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A unified framework for analysing price interdependence, innovative activity and exchange rate pass-through

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HIGHLIGHTS

- We present an international oligopoly model.
- The model endogenises price and innovation decisions of foreign and domestic firms.
- The paper introduces process innovation in the exchange rate pass-through literature.
- Innovative activity is an important determinant of pass-through.

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ABSTRACT

This paper develops an international oligopoly model in which domestic and foreign firms simultaneously choose their price and innovation strategies under the assumption of non-zero conjectural variations in relation to their competitors' price changes. The model captures the links between the exchange rate, foreign and domestic firms' prices and investment in process innovation and provides a unified framework for analysing exchange rate pass-through.

1. Introduction

The available evidence on the unresponsiveness of traded goods prices to exchange rate changes has motivated a lot of work on the issue. Many studies adopt an international oligopoly setting as the framework of analysis and regard incomplete exchange rate pass-through as a profit maximising strategy of firms that sell their products in international markets. However, even though these studies recognise the existence of domestic competitors, they restrict their attention to the analysis of foreign firms' reaction function.

Studies extending the analysis to account for the effect of the exchange rate on firms' market share, cost structure and investment in process innovation (e.g. Brissimis and Kosma, 2005) still analyse the foreign firms' reaction functions only. Domestic producers are, however, also affected by the exchange rate. First, domestic firms' prices are found to depend on their foreign competitors' prices (Allen, 1998) and are, thus, indirectly linked to the exchange rate. Second, the exchange rate, by influencing the market share of domestic firms,[1] is likely to affect these firms' incentive to adopt process-improving R&D investment.[2]

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[1] The translog demand structure adopted in a number of studies (e.g., Allen, 1998, Bergin and Feenstra, 2001, Feenstra, 2003) suggests that domestic firms' market share depends on their prices and the prices of their foreign competitors. Since the latter prices depend on the exchange rate, the domestic firms' market share will be indirectly linked to the exchange rate.

[2] Market structures that guarantee a larger market share to firms are likely to lead to more investment in process innovation (Bester and Petrakis, 1993; Yi, 1999; Lin and Saggi, 2002).

Therefore, in order to obtain more accurate estimates of exchange rate pass-through, all possible channels of influence of the exