EXCHANGE RATE AND PRICES:
FIRMS' BEHAVIOUR IN THE OPEN ECONOMY*

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1. INTRODUCTION

This paper is concerned with the behaviour of firms operating in international markets, i.e. exporting and/or facing import competition, with specific reference to the effects of exchange rate movements.

The issue is relevant both at the microeconomic and macroeconomic level. At the macroeconomic level it plays an important role in the debate on the validity of purchasing power parity (PPP henceforth) theory and the deviations from that, both in the short and in the long run, and in the debate on the role of exchange rate changes in inflationary/deflationary processes.

The flexible exchange rates experience of the last fifteen years seems to suggest that the law of one price (loosely defined) is a poor and unsatisfactory description of the real world; this can be seen not only in terms of real exchange rate behaviour at aggregate level, but also at a very high level of disaggregation. Empirical studies for manufactures show a strong positive correlation betweeen exchange rate changes and relative price movements, with changes in relative prices lasting for a long time (1).

These empirical results indicate that a deeper analysis both at

the theoretical and empirical level may be fruitful.

As Dornbusch points out in some recent contributions (1985a, 1987a, 1987b) the analysis of price formation for goods sold in markets open to international competition should be based on microeconomic models of firms' behaviour in imperfectly competitive markets (2).

In this framework the adjustment of prices and output following an exchange rate change depends on structural characteristics like the extent of product omogeneity or substitutability and the market structure in terms of degree of concentration and different interaction among firms (3).

In this paper I assume that the product market is characterized by monopolistic competition (4).

The hypothesis of monopolistic competition provides a simple framework of analysis because it allows to sidestep the problem of strategic interaction among firms.

Exchange rate movements are taken as exogenous, without introducing a complete macroeconomic model.

Along these lines Aizenman(1986) derives a pricing rule used by the firms in the domestic product market. Under the assumptions of given real wages and no imported inputs he shows that in the long run prices adjust according to the relative PPP doctrine. However, in the intermediate run, in a market characterized by monopolistic competition and costly pricing decisions, there are systematic deviations from relative PPP. The speed of adjustment is shown to depend on the degree of substitutability between domestic and foreign goods.

The analysis in this paper extends and modifies the results

obtained by Aizenman(1986).

While Aizenman focuses only on the characteristics of the product market in terms of product substitutability, I show that in an economy open to international competition the behaviour of prices and output following an exchange rate change depends on the interaction between product substitutability and the cost structure, with specific reference to the behaviour of input prices (domestic and imported inputs) relative to that of the output price.

Moreover while the standard assumption in the literature is that the firm uses the price as choice variable, I discuss both price setting and quantity setting behaviour and compare the main results in the two cases.

All the results are obtained by assuming an optimizing behaviour by firms.

The paper is organized as follow. Section 2 describes the model. In section 3 I discuss a comparative static analysis in the spirit of Dornbusch(1987a); I analyse the change in the equilibrium solution after an exchange rate change under different assumptions about the structural parameters characterizing the economy. Section 4 studies price adjustment with information costs related to the determination of the optimal choice. Both price setting and quantity setting behaviour are analyzed and the most relevant results from the comparison between the two behavioural modes are presented. Section 5 provides concluding remarks.

2. THE MODEL

Consider an economy with s firms facing international competition only in terms of imports competing with national producers on the domestic market. Each firm produces one differentiated product; it faces a downward sloping demand curve and competes with the other (s-1) domestic firms and with imports coming from abroad.

Demand function for the good produced by firm k is

$$(1) \qquad D(k) = \left(\frac{EP^*}{P(k)}\right)^{\alpha} \prod_{\substack{j=1 \\ j\neq k}}^{s} \left(\frac{P(j)}{P(k)}\right)^{\beta} \qquad k=1,..,s$$

that can be written also

$$(1') \qquad D(k) = (EP^*)^{\alpha} P(k)^{-\delta} \prod_{\substack{j=1 \\ j\neq k}}^{s} P(j)^{\beta} \qquad \text{with} \quad \delta=\alpha+\beta(s-1)$$

where

D(k) = quantity demanded of good k, k=1,....s;

P(j) = price of good j, j=1,..,k,...s;

EP* = import price in domestic currency (E is the exchange rate and P* the price in foreign currency).

Domestic firms face identical demand functions.

This system of demand functions may be thought of as being derived from a particular characterization of preferences following Dixit and Stiglitz (1977); the elasticity of demand in this type of model is closely related to the elasticity of substitution in preferences among different goods. α that tends to ∞

implies that national and foreign goods are perfect substitutes in consumption. As in Aizenman(1986) particular attention is paid here to the effects of increased substitutability on the determination of the prices of domestically produced goods facing import competition.

The domestic currency price of imports is EP* with P* exogenously given. P* is assumed constant (and set equal to one for simplicity), therefore a change in the exchange rate gives rise to an equal change in the domestic currency price of imported goods (5).

The domestic price level P is given by

$$(2) \qquad P = \prod_{j=1}^{s} P(j)^{1/s}$$

Consider now the cost function. It plays a crucial role in the analysis developed in this paper. The firm's optimal policy depends on the behaviour of both marginal revenues and marginal costs, therefore the interaction between the elements influencing revenues and costs must be carefully considered. While on the revenue side, firms look at competitors' prices, on the cost side, they must take into account input prices (6).

Assume that production requires one domestic input, labour, and one imported input, raw materials for example. Technology exhibits decreasing return to scale. A Cobb Douglas production function is used in order to get simple analitical results.

The cost function, identical for all domestic firms, is

$$(3) \qquad C(k) = Z \; W^{\frac{a}{a+b}} \; (EPN^*)^{\frac{b}{a+b}} \; Q(k)^{\frac{1}{a+b}} \qquad k=1,\ldots,s$$

where

W = nominal wage rate;

EPN^* = domestic currency price of imported inputs; PN^* is the foreign currency price, it is assumed exogenously given and constant (let $PN^*=1$ for simplicity), therefore a change in the exchange rate gives rise to an equal change in the domestic currency price of imported inputs;

Z is a constant term (7).

Capital stock is given and $(a+b)<1$ with decreasing returns to scale.

Next consider nominal input prices.

The assumptions about the price of imported inputs are stated above. With reference to the determination of nominal wages what is relevant in the analysis is the behaviour of W relative to output price behaviour. It can be described in terms of indexation (μ) of nominal wages to a price index, as a way to show to what extent wages follow the output price and the exchange rate.

$$\text{Let } W = (P^{T} \; (EP^*)^{(1-T)})^{\mu} \; W^*, \qquad \text{with } 0 \leq \mu \leq 1 \text{ and } 0 \leq T \leq 1,$$

where wages are indexed to a price index including both domestic and imported consumer goods (8) and W^* is a constant term.

This formulation includes those used in other recent contributions as special cases.

With $\mu=1$ there is complete indexation. Real wages are given. The cost function is homogeneous of degree one in P and E. This is the assumption in Aizenman model(1986), where real wages are given in terms of the domestic price level only.

