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PRICE DYNAMICS OF
EXPORTING AND IMPORT COMPETING FIRMS

by

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Abstract

This paper presents a model of a market for an internationally traded good. Buyers, who are customers of one firm, are imperfectly informed about other firms' prices and it is costly for them to change from one supplier to another. This leads to dynamic market share equations, which allow analysis of the interaction between price/quantity decisions of exporting and import competing firms. The model generates results which are consistent with empirical findings.

1. Introduction¹⁾

This paper deals with the short run determination of prices and outputs of exporting and import competing firms. Finding better micro-foundations for the analysis of these issues is important for analysing effects of economic policy in the open economy (specifically devaluation) as well as for analysing the international transmission of inflation and for short run forecasting of prices and quantities in international trade.

One starting point of this study is the realisation that the model of perfect competition is not consistent with the price behavior that can be observed in many international markets. Kravis and Lipsey (1978, p. 242) are representative of a number of empirical studies as they conclude that "Export prices for like goods from different countries often change substantially relative to each other and for a given country export and domestic prices for the same kind of goods differ and do not necessarily change identically from year to year." Other studies, which contain evidence against the "law of one price" are e.g. Isard (1977), Richardson (1978), Chipman (1981).

Calmfors and Herin (1979) summarize the results of an econometric study of price determination in different sectors of the Swedish economy: "Our results indicate that important foreign price links seem to exist in all export sectors studied but usually not in import-competing and sheltered industries. Also, cost variables appear to be important in all sectors and especially so in the latter two types of sectors." Similarly, Ringstad (1974) and Coutts, Godley and Nordhaus (1978) did not find any foreign price effects on domestic prices and Franzen (1983) reports that foreign price influences are found to be stronger on the export markets, when compared with the domestic market.

Another starting point for this study is a fundamental inconsistency in the empirically oriented literature on prices and quantities of

¹⁾ In an independently written paper Robert S. Dohner (1982) develops a partly similar analysis. This paper differs from Dohner's in that it develops different microfoundations of the market share equation, which in turn allow explicit formulation of a rational expectations market equilibrium where interactions between exporting and import competing firms can be analysed.

exporting and import competing firms. In econometric studies as well as in practical policy oriented analysis of quantities exported and imported it is almost invariably assumed that sales react to prices with a lag (Learner and Stern (1970), Wilson and Takacs (1979), Akhtar (1980), Witte (1981)).¹⁾

Yet, all empirical studies of prices in the open economy use price equations, which are either ad hoc or derived from models where the quantity responds immediately to price changes (Ringstad (1974), Coutts, Godley and Nordhaus (1978), Calmfors and Herin (1979, Bruno (1979, 1980), Aspe and Giavazzi (1982)).

Two questions may then be asked:

- What could be the microeconomic reasons for lags in the response of quantities to prices?
- If there are lags of this kind, what implications do they have for price setting?

The model used to analyse these questions will be very similar to the model developed by Phelps and Winter (1970). Some non-trivial modifications will be made, however, to allow analysis of market price dynamics - not only the price adjustment of the individual firm as in the Phelps-Winter paper.

Returning to the first question - about the reasons for lags - let us start with two observations. First, in most markets buyers make repeated purchases. Second, in such markets there are often stable long run relations between buyers and sellers, i.e. a buyer tends to stay with the same seller. What could then be the reasons for such stability of relations?

One reason why customers of one firm tend to stay with that firm may be that they have imperfect information about the offers of other firms. If information collection is costly they will only make a limited number of price comparisons in each period. It seems that in

¹⁾ Aspe and Giavazzi (1982) estimate a model without adjustment lags. They find an unreasonably low price elasticity of export demand, which they take as evidence that there is slow adjustment.

many situations some information is available at a very low cost, but that additional information may be quite expensive. It may be easy, for example, to ask your friends or colleagues where they buy certain products and what prices they pay. Similarly, the cost may be very low for going into a shop when you happen to pass by. To actively shop around, on the other hand, may be quite expensive.

This picture is simply represented by assuming that some information is free while other information is too costly to acquire. Each buyer, in this model makes one price comparison per period. He compares the price charged by his supplier with the price quotation obtained by randomly chosen customer in the market.

