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**”Imperfectly competitive markets, trade unions and inflation: Do imperfectly competitive markets transmit more inflation than perfectly competitive ones? A theoretical appraisal”**

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# A discusión

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AND INFLATION: DO IMPERFECTLY COMPETITIVE MARKETS  
TRANSMIT MORE INFLATION THAN PERFECTLY  
COMPETITIVE ONES? A THEORETICAL APPRAISAL**

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WP-AD 94-09

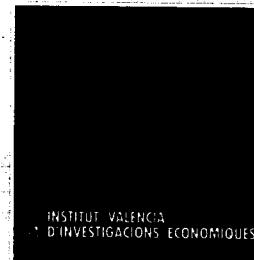
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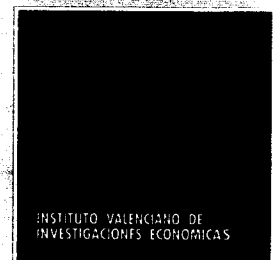
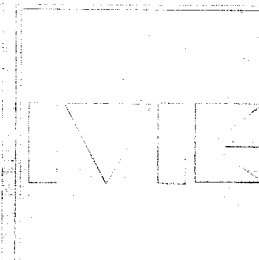
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**IMPERFECTLY COMPETITIVE MARKETS, TRADE UNIONS AND INFLATION:  
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THAN PERFECTLY COMPETITIVE ONES?: A THEORETICAL APPRAISAL**

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**A B S T R A C T**

In this paper we study the theoretical plausibility of the conjecture that inflation arises because imperfectly competitive markets (ICM in the sequel) translate cost pushes in large price increases. We define two different measures of inflation transmission. We compare these measures in several models of ICM and in perfectly competitive markets (PCM in the sequel). In each case we find a necessary and sufficient condition for an ICM to transmit more inflation -according to the two measures- than that transmitted by a PCM.

**Keywords:** Inflation, Imperfect Competition.

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## I. INTRODUCTION

A popular theory of inflation asserts that the two key ingredients of persistent price increases in some industries are 1) an exogenous increase in (marginal) costs and 2) the imperfectly competitive structure of these markets (see e.g. Scitovsky (1978)). The latter contrasts with the earlier association of oligopoly with rigid prices (see e.g. Carlton (1989)). In any case the argument looks suspicious because of the difference between *high prices* (in an oligopolistic market, *ceteris paribus*, prices are always higher than in a competitive market) and the *sensitivity of prices to an exogenous cost push*.

In this paper we study the theoretical plausibility of the above argument by considering several partial equilibrium models of imperfectly competitive markets (a review of the empirical evidence can be found in Zaleski (1992)). Throughout the paper we will assume identical firms and constant returns to scale. We study, by means of two different measures, the impact of an increase in marginal costs on equilibrium prices. These measures are the derivative and the elasticity of equilibrium price with respect to marginal cost. The key test consists in a comparison of the value of each measure in an imperfectly competitive market with the corresponding value in a perfectly competitive market which, under our assumptions, equals to one.

We first consider Cournot oligopoly with and without entry. In both models, we find necessary and sufficient conditions for an exogenous cost push to transmit more inflation in oligopoly than in perfect competition under each of the aforementioned two measures. As we will see some of these conditions do not have an easy interpretation, but in any case there are perfectly reasonable examples in which, *ceteris paribus*, an oligopolistic market transmits less inflation than a perfectly competitive one and vice versa whatever measure is considered (the same exercise could have been performed with a differentiated product and price-setting firms with qualitatively similar results). Later, we focus our attention on Monopolistic Competition. We consider two models: the Spence (1976)-Dixit-Stiglitz (1977) model of a

representative consumer and the circular city as modeled by Salop (1979). Since both models are heavily parameterized the comparison of inflation transmission in these models and in perfect competition is a simple matter.

The purpose of the above exercise -eight cases considered (four models times, two measures of transmission)- is to see if some kind of general pattern emerges. And it does. *If inverse demand functions are isoelastic with elasticity less or equal than one, imperfectly competitive markets transmit more or equal (but never less) inflation than perfectly competitive ones. Moreover, if inverse demand functions are linear, imperfectly competitive markets transmit equal or less (but never more) inflation than perfectly competitive ones.* Thus, an apparently innocent choice, i.e. the functional form of the inverse demand function, determines completely the question of inflation transmission in imperfect vs. perfect markets.

Next we study bargaining by considering that wages are either negotiated à la Nash or are set by trade unions in order to maximize wage bill. We only consider the cases in which the inverse demand function is either linear or isoelastic. Because of the parameterization, we are able to compute explicit formulae for the two measures of inflation transmission. Again, we have eight cases and a general pattern: *when the market is more competitive -i.e. when there are more firms in the market- both inflationary sensitivity and elasticity go up or remain constant.* In other words, more competition implies higher or equal (but never less) inflationary transmission, exactly the opposite from what it was suggested by the popular theory quoted before. Thus, under endogenous wages, the key issued is the degree of competition and not the shape of the inverse demand function, as it happens under exogenous wages.

It goes without saying the limitations of our approach, specially the static partial equilibrium character of the model considered here. However, we may consider this paper as a first step in the construction of more satisfactory models. In an Appendix, we sketch two dynamic models with some general equilibrium features. These models should be taken as purely illustrative.