With $\mu=0$ there is no indexation; nominal wages are set with no reference to the output price, they are given in nominal terms as in Dornbusch (1985a, 1987a, 1987b) models.

With $0<\mu<1$ there is less than perfect indexation: this is the intermediate case and the general case in this paper.

The model includes several channels through which the exchange rate affects domestic price level. There is a direct effect through imported inputs used in domestic production, a competitiveness effect through foreign consumer goods competing with domestic production and a wage effect through the determination of nominal wages and the consequent effect on production costs. All these aspects have been discussed also in the empirical analysis of the exchange rate effects on inflation recently presented by Sachs(1985), but see also Woo(1984), Dornbusch and Fischer(1984) and Dornbusch(1985b). The relative importance of each channel may differ across countries and/or over time.

Given the model I derive the flexible equilibrium solution first.

From profit maximization the optimal price is in logs:

$$(4) \quad p(k) = \Theta(\alpha,\mu) + A(\alpha,\mu)e + B(\alpha,\mu) \sum_{\substack{j=1 \\ j\neq k}}^{s} p(j)$$

where low-case letters denote the log of the corrisponding upper-case variables (for ex. $p_k = \log P_k$) and

$$A(\alpha,\mu) = \frac{\alpha\left(\frac{1}{a+b} - 1\right) + (1-\tau)\mu\,\frac{a}{a+b} + \frac{b}{a+b}}{\delta\left(\frac{1}{a+b} - 1\right) + 1 - \tau\mu\,\frac{a}{(a+b)s}}$$

$$B(\alpha,\mu) = \frac{\beta\left(\frac{1}{a+b} - 1\right) + \tau\mu\,\frac{a}{(a+b)s}}{\delta\left(\frac{1}{a+b} - 1\right) + 1 - \tau\mu\,\frac{a}{(a+b)s}}$$

$$\Theta(\alpha,\mu) = \log\left(\frac{\frac{\delta}{a+b} - \tau\mu\,\frac{a}{(a+b)s}}{\delta-1}\, ZW^*\right)^{\frac{1}{\delta\left(\frac{1}{a+b} - 1\right) + 1 - \tau\mu\frac{a}{(a+b)s}}}$$

Note that with $\mu<1$ $A(\alpha,\mu) + (s-1)\,B(\alpha,\mu) < 1$, i.e. an equiproportionate change in the exchange rate and in the prices $p(j)$ charged by the other domestic firms does not lead to a change of equal amount in the price set by firm k unless $\mu=1$.

To simplify notation I define $C(\alpha,\mu) = 1 - A(\alpha,\mu) - (s-1)B(\alpha,\mu)$; it can be easily shown that $C(\alpha,\mu)>1$ for $\mu<1$ and $C(\alpha,\mu)=0$ for $\mu=1$.

Since all domestic firms face identical demand and cost

functions the equilibrium solution is symmetric, p(k) = p(j) = p:

$$(5) \qquad p = \frac{\Theta}{A+C} + \frac{A}{A+C}\, e.$$

With $\mu=1$

$$p = \frac{\Theta}{A} + e.$$

3. COMPARATIVE STATICS

In this section I analyse how structural parameters influence the size of the adjustment of domestic prices to exchange rate movements.

I discuss the role of substitutability between domestic and foreign goods, of wage indexation and of the technological structure in terms of relative shares of domestic and imported inputs in production.

An increase in substitutability between domestic and foreign goods, expressed here in terms of demand elasticity α, implies an increase in the exchange rate coefficient A and a decrease in the coefficient B relative to the prices of the other domestic firms in eq.(4). The coefficient A/(A+C) of the exchange rate in the symmetric equilibrium (eq.(5)) is increasing in α as well.

Higher product substitutability requires more complete adjustment of domestic prices to exchange rate movements. When α tends to ∞, i.e. domestic and foreign goods become perfect substitutes,

the law of one price holds ($P = EP^*$ in absolute terms) and domestic price level cannot diverge from the price set abroad.

With complete wage indexation ($\mu = 1$), the coefficient $A/(A+C)$ in eq.(5) is equal to one; what can be called a relative version of PPP holds, in the sense that to an exchange rate change corrisponds an 1:1 change in the domestic price level (9). This result, that is the same as the one obtained by Aizenman(1986), is entirely due to the homogeneity of degree one of the cost function with respect to the domestic prices and the exchange rate when $\mu = 1$. In this case price adjustment is complete because there is a full response of input prices to exchange rate changes.

Aizenman's result that in the long run prices adjust according to the relative PPP doctrine holds only if in the time horizon considered, input costs adjust completely to price and exchange rate changes.

With complete indexation quantity produced doesn't change, real equilibrium is completely independent of the exchange rate level and therefore it is not influenced by exchange rate movements.

With less than perfect indexation ($\mu<1$) the relative version of PPP doesn't hold anymore, an exchange rate change doesn't generate a 1:1 change in the domestic price level. The adjustment of the price level is only partial; in fact, with $\mu<1$, $A/(A+C)$ is less than one. This happens because one element in the cost function (here the nominal wage rate) doesn't change and domestic firms take advantage of this differential in input costs. In this case an exchange rate change modifies the relative price between

domestic and foreign goods. The higher the substitutability in demand (α), the lower is the role these cost elements can play. Whether domestic firms exploit the cost differential or not, it depends on the level of substitutability in consumption.

With $\mu<1$ the output level is not independent of the exchange rate; by substituting the equilibrium price level in the demand function it is easy to show that the output depends on the level of the exchange rate.

An increase in the degree of indexation μ gives rise to an increase in the coefficients A and B in eq.(4). A/(A+C) in eq.(5) is increasing in μ as well and it tends to one when μ tends to one. The influence of the exchange rate on the firm's optimal choice increases when μ is higher, because there is a lower cost differential to exploit. In fact higher indexation implies that wage behaviour follows more closely exchange rate and output price movements reducing the cost differential.

Other structural elements that may be interesting to examine are the technology in terms of relative shares of domestic and imported inputs in production and the existence of a direct link between nominal wage determination and the exchange rate through the price of imported goods in the price index used in wage indexation ($\Upsilon<1$).

A high share of imported inputs and/or a direct link between wages and the exchange rate imply a tighter relationship between domestic prices and the exchange rate, since in both cases input costs follow more closely exchange rate movements. If it is assumed that production doesn't require imported inputs ($b/(a+b)=0$ in the general formulation) or that wages are indexed

to domestic prices only ($\tau=1$), the coefficients of the exchange rate in eqs. (4) and (5) are lower. The coefficients are still lower if both assumptions are combined, with labour as the only factor of production and wages indexed to domestic price level P only ($b/(a+b)=0$ and $\tau=1$).

Note that when $\mu=1$ the results coincide in all the cases ($0\leq\tau\leq1$ and $0\leq b/(a+b)\leq1$). It may appear surprising, but it can be intuitively explained by the fact that with complete wage indexation the cost function is homogeneous of degree one in P and E in all the cases (or in P alone in the last case). $\mu<1$ is required to obtain quantitative different results in the various cases, while with $\mu=1$ the coefficient $A/(A+C)$ is always equal to one for any value of τ and $b/(a+b)$ and the relative version of PPP always holds.

