of the dynamic price stickiness. To make things particularly clear, let us take the following simple process for \( \omega_t \):

\[ \omega_t - \omega_{t-1} = \epsilon_t \] (39)

where the \( \epsilon_t \) are i.i.d. Then it is shown in the appendix that eqs. (34) and (35) simplify to (eq. 81):

\[ p_t = \omega_t - \frac{\phi \epsilon_t}{1 - \phi L} \] (40)

We see that, following a shock, the discrepancy between the price and its benchmark market clearing value \( \omega_t \) is both higher on impact, and returns more slowly to zero when \( \phi \) is high. So the parameter \( \phi \) appears indeed as a natural parameter to characterize price stickiness.

We can also compute the expression of output. Using \( y_t = m_t - p_t \), eq. (40) yields:

\[ y_t = z_t + \frac{\phi \epsilon_t}{1 - \phi L} \] (41)

We want to see finally how the index of price stickiness \( \phi \) relates to the index of competitiveness \( \theta \). Combining (33) and (36) we obtain the characteristic equation giving \( \phi \):

\[ \Phi (\phi) = \beta \gamma \phi^2 - [(1 - \delta) (1 - \gamma) (1 - \beta \gamma) + \gamma + \beta \gamma] \phi + \gamma = 0 \] (42)

We can compute:

\[ \Phi (0) = \gamma \geq 0 \quad \Phi (1) = - (1 - \delta) (1 - \gamma) (1 - \beta \gamma) \leq 0 \] (43)

So there is a root \( \phi \) between 0 and 1. Let us now find out how this index of price stickiness \( \phi \) relates to the index of competitiveness \( \theta \). Differentiate eq. (42). This yields:

\[ \frac{\partial \phi}{\partial \delta} = \frac{\phi (1 - \gamma) (1 - \beta \gamma)}{\gamma (1 - \beta \phi^2)} > 0 \] (44)

So finally, combining (24) and (44):
\[ \frac{\partial \phi}{\partial \theta} = \frac{\partial \phi}{\partial \delta} \frac{\partial \delta}{\partial \theta} > 0 \]  

(45)

We therefore have the paradoxical relation between competitiveness and price stickiness.

5 Price dynamics under costs of changing prices

We shall now show that if price sluggishness is due to a convex cost of changing prices as in Rotemberg (1982a,b), then one finds the natural result that price stickiness is negatively related to competitiveness.

5.1 Optimal price setting

With the cost of changing prices \( \chi_{jt} \), the real profit of intermediate firm \( j \) in period \( t \) is:

\[
\frac{\Pi_{jt}}{P_t} = \frac{P_{jt}Y_{jt} - W_tL_{jt}}{P_t} - \chi_{jt}
\]

\[= \frac{P_{jt}Y_{jt}}{P_t} - \frac{W_t}{P_t} \left( \frac{Y_{jt}}{Z_t} \right)^{1/\alpha} - \frac{\lambda}{2} Y_t \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \]  

(46)

Firm \( j \) maximizes discounted real profits, multiplied by the marginal utility of consumption, equal to \( 1/C_t = 1/Y_t \), so that firm \( j \) maximizes the expected value of the following criterion:

\[
\sum_t \beta^t \frac{\Pi_{jt}}{P_t Y_t} = \sum_t \beta^t \left[ \frac{P_{jt}Y_{jt}}{P_t Y_t} - \frac{W_t}{P_t Y_t} \left( \frac{Y_{jt}}{Z_t} \right)^{1/\alpha} - \frac{\lambda}{2} \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \right] \]  

(47)

Insert into the discounted profits (eq. 47) the expression of \( Y_{jt} \) (eq. 14). We obtain:

\[
\sum_t \beta^t \left[ \left( \frac{P_{jt}}{P_t} \right)^{-\theta/(1-\theta)} - \frac{W_t}{P_t Y_t} \left( \frac{Y_{jt}}{Z_t} \right)^{1/\alpha} \left( \frac{P_{jt}}{P_t} \right)^{-1/\alpha(1-\theta)} - \frac{\lambda}{2} \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \right] \]  

(48)

Now insert (11) and \( Y_t = C_t \) into (48). Keeping only the terms where \( P_{jt} \) appears, we obtain the maximand:
\[
\left( \frac{P_{jt}}{P_{t}} \right)^{-\theta/(1-\theta)} - \xi \left( \frac{Y_t}{Z_t} \right)^{\nu/\alpha} \left( \frac{P_{jt}}{P_{t}} \right)^{-1/\alpha(1-\theta)}
\]

\[-\frac{\lambda}{2} \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 - \frac{\beta \lambda}{2} E_t \left( \frac{P_{jt+1}}{P_{jt}} - 1 \right)^2 \]