The rest of the paper goes as follows. Section 2 explains the main concepts to be used in the rest of the paper. Section 3 explores the Cournot model -with and without free entry- and two models of monopolistic competition. Section 4 studies two bargaining models. Section 5 gathers our main conclusions.

## II. THE FRAMEWORK OF ANALYSIS

In this paper we will consider only partial equilibrium models. The case of general equilibrium is left for further study (but see the Appendix).

Assuming that there are  $n$  firms in the market, each selling a different good, let  $x_i$  be the output of firm  $i$  and  $p_i$  be the price of good  $i = 1, \dots, n$  (in some models  $n$  will be an endogenous variable). The inverse demand function for good  $i$  reads  $p_i = p_i(x_1, \dots, x_n)$ . When the good is homogeneous, let  $x$  be the aggregate output in the market,  $p$  be the price of the good and  $p = p(x)$  be the inverse demand function.

Throughout the paper we will assume that markets under study, whether perfectly or imperfectly competitive, satisfy the following assumptions:

- a). Firms are identical with constant marginal costs denoted by  $c$ .
- b). Any equilibrium concept yields symmetrical allocations.
- c).  $p(\cdot)$  is  $C^2$  and strictly decreasing on  $x$ .

These assumptions are adopted in order to obtain sharp results, since the consideration of the general case would only add some extra complications.

We will consider two kinds of models. In the first class the marginal cost is exogenously given. In the second class the marginal cost  $c$  is separated into two parts  $e$  and  $w$  such that  $c = e + w$ . The first part ( $e$ ) is

supposed to be exogenously given (i.e. raw materials, or capital cost) but the second part ( $w$ ) is assumed to be subject to bargaining (i.e. wages).

In order to gauge the inflationary impact of an exogenous change in costs we will use two different measures.

**Definition:** The inflationary sensitivity of a market is the derivative of the equilibrium price with respect to an exogenous change in marginal costs.

Assuming that the product is homogeneous, the inflationary sensitivity when the marginal cost is exogenous is  $dp^* / dc$  where  $p^*$  denotes the equilibrium price according to an equilibrium concept (to be specified later). In the class of models in which the marginal cost is partially endogenous, the inflationary sensibility is  $dp^* / de$ . An alternative way of measuring the inflationary impact of an exogenous change in costs is the following:

**Definition:** The inflationary elasticity of a market is the elasticity of the equilibrium price with respect to the exogenously given marginal costs.

Thus assuming that the product is homogeneous, the inflationary elasticity -which will be denoted by  $\mu$ - in the class of models in which the marginal cost is exogenous, is  $\mu \equiv c \cdot dp^* / dc \cdot p^*$ , i.e. the elasticity of  $p^*$  with respect to  $c$ . In the class of models in which the marginal cost is partially endogenous the inflationary sensibility is  $\mu' \equiv e \cdot dp^* / de \cdot p^*$ .

Both measures, inflationary sensitivity and inflationary elasticity, attempt to capture how rising costs translate into price increases, and thus they measure how much inflation is transmitted by the market, given an exogenous cost push. Notice that if firms are profit maximizers,  $\mu > 1$  implies  $dp^* / dc > 1$ , since under imperfect competition equilibrium price is greater than marginal cost.

The exercise that we will perform in this paper is the following: we will consider several models of imperfect competition and we will find the values

of the inflationary sensitivity and the inflationary elasticity. We will compare these values with the corresponding values in a perfectly competitive market. By assumption a) above, both the inflationary sensitivity and the inflationary elasticity in a perfectly competitive market with exogenous wages equals to one. Thus we will find necessary and sufficient conditions for  $dp^* / dc$ ,  $dp^* / de$  and  $\mu$  to be greater than one, i.e. for the imperfectly competitive market to transmit more inflation -i.e. to be more inflationary- than perfect competition. When the marginal cost is partially endogenous we will obtain explicit formulae for  $\mu'$  under perfect and imperfect competition. At the end of each section we will see if there is some connection between the results obtained for each model. We will see that comparing the different results obtained throughout the paper, some regularities do emerge.

Finally, let us define two magnitudes that will play an important part in our analysis. Let  $\epsilon = p''(x) x / p'(x)$  be the elasticity of  $p'(x)$  with respect to  $x$  evaluated at the corresponding equilibrium. Roughly speaking  $\epsilon$  measures the degree of concavity (or convexity) of the inverse demand function. Clearly  $\epsilon \geq$  (resp.  $\leq$ )  $0$  iff  $p''(x)$  is concave (resp. convex). Similarly let  $\beta = p'(x) x / p(x)$  be the elasticity of demand evaluated at the corresponding equilibrium. Simple calculations can show that if  $\beta$  is constant,  $\epsilon = \beta - 1$  and that if  $\beta$  were increasing  $\beta > \epsilon + 1$ .

### III. MODELS WITH EXOGENOUS MARGINAL COSTS

In this section we will consider four different models: in the two firsts (Cournot model with a given number of firms and Cournot model with free entry), the product is assumed to be homogeneous. The other two models (Spence-Dixit-Stiglitz and Salop) consider monopolistic competition.