Although the assumptions about the behaviour of input prices are of crucial importance for the results presented, it doesn't simply mean that the problem is shifted one step backwards, from the product market to the input market. The analysis shows that in order to reach any precise conclusion about the effects of exchange rate changes we must take into account the interaction between the demand (revenue) and the cost structure, characterized here by the parameters α and β, on one hand, and μ,τ,a and b, on the other hand. Moreover some of the results recently presented in the literature, as in Aizenman(1986) and in Dornbusch(1987a), are based on precise but different assumptions about the behaviour of input prices, whose role must be clearly understood.

Labour is the only domestic input in the model. The analysis can be extended by introducing other domestic inputs, but the only problem is the description of the relative behaviour of input and output prices that in the case of labour can be expressed in a simple way in terms of indexation.

The foreign currency price of imports (both consumer goods and inputs) is assumed constant in the analysis because the focus is on the exchange rate movements as source of disturbances from abroad.

The analysis developed in this first part is static. There are no dynamic elements generating a gradual adjustment over time, but they will be introduced in the following section.

One last remark: in this static situation, without uncertainty and/or adjustment costs, the choice variable used by firms is irrelevant. As it is well known, the maximization with respect to the price gives exactly the same solution as the maximization with respect to the output level.

4. PRICE ADJUSTMENT WITH INFORMATION COSTS

4.1 INTRODUCTION

Further interesting results may be obtained if we extend the static analysis developed in the preceding section.

Empirical studies show that the adjustment of prices to exchange

rate movements is not instantaneous, but there is a gradual adjustment over time (see recently, for example, Daniel (1986b,d) and Mussa (1986)).

Sluggish price adjustment can be obtained from profit maximizing behaviour if some kind of market imperfection, like costs of adjustment or imperfect information, is introduced. If these imperfections exist they must be taken explicitly into account by agents in the maximization process.

I assume that the firms face costs in modifying the policy choice already made.

These costs are related to the decision process that leads to the determination of the optimal choice. They are essentially information costs, i.e. costs of acquiring and processing new information in order to determine the optimal value of the choice variable (10).

The same assumption is used in Aizenman(1986) and in Daniel(1986c).

Other contributions in the literature assume the existence of costs related to the change of the value of the choice variable previously set (small menu costs)(11) or the existence of imperfect information by customers (12).

In the literature that analyses sluggish price adjustment, the standard assumption is that firms use the price as choice variable. However, I discuss both price setting and quantity setting behaviour with information costs of the kind described above.

Recently, Parkin(1986) analyses both price setting and quantity setting behaviour in a macroeconomic equilibrium context with small menu costs related to price changes. He shows that the

predominance of one behavioural mode over the other may depend on economic factors like the characteristics of the money supply process (counterinflationary or accomodating), instead of being thought of as an exogenously given institutional feature of the economy.

In this paper it is assumed that the product market is characterized by monopolistic competition. Without introducing uncertainty or adjustment costs the choice variable (price or quantity) is irrelevant. As Leland(1972) shows, the equivalence breaks down, for example, under uncertainty about demand conditions: price setting and quantity setting give rise to different economic results. Along the same lines Lim(1980) derives conditions for strict preference of one behavioural mode over the other (see also Weitzman(1974)), suggesting that the choice may be considered endogenous and depends on the structural elements that characterize the market (13).

I analyse the implications of price setting and quantity setting behaviour in a model with

- information costs that are assumed to arise both with price and quantity setting, and with
- the exchange rate as the only exogenous stochastic element in the economy.

Lump sum information costs are assumed (14).

With lump sum costs of this kind it is in general profitable collecting and processing information and determining the optimal choice at discrete time intervals for more than one period. The firm does not choose necessarily one single optimal value for the

relevant horizon, but an optimal path is preset conditional on the information available when the decision is taken (15).

I assume that it is profitable for the firm to preset its policy for n periods (n≥1). The value of n is endogenously determined and is chosen by firms through an explicit optimization process as in Aizenman(1986) (16).

A staggered structure is assumed where firms' decisions are not taken simultaneously, but are uniformly distributed over time so that in each period m firms decide their policy (m = s/n, with s = number of firms and n = length of the presetting period)(17).

Exchange rate is assumed to follow a random walk process.

4.2 PRICE SETTING

The firm fixes the price path for n periods and accomodates demand, i.e. it is ready to offer in each period the quantity demanded at the preset price.

The analysis is close to the one developed in Aizenman(1986) and will be briefly sketched.

The firm chooses the price path and the length n of the presetting horizon. The solution is obtained backwards. Taking n as given, the sequence of optimal prices p(t),p(t+1),...p(t+n-1) is determined first. Each price is the solution of the profit maximization problem given the information available at time t (18). Then the optimal presetting horizon (n*) is obtained by minimizing the present discounted value of the expected total losses

from the policy.

In the determination of the optimal price path the firm must take into account not only the exogenous stochastic elements, here the exchange rate, but also the behaviour of the other domestic competitors that have identical demand and cost functions but set the prices in different periods.

With reference to nominal wages, I do not introduce a dynamic specification of wage contracts because the analysis of the firm's behaviour would result extremely complicated. The assumption that the wage determination rule is not modified over time can be in part justified by the fact that with long term labour contracts the time horizon of the price adjustment to exchange rate movements can be assumed shorter than the duration of the contracts.

Firms have rational expectations.

With staggered pricing decisions the price at time t set j periods before by the firm (19) is

$$(6)\quad p(t,j) = \frac{\Theta}{A+C} + \frac{A}{A+C} E_{t-(n-1)} e(t) + \sum_{k=j}^{n-2} \frac{A^*}{1-kB^*} u(t-k)$$

for $0 \leq j \leq n-2$

$$\text{and} \quad p(t,n-1) = \frac{\Theta}{A+C} + \frac{A}{A+C} E_{t-(n-1)} e(t)$$

where

p(t,j) is the price at time t set j periods before;

$\frac{B}{A+C} + \frac{A}{A+C} E_{t-(n-1)}$ e(t) is the expectation held at time t-(n-1) of the optimal symmetric equilibrium solution at time t (given by eq.5).

Exchange rate is assumed to follow a random walk process:

$e(t) = e(t-1) + u(t)$

where u(t), the innovation in the stochastic process, is $iid(0,\sigma^2)$.

The new coefficients introduced are defined as follows:

$$A^* = \frac{A}{1-B(m-1)}; \qquad B^* = \frac{B}{1-B(m-1)}.$$

As is shown by eq.(6) in addition to the phenomenon of partial adjustment to exchange rate changes obtained also in the static case when indexation is less than complete, there is a gradual adjustment of the price to the innovations in the exchange rate.

Note that the firm sets the price for time t using only information up to time t-j ($0 \leq j \leq n-1$). Moreover the price doesn't adjust completely even to innovations fully known when the price is set, since with a staggered pricing structure the firm must take into account the choice already made by the other firms (20).

