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Competitiveness, market power and price stickiness:

A paradox and a resolution

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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 prices¹? 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) models². 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

¹By 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 ϕ , and stickiness will be measured by the size of that root.

²See for example Ascari (2000), Ascari and Rankin (2002), Bénassy (2002, 2003a,b), Chari, Kehoe and McGrattan (2000), Christiano, Eichenbaum and Evans (2001), Collard and Ertz (2000), Hairault and Portier (1993), Huang and Liu (2002), Jeanne (1998), Kim (2000), Smets and Wouters (2003), Woodford (2003), Yun (1996), and several others.

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:

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

and are submitted in each period to a budget constraint:

$$P_t C_t + M_t = W_t L_t + \Pi_t + \mu_t M_{t-1} \quad (2)$$

where μ_t is a multiplicative money shock à la Lucas (1972) and Π_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:

$$Y_t = \left(\int_0^1 Y_{jt}^\theta dj \right)^{1/\theta} \quad 0 < \theta \leq 1 \quad (3)$$

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 θ is a good index of competitiveness.

These output firms competitively maximize profits:

$$P_t \left(\int_0^1 Y_{jt}^\theta dj \right)^{1/\theta} - \int_0^1 P_{jt} Y_{jt} \quad (4)$$

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

$$Y_{jt} = Z_t L_{jt}^\alpha \quad 0 < \alpha \leq 1 \quad (5)$$

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 γ . 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 χ_{jt} in real terms, where:

$$\chi_{jt} = \frac{\lambda}{2} Y_t \left(\frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \quad (6)$$

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:

$$\sum_t \beta^t \left[\text{Log} C_t + \sigma \text{Log} \left(\frac{M_t}{P_t} \right) - \xi \frac{L_t^\nu}{\nu} + \zeta_t (W_t L_t + \mu_t M_{t-1} - P_t C_t - M_t) \right] \quad (7)$$

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

$$\zeta_t P_t = \frac{1}{C_t} \quad (8)$$

$$\zeta_t W_t = \xi L_t^{\nu-1} \quad (9)$$

$$\zeta_t = \frac{\sigma}{M_t} + \beta E_t (\zeta_{t+1} \mu_{t+1}) \quad (10)$$

Combining (8) and (9) we find:

$$\frac{W_t}{P_t C_t} = \xi L_t^{\nu-1} \quad (11)$$

Now combining (8) and (10) and using $\mu_{t+1} = M_{t+1}/M_t$, we obtain:

$$\frac{M_t}{P_t C_t} = \sigma + \beta E_t \left(\frac{M_{t+1}}{P_{t+1} C_{t+1}} \right) \quad (12)$$

which solves as:

$$\frac{M_t}{P_t C_t} = \frac{\sigma}{1 - \beta} \quad (13)$$

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 :

$$Y_{jt} = Y_t \left(\frac{P_{jt}}{P_t} \right)^{-1/(1-\theta)} \quad (14)$$

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

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

$$P_t = \left[\int_0^1 P_{jt}^{-\theta/(1-\theta)} \right]^{-(1-\theta)/\theta} \quad (15)$$

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 γ^{s-t}), the corresponding real profit in period s will be:

$$\frac{\Pi_{js}}{P_s} = \frac{X_{jt} Y_{js} - W_s L_{js}}{P_s} = \frac{X_{jt} Y_{js}}{P_s} - \frac{W_s}{P_s} \left(\frac{Y_{js}}{Z_s} \right)^{1/\alpha} \quad (16)$$

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 γ^{s-t} represents the probability that the price contract X_{jt} signed in t is still in effect at time s :

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

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:

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

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

$$\begin{aligned} X_{jt}^{(1-\alpha\theta)/\alpha(1-\theta)} E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} P_s^{\theta/(1-\theta)} = \\ \frac{1}{\alpha\theta} E_t \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} \frac{W_s}{P_s Y_s} \left(\frac{Y_s}{Z_s} \right)^{1/\alpha} P_s^{1/\alpha(1-\theta)} \end{aligned} \quad (19)$$

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 :

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

4.2 Price dynamics

Let us start with newly set prices and loglinearize eq. (20). We obtain, omitting constant terms³:

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

³Lowercase letters represent the logarithms of the corresponding uppercase letters.

$$= (1 - \beta\gamma) \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} E_t \left[\frac{\nu}{\alpha} (y_s - z_s) + \frac{1}{\alpha(1-\theta)} p_s \right] \quad (21)$$

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

$$x_t = (1 - \beta\gamma) \sum_{s \geq t} \beta^{s-t} \gamma^{s-t} E_t [(1 - \delta) (m_s - z_s) + \delta p_s] \quad (22)$$

with:

$$\delta = \frac{1 - \alpha\theta - \nu + \theta\nu}{1 - \alpha\theta} = 1 - \frac{\nu(1-\theta)}{1 - \alpha\theta} \quad (23)$$

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:

$$\frac{\partial \delta}{\partial \theta} = \frac{\nu(1-\alpha)}{(1-\alpha\theta)^2} > 0 \quad (24)$$

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 $t - i$, $i = 0, 1, \dots, \infty$, so that (15) is rewritten:

$$P_t = \left[(1 - \gamma) \sum_{i=0}^{\infty} \gamma^i X_{t-i}^{-\theta/(1-\theta)} \right]^{-(1-\theta)/\theta} \quad (25)$$

which yields after loglinearization:

$$p_t = (1 - \gamma) \sum_{i=0}^{\infty} \gamma^i x_{t-i} = \frac{1 - \gamma}{1 - \gamma L} x_t \quad (26)$$

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 :

$$E_t x_{t+1} = (1 - \beta\gamma) \sum_{s \geq t+1} \beta^{s-t-1} \gamma^{s-t-1} E_t [(1 - \delta) (m_s - z_s) + \delta p_s] \quad (27)$$

Combining with (22) we obtain:

$$x_t = \beta\gamma E_t x_{t+1} + (1 - \beta\gamma) [(1 - \delta) (m_t - z_t) + \delta p_t] \quad (28)$$

Now (26) can be written:

$$p_t - \gamma p_{t-1} = (1 - \gamma) x_t \quad (29)$$

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

$$E_t p_{t+1} - \gamma p_t = (1 - \gamma) E_t x_{t+1} \quad (30)$$

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

$$(1 - \delta)(1 - \gamma)(1 - \beta\gamma)(p_t - m_t + z_t) + \gamma(p_t - p_{t-1}) + \beta\gamma(p_t - E_t p_{t+1}) = 0 \quad (31)$$

This equation is of the form:

$$a(p_t - m_t + z_t) + b(p_t - p_{t-1}) + c(p_t - E_t p_{t+1}) = 0 \quad (32)$$

with:

$$a = (1 - \delta)(1 - \gamma)(1 - \beta\gamma) \quad b = \gamma \quad c = \beta\gamma \quad (33)$$

This solves as (see the appendix):

$$p_t = \phi p_{t-1} + \sum_{j=0}^{\infty} \kappa_j E_t (m_{t+j} - z_{t+j}) \quad (34)$$

where:

$$\kappa_0 = \frac{a}{a + b + c(1 - \phi)} \quad \kappa_j = \frac{c}{a + b + c(1 - \phi)} \kappa_{j-1} \quad (35)$$

and the autoregressive root ϕ is solution of the characteristic equation:

$$\Phi(\phi) = c\phi^2 - (a + b + c)\phi + b = 0 \quad (36)$$

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 ω_t :

$$\omega_t = m_t - z_t \quad (37)$$

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:

$$p_t = m_t - z_t = \omega_t \quad (38)$$

We shall now consider the case $\gamma \neq 0$, and see that the parameter ϕ 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 ω_t :

$$\omega_t - \omega_{t-1} = \varepsilon_t \quad (39)$$

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

$$p_t = \omega_t - \frac{\phi \varepsilon_t}{1 - \phi L} \quad (40)$$

We see that, following a shock, the discrepancy between the price and its benchmark market clearing value ω_t is both higher on impact, and returns more slowly to zero when ϕ is high. So the parameter ϕ 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:

$$y_t = z_t + \frac{\phi \varepsilon_t}{1 - \phi L} \quad (41)$$

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

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

We can compute:

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

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

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

So finally, combining (24) and (44):

$$\frac{\partial \phi}{\partial \theta} = \frac{\partial \phi}{\partial \delta} \frac{\partial \delta}{\partial \theta} > 0 \quad (45)$$

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 χ_{jt} the real profit of intermediate firm j in period t is:

$$\begin{aligned} \frac{\Pi_{jt}}{P_t} &= \frac{P_{jt}Y_{jt} - W_t L_{jt}}{P_t} - \chi_{jt} \\ &= \frac{P_{jt}Y_{jt}}{P_t} - \frac{W_t}{P_t} \left(\frac{Y_{jt}}{Z_t} \right)^{1/\alpha} - \frac{\lambda}{2} Y_t \left(\frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \end{aligned} \quad (46)$$

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:

$$\sum_t \beta^t \frac{\Pi_{jt}}{P_t Y_t} = \sum_t \beta^t \left[\frac{P_{jt}Y_{jt}}{P_t Y_t} - \frac{W_t}{P_t Y_t} \left(\frac{Y_{jt}}{Z_t} \right)^{1/\alpha} - \frac{\lambda}{2} \left(\frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \right] \quad (47)$$

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

$$\sum_t \beta^t \left[\left(\frac{P_{jt}}{P_t} \right)^{-\theta/(1-\theta)} - \frac{W_t}{P_t Y_t} \left(\frac{Y_t}{Z_t} \right)^{1/\alpha} \left(\frac{P_{jt}}{P_t} \right)^{-1/\alpha(1-\theta)} - \frac{\lambda}{2} \left(\frac{P_{jt}}{P_{jt-1}} - 1 \right)^2 \right] \quad (48)$$

Now insert (11) and $Y_t = C_t$ into (48). Keeping only the terms where P_{jt} appears, we obtain the maximand:

$$\begin{aligned}
& \left(\frac{P_{jt}}{P_t}\right)^{-\theta/(1-\theta)} - \xi \left(\frac{Y_t}{Z_t}\right)^{\nu/\alpha} \left(\frac{P_{jt}}{P_t}\right)^{-1/\alpha(1-\theta)} \\
& - \frac{\lambda}{2} \left(\frac{P_{jt}}{P_{jt-1}} - 1\right)^2 - \frac{\beta\lambda}{2} E_t \left(\frac{P_{jt+1}}{P_{jt}} - 1\right)^2
\end{aligned} \tag{49}$$

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

$$\begin{aligned}
& -\frac{\theta}{1-\theta} \left(\frac{P_{jt}}{P_t}\right)^{-1/(1-\theta)} + \frac{\xi}{\alpha(1-\theta)} \left(\frac{Y_t}{Z_t}\right)^{\nu/\alpha} \left(\frac{P_{jt}}{P_t}\right)^{-1/\alpha(1-\theta)-1} \\
& - \lambda \frac{P_t}{P_{jt-1}} \left(\frac{P_{jt}}{P_{jt-1}} - 1\right) + \beta\lambda E_t \frac{P_t P_{jt+1}}{P_{jt}^2} \left(\frac{P_{jt+1}}{P_{jt}} - 1\right) = 0
\end{aligned} \tag{50}$$

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:

$$\begin{aligned}
& -\frac{\theta}{1-\theta} + \frac{\xi}{\alpha(1-\theta)} \left(\frac{Y_t}{Z_t}\right)^{\nu/\alpha} \\
& - \lambda \frac{P_t}{P_{t-1}} \left(\frac{P_t}{P_{t-1}} - 1\right) + \beta\lambda E_t \frac{P_{t+1}}{P_t} \left(\frac{P_{t+1}}{P_t} - 1\right) = 0
\end{aligned} \tag{51}$$