III. a) Homogeneous Product.

First, let us consider the case in which the number of firms is given. Assuming that firms are quantity determiners, the first order condition of profit maximization (assuming interiority) is

$$p(x) + p'(x) x_1 - c = 0 \quad (1)$$

Let  $p^*$  be the Cournot equilibrium price (assumed to exist). From (1) above we can calculate  $dp^* / dc$ . Then we have our first result:

**Proposition 1.** *In the Cournot model with a given number of firms:*

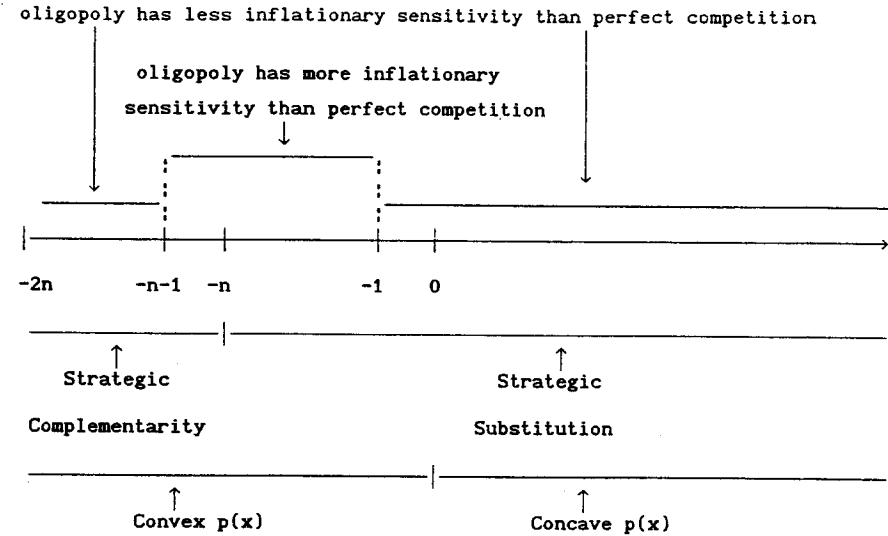
a) *An oligopolistic market has a higher inflationary sensibility than a perfectly competitive one if and only if  $-1 - n < \epsilon < -1$ .*

b) *An oligopolistic market has identical inflationary sensibility than a perfectly competitive one if and only if  $\epsilon = -1$ .*

**Proof:** Since  $dp^* / dc = p' dx / dc$ , differentiating (1) above we obtain that

$$dp^* / dc = n / (n + \epsilon + 1). \quad (2)$$

Let us first prove part a). Suppose that  $dp^* / dc > 1$ . From (2) above we deduct that the denominator must be positive, i.e.  $n + \epsilon + 1 > 0$  and a simple manipulation leads to  $\epsilon + 1 < 0$ . Conversely, if  $-1 - n < \epsilon < -1$  but  $dp^* / dc \leq 1$  we reach a contradiction. Part b) follows from equation (2) directly. ■



**Figure 1: Inflationary Sensitivity of the Cournot Equilibrium Given n.**

Let us now discuss the necessary and sufficient condition in part a) of Proposition 1. It is easy to find examples in which this condition is not fulfilled. For instance, if the inverse demand function were  $p = a - b x^\alpha$  with  $\alpha > 0$ , this condition is not satisfied since  $dp^* / dc = n / (n + \alpha) < 1$ . Therefore, in this case, an oligopolistic market transmits less inflation than a perfectly competitive one. However, if the inverse demand function were  $p = A / x^\gamma$  with  $0 < \gamma < n$  the condition holds, since  $dp^* / dc = n / (n - \gamma) > 1$ .

Returning to the general model, it is easy to show that  $1 + \epsilon + n > 0$  if and only if  $dx / dc < 0$ , i.e. an increase in the marginal cost decreases total output. Also,  $1 + \epsilon + n > 0$  is a sufficient condition for uniqueness of equilibrium. On the other hand, the range of variation of  $\epsilon$  allowed by the



second order condition of profit maximization, given symmetric equilibrium and that  $p'(x) < 0$ , is  $-2n < \epsilon$  (see Figure 1).

Strategic Substitution (resp. Strategic Complementarity) (see Bulow, Geanakoplos and Klemperer (1985)) means that the best reply function -which picks up the best strategy of a firm, given the remaining firms' strategy- is a strictly decreasing (resp. increasing) function. Differentiating (1), Strategic Substitution (resp. Strategic Complementarity) is equivalent to  $\epsilon > -n$  (resp.  $\epsilon < -n$ ). As it is easily seen, neither Strategic Substitution, nor Strategic Complementarity is necessary or sufficient condition for an oligopolistic market to transmit more (or less) inflation than a perfectly competitive one. Concavity of  $p(x)$ , which is equivalent to  $\epsilon \geq 0$ , is a sufficient (but not a necessary) condition for the oligopolistic market to be less inflationary than the perfectly competitive one, and convexity of  $p(x)$  at the Cournot equilibrium is a necessary (but not a sufficient) condition for the oligopolistic market to be more inflationary than the perfectly competitive one. Thus, a possible interpretation of the necessary and sufficient condition in Proposition 1 part a) is that  $p(\cdot)$  must have some degree of convexity, but not too much (see Figure 1).