A second reason why relations between buyer and seller are stable may be that ~~it is costly for the buyer to change supplier. For a consumer~~ there may be costs involved in getting used to a new product brand or a new outlet facility. For a firm that buys intermediary products it may be necessary to change production equipment to use a new input. The sale of a product from one firm to another may require continuous contact between the two firms. Organising such contacts may be costly. New lines of transportation may have to be organised. However, once these costs are paid, goods may be very close substitutes.

These costs imply that a customer who has observed a lower price charged by a competing firm will only start buying at the new firm if the value of the achieved price reduction is higher than the cost of change. These assumptions will be shown to imply that a firm charging a higher price than other firms will gradually lose customers. The following equation will be derived

$$(1) \quad x_{i,t} - x_{i,t-1} = h(\bar{p}_t - p_{i,t}) x_{i,t-1} \quad h > 0$$

where $x_{i,t}$ is the customer stock of firm i and $\bar{p}$ is the customer weighted average price charged by other firms in the market.

Phelps and Winter derived a similar equation without costs of change but assuming a distribution of prices. A problem with that analysis is that the existence of a persistent distribution of prices is left unexplained. Rather, the model seems to imply that the distribution collapses over time - but then that is inconsistent with the derivation of equation (1) made by Phelps and Winter.

The present model allows construction of a market equilibrium in which firms' plans are optimal given the planned behavior of all other firms. Thus I can explicitly analyse the interaction of exporting and import competing firms in a market.

Exporting, as well as import competing firms are price takers in the long run. Yet, variations in relative costs produce variations in relative prices in the short run. When foreign prices and nominal incomes increase the exporting firm will increase its price - though less than in proportion to the foreign price increase. In this sense the exporting firm is a partial price taker in the short run with respect to an increase in the general foreign price level.

On the other hand, the effect on the import competing firm of an increase in foreign competitors' prices is ambiguous. The import competing firm may even initially reduce its price when import prices go up - and then raise the price as the market share builds up. So the import competing firm may not at all be a price taker in the short run. This implication is consistent with the earlier mentioned empirical results.

2. Customer Behavior

At the beginning of a period each buyer observes the price of the supplier where he bought the good in the previous period, p_t^o .¹⁾ He also observes the price charged by one other, randomly drawn, supplier and a random adjustment cost, i.e. cost for changing to a new supplier. Let p_t^N be the random drawing from the price distribution and K_t the cost of adjustment with the distribution function $F(K) = 0$ for $K \leq 0$, $F_1(K) \geq 0$ for $K \geq 0$.

Having made these observations the buyer chooses whether to change supplier. Let S_t be an index of the choice, taking the value 1 if he changes and zero otherwise. Thus, the price actually paid is determined by

$$(2) \quad p_t = \begin{cases} p_t^o & \text{if } S_t = 0 \\ p_t^N & \text{if } S_t = 1 \end{cases}$$

When the choice has been made he gets the utility

$$v(p_t) - S_t K_t$$

where $v_1 \equiv \frac{\partial v(p_t)}{\partial p_t} < 0$

The decision of the buyer is affected by expectations about future prices. I assume that buyers perceive each firm's price as generated by a stochastic equation

$$(3) \quad p_{i,t} = g(p_{i,t-1}, \varepsilon_{i,t})$$

where $g_1 \geq 0$. The index of the firm, i , will be left out below as it is irrelevant for the customer's decision.

The maximization problem for the buyer when $(\bar{p}_t^o, \bar{p}_t^N, \bar{K}_t)$ have been observed can be formulated as:

¹⁾ Although p_t^o, p_t^N, K_t, p_t etc in this section are particular to each customer. I do not include any index for the customer.

$$(4) \quad \max V_t = E \sum_{j=0}^{\infty} b^j (v(p_{t+j}) - s_{t+j} K_{t+j})$$

$$\text{s.t.} \quad p_{t+j} = \begin{cases} p_{t+j}^O & \text{if } s_t = 0 \\ p_{t+j}^N & \text{if } s_t = 1 \end{cases}$$

$$p_{t+j+1}^O = g(p_{t+j}, \varepsilon_t) \quad j \geq 0$$

and

$$(p_t^O, p_t^N, K_t) = (\bar{p}_t^O, \bar{p}_t^N, \bar{K}_t)$$

Let $V^*(\bar{p}_t^O, \bar{p}_t^N, \bar{K}_t)$ be the maximized value of V_t . Then it must be true that

$$(5) \quad V^*(\bar{p}_t^O, \bar{p}_t^N, \bar{K}_t) = \max \left\{ v(\bar{p}_t^O) + b E V^* \left[g(\bar{p}_t^O, \varepsilon_{t+1}), p_{t+1}^N, K_{t+1} \right], \right. \\ \left. v(\bar{p}_t^N) - \bar{K}_t + b E V^* \left[g(\bar{p}_t^N, \varepsilon_{t+1}), p_{t+1}^N, K_{t+1} \right] \right\}$$

Differentiating with respect to p_t^O we get

$$(6) \quad V_1(-) = \begin{cases} v_1 + b E V_1^* g_1 & \text{if } v(p_t^O) + b E V^* \left[g(p_t^O, \varepsilon_{t+1}), p_{t+1}^N, K_{t+1} \right] \\ & \geq v(p_t^N) - K_t + b E V^* \left[g(p_t^N, \varepsilon_{t+1}), p_{t+1}^N, K_{t+1} \right] \\ 0 & \text{otherwise} \end{cases}$$

This implies $V_1 \leq 0$. Analogously it can be shown that $V_2 \leq 0$.

The customer will change to the new supplier if the latter expression in the maximization is largest. Define

$$(7) \quad \Phi(p_t^N, p_t^O) = v(p_t^N) - v(p_t^O) + \\ + b E \left\{ V^* \left[g(p_t^N, \varepsilon_t), p_{t+1}^N, K_{t+1} \right] - \right. \\ \left. - V^* \left[g(p_t^O, \varepsilon_t), p_{t+1}^N, K_{t+1} \right] \right\}$$

Then the customer changes to the new supplier if

$$(8) \quad K < \Phi(p_t^N, p_t^O)$$

This means that, given p_t^N and p_t^O the probability that the customer changes supplier is

$$(9) \quad F[\Phi(p_t^N, p_t^O)]$$

Now, suppose we have two firms i and k charging the prices $p_{i,t}$ and $p_{k,t}$ in period t . The probability that a given customer of firm k will compare prices with a customer of firm i is equal to firm i 's market share, x_i . Thus, assuming a large number of customers per firm, the flow of customers from firm k to firm i is

$$(10) \quad F[\Phi(p_{i,t}, p_{k,t})] x_i x_k$$

The flow from firm i to firm k is given by the same expression with i and k reversed. Thus we have the net flow from k to i

$$(11) \quad \left[F[\Phi(p_{i,t}, p_{k,t})] - F[\Phi(p_{k,t}, p_{i,t})] \right] x_k x_i$$

A linear approximation around $p_{i,t} = p_{k,t} = \bar{p}$ is

$$(12) \quad h(p_{k,t} - p_{i,t}) x_k x_i$$

where $h = F_1(0) \Phi_2(\bar{p}, \bar{p}) > 0$

Summation across firms completes the derivation of the customer flow equation:

$$(1) \quad x_{i,t} - x_{i,t-1} = h(\bar{p}_t - p_{i,t}) x_{i,t-1}$$

where

$$\bar{p}_t = \sum_{k=1}^m p_{k,t} x_{k,t}$$

will be denoted the "market" price.

3. Optimum for the Firm

Firms produce identical goods and have perfect information about current demand and costs of their own and their competitors and expectations about future demand and costs. They also have expectations about current and future market prices. (In equilibrium expectations about current market prices are correct and expectations about future market prices are consistent with the model.)