Given the optimal price path, optimal presetting horizon (n*) is obtained by minimizing the present discounted value of expected total losses with respect to n. Total losses are given by the lump sum cost c incurred by the firm at each pricing decision and by the losses in terms of profits that arise when the optimal

solution is not reached. The loss in terms of profits in each period is calculated by comparing the level of profits when the price is preset with that obtained with reoptimization in that period.

The expected loss in terms of profits in period t+h (with $0 \leq h \leq (n-1)$), using a Taylor-series approximation around the optimal value, is approximately equal to

$$(8) \quad H(t+h) = -\pi_{pp} \, E_t \left(P^*(t+h) - P(t+h,h) \right)^2$$

where

$P^*(t+h)$ is the optimal price in period t+h using all information;

$P(t+h,h)$ is the price at time t+h preset h periods before;

π_{pp} is the second order derivative of the profit function with respect to the price, evaluated at the optimal solution; in order to obtain the loss in real terms this derivative is deflated by the optimal price level (21).

Substituting the formulas for the prices in eq.(8)

$$(8') \quad H(t+h) = -\pi_{pp} \sum_{k=0}^{h-1} \frac{A^{*2}}{(1-kB^*)^2} \, E_t \left(u(t+h-k) \right)^2 =$$

$$= -\pi_{pp} \, A^{*2} \sigma^2 \sum_{k=0}^{h-1} \frac{1}{(1-kB^*)^2}$$

The trade off between the two elements of the expected total losses (the cost related to each policy decision and the loss in

terms of reduced profits) is evident: if the firm reoptimizes each period, there are no losses in terms of lost profits since the optimal solution is always obtained, but the loss in terms of costs of adjustment is maximized. If the firm chooses the price path once and for all, it incurs the minimum adjustment cost but the loss in terms of profits is maximized. Therefore in general the two costs will be balanced at the margin (22).

It can be proved that, as in Aizenman(1986), the optimal value of n (n*) depends positively on the cost of adjustment c and negatively on the variance of exchange rate innovations.

The expected loss in terms of profits in each period and consequently n* depend on structural parameters as well, like product substitutability (α), technology (a,b) and indexation (τ,μ) (23). It is worth analysing how these structural parameters influence the optimal speed of adjustment.

When α tends to infinity the loss becomes infinite, n* is equal to one, i.e. the firm optimizes all periods.

An increase in product substitutability generates a higher loss and a reduction in n*; therefore price adjustment to exchange rate innovations is not only more complete (as proved in section 3) but also faster when substitutability is higher.

A steeper marginal cost curve (measured by a higher (1/(a+b)-1)) has an ambiguous effect on n* in the general model. Only in the simplified case with no direct effects of the exchange rate on the cost side (no imported inputs (b/(a+b)=0) and wage indexed to domestic prices only (τ=1)) a clear-cut result is obtained: a steeper marginal cost curve generates a higher loss and reduces n*.

Moreover n* depends inversely on the share of imported inputs in production (b/(a+b)) and on the share of imported goods in the price index used in wage indexation (T). In other words, with a direct influence of the exchange rate on the cost side the adjustment of the price to exchange rate innovations is both more complete (see section 3) and faster. No unambiguous result can be derived for the level of indexation μ.

Finally aggregating over all firms I obtain the behaviour of the aggregate price level.

Given eq.(6), the domestic price level, defined as

$$ap(t) = \frac{1}{n}\sum_{j=0}^{n-1} p(t,j), \quad \text{is:}$$

$$(9)\quad ap(t) = \frac{\Theta}{A+C} + \frac{A}{A+C}\,E_{t-(n-1)}\, e(t) + \frac{A^*}{n}\sum_{j=0}^{n-2}\frac{(1+j)}{(1-jB^*)}\,u(t-j)$$

A positive innovation in the exchange rate, u(t)>0, gives rise to a contemporaneous change in the domestic price level equal to A*/n u(t); the longer the presetting horizon (the higher n), the smaller is the impact effect of the shock. The shock continues to exert its influence in the following periods and there is a gradual adjustment of the domestic price level. The length of the period of adjustment is determined by the value of n*.

4.3 QUANTITY SETTING

Assume now that the choice variable for the domestic firms is the output produced instead of the price charged. The firms decide the output level and are ready to sell the quantity produced at whatever price will clear the market. I consider here the price taking behaviour instead of the price setting behaviour previously examined.

The exchange rate is still the only exogenous stochastic variable and follows a random walk process.

The case of complete wage indexation and that of less than complete indexation are analysed separately in the following subsections, since the results differ significantly in the two cases.

4.3.1 QUANTITY SETTING WITH COMPLETE WAGE INDEXATION

I examine the case of complete indexation first. This is the assumption used by Aizenman(1986) in the analysis of the price setting behaviour. Note that in Aizenman there is no discussion of the quantity setting case.

Profit function is obtained from eqs. (1), (2) and (3) by setting $\mu = 1$.

From profit maximization the flexible equilibrium solution $Q(k)$ is in logs

$$(11)\quad q(k) = \log\left(\frac{(\delta-1)}{\left(\frac{\delta}{a+b} - \frac{Ta}{s(a+b)}\right)} \frac{1}{ZW^*} \right) \frac{1}{F'} + \frac{G'}{F'} \sum_{\substack{j=1 \\ j\neq k}}^{s} q(j)$$

where q(j)= log of the quantity produced by firm j, j=1,..,k,..s,

$$F' = \frac{1}{a+b} - 1 + \frac{\beta+\alpha-(\beta+\frac{\alpha}{s})T\frac{a}{a+b}}{\alpha(\delta+\beta)} \quad \text{and} \quad G' = \frac{\beta-T\frac{\alpha}{s}(\beta+\frac{a}{a+b})}{\alpha(\delta+\beta)}$$

In this case the equilibrium solution is <u>independent</u> of the exchange rate, but it depends only on the output of the other domestic firms. When the exchange rate changes there are no changes in the quantities sold, since a 1:1 change in domestic prices offsets completely the exchange rate change.

The result is not surprising since the system of demand functions P =f(Q(j) j=1,..,1;E) is homogeneous of degree one in E and the cost function is homogeneous of degree one in P and E. Therefore a neutrality result with respect to the exchange rate changes is obtained: output produced is invariant to exchange rate fluctuations.

If the exchange rate is the only stochastic element of the model, information costs don't play any role in the quantity setting case because there are no changes in the optimal value of

the choice variable. The optimal solution is invariant to exchange rate movements and is always mantained without incurring any cost of adjustment.

With given real wages, quantity setting behaviour always gives a higher level of profits than price setting behaviour since the unconstrained maximum of the profit function is attained in all periods.

Note that here the relative version of PPP always holds, $p(k) = p(j) = p = \frac{\Theta}{A} + e$, i.e. an exchange rate change gives rise to a contemporaneous 1:1 change in the domestic price level (24). The adjustment of the price level to exchange rate innovations is instantaneous.