With respect to the inflationary elasticity we have the following result:

**Proposition 2.** *In the Cournot model with a given number of firms:*

a) *An oligopolistic market has a higher inflationary elasticity than a perfectly competitive one if and only if  $-n-1 < \epsilon < \beta-1$ .*

b) *The inflationary elasticity of oligopoly and perfectly competitive markets are identical if and only if  $\beta = \epsilon + 1$ .*

**Proof:** *It is easily calculated that*

$$\mu = (\beta + n) / (1 + n + \epsilon) \quad (3)$$

Since  $c$  and  $p^*$  are positive from the definition of  $\mu$  we have that

$$\text{sign of } \mu = \text{sign } dp^* / dc = \text{sign of } (n + \epsilon + 1) \quad (4)$$

Let us prove part a) first. Suppose that  $\mu > 1$ . If  $n + \epsilon + 1 \leq 0$  by Proposition 1 we have that  $dp^* / dc \leq 0$  so (4) above implies that  $\mu \leq 0$  which is a contradiction. Therefore  $n + \epsilon + 1 > 0$ . So if  $\mu > 1$  from (3) above we obtain that  $\beta > 1 + \epsilon$ .

Suppose that  $n + \epsilon + 1 > 0$  and  $\epsilon < \beta - 1$  but  $\mu \leq 1$ . Then, the first two inequalities imply that  $\beta + n > 0$ . Thus if  $\mu \leq 1$ , we have that (3) implies  $1 + \epsilon \geq \beta$  which contradicts  $\epsilon < \beta - 1$ . Part b) follows trivially. ■

The condition  $n + \epsilon + 1 > 0$  has been discussed before. As we noticed above, the condition  $\epsilon < \beta - 1$  is equivalent to assuming that  $\beta$  is increasing locally. A necessary (but not sufficient) condition for  $\beta$  to be increasing on  $x$  is the convexity of the inverse demand curve. An example of an inverse demand function with  $\beta$  locally increasing on  $x$ , is when it can be written as  $p = a + x^{-\rho}$  in a neighborhood of the Cournot equilibrium. In particular notice that if  $p = a - x$ ,  $\mu = nc/(a + nc) < 1$ , and that if  $p = A / x^\gamma$  with  $0 < \gamma < n$ ,  $\mu = 1$  (see Figure 2). When  $0 < \gamma < 1$ , this is an example of an inverse demand function for which  $dp^* / dc > 1$  but  $\mu \leq 1$ .

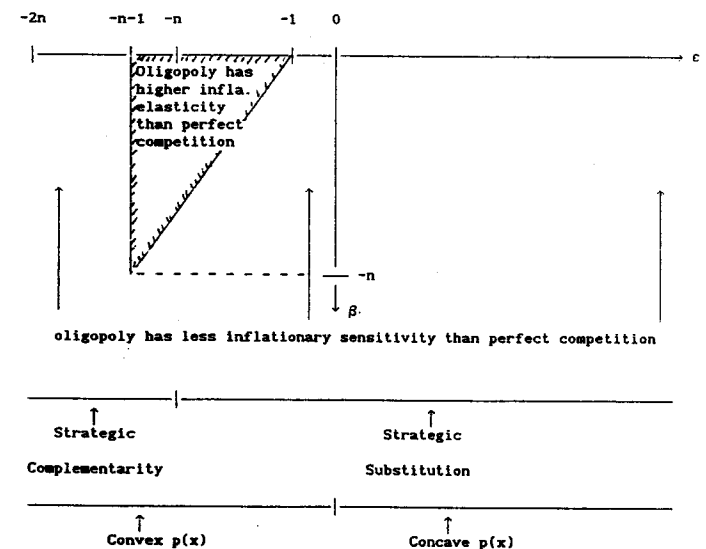


Figure 2: Inflationary Elasticity of the Cournot Equilibrium Given  $n$

Let us remark that under our assumptions  $\epsilon$  is continuous on  $x$  so if the range of variation of  $x$  is bounded (as it happens under standard assumptions) for large enough  $n$  we have that  $dp^*/dc \approx 1$  and that  $\mu \approx 1$ . However, conditions under which  $dp^*/dc$  and  $\mu$  are decreasing on  $n$  depend on the third derivative of  $p(\cdot)$  and therefore they are difficult to interpret. Thus, there is no guarantee that an increase in  $n$  makes the market less inflationary<sup>(1)</sup>.

Let us now consider the Cournot model with free entry. In this case we will assume that there is a fixed cost  $K$ . This fixed cost is not affected by the changes in  $c$ . Thus, the equations that determine the equilibrium are

$$p(x) + p'(x) x_1 - c = 0 \quad (1)$$

$$(p(x) - c) x_1 = K \quad (1')$$

where it is implicit in (1') that we do not consider the whole problem. Then, we have the following result:

**Proposition 3.** *In the Cournot model with free entry:*

a) *An oligopolistic market has a higher inflationary sensitivity than a perfectly competitive one if and only if  $\epsilon < 0$ .*

b) *An oligopolistic market has inflationary sensitivity identical to that of a perfectly competitive one if and only if  $\epsilon = 0$ .*

**Proof:** Clearly,  $dp^*/dc = p'(x)dx/dc$ . Equations (1) and (1') above imply that  $p(x) - c = (-p'(x)K)^{1/2}$ . Differentiating this equation we obtain that  $dx/dc = 1/p'(x) (1 + \epsilon/2n)$  and therefore  $dp^*/dc = 2n/(2n + \epsilon)$ . Proposition 3 follows from that. ■

Proposition 3 says that the necessary and sufficient condition for an oligopolistic market to have higher inflationary sensibility than a perfectly

competitive one is that  $p''(x) > 0$ . This implies that the inverse demand curve is strictly convex when evaluated at equilibrium. Notice that if  $p(\cdot)$  is isoelastic, markets characterized by Cournot competition with free entry are more inflationary than perfectly competitive ones. If  $p(\cdot)$  is linear, both kinds of competition have identical inflationary sensibility<sup>(2)</sup>.