The demand per customer depends on the price charged by the firm, p_t , a (composite) price for other goods bought by the customers, p_t^o , and nominal income (or expenditure) Y_t . Total demand in period t is therefore

$$(13) \quad Q = J(p_t, p_t^o) Y_t x_t \quad J_1 < 0, J_2 > 0$$

where x_t is the customer stock. There is a large number of customers so x_t may be treated as continuous. (The index for the individual firm is left out in this section.) Because of the linear homogeneity of demand in prices and income

$$(14) \quad Q = J(p_t) y_t x \quad J_1 < 0$$

where

$$(15) \quad p = p_t / p_t^o$$

For simplicity, the demand curve is assumed to be linear in price ($J_{11} = 0$).

This is a short run analysis in the sense that the capital stock of the firm is taken as given and marginal cost therefore increases with the quantity produced. The cost (C) is given by

$$(16) \quad C = F(Q)W \quad F_1 > 0 \quad F_{11} > 0$$

where W , the "wage", is the nominal composite price of flexible factors of production (the relative proportions of which are assumed given in the short run). The real profit in period t is

$$(17) \quad \frac{1}{p_t^0} \left(p_t J(p_t) y_t x_t - F(J(p_t) y_t x_t) w_t \right) =$$

$$= p_t J(p_t) y_t x_t - F(J(p_t) y_t x_t) w_t$$

where y_t, w_t are real income, $(\bar{p}_t, y_t, w_t)$ are taken as given by the firm. The firm takes account of the customer flow equation derived in the previous section:

$$(1) \quad x_t - x_{t-1} = h(\bar{p}_t - p_t) x_{t-1}$$

or

$$(18) \quad p_t = g(x_{t-1}, x_t, \bar{p}_t) \equiv \bar{p}_t - \frac{1}{h} \left(\frac{x_t}{x_{t-1}} - 1 \right)$$

Substituting into the objective function the problem can be stated as

$$(19) \quad \max_{\{x_{t+j}\}} E \sum_{j=0}^{\infty} d^j f(x_{t+j-1}, x_{t+j}, \bar{p}_{t+j}, y_{t+j}, w_{t+j})$$

$$\text{s.t.} \quad x_{t-1} = \bar{x}_{t-1}$$

where

$$f(x_{t-1}, x_t, \bar{p}_t, y_t, w_t) = g(x_{t-1}, x_t, \bar{p}_t) x_t J(x_{t-1}, x_t, \bar{p}_t) y_t$$

$$- F(x_t J(g(x_{t-1}, x_t, \bar{p}_t)) y_t) w_t$$

This problem is very difficult to solve and therefore approximations will be made. The technique will be to first look at the problem when $\{\bar{p}_t, y_t, w_t\}$ are known with certainty to be constant for all future periods. It will be assumed that a stationary solution exists for this case. Then a quadratic approximation to the objective function is taken around this stationary solution. Maximization of this approximate objective function can be made by first solving the problem for a known sequence $\{\bar{p}_t, y_t, w_t\}$ and then, by certainty equivalence replacing these with the expected values of the variables.

Maximization of (19) for constant $(\bar{p}^0, y^0, w^0)$ gives

$$(20) \quad d^t f_2(x_{t+j-1}, x_{t+j}, \bar{p}^0, y^0, w^0) + \\ + d^{t+1} f_1(x_{t+j}, x_{t+j+1}, \bar{p}^0, y^0, w^0) = 0$$

In the stationary solution

$$x_{t+j} = x^0 \quad \text{for all } j \geq 0$$

so

$$(21) \quad f_2(x^0, x^0, \bar{p}^0, y^0, w^0) + d f_1(x^0, x^0, \bar{p}^0, y^0, w^0) = 0$$

The quadratic approximation is

$$(22) \quad \Phi(x_{t-1}, x_t, p_t^*, z_t) = f(\cdot) + f_1 x_{t-1} + f_2 x_t + f_3 \bar{p}_t + \\ + f_z z_t + \frac{1}{2} (x_{t-1}, x_t, \bar{p}_t, z_t) Q \begin{bmatrix} x_{t-1} \\ x_t \\ p_t^* \\ z_t \end{bmatrix}$$

where $x_t, \bar{p}_t, z_t$ now denote deviations from the stationary values and

$$z_t = (y_t, w_t)$$

$$f_z = (f_4, f_5)$$

Q is the matrix of second order derivatives. All derivatives are evaluated at the stationary solution.