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

$$\left(\frac{Y_t}{Z_t}\right)^{\nu/\alpha} = \frac{\alpha\theta}{\xi} \tag{52}$$

or:

$$L_t = \left(\frac{\alpha\theta}{\xi}\right)^{1/\nu} = L_0 \tag{53}$$

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

$$\frac{\theta}{1-\theta} \frac{\nu}{\alpha} (y_t - z_t) - \lambda (p_t - p_{t-1}) + \beta\lambda (E_t p_{t+1} - p_t) = 0 \tag{54}$$

and since, from (13), $y_t = c_t = m_t - p_t$, this becomes:

$$\nu\theta(p_t - m_t + z_t) + \alpha\lambda(1 - \theta)(p_t - p_{t-1}) + \alpha\beta\lambda(1 - \theta)(p_t - E_t p_{t+1}) = 0 \quad (55)$$

5.3 Resolution

Again we have an equation of the form:

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

with:

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

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:

$$p_t = m_t - z_t = \omega_t \quad (58)$$

Let us now consider the case $\lambda \neq 0$, and assume again the simple process for ω_t :

$$\omega_t - \omega_{t-1} = \varepsilon_t \quad (59)$$

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

$$p_t = \omega_t - \frac{\phi\varepsilon_t}{1 - \phi L} \quad (60)$$

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

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

We can compute:

$$\Phi(0) = \alpha\lambda(1 - \theta) \geq 0 \quad \Phi(1) = -\nu\theta \leq 0 \quad (62)$$

so that:

$$0 \leq \phi \leq 1 \tag{63}$$

We want now to see finally how the index of price stickiness ϕ relates to the index of competitiveness θ . 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:

$$\frac{\partial\phi}{\partial\theta} = -\frac{\nu\phi}{(1-\theta)[\nu\theta + \alpha\lambda(1-\theta)(1+\beta-2\beta\phi)]} = -\frac{\nu\phi^2}{\alpha\lambda(1-\theta)^2(1-\beta\phi^2)} \tag{64}$$

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 θ which is higher, the higher the substitutability between goods. Price stickiness is measured by the size of the autoregressive root ϕ 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 θ 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 competitiveness⁴.

⁴We 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

- [1] Ascari, Guido (2000), “Optimising agents, staggered wages and persistence in the real effects of money shocks”, *The Economic Journal*, **110**, 664-686.
- [2] Ascari, Guido and Neil Rankin (2002), “Staggered wages and output dynamics under disinflation”, *Journal of Economic Economic Dynamics and Control*, **26**, 653-680.
- [3] Bénassy, Jean-Pascal (2002), *The Macroeconomics of Imperfect Competition and Nonclearing Markets: A Dynamic General Equilibrium Approach*, M.I.T. Press, Cambridge, Massachusetts.
- [4] Bénassy, Jean-Pascal (2003a), “Staggered contracts and persistence: microeconomic foundations and macroeconomic dynamics”, *Louvain Economic Review*, **69**, 125-144.
- [5] Bénassy, Jean-Pascal (2003b), “Output and inflation persistence under price and wage staggering: analytical results”, *Annales d’Economie et de Statistique*, n° 69, 1-30.
- [6] Calvo, Guillermo (1983), “Staggered prices in a utility-maximizing framework”, *Journal of Monetary Economics*, **12**, 383-398.
- [7] Chari, V.V., Patrick J. Kehoe and Ellen R. McGrattan (2000), “Sticky price models of the business cycle: can the contract multiplier solve the persistence problem?”, *Econometrica*, **68**, 1151-1179.
- [8] Christiano, Lawrence J., Martin Eichenbaum and Charles Evans (2001), “Nominal rigidities and the dynamic effects of a shock to monetary policy”, NBER, Cambridge, forthcoming, *Journal of Political Economy*.
- [9] Collard, Fabrice and Guy Ertz (2000), “Stochastic nominal wage contracts in a cash-in-advance model”, *Recherches Economiques de Louvain*, **66**, 281-301.
- [10] Hairault, Jean-Olivier and Franck Portier (1993), “Money, new-Keynesian macroeconomics and the business cycle”, *European Economic Review*, **37**, 1533-1568.
- [11] Huang, Kevin X.D. and Zheng Liu (2002), “Staggered price-setting, staggered wage-setting, and business cycle persistence”, *Journal of Monetary Economics*, **49**, 405-433.