Let us now turn our attention to the inflationary elasticity of Cournot equilibrium with free entry.

**Proposition 4.** *In the Cournot model with free entry:*

a) *An oligopolistic market has higher inflationary elasticity than a perfectly competitive one if and only if  $2\beta - \epsilon > 0$ .*

b) *An oligopolistic market has inflationary elasticity identical to that of a perfectly competitive one if and only if  $2\beta - \epsilon = 0$ .*

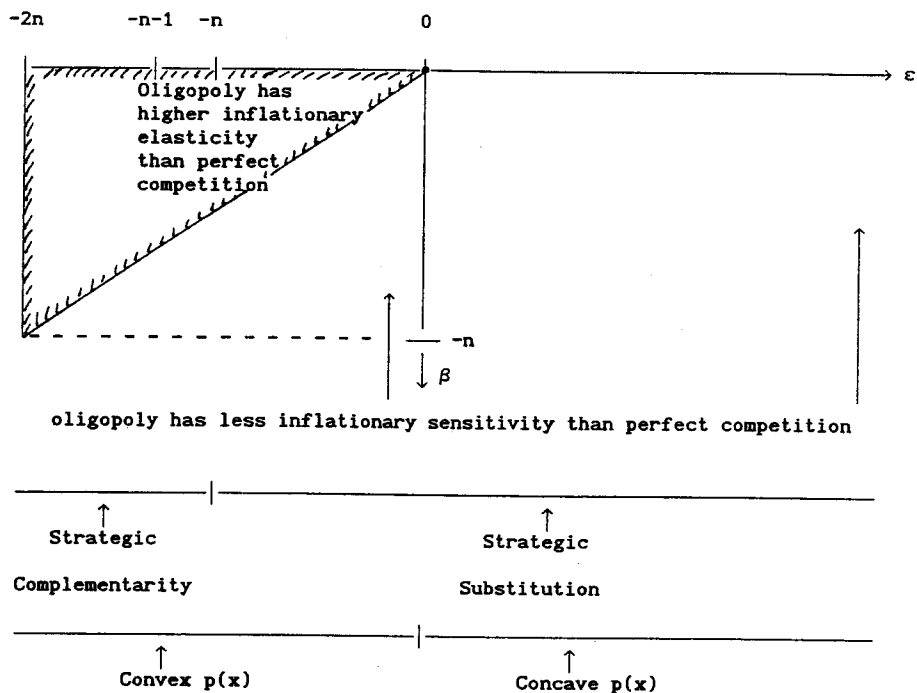
**Proof:** From Proposition 3 we obtain that  $\mu > 1$  if  $c > p(x) (1 + \epsilon/2n)$ . Using the first order condition of profit maximization we get the result. ■

Notice that if  $p(\cdot)$  is linear the condition in Proposition 4 part a) is not fulfilled. However if  $p = A/x^\gamma$  with  $0 < \gamma < 1$  this condition is satisfied, see Figure 3<sup>(3)</sup>. If  $\gamma = 1$  the condition in part b) is fulfilled.

(2) If the cost push affects proportionally  $K$  and  $c$  it can be shown that  $dp^*/dc = n(2n + \beta)/(2n + \epsilon)(n + \beta)$ . Thus under both linear and isoelastic inverse demand functions, an oligopolistic market characterized by Cournot competition with free entry has greater inflationary sensitivity than a perfectly competitive one. However under constant returns to scale, a perfectly competitive equilibrium exists only if fixed costs are zero. Therefore when the push affects both  $K$  and  $c$ , an oligopolistic market is subject to a higher push than a perfectly competitive market. This may be the explanation of the higher inflationary sensitivity of the former one in the linear and the isoelastic cases. This explanation is reinforced by the fact that when we consider the inflationary elasticity we are back at the familiar situation in which isoelastic and linear inverse demand functions yield different answers.

(3) If the push affects proportionally both  $c$  and  $K$  it can be shown that in this case  $\mu = (2n + \beta)/(2n + \epsilon)$ . Thus  $\mu > 1$  iff  $\beta > \epsilon$ . Again if  $p(\cdot)$  is isoelastic this condition is met but if  $p(\cdot)$  is linear the reverse is true.

(1) It can be shown that Propositions 1 and 2 apply mutatis mutandis to markets with heterogeneous goods and a given number of quantity -or price-determiner firms. For the case of a variable number of firms see Propositions 3-6.