The Euler equation for the approximate objective function is now

$$(23) \quad \Phi_2(x_{t-1}, x_t, \bar{p}_t, z_t) + d\Phi_1(x_t, x_{t+1}, \bar{p}_{t+1}, z_{t+1}) = \\ f_2 + f_{21}x_{t+j-1} + f_{22}x_{t+j} + f_{23}\bar{p}_{t+j} + f_{22}z_{t+j} \\ + d[f_1 + f_{11}x_{t+j} + f_{12}x_{t+j+1} + f_{13}p_{t+j+1} + f_{1z}z_{t+j+1}] = 0$$

Observing that in the stationary solution $f_2 + df_1 = 0$ this may be rewritten

$$(24) \quad (1 + \frac{c}{d}L + \frac{1}{d}L^2) x_{t+j+1} = - \frac{1}{df_{12}} \left[(f_{23} + df_{13} L^{-1}) \bar{p}_{t+j} + (f_{2z} - df_{1z} L^{-1}) z_{t+j} \right]$$

$$\text{where } c = \frac{f_{22} + df_{11}}{f_{12}} \leq - (1 + d)$$

The signs of the derivatives of $f(\cdot)$ are analyzed in Appendix A. The polynomial in the lag operator can be factorized $1 + \frac{c}{d}L + \frac{1}{d}L^2 = (1 - v_1 L)(1 - v_2 L)$ where $0 < v_1 < 1$ and $\frac{1}{d} < v_2$ (c.f. Sargent 1979, pp 197-98). Shifting the time index one period and solving for x_{t+j} we get

$$(25) \quad (1 - v_1 L)x_{t+j} = \frac{-1}{df_{12}(1 - v_2 L)} \left[(f_{23} - df_{13} L^{-1}) \bar{p}_{t+j-1} + (f_{2z} + df_{1z} L^{-1}) z_{t+j-1} \right]$$

and, for $j = 0$, we get

$$\begin{aligned} x_t &= \tilde{x}(x_{t-1}, \bar{p}_t, \bar{p}_{t+1}, \dots, z_t, z_{t+1}, \dots) = \\ &= v_1 x_{t-1} + \frac{1}{v_2 df_{12} (1 - v_2^{-1} L^{-1})} \left[(f_{23} + df_{13} L^{-1}) \bar{p}_t + \right. \\ &\quad \left. + (f_{2z} + df_{1z} L^{-1}) z_t \right] = v_1 x_{t-1} + \frac{1}{v_2 df_{12}} \sum_{j=0}^{\infty} \bar{v}_2^j \left[(f_{23} + df_{13} L^{-1}) \bar{p}_{t+j} + \right. \\ &\quad \left. + (f_{2z} - df_{1z} L^{-1}) z_{t+j} \right] \end{aligned}$$

as the only solution satisfying the transversality condition.

This is the rule expressing the optimal market share as a function of x_{t-1} and expectations about all future market prices and exogenous shocks. The optimal decision rule for the price is thus

$$(26) \quad p_t = \tilde{p}_t = g \left[x_{t-1}, \tilde{x}(x_{t-1}, \bar{p}_t, \bar{p}_{t+1}, \dots, z_t, z_{t+1}, \dots), \bar{p}_t \right]$$

4. Price Behavior of the Small Country Exporting Firm

The decision rule derived in the previous section may be used to analyze how the individual firm responds to different shocks, taking the "market" as given. Such an analysis describes the behavior of a small country exporting firm when the shocks do not affect other firms in the market.

The effect of an increase in the previous period's customer stock is

$$(27) \quad \frac{\tilde{dp}_t}{dx_{t-1}} = g_1 + g_2 v_1 = g_1(1 - v_1) > 0$$

as $g_1 = -g_2$ in the stationary solution.

I will in this paper focus on permanent shocks to exogenous factors.

Temporary shocks could easily be analyzed, as in Dohner (1982) and Gottfries (1983). A permanent wage increase leads to a higher price

$$(28) \quad \frac{\tilde{dp}_t}{dw} = g_2 \frac{f_{25} + df_{15}}{df_{12}(v_2 - 1)} > 0$$

The effect of a permanent increase in the market price is

$$(29) \quad \frac{\tilde{dp}_t}{d\bar{p}} = 1 + g_2 \frac{\overbrace{f_{23} + df_{13}}^{+}}{\underbrace{df_{12}(v_2 - 1)}_{- \quad +}} \gtrless 0 ?$$

The ambiguity of this expression may be understood if it is remembered that the firm in its optimization balances effects on current revenue against effects on the market share and therefore on future revenues. To illuminate the different effects it is helpful to examine two special disturbances.

First, suppose the increase in the market price was purely temporary

$$\Delta \bar{p}_t > 0 \quad \Delta \bar{p}_{t+j} = 0 \quad \text{for } j = 1, 2, \dots$$

the effect on the price would be positive but smaller than unity (compare Appendix B):

$$\frac{\tilde{dp}_t}{d\bar{p}_t} = 1 - \frac{1}{v_2} \frac{\overbrace{f_{23}}^{+}}{\underbrace{df_{12}}_{+}} > 0$$

In this case the incentive to invest in market share does not change (i.e. the value of a given market share at the end of the period is unchanged). The firm lets part of the increase in the market price lead to increased market share, while part of it is "taken out" in increased current revenues.

Next, suppose the market price in some future period increases:

$$\Delta \bar{p}_{t+k} > 0 \quad \Delta p_{t+j} = 0 \quad \text{for } j \neq k$$

$$\frac{\tilde{dp}_t}{d\bar{p}_{t+k}} = \frac{g_2 v_2^{k-1} v_2^{-1} d f_{13} + f_{23}}{d f_{12}} < 0$$

In this case current revenues and costs are not affected but the higher future market prices strengthen the incentive to invest in market share, so the firm lowers its price.

Returning to the permanent increase in the market price, it can be seen as a combination of these two types of disturbances. As is shown by the numerical example in Appendix C the latter effect may very well dominate. If this is the case the firm initially lowers its price as the market price increases and then raises the price as the market share builds up towards the new equilibrium level.

Note, however, that this referred to a rise in the price charged by competitors in the export market, given all other prices and nominal income abroad. Such a change in the exporting firm's environment would result from e.g. a local cost shock hitting foreign competitors. A general inflation abroad would rather mean that all foreign prices and nominal income abroad would rise along with competitors' prices. Such a shock is formally seen as a decrease in w , the wage measured in foreign goods. The effect will be that the small exporting firm reduces its real price (measured in foreign goods). Assuming that the elasticity of the price with respect to the wage is smaller than unity the exporting firm will rise its nominal price, however, and thus partially go along with the rise in the foreign price level. Analogously, a depreciation of the home currency, given foreign prices and domestic nominal wages, leads the exporting firm to lower its prices (measured in foreign currency) less than proportionately. So, in response to such global shocks the small exporting firm can be considered a "partial" price taker in the short run, while it is a perfect price taker in the long run.

5. Interaction Between Exporting and Import Competing Firms

The previous section analyzed the behavior of one firm, taking the rest of the market as given. Now it is time to analyze a market where there are some domestic and some foreign firms. Let there be N domestic firms with decision rules (26) and M foreign firms with decision rules.

$$(30) \quad \tilde{p}_{t+j}^* = g(x_{t+j-1}^*, \bar{x}_{t+j}^*, \bar{p}_{t+j})$$

where

$$\begin{aligned} \hat{x}_{t+j}^* = & v_1 x_{t+j-1}^* + \frac{1}{v_2 d f_{12} (1 - v_2^{-1} L^{-1})} \left[(f_{23} + d f_{13} L^{-1}) \bar{p}_{t+j} + \right. \\ & \left. + (f_{2z} + d f_{1z} L^{-1}) z_{t+j}^* \right] \end{aligned}$$