(49)

Let us differentiate with respect to \(P_{jt}\). We obtain the first-order condition:

\[-\theta \left( \frac{P_{jt}}{P_{t}} \right)^{-1/(1-\theta)} + \frac{\xi}{\alpha (1-\theta)} \left( \frac{Y_t}{Z_t} \right)^{\nu/\alpha} \left( \frac{P_{jt}}{P_{t}} \right)^{-1/\alpha(1-\theta)-1} \]

\[-\lambda \frac{P_t}{P_{jt-1}} \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right) + \beta \lambda E_t \frac{P_{jt+1} P_{jt}}{P_{jt}^2} \left( \frac{P_{jt+1}}{P_{jt}} - 1 \right) = 0 \]

(50)

5.2 Price dynamics

All firms \(j\) are actually in a symmetric situation, so that in equilibrium \(P_{jt} = P_t\). Inserting this into (50) we obtain the dynamic equation for prices:

\[-\theta \left( \frac{P_{jt}}{P_{t}} \right)^{-1/(1-\theta)} + \frac{\xi}{\alpha (1-\theta)} \left( \frac{Y_t}{Z_t} \right)^{\nu/\alpha} \left( \frac{P_{jt}}{P_{t}} \right)^{-1/\alpha(1-\theta)-1} \]

\[-\lambda \frac{P_t}{P_{jt-1}} \left( \frac{P_{jt}}{P_{jt-1}} - 1 \right) + \beta \lambda E_t \frac{P_{jt+1} P_{jt}}{P_{jt}^2} \left( \frac{P_{jt+1}}{P_{jt}} - 1 \right) = 0 \]

(51)

We first characterize the long run equilibrium where all prices are equal over time. Then (51) yields:

\[\left( \frac{Y_t}{Z_t} \right)^{\nu/\alpha} = \frac{\alpha \theta}{\xi} \]

(52)

or:

\[L_t = \left( \frac{\alpha \theta}{\xi} \right)^{1/\nu} = L_0 \]

(53)

Now let us go back to the dynamics. Loglinearizing (51) we find:

\[\frac{\theta}{1-\theta} \nu (y_t - z_t) - \lambda (p_t - p_{t-1}) + \beta \lambda (E_t p_{t+1} - p_t) = 0 \]

(54)

and since, from (13), \(y_t = c_t = m_t - p_t\), this becomes:
\[ \nu \theta (p_t - m_t + z_t) + \alpha \lambda (1 - \theta) (p_t - p_{t-1}) + \alpha \beta \lambda (1 - \theta) (p_t - E_t p_{t+1}) = 0 \]  
(55)

### 5.3 Resolution

Again we have an equation of the form:

\[ a (p_t - m_t + z_t) + b (p_t - p_{t-1}) + c (p_t - E_t p_{t+1}) = 0 \]  
(56)

with:

\[ a = \nu \theta \quad b = \alpha \lambda (1 - \theta) \quad c = \alpha \beta \lambda (1 - \theta) \]  
(57)

Eq. (56) is solved in the appendix, and the solution has been already described above (eqs. 34, 35 and 36).

### 5.4 Competitiveness and price stickiness

Let us first take as a benchmark the case where the cost of changing prices is zero, i.e. where \( \lambda = 0 \). In that case (55) immediately yields:

\[ p_t = m_t - z_t = \omega_t \]  
(58)

Let us now consider the case \( \lambda \neq 0 \), and assume again the simple process for \( \omega_t \):

\[ \omega_t - \omega_{t-1} = \varepsilon_t \]  
(59)

Then the price is given by (appendix, eq. 81):

\[ p_t = \omega_t - \frac{\phi \varepsilon_t}{1 - \phi} \]  
(60)

where \( \phi \) is solution of the following characteristic equation, obtained by combining (36) and (57):

\[ \Phi (\phi) = \alpha \beta \lambda (1 - \theta) \phi^2 - [\nu \theta + \alpha \lambda (1 - \theta) (1 + \beta)] \phi + \alpha \lambda (1 - \theta) = 0 \]  
(61)

We can compute:

\[ \Phi (0) = \alpha \lambda (1 - \theta) \geq 0 \quad \Phi (1) = -\nu \theta \leq 0 \]  
(62)
so that:

\[ 0 \leq \phi \leq 1 \]  \hspace{1cm} (63)

We want now to see finally how the index of price stickiness \( \phi \) relates to the index of competitiveness \( \theta \). Considering first the extreme cases, we note that \( \phi = 0 \) if \( \theta = 1 \) and \( \phi = 1 \) if \( \theta = 0 \).

Now let us compute \( \partial \phi / \partial \theta \). Differentiating (61) we find:

\[
\frac{\partial \phi}{\partial \theta} = -\frac{\nu \phi}{(1 - \theta) \left[ \nu \theta + \alpha \lambda (1 - \theta) (1 + \beta - 2 \beta \phi) \right]} = -\frac{\nu \phi^2}{\alpha \lambda (1 - \theta)^2 (1 - \beta \phi^2)} \hspace{1cm} (64)
\]

This is negative since \( \phi \leq 1 \), and we therefore have a negative relation between competitiveness and price stickiness, as our intuition would tell us, but unlike the model we considered in section 4.

6 Conclusions

We studied in this article simple dynamic models where prices are sticky either because of staggered price contracts, or because there is a convex cost of changing them. In these models competitiveness is measured by a parameter \( \theta \) which is higher, the higher the substitutability between goods. Price stickiness is measured by the size of the autoregressive root \( \phi \) in the dynamic price process.

We saw that in a model with staggered price contracts (section 4) price stickiness is, quite counterintuitively, positively related to the parameter \( \theta \) representing competitiveness. Although this is clearly disturbing, this should not deter us from using DSGE models with sticky prices, since we saw that in an alternative model with convex costs of changing prices (section 5) price stickiness is, in accordance with intuition, a decreasing function of competitiveness\(^4\).

\(^4\)We may note that convex costs of changing prices have already been used in DSGE models. See, for example, Hairault and Portier (1993) and Kim (2000).
References


Appendix

We want to solve the dynamic equation:

\[ a (p_t - m_t + z_t) + b (p_t - p_{t-1}) + c (p_t - E_t p_{t+1}) = 0 \]  \hspace{1cm} (65)

with:

\[ a > 0 \quad b > 0 \quad c > 0 \]  \hspace{1cm} (66)

Let us define the composite shock:

\[ \omega_t = m_t - z_t \]  \hspace{1cm} (67)

We hypothesize a solution of the form:

\[ p_t = \phi p_{t-1} + \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} \]  \hspace{1cm} (68)

From that we deduce:

\[ E_t p_{t+1} = \phi p_t + \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+1+j} \]

\[ = \phi p_t + \sum_{j=1}^{\infty} \kappa_{j-1} E_t \omega_{t+j} = \phi^2 p_{t-1} + \phi \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} + \sum_{j=1}^{\infty} \kappa_{j-1} E_t \omega_{t+j} \]  \hspace{1cm} (69)

Inserting these into the initial formula (65) we obtain:

\[ (a + b + c) \left[ \phi p_{t-1} + \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} \right] - a \omega_t - b p_{t-1} \]

\[ - c \left[ \phi^2 p_{t-1} + \phi \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} + \sum_{j=1}^{\infty} \kappa_{j-1} E_t \omega_{t+j} \right] = 0 \]  \hspace{1cm} (70)

Identifying to zero the term in \( p_{t-1} \) we find the characteristic equation giving \( \phi \):

\[ \Phi (\phi) = c \phi^2 - (a + b + c) \phi + b \]  \hspace{1cm} (71)

We can compute:
\[ \Phi(0) = b > 0 \quad \Phi(1) = -a > 0 \] (72)

so that:

\[ 0 < \phi < 1 \] (73)

Now identifying to zero the term in \( \omega_t \) in (70) yields:

\[ \kappa_0 = \frac{a}{a + b + c(1 - \phi)} \] (74)

Finally identifying to zero the term in \( E_t \omega_{t+1} \) gives:

\[ \kappa_j = \frac{c}{a + b + c(1 - \phi)} \kappa_{j-1} = \eta \kappa_{j-1} \] (75)

We want to check that \( \eta < 1 \). This will be the case if:

\[ \phi < \frac{a + b}{c} \] (76)

So we compute:

\[ \Phi \left( \frac{a + b}{c} \right) = -a < 0 \] (77)

so we have indeed \( \eta < 1 \).

We want finally to compute the solution in the particular case where

\[ \omega_t - \omega_{t-1} = \varepsilon_t \] (78)

In that case, using (74) and (75), equation (68) yields:

\[ p_t = \phi p_{t-1} + \frac{\kappa_0}{1 - \eta} \omega_t = \phi p_{t-1} + \frac{a}{a + b - \phi c} \omega_t \] (79)

This, in view of (71), becomes:

\[ p_t = \phi p_{t-1} + (1 - \phi) \omega_t \] (80)

which can also be rewritten:

\[ p_t = \omega_t - \frac{\phi}{1 - \phi L} \varepsilon_t \] (81)