**Figure 3: Inflationary Elasticity of the Cournot Equilibrium with free entry**

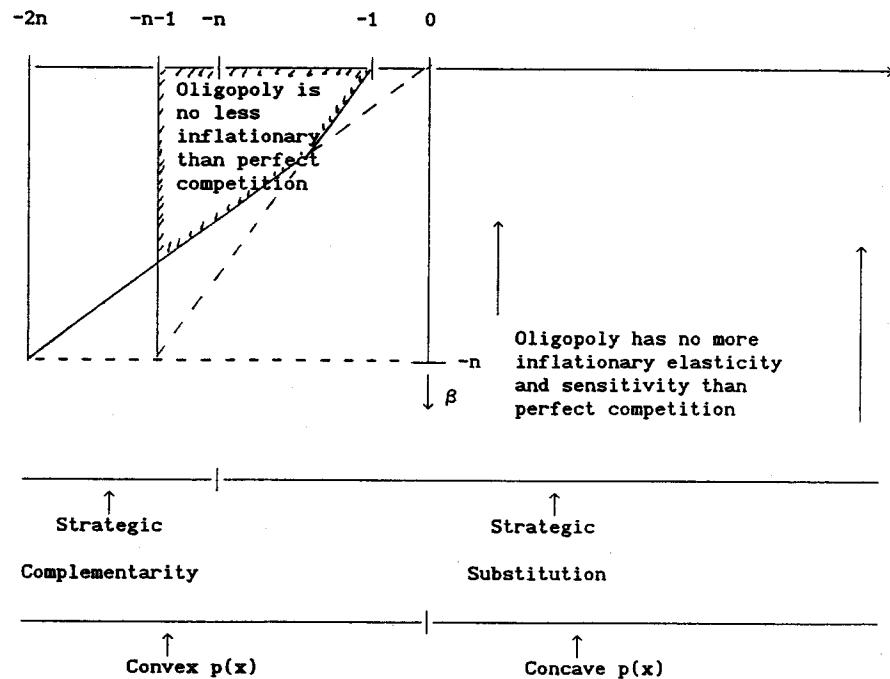
It is now time to recapitulate what we have learnt in Propositions 1-4 above.

**Theorem 1:** Under oligopoly à la Cournot, with or without free entry:

a) If  $-1 - n < \epsilon \leq \min(2\beta, \beta - 1)$ , oligopoly is never less inflationary than perfect competition

b) If  $\epsilon \geq 0$ , oligopoly is never more inflationary than perfect competition.

In particular if the inverse demand function is  $p = A / x^\gamma$  with  $0 < \gamma \leq 1$  the condition in part a) of the theorem is fulfilled and if  $p(\cdot)$  is linear the condition in part b) is met, see Figure 4.



**Figure 4: Theorem 1**

**III. b) Heterogeneous Product: Monopolistic Competition.**

First let us consider the model of a representative consumer (see Spence (1976) and Dixit-Stiglitz (1977)). In this case the unique consumer has a utility function of the form  $U = U(y, \sum_{i=1}^n x_i^\rho)$  where  $y$  represents the outside good and  $0 < \rho < 1$ . Notice that if  $\rho = 1$  we are back to the case in which the

product is homogeneous. For later reference it is important to remark that the inverse demand function in the "Large Group" case is isoelastic (see Dixit-Stiglitz (1977) p. 299 above equation 15 and p. 298 below equation 4). In this case, the equilibrium price can be shown to be  $p_i^* = c/\rho$ ,  $i = 1, \dots, n$  (see Dixit-Stiglitz (1977) p. 299 eq. 15). Thus, the following Proposition follows trivially.

**Proposition 5.** *In the representative consumer model of monopolistic competition we have that*

a) *The inflationary sensitivity is greater under monopolistic competition than under perfect competition.*

b) *The inflationary elasticity of monopolistic competition and perfect competition are identical.*

In the circular model, due to Salop (1979), consumers are supposed to be uniformly distributed around a circle of unit length. We will concentrate on the so called "Competitive Case". There, demand functions are shown to be linear. Let  $d$  be the unit cost of transportation, paid by the consumer. Then, it can be shown that  $p^* = c + (dK)^{1/2}$ . Then, we have the following:

**Proposition 6.** *In the circular model of monopolistic competition we have that*

a) *The inflationary sensitivity under monopolistic competition and under perfect competition are identical.*

b) *The inflationary elasticity is less under monopolistic competition than under perfect competition.*

The following theorem recapitulates what we have learnt from all the models in this Section.

**Theorem 2:** *In all the models of oligopoly and Monopolistic Competition considered in this Section:*

a) *If the inverse demand function is isoelastic with elasticity less than one, imperfectly competitive markets are never less inflationary than perfect competition*

b) *If the (inverse) demand function is linear, imperfectly competitive markets are never more inflationary than perfect competition.*

In other words, under constant and exogenous marginal costs, the choice of the functional form of the demand or the inverse demand function is a crucial determinant of the results<sup>(4)</sup>. In the next section we will consider that the value of the marginal cost is partially determined by bargaining. We will see that results there are different from those obtained in this section.

#### IV. BARGAINING MODELS

In this section we will consider a different class of models. For simplicity, let us assume that the product is homogeneous. Here, the marginal cost  $c$  is divided into two components  $w$  and  $e$ , i.e.  $c = w + e$ . Think of  $w$  as the wage rate, determined by bargaining between firms and workers. The former ones care only about overall profits and the latter ones only about total wage bill. The remaining part of the marginal cost,  $e$ , is assumed to be exogenously given.

If both  $w$  and  $x$  are negotiated, both parties have incentives to raise as much revenue as they can, i.e. to maximize  $p(x).x - e.x$ . Thus the analysis of the previous section can be used to find the inflationary sensitivity and elasticity of  $p^*$  with respect to  $e$ . In this section we will concentrate on the case in which  $w$  is negotiated but  $x$  is determined by a Cournot equilibrium with a given number of firms for given  $w$ <sup>(5)</sup>. In other words, firms can commit

(4) If we consider that  $c$  and  $K$  change proportionally, our results in the representative consumer model do not change. However, in the circular model the inflationary sensitivity is greater than one, but the inflationary elasticity can be shown to be less than one. Therefore the explanation of this anomaly given in footnote 2 seems also valid here.