4.3.2 QUANTITY SETTING WITH LESS THAN COMPLETE INDEXATION

With less than complete indexation ($\mu<1$) the homogeneity of degree one in P and E of the cost function doesn't hold anymore.

The optimal quantity produced in the flexible equilibrium Q(k) is in logs

$$(12)\quad qk = \log\left(\frac{(\delta-1)}{\left(\frac{\delta}{a+b} - \frac{\mu Ta}{s(a+b)}\right)}\right)\left(\frac{1}{ZW^*}\right)\frac{1}{F} + \frac{H}{F}e - \frac{G}{F}\sum_{\substack{j=1\\ j\neq k}}^{s} qj$$

$$\text{where } F = \frac{1}{a+b} - 1 + \frac{\beta+\alpha-\mu(\beta+\alpha/s)\mu Ta/(a+b)}{\alpha(\delta+\beta)},$$

$$G = \frac{\beta-\mu(\beta+\alpha/s)\mu Ta/(a+b)}{\alpha(\delta+\beta)} \qquad \text{and} \qquad H = (1-\mu)\frac{a}{a+b}.$$

In this case equilibrium solution is <u>not</u> <u>independent</u> of the exchange rate; the adjustment costs relative to the modification of the choice already made by the firm become relevant and the analysis can be developed along the lines described in the case of price setting behaviour.

With lump sum information costs related to the determination of the optimal output level and staggered structure in output decisions (decisions are uniformly distribuited over time), the firm fixes the production plans for a number n of periods. It takes into account both the exogenous stochastic elements and the behaviour of the other domestic firms, that are price takers as well (25).

Taking n as given, the sequence of optimal production plans is determined first. The quantity at t set j periods before by the firm is in logs

$$(13) \quad q(t,j) = E_{t-(n-1)} C(t) + \sum_{k=j}^{n-2} \frac{f}{1+dk} u(t-k)$$

$$0 \leq j \leq n-2$$

and

$$q(t,n-1) = E_{t-(n-1)}\, C(t)$$

where

$q(t,j)$ = log of the quantity at t set j periods before;

$E_{t-(n-1)}\, C(t)$ is the expectation held at time $t-(n-1)$ of the optimal symmetric equilibrium solution at t, which is obtained from eq(12) by setting $q(k)=q(j)=q$:

$$(14)\quad q(t) = \log\left(\frac{(\delta-1)}{\left(\frac{\delta}{a+b} - \frac{\mu Ta}{s(a+b)}\right)} \frac{1}{ZW^*}\right) \frac{1}{L} + \frac{H}{L}\, e(t)$$

$$\text{with } L = \frac{1}{a+b} - 1 + \frac{1 - \mu Ta/(a+b)}{\alpha}$$

therefore $E_{t-(n-1)}\, C(t) = E_{t-(n-1)}\, q(t)$;

as before u(t) is the innovation in the stochastic process generating the exchange rate;

$$\frac{f}{1+dk} = \frac{(1-\mu)a/(a+b)}{\frac{1}{a+b} - 1 + \frac{(\beta - (\beta+\alpha/s)\mu Ta/(a+b))\; s/n\; (1+k)}{\alpha(\delta+\beta)}}$$

Note that with $\mu=1$ the exchange rate doesn't appear in these formulas and the analysis developed in the previous subsection

applies.

The expected loss in term of profits in period t+h, using a Taylor-series approximation around the optimal value, is approximately equal to

$$(15) \qquad H^*(t+h) = -\pi_{qq} \, E_t \left(Q^*(t+h) - Q(t+h,t) \right)^2$$

where

$Q^*(t+h)$ is the optimal output level in period t+h using all information;

$Q(t+h,t)$ is the output level at time t+h set h periods before;

π_{qq} is the second order derivative of the profit function with respect to the quantity, evaluated at the optimal solution; in order to obtain the loss in real terms this derivative is deflated by the optimal price level.

Substituting the formulas for the quantities in eq.(15)

$$(15') \qquad H^*(t+h) = -\pi_{qq} \sum_{k=0}^{h-1} \left(\frac{f}{1+dk} E_t \, u(t+h-k) \right)^2 =$$

$$= -\pi_{qq} \, \sigma^2 \sum_{k=0}^{n-1} \left(\frac{f}{1+dk} \right)^2 .$$

Given the lump sum cost c** related to each production decision, the optimal presetting horizon n* is obtained, as before, by minimizing the present discounted value of expected total losses

as formulated in footnote (21).

Optimal presetting horizon n* depends positively on the cost of adjustment c** and negatively on the variance of exchange rate innovations as in the price setting case.

H*(t+h) and n* depend on other structural parameters as well. Higher substitutability between domestic and foreign goods and a steeper marginal cost curve have in general an ambiguous effect on H* and n* (26). It can be shown that for high values of μ, higher product substitutability generates a lower loss and an increase in n*, while a steeper marginal cost curve increases the loss and reduces n*.

When α tends to ∞, H*(t+h) takes a finite value and there is no incentive in this case to reoptimize in all periods, while n*=1 is optimal in the price setting case.

It can be proved that higher wage indexation (higher μ) reduces unambiguously H*(t+h) and increases n*. A higher share of imported input in production and a higher share of imported goods in the consumer price index have no clear-cut effects in general on the optimal presetting horizon n*; nevertheless it can be shown that, for high values of μ, they genarate a higher loss and a decrease in n*.

The behaviour of the domestic price level with quantity setting firms will be described in the following section.

4.4 COMPARISON BETWEEN PRICE SETTING AND QUANTITY SETTING

Both price setting and quantity setting behaviour have been described in the preceding sections.

Since domestic firms are assumed to be rational profit maximizers, it may be suggested that they will choose to be price takers or price setters depending on which behavioural mode gives the minimum expected total losses, once the optimal presetting horizon n^* (that may differ in the two cases) has been determined.

It has been shown that when the exchange rate is the only stochastic element and there is complete wage indexation, the price taking behaviour is strictly preferred because no losses arise and the maximum level of profits is always attained. This implies that the price setting behaviour described in Aizenman(1986) is suboptimal once both behavioural modes are considered.

In the quantity setting case with $\mu=1$ an instantaneous adjustment of the price level to an exchange rate change should be observed according to the relative PPP version.

With less than complete indexation, no general conclusion can be reached about the more profitable type of behaviour. The result depends on the actual values of all exogenous parameters (27). Maybe through numerical calculations with plausible values for the various parameters some additional information could be obtained.

With less than complete indexation an interesting result relative to the behaviour of the domestic price level can be presen-

ted.

Domestic price level in the quantity setting case can be easily obtained by substituting the optimal quantity set by each firm in the demand functions.