Define the average market share to be

$$(31) \quad \bar{x}_t = \frac{N x_t + M x_t^*}{N + M}$$

Using the decision rules (26) and (30) we get the planned average market share as a function of current and future market prices and average disturbances:

$$\begin{aligned} (32) \quad \tilde{x}_{t+j} = & v_1 \bar{x}_{t+j-1} + \frac{1}{v_2 d f_{12} (1 - v_2^{-1} L^{-1})} \left[(f_{23} + d f_{13} L^{-1}) \bar{p}_{t+j} \right. \\ & \left. + (f_{2z} + d f_{1z} L^{-1}) \bar{z}_{t+j} \right] \end{aligned}$$

where

$$\bar{z}_t = \frac{N z_t + M z_t^*}{N + M}$$

Now, by definition $\bar{x}_t = 0$ and for this to be an equilibrium we must have $\tilde{x}_{t+j} = 0$ for all j , so the equilibrium market price is

$$(33) \quad \bar{p}_{t+j} = - \frac{f_{2z} + d f_{1z} L^{-1}}{f_{23} (1 - s L^{-1})} \bar{z}_{t+j}$$

where

$$0 < s = d \frac{f_{13}}{f_{23}} < 1$$

Differentiating, we find that increases in demand as well as average costs tend to increase the market price.

Substituting into (25) the market share of a domestic firm may be expressed as a function of exogenous shocks:

$$(34) \quad x_t = v_1 x_{t-1} + \frac{f_{22} + df_{12} L^{-1}}{v_2 d f_{12} (1 - v_2^{-1} L^{-1})} (z_t - \bar{z}_t).$$

The market share depends on the historic market share and current and future deviations from average shocks in the market.

A demand shock will affect all firms the same way and therefore does not affect market shares or relative prices. The effect of a foreign cost shock to foreign firms' prices is

$$(35) \quad \frac{dp_t^*}{dw^*} = - \frac{f_{25} - df_{15}}{f_{23} (1 - s)} \frac{M}{N + M} + g_2 \frac{f_{25} + df_{15}}{(v_2 - 1) df_{12}} \left(1 - \frac{M}{N + M}\right) > 0$$

The first term is the increase in the market price level and the second is the increase in the relative price of foreign firms. The effect on prices of domestic firms is

$$(36) \quad \frac{dp_t^*}{dw^*} = \frac{\hat{dp}_t}{dp} \frac{d\bar{p}}{dw^*} \gtrless 0$$

? +

As discussed earlier the first factor may very well be negative. So it is seen that exporting and import competing firms differ in their short run response to an increase in the foreign price level: while exporting firms partially go along with the foreign price increase, import competing firms may initially not respond or even lower their prices as import prices go up. The difference, of course, depends on the fact that the demand curve of a foreign customer shifts up (in nominal terms), while that of a domestic customer is unchanged.

6. Final comment

In the author's view, a model of this type has several advantages as a vehicle for studying the development of prices and quantities of tradable goods. It allows a reconciliation of observations and views, which appear contradictory in the static framework. For example, products exported from different countries often appear to be close substitutes, but at the same time market shares tend to change slowly in spite of substantial variations in relative prices.

Also, the model incorporates the view that in the long run tradables' prices can only vary to a limited extent between countries and exports of the small country, as well as production in the import competing sector, are in the long run determined by domestic supply factors and world market prices.

The model also has the reasonable implication that firms care about the level of demand as much as about the "market price". For the economist it implies that demand is an important factor to consider (in itself) when e.g. exports from a small country are to be explained or forecasted. To understand the short run development it is not sufficient, as under perfect competition, to consider world market prices and supply conditions in the small country.

In the end, of course, only empirical testing will show the usefulness of the model.

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Appendix A: Derivatives of $g(x_{-1}, x, \bar{p})$ and $f(x_{-1}, x, \bar{p}, y, w)$
in stationary equilibrium

Derivation of $g(x_{-1}, x, \bar{p})$ gives immediately

$$g_1 = -g_2 > 0 \quad g_3 = 1$$

$$g_{11} < 0 \quad g_{12} > 0$$

$$g_{22} = g_{33} = g_{13} = g_{23} = 0$$

$$f(x_{-1}, x, \bar{p}, y, w) = g(x_{-1}, x, \bar{p}) \times J(g(x_{-1}, x, \bar{p})) y$$

$$- F \left[x J(g(x_{-1}, x, \bar{p})) y \right] w$$

$$f_1 = \left[J(-) + (g(-) - F_1(-) w) J_1 \right] g_1(-) \times y$$

$$f_2 = \left[g_2(-) \times [J(-) + (g(-) - F_1(-) w) J_1] + (g - F_1(-) w) J \right] y$$