(5) Notice that the other equilibrium concepts considered in this paper do not allow for positive profits and thus they are not suitable for consideration within the framework of bargaining.

themselves to paying a wage rate  $w$  but they can not commit themselves to the output level. A similar assumption has been used by Hart (1982) among others. The question of why wages are negotiated but employment is not, is left for future research.

We will study two different models, namely Nash Bargaining Solution and wage bill maximization. For reasons of tractability, and in order to facilitate the comparison with the results obtained in the previous section, we will assume that the inverse demand function is either linear or isoelastic. In the general case, the effect of  $e$  on  $p^*$  depends on the third derivative of  $p(\cdot)$  and therefore any possible result here would be difficult to interpret.

Let us consider first the case where workers and firms bargain according to Nash's axioms (Nash (1950)). Thus wages are determined by the maximization of the product of total profits and the wage bill. Let  $x(w)$  be the aggregate output as a function of the wage rate  $w$ . This function will be assumed to be  $C^1$ . Thus, the first order condition of the maximization of the product of total profits and the wage bill is:

$$(p'(x) \cdot x + p - 2w - 2e) \cdot w \cdot x \cdot dx(w)/dw + (p(x) - 2w - e) \cdot x^2 = 0$$

Using the first order condition of profit maximization we obtain that

$$(x - 2x_1) \cdot w \cdot p'(x) \cdot dx(w)/dw + x(-p'(x) - w) = 0. \text{ Since } dx(w)/dw = n/(p'(x)(\epsilon + n + 1)), \text{ we get that } w = -p'(x) \cdot x_1(\epsilon + 1 + n) / (\epsilon + 3).$$

**Proposition 7.** *If firms and workers negotiate à la Nash:*

- a) *If the inverse demand function is linear, both the inflationary sensitivity and the inflationary elasticity are increasing with  $n$ .*
- b) *If the inverse demand function is isoelastic, then the inflationary sensitivity is increasing with  $n$  and the inflationary elasticity equals one.*

**Proof:** *If  $p = a - x$ , the Cournot equilibrium output for given  $w$  and  $n$  is  $x = n(a - w - e)/(n + 1)$ . Thus  $w = (a - w - e)/3$  since  $\epsilon = 0$  in this case. From*

*there we obtain that  $w = (a - e)/4$  and that  $p^* = (a(n + 4) + 3ne)/4(n + 1)$ . Thus  $dp^*/de = 3n/4(n + 1)$ ,  $\mu' = 3ne/(a(n + 4) + 3ne)$  and the result follows.*

*If  $p(\cdot)$  is isoelastic it is easy to show that  $w = -e\beta/2(\beta + 1)$  and that  $p^* = en(\beta + 2)/2(\beta + 1)(n + \beta)$ . Thus  $dp^*/de = n(\beta + 2)/2(\beta + 1)(n + \beta)$  which is increasing with  $n$ . Trivially  $\mu' = 1$ .*

Let us consider now the case in which trade unions set wages in order to maximize the wage bill. In this case, the first order condition reads  $x(w) + w \cdot dx(w)/dw = 0$ . Thus we have the following result:

**Proposition 8.** *If trade unions set wages to maximize the wage bill:*

- a) *If the inverse demand function is linear, both the inflationary sensitivity and the inflationary elasticity are increasing with  $n$ .*
- b) *If the inverse demand function is isoelastic, the inflationary sensitivity is increasing with  $n$  and the inflationary elasticity equals one.*

**Proof:** *If  $p = a - x$ , the Cournot equilibrium output for given  $w$  and  $n$  is  $x = n(a - w - e)/(n + 1)$ . Thus  $w = (a - e)/2$  and  $p = (a + an/2 + en/2)/(n + 1)$ . Simple calculations suffice to prove part a). If  $p(\cdot)$  is isoelastic,  $w = -e\beta/(\beta + 1)$  and  $p = ne/(\beta + 1)(\beta + n)$  and part b) follows easily.*

Propositions 7-8 can be summarized in the following theorem:

**Theorem 3:** *Suppose that the marginal cost is partially negotiated, that Cournot competition with a given number of firms prevails in the market and that the inverse demand function is either linear or isoelastic. Then:*

- a) *An increase in the degree of competition never decreases the degree of inflation transmission.*
- b) *When the market is perfectly competitive (i.e.  $n = \infty$ ) the degree of inflation transmission is larger or equal than under oligopoly.*

## V. CONCLUSIONS

In this paper we have examined closely the theoretical basis of the conjecture that imperfectly competitive markets tend to transmit too much inflation. In order to do this we have used the methodology of reviewing six models by using two different measures of inflation transmission. The picture that emerges as a result can be summarized as follows:

1) The relevant factors determining the relative degree of inflation transmission in imperfectly competitive and perfectly competitive markets are different in the case in which the marginal cost is totally exogenous from the case in which the marginal cost is only partially exogenous.