In logs

$$(16)\quad ap(t) = e(t) - \frac{1}{\alpha n}\sum_{j=0}^{n-1} q(t,j)$$

substituting for q(t,j) from eq.(13)

$$(16')\quad ap(t) = \frac{\Theta}{A+C} + \frac{A}{A+C}E_{t-(n-1)}\, e(t) + \sum_{j=0}^{n-2}\left(1 - \frac{f(j+1)}{\alpha n(1+jd)}\right)u(t-j)$$

Comparing this equation with that of the domestic price level in the price setting case (eq.(9))

$$(9)\quad ap(t) = \frac{\Theta}{A+C} + \frac{A}{A+C}E_{t-(n-1)}\, e(t) + \frac{A^*}{n}\sum_{j=0}^{n-2}\frac{(1+j)}{(1-jB^*)}\, u(t-j)$$

shows that the behaviour of aggregate price level is qualitatively very similar in both cases with a small impact effect and a gradual adjustment of the price level to exchange rate innovations. There are differences related to the speed of adjustment

that depends on the optimal value n* in the two cases, and to the shape of the adjustment path, i.e. to the distribution of the weights attached to the exchange rate innovations of the past periods.

Sluggish price adjustment to exchange rate fluctuations is obtained in both cases and it doesn't require the assumption of price setting behaviour. Once again this result depends crucially on the different reaction of input costs and output price to the exchange rate movements.

Recall that with $\mu=1$ in the quantity setting case $ap(t) = e(t) + \frac{\theta}{A}$, i.e. the relative version of PPP holds instantaneously, while in the price setting case it holds only in the long run.

When α tends to ∞ in both cases $ap(t) = e(t)$, i.e. domestic prices cannot differ from the price charged by foreign competitors.

The analysis developed in this paper may be extended by introducing other sources of uncertainty like real shocks in terms of productivity shifts (28).

Moreover the goods could be assumed storable and the firm allowed to keep inventories. Various contributions (29) discuss the role played by inventories in explaining price and output adjustment to shocks, particularly aggregate demand changes in a closed economy. The analysis of the possible implications of the introduction of inventories in the model presented in this paper is left to future research.

5. CONCLUSIONS

In this paper I discuss how different structural elements influence the behaviour of firms operating in markets open to international competition (only import competition is considered here) with particular reference to the effects of exchange rate changes in a flexible exchange rate context.

The assumption of monopolistic competition in the product market seems to offer a useful framework to analyze how elements like product differentiation, technological structure and input price behaviour interact to give rise to different patterns in the reaction of domestic prices to exchange rate movements.

The exchange rate affects domestic price level through several channels: imported inputs, foreign consumer goods competing with domestic production and a direct influence on wage determination through the price index used in wage indexation.

The analysis shows in particular that the change in the domestic price level following an exchange rate change depends crucially on the relative behaviour of input and output prices, described here in terms of wage indexation and relative share of imported inputs in production.

The relative version of PPP (a 1:1 change in domestic price level following an exchange rate change) holds only in the case of complete wage indexation because only in this case there is a full response of input costs to exchange rate changes.

Dynamic adjustment is obtained by introducing information costs related to the determination of the optimal choice.

Both price setting and quantity setting behaviours are discussed. The optimal speed of adjustment is endogenously determined and it is influenced by the structural elements characterizing the economy.

With complete wage indexation, quantity setting behaviour is strictly preferred in terms of profit maximization. If firms decide on the output level, price adjustment to exchange rate innovations takes place instantaneously. The relative version of PPP always holds while in the price setting case it holds only in the long run.

With less than complete indexation no general conclusions can be reached about the most profitable behavioural mode and the result depends on the actual values of all exogenous parameters.

The most relevant result in this case is that sluggish price adjustment to exchange rate fluctuations is obtained both with price setting and quantity setting behaviour and it doesn't require a priori the assumption of price setting behaviour.

FOOTNOTES

(1) See the well-known results by Kravis and Lipsey(1977, 1978), Isard(1977), Richardson(1978) and recently Dornbusch(1987a) and Krugman(1986).

(2) Among the contributions analyzing firms' behaviour in an open economy see Aspe-Giavazzi(1978,1982), Silva(1979), Kawai(1981), Katz, Paroush and Kahana(1982) and Giovannini(1985).

(3) A third element is the integration/separation of markets located in different countries, with the possibility of price discrimination. Various contributions (see, for example, Aspe-Giavazzi(1978,1982), Katz, Paroush and Kahana(1982) and Giovannini(1985)) focus on this last aspect that is not discussed in this paper.

(4) This assumption has been recently used also in macroeconomics in the analysis of problems like keynesian unemployment (Hart(1982), Akerlof and Yellen(1985b)) or the neutrality of money (Blanchard(1985)).

(5) This assumption has been criticized because it generates an asymmetry in the pricing of domestic and foreign goods (see Flood and Hodrick(1984) and Daniel(1986c)); nevertheless it is only a simplifying assumption in the analysis.

(6) The analysis in this paper is related to some extent to Gordon(1981) and Blanchard (1983). In fact the role of input prices is stressed in those papers as well, although the analysis focuses there on the adjustment to aggregate demand shocks in a closed economy.

(7) This cost function derives from the following production

function: $Q(k)=V \cdot L^{a} \cdot N^{b}$, where L = labour, N = imported input and V is a productivity shift.

Given this production function the constant term Z in the cost function is equal to

$$Z = (1/V)^{\frac{1}{a+b}} \left((a/b)^{\frac{b}{a+b}} + (b/a)^{\frac{a}{a+b}}\right).$$

(8) It can also be assumed that the relevant price index is P, where only domestic goods are included as in Aizenman(1986). In this case a direct effect of the exchange rate on wages through imported consumer goods is ruled out.

(9) Note that this result holds in the model also under the assumption of constant returns to scale. With no imported inputs and wages indexed to the domestic price level or given in nominal terms, as in Aizenman(1986) and in Dornbusch(1987a,b), the hypothesis of non-constant marginal costs is required to obtain the result presented in the text. In fact with constant marginal costs domestic prices are independent of the exchange rate.

(10) I assume that information is not freely provided. Economic agents face a signal extraction problem; based on the signals they choose to observe, they must infer the values of the variables which matter in their decision making. The idea is that both observation of signals and inference problem can be costly. Acquisition of additional information requires research. The information necessary to determine the optimal choice is costly to acquire and/or to process.

(11) When the choice variable is the price level, these costs are

administrative costs related to printing new catalogs, informing sellers about the new prices (small "menu" costs) or costs that arises from the negative reaction of customers to large price changes. See among the papers that introduce explicitly this kind of adjustment costs in the maximization process Barro(1972), Shesninski and Weiss(1977 and 1983), Rotemberg(1982) and Daniel(1986a).

(12) For an analysis of the effects of imperfect information by buyers in markets open to international competition see Dohmer(1984) and Gottfries(1986). Other contributions discuss the effects of misperception (see Koh(1984) and Ueda(1983)).

(13) In another framework (duopoly with differentiated products) Klemperer and Meyer (1986) show that the choice between price and quantity as strategic variables in the presence of uncertainty can be endogenized in terms of expected profit maximization; conditions for strict preference in terms of the values of the structural parameters are derived.

Another line of research in a different context discusses the optimal choice of the instrument for monetary policy. See for example Poole(1970).