- [12] Jeanne, Olivier (1998), “Generating real persistent effects of monetary shocks: How much nominal rigidity do we really need?”, *European Economic Review*, **42**, 1009–1032.
- [13] Kim, Jinill (2000), “Constructing and estimating a realistic optimizing model of monetary policy”, *Journal of Monetary Economics*, **45**, 329–359.
- [14] Lucas, Robert E. Jr (1972), “Expectations and the neutrality of money”, *Journal of Economic Theory*, **4**, 103–124.
- [15] Means, Gardiner C. (1935a), “Industrial prices and their relative inflexibility”, Senate document n° 13, 74th Congress, *U.S. Government Printing Office*, Washington D.C.
- [16] Means, Gardiner C. (1935b), “Price inflexibility and the requirements of a stabilizing monetary policy”, *Journal of the American Statistical Association*, **30**.
- [17] Rotemberg, Julio J. (1982a) “Monopolistic price adjustment and aggregate output”, *Review of Economic Studies*, **44**, 517–531.
- [18] Rotemberg, Julio J. (1982b) “Sticky prices in the United States”, *Journal of Political Economy*, **90**, 1187–1211.
- [19] Smets, Frank and Raf Wouters (2003), “An estimated dynamic stochastic general equilibrium model of the euro area”, *Journal of the European Economic Association*, **1**, 1123–1175.
- [20] Taylor, John B. (1979), “Staggered wage setting in a macro model” *American Economic Review*, **69**, 108–113.
- [21] Taylor, John B. (1980), “Aggregate dynamics and staggered contracts” *Journal of Political Economy*, **88**, 1–23.
- [22] Woodford, Michael (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press, Princeton and Oxford.
- [23] Yun, Tack (1996), “Nominal price rigidity, money supply endogeneity, and business cycles”, *Journal of Monetary Economics*, **37**, 345–370.

Appendix

We want to solve the dynamic equation:

$$a(p_t - m_t + z_t) + b(p_t - p_{t-1}) + c(p_t - E_t p_{t+1}) = 0 \quad (65)$$

with:

$$a > 0 \quad b > 0 \quad c > 0 \quad (66)$$

Let us define the composite shock:

$$\omega_t = m_t - z_t \quad (67)$$

We hypothesize a solution of the form:

$$p_t = \phi p_{t-1} + \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} \quad (68)$$

From that we deduce:

$$\begin{aligned} E_t p_{t+1} &= \phi p_t + \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+1+j} \\ &= \phi p_t + \sum_{j=1}^{\infty} \kappa_{j-1} E_t \omega_{t+j} = \phi^2 p_{t-1} + \phi \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} + \sum_{j=1}^{\infty} \kappa_{j-1} E_t \omega_{t+j} \end{aligned} \quad (69)$$

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

$$\begin{aligned} &(a + b + c) \left[\phi p_{t-1} + \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} \right] - a \omega_t - b p_{t-1} \\ &- c \left[\phi^2 p_{t-1} + \phi \sum_{j=0}^{\infty} \kappa_j E_t \omega_{t+j} + \sum_{j=1}^{\infty} \kappa_{j-1} E_t \omega_{t+j} \right] = 0 \end{aligned} \quad (70)$$

Identifying to zero the term in p_{t-1} we find the characteristic equation giving ϕ :

$$\Phi(\phi) = c\phi^2 - (a + b + c)\phi + b \quad (71)$$

We can compute:

$$\Phi(0) = b > 0 \quad \Phi(1) = -a > 0 \quad (72)$$

so that:

$$0 < \phi < 1 \quad (73)$$

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

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

Finally identifying to zero the term in $E_t \omega_{t+j}$ gives:

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

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

$$\phi < \frac{a + b}{c} \quad (76)$$

So we compute:

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

so we have indeed $\eta < 1$.

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

$$\omega_t - \omega_{t-1} = \varepsilon_t \quad (78)$$

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

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

This, in view of (71), becomes:

$$p_t = \phi p_{t-1} + (1 - \phi) \omega_t \quad (80)$$

which can also be rewritten:

$$p_t = \omega_t - \frac{\phi}{1 - \phi} \varepsilon_t \quad (81)$$