2) If the marginal cost is totally exogenous, the relevant factor is the shape of the inverse demand function. If this function is isoelastic (with elasticity less or equal than one), imperfectly competitive markets transmit more or equal (but never less) inflation than perfectly competitive ones. If this function is linear, imperfectly competitive markets transmit equal or less (but never more) inflation than perfectly competitive ones. The (rather algebraic) intuition behind our results is the following: If the inverse demand function is isoelastic, the final expression for the equilibrium price tends to be of the form  $p^* = q \cdot c$  (where  $q$  is a constant). Thus  $\mu = 1$  and given that price exceeds marginal cost,  $dp^* / dc > 1$ . If the inverse demand function is linear, the final expression for the equilibrium price tends to be of the form  $p^* = r + q \cdot c$  and thus, given that  $r$  and  $q$  are non negative  $\mu \leq 1$ . Also, since for large enough  $c$ ,  $p = c$ ,  $dp^* / dc < 1$ <sup>(6)</sup>.

3) If the marginal cost is partially exogenous, then the degree of inflation transmission never decreases with an increase in competition, i.e. with the number of firms. This contradicts the conjecture mentioned before.

Summing up, our methodology has allowed us to identify some potentially important problems in applied work. We believe that the use of a similar methodology might be useful in identifying other regularities in the theory of industrial organization. Clearly, they can be applied to the study of the (perhaps old-fashioned) question of the relative flexibility of outputs under oligopoly and perfect competition.

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(6) This intuition should not be taken as an explanation of what is going on. If  $-\beta < 1$  the necessary and sufficient condition of Proposition 4 part a) is not met and therefore oligopoly is less inflationary than perfect competition.

## APPENDIX

The motivation for this Appendix is the observation that, in oligopolistic industries, it often happens the case that demands of workers depend on profits (Salinger (1984)). Thus, inflation results from the effort of the suppliers of inputs to capture oligopolistic rents. Here, we will study two dynamic models in which bargaining occurs according to the above lines. In order to simplify the story, we will assume that there are no costs other than labor. The reader must be warned that all the results in this Appendix must be understood as extended examples, valid only for illustrative purposes.

Let time be indicated by the subindex  $t$ . Also, the rate of growth of a variable, say  $z$ , will be denoted by  $g_z$ .

In the first model, workers demand (and obtain) an increase in wage bill proportional to the profits in the last period. Thus  $c_{t+1} \cdot x_{t+1} - c_t \cdot x_t = \alpha \cdot \Pi_t$  where  $\Pi_t$  stands for profits in  $t$ . Let us assume that the inverse demand function reads  $p_t = y_t / x_t$  where  $y_t$  is aggregate income in  $t$ . The Cournot equilibrium with  $n$  firms is  $x_t = (y_t(n - \beta)/nc_t)^{1/\beta}$  and  $p_t = nc_t/(n - \beta)$ . Thus, from the bargaining equation we get that  $c_{t+1} = c_t(\alpha\beta + n - \beta)/(n - \beta)(1 + g_x)$  and therefore  $g_c = ((\alpha\beta + n - \beta)/(n - \beta)(1 + g_x)) - 1 = g_p$ .

Now, if the economy is composed by, say  $k$ , productive sectors like the one described above, it is reasonable to expect that aggregate income will grow at the same rate as  $c_t \cdot x_t + \Pi_t$  does. But  $c_t \cdot x_t + \Pi_t = p_t \cdot x_t$  and thus  $g_y = g_p + g_x$ . However  $\beta g_x = g_y - g_c$  and thus if  $\beta \neq 1$ ,  $g_x = 0$   $g_c = \alpha\beta / (n - \beta) = g_p$ . Therefore this model predicts constant output and employment and a constant rate of inflation.

In the second model, workers set wages myopically in order to achieve a target given by a certain ratio of wage bill to overall profits. Let bargaining be summarized by  $c_t \cdot x_t = \alpha \cdot \Pi_{t-1}$ , where  $\Pi_{t-1}$  stands for profits in  $t - 1$ . We will assume that the inverse demand function reads  $p = a - x/y$ . Thus

in a Cournot equilibrium with  $n$  firms we have that  $x_t = n(a - c_t) y_t / (n + 1)$  and  $p_t = (a + nc_t) / (n + 1)$ .

There are two rest points of this process, namely  $c^* = a$  and  $c^* = a\beta / (1 + \beta)$  where  $\beta \equiv \alpha / (1 + g_y) (1 + n)$ . Thus in the first case wage rise wipes out not only profits, but the whole industry. In the second case wage rise settles in an interior equilibrium. We will call this equilibrium B (for bad) and G (for good). We now turn to the study of the dynamic stability of B and G.

Then,  $c_t \cdot x_t = \alpha \cdot \Pi_{t-1}$  yields

$$c_t^2 - ac_t + \beta(a - c_{t-1})^2 = 0$$

Assuming that  $1 - 4\beta > 0$  we obtain that the two solutions to the above equation are

$$2c_t = a \pm (a - 4\beta(a - c_{t-1})^2)^{1/2}$$

It is easy to see that the bigger root of the above equation converges globally to equilibrium B, with increasing prices, wages and unemployment. It is interesting to notice that once this root has been selected, there is no way to stop the destruction of the industry. In other words, a change in  $\alpha$ ,  $n$  or in the rate of growth of income will only delay, but not stop the process.

The smaller root converges -at least locally- to equilibrium G with cycles for wages, prices and employment.

Notice that in the linear case our model does not put any restriction on the long-run value of  $g_y$ . Indeed assuming as before that the economy is composed by markets like the previous one we have that  $g_y = g_{px} = g_p + g_x$ . Thus, in the long run  $g_p = 0$  and  $g_y = g_x$ . From the equilibrium equation for  $x$  we obtain that in the long run  $g_y = g_x$ . Therefore both equations are identical.

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