(14) The nature of the adjustment costs and the functional form chosen influence the characteristics of the optimal solution (see Rothschild(1971)). In this paper, following Aizenman(1986) and Daniel(1986c), I assume that information costs are characterized primarily by a fixed component.

(15) With small menu costs, on the contrary, the firm sets a single price for the relevant pricing horizon.

Compare in a different context the two types of contract models

used in the literature on the labour market: Taylor(1979,1980) model, where one wage rate is set for more than one period, and Fischer(1977) model, where a wage path is set. See Canzoneri(1980) and Gray(1978) for an analysis of the optimal contract length.

(16) When a shock takes place, the agent's optimizing behaviour requires the comparison between the loss arising from the lack of adjustment and the cost of adjustment itself. When the cost of adjustment is small the agent is likely to choose not to adjust if the loss arising in that case is small as well. The size of the loss from not adjusting, that depends on the structural characteristics of the market, creates an higher or lower incentive to modify the policy.

Recent contributions that point out these aspects are Blanchard(1985), Akerlof-Yellen(1985a,1985b) and Rotemberg-Salonner(1986).

In Akerlof and Yellen(1985a,b), there is no explicit comparison between gains and losses but some inertia in agents' behaviour is assumed. Adjustment is less likely when the loss is "small" in a well defined sense so that a nonmaximizer doesn't gain a significant amount by becoming a maximizer. See Akerlof and Yellen (1985a,b) for details.

(17) Parkin(1986) discusses under which conditions a staggering structure or a bunching structure (all decisions concentrated in one single period) predominates with price setting firms: see also Fethke and Policano(1984) with reference to labour contracts.

(18) Note that there are no elements that connect one period with the other, therefore multiperiod maximization collapses into a sequence of independent static maximizations.

(19) The firm sets the price path for n periods. Each price is the solution of the profit maximization problem given the information available at the beginning of the pricing cycle. The firm uses information regarding all the prices that have already been set, the expected path of the exchange rate and the prices that other competitors are expected to set in the future.

In Aizenman(1986) pages 9-12 the price equation is derived in more detail.

(20) For a deeper discussion of these aspects see Aizenman(1986), pages 13 and 14.

(21) Note that the loss for lack of reoptimization is not approximately proportional to the deviation of the choice variable from the optimal value, but it is approximately proportional to the square of the deviation, i.e. the loss due to nonmaximization is second-order small since the first order derivative of the profit function evaluated at the optimal solution is zero by construction. In this case Akerlof and Yellen(1985a,b) use the concept of near-rationality, defining near rational a nonmaximizing behaviour in which the gains from maximization rather than nonmaximization are smaller by an order of magnitude than the change in optimal solution due to the shock.

Moreover note that I use an approximate measure of the loss since I disregard the terms of order higher than two of the Taylor expansion around the equilibrium value.

(22) The firm minimizes expected total losses with respect to the

length of the presetting horizon (n).

Assuming that the firm has an infinite horizon the objective is

$$\min LOSS = \sum_{n=0}^{\infty} \left(\sum_{j=1}^{n-1} \frac{H(t+j)}{(1+r)^{j}} + c \right) \frac{1}{(1+r)^{hn}}$$

(23) A change in the structural parameters influences H(t+h) and n* through the effects on π_{pp}, on one hand, and on the size of the divergence of the preset price from the optimal value, on the other hand.

(24) All these results are not influenced by the technological structure assumed in terms of relative shares of domestic and imported inputs (unless b/(a+b)=1) and by the price index used in wage indexation.

(25) In a much more simplified macroeconomic framework Parkin(1986) analyses the case where both price setting and price taking behaviour coexist and tries to explain when one of the two behavioural modes prevails.

(26) This result depends on the fact that the effects of α or $(1/(a+b) - 1)$ on $-\pi_{qq}$ and on $E\,(Q^*(t+h)-Q(t+h,h))^2_t$ have opposite signs and therefore the overall effect on H*(t+h) is ambiguous. For high values of μ the effect on π_{qq} prevails.

(27) The comparison between the two behavioural modes must be carried out by using the minimum value of the loss function, i.e. the value obtained when the optimal value of n (n*) has been substituted in the objective function. Since it is impossible to obtain an explicit solution of the minimization problem, the

minimum values of the expected total losses in the two cases cannot be explicitly calculated and compared.

(28) The analysis can be developed along the same lines as in the case of exchange rate movements only. I do not report here the new equations obtained, but it may be interesting to make a few remarks.

In the price setting case the role of productivity shocks becomes irrelevant when α tends to ∞. For finite values of α, the variances of the innovations in both stochastic elements and their covariance play a role in the determination of the optimal presetting horizon n^*. The relative role of these elements depends again on the substitutability between domestic and foreign goods. The higher the substitutability, the lower is the role of productivity shocks, while a higher degree of indexation μ implies a more relevant role of the real shocks. It is interesting to notice that, ceteris paribus, a negative covariance between the innovations reduces the loss compared with a positive covariance because expected losses are reduced if the firm expects productivity to move in the opposite direction of the exchange rate.

In the quantity setting case if $\mu<1$ both stochastic elements play a role, while with $\mu=1$ only productivity shocks are relevant. The variance of the innovations in both stochastic elements influences negatively the presetting horizon (n^*). The covariance has the opposite effect on loss and n^* compared with the price setting case: here a negative covariance increases the loss compared with a positive covariance. A higher level of indexation

implies a more relevant role for productivity shocks.

(29) See Blinder(1982), Brunner, Cuckierman and Meltzer(1983), Fiuta and Modrick(1983).

REFERENCES

AIZENMAN J.(1986), Monopolistic Competition, Relative Prices and Output Adjustment in the Open Economy, NBER working paper No.1787.

AKERLOF G.A. and YELLEN J.L.(1985), A Near Rational Model of Business Cycle with Wage and Price Inertia, Quarterly Journal of Economics, 100, suppl., 823-838.

AKERLOF G.A. and YELLEN J.L.(1985), Can Small Deviations from Rationality make Significant Differences to Economic Equilibria?, American Economic Review, September, 75, 708-720.

ASPE P. and GIAVAZZI F.(1978), L'impresa nell'economia aperta in presenza di incertezza, Giornale degli Economisti, 37, 345-361.

ASPE P. and GIAVAZZI F.(1982), The Short Run Behaviour of Prices and Output in the Exportables Sector. The Case of German Machinery, Journal of International Economics, 12, 83-93.

BARRO R.J.(1972), A Theory of Monopolistic Price Adjustment, Review of Economic Studies, January, 39, 17-26.

BLANCHARD O.(1983), Price Asynchronization and Price Level Inertia, in DORNBUSCH R. and SIMONSEN M.H.(Eds) "Inflation, Debt and Indexation", Cambridge, MIT Press.

BLANCHARD O.(1985), Monopolistic Competition, Small Menu Costs and Real Effects of Nominal Money, unpublished manuscript, MIT.

BLINDER A.S.(1982), Inventories and Sticky Prices: More on the Microfoundations of Macroeconomics, American Economic Review, June, 72, 334-48.