In the stationary solution

$$f_2 + df_1 = (1 - d) \left[J(-) + (g(-) - F_1(-) w) J_1 \right] g_2 \times y + (g - F_1(-) w) J y = 0$$

which implies

$$N \equiv J + (g - F_1 w) J_1 > 0$$

and therefore

$$f_1 > 0 \quad f_2 = -df_1 < 0$$

$$\text{Define} \quad M = (2 - F_{11} \times J_1 y w) J_1 < 0$$

then

$$f_{11} = g_{11} \times y N + g_1^2 \times y M < 0$$

$$f_{12} = g_{12} \times y N + g_1 y N + g_1 g_2 \times y M - g_1 \times y F_{11} J y w J_1 > 0$$

$$f_{13} = g_1 \times y M < 0$$

$$f_{14} = g_1 \times (N - y F_{11} \times J w J_1) > 0$$

$$f_{15} = - g_1 \times y F_1 J_1 > 0$$

$$f_{21} = g_{21} \times y N + g_2 g_1 \times y M + g_1 y N - J y F_{11} J_1 g_1 \times y w > 0$$

$$f_{22} = 2 g_2 y N + g_2^2 \times y M - 2 g_2 \times y^2 F_{11} J w J_1 - J^2 y^2 F_{11} w < 0$$

$$f_{23} = g_2 \times y M + y N - J y^2 F_{11} J_1 \times w > 0$$

$$f_{24} = - F_{11} \times J y (x J_1 g_2 + J) w + \frac{f_2}{y} < 0$$

$$f_{25} = F_1 y (- g_2 \times J_1 - J) < 0$$

Appendix B: Effects of shocks

Substituting for the derivatives of $f(-)$ it can be shown that

$$f_{23} + df_{13} > 0$$

$$f_{24} + df_{14} = \underbrace{\frac{f_2 + df_1}{y}}_0 - F_{11} x y J w \left[x J_1 g_2 (1-d) + J \right] < 0$$

$$f_{25} + df_{15} < 0$$

$$\frac{\tilde{dp}_t}{d\bar{p}_t} = g_2 \frac{\tilde{dx}}{d\bar{p}_t} + g_3 = g_2 \frac{f_{23}}{v_2 df_{12}} + 1 =$$

$$= 1 - \underbrace{\frac{1}{v_2 d}}_{0 < " < 1} \cdot \underbrace{\frac{h^{-1} M - N + J F_{11} J_1 x}{h^{-1} M - 2N + J F_{11} J_1 x}}_{0 < " < 1} > 1$$

$$\frac{\tilde{dp}_t}{d\bar{p}_{t+k}} = g_2 \frac{\tilde{dx}}{d\bar{p}_{t+k}} = g_2 \frac{1}{v_2 df_{12}} (v_2^{j-1} df_{13} + v_2^j f_{23})$$

$$= - \frac{v_2^{j-1}}{d} \cdot \frac{N - (1 - v_2^{-1} d) h^{-1} M - J F_{11} J_1 x}{2N - h^{-1} M - J F_{11} J_1 x} < 0$$

Appendix C: Numerical example

Assume the following functions and parameters:

$$J(p) = 2 - p$$

$$F_1(Q) = .6 + .4 Q$$

$$x^0 = y^0 = w^0 = 1$$

Think of the period as being one quarter and assume

$$r = .025 \quad h = .5$$

The equilibrium price would be at unity under perfect competition.

Using the first order condition and the stationary state condition $x^0 = 1$ the equilibrium price will be

$$\bar{p} = 1.034$$

i.e. close to the perfectly competitive solution.

Differentiating the decision rule for the individual firm we get

$$\frac{dp}{dw} = .74$$

and

$$\frac{dp}{d\bar{p}} = - .047$$

The firm will pass forward cost increases to a great extent and react to an increase in competitors prices by initially lowering its price!

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