BRUNNER K., CUCKIERMAN A. and MELTZER A.H.(1983), Money and Economic Activity, Inventories and Business Cycles, Journal of

Monetary Economics, 11, 281-319.

CANZONERI M.B.(1980), Labor Contracts and Monetary Policy, Journal of Monetary Economics, 6, 241-255.

DANIEL B.C.(1986), Optimal Purchasing Power Parity Deviations, International Economic Review, 27, June, 483-511.

DANIEL B.C.(1986), Empirical Determinants of Purchasing Power Parity Deviations, Journal of International Economics, 21, 313-226.

DANIEL B.C.(1986), Real and Nominal Shocks in a Two Country Price Setting world, Journal of International Economics, 20, 269-289.

DANIEL B.C.(1986), Sticky Prices and Purchasing Power Parity Deviations. Empirical Investigations, Economics Letters, 20, 187-190.

DIXIT A.K. and STIGLITZ J.E.(1977), Monopolistic Competition and Optimum Product Diversity, American Economic Review, June, 67, 297-308.

DOHNER R.S..(1984), Export Pricing, Flexible Exchange Rates and Divergence in the Prices of Traded Goods, Journal of International Economics, 16, 79-101.

DORNBUSCH R.(1985), Purchasing Power Parity, NBER Working Paper No.1591, in "Palgrave's Dictionary of Economics, London: Macmillan, forthcoming.

DORNBUSCH R.(1985), Inflation, Exchange Rates and Stabilization, NBER Working Paper No.1739.

DORNBUSCH R.(1987), Exchange Rate and Prices, American Economic Review, March, 77, 93-106.

DORNBUSCH R.(1987), Exchange Rate Economics: 1986, The Economic

Journal, 97, March, 1-18.

DORNBUSCH R. and FISCHER S.(1984), The Open Economy: Implications for Monetary and Fiscal Policy, NBER Working Paper No.1422.

FETHKE G. and POLICANO A.(1984), Wage Contingencies, the Pattern of Negotiation and Aggregate Implications of Alternative Contract Structures, Journal of Monetary Economics, 14, 151-170.

FISCHER S.(1977), Long Term Contracts, Rational Expectations and the Optimal Money Supply Rule, Journal of Political Economy, 85, 191-205.

FLOOD R.P. and HODRICK R.J.(1983), Optimal Price and Inventory Adjustment in an Open Economy Model of the Business Cycle, NBER Working Paper No. 1089.

FLOOD R.P. and HODRICK R.J.(1984), Exchange Rate and Price Dynamics with Asymmetric Information, International Economic Review, 25, October, 513-526.

GIOVANNINI A.(1985), Exchange Rate and Traded Goods Prices, unpublished manuscript, Columbia University.

GORDON R.J.(1981), Output Fluctuations and Gradual Price Adjustment, Journal of Economic Literature, 19, June, 493-530.

GOTTFRIES N.(1986), Price Dynamics of Exporting and Import-Competing Firms, Scandinavian Journal of Economics, 88 , 417-436.

GRAY J.A.(1978), On Indexation and Contract Length, Journal of Political Economy, 86, February, 1-18.

HART O.D.(1982), A Model of Imperfect Competition with Keynesian Features, Quarterly Journal of Economics, February, 97, 109-38.

ISARD P.(1977), How far can we push the "Law of One Price"?, American Economic Review, 67, 943-948.

KATZ E., PAROUSH J. and KAHANA N.(1982), Price Uncertainty and

Price Discriminating Firm in International Trade, International Economic Review, 23, June, 389-400.

KAWAI M.(1981), The Behaviour of an Open-economy Firm under Flexible Exchange Rates, Economica, 48, 45-60.

KLEMPERER P. and MEYER M.(1986), Price Competition vs. Quantity Competition: the Role of Uncertainty, Rand Journal of Economics, 17, 618-638.

KOH A.(1984), Money Shocks and Deviations from Purchasing Power Parity, Journal of Monetary Economics, 14, 105-122.

KRAVIS I.B. and LIPSEY R.E.(1977), Export Prices and the Transmission of Inflation, American Economic Review, 67, February, 155-163.

KRAVIS I. B. and LIPSEY R.E.(1978), Price Behaviour in the Light of Balance of Payments Theories, Journal of International Economics, May, 8, 193-246.

KRUGMAN P.(1986), Pricing to Market when the Exchange Rate Changes, NBER Working Paper No.1926.

LELAND H.E.(1972), Theory of Firm Facing Uncertain Demand, American Economic Review, 62, June, 278-91.

LIM C.(1980), The Ranking of Behavioral Modes of the Firm Facing Uncertain Demand, American Economic Review, 70, 217-224.

MUSSA M.(1986), Nominal Exchange Rate Regimes and the Behaviour of Real Exchange Rates: Evidence and Implications, Carnagie-Rochester Conference Series on Public Policy, 25, 117-214.

PARKIN M.(1986), The Output-Inflation Trade off when Prices are costly to change, Journal of Political Economy, 94, 200-224.

POOLE W. (1970), Optimal Choice of Monetary Instruments in a

Simple Stochastic Macro Model, Quarterly Journal of Economics, 84, May, 197-216.

RICHARDSON J.D.(1978), Some Empirical Evidence on Commodity Arbitrage and the Law of One Price, Journal of International Economics, 8, 341-351.

ROTEMBERG J.J.(1982), Monopolistic Price Adjustment and Aggregate Output, Review of Economic Studies, 49, 517-531.

ROTEMBERG J.J. and SALONER G.(1986), The Relative Rigidity of Monopoly Pricing, NBER Working Paper No.1943.

ROTHSCHILD M.(1971), On the Cost of Adjustment, Quarterly Journal of Economics, 85, 605-622.

SACHS J.(1985), The Dollar and the Policy Mix: 1985, Brookings Papers on Economic Activity, 1, 117-197.

SHESHINSKY E. and WEISS Y.(1977), Inflation and Costs of Price Adjustment, Review of Economic Studies, 44, June, 287-304.

SHESHINSKI E. and WEISS Y.(1983), Optimal Pricing Policy under Stochastic Inflation, Review of Economic Studies, 50, July, 513-529.

SILVA F.(1979), L'impresa esportatrice, Giornale degli Economisti, 38, 35-65.

TAYLOR J.B.(1979), Staggered Wage Setting in a Macro Model, American Economic Review, 69, 2, 108-113.

TAYLOR J.B.(1980), Aggregate Dynamics and Staggered Contracts, Journal of Political Economy, 88, February, 1-23.

UEDA K.(1983), Permanent and Temporary Changes in the Exchange Rate and Trade Balance Dynamics, Journal of International Economics, 15, 27-43.

WEITZMAN M.L.(1974), Prices vs. Quantities, Review of Economic

Studies, 41, October, 479-91.

WOO W.T.(1984), Exchange Rates and Prices of Nonfood, Nonfuel Products, Brookings Papers on Economic Activity, 2, 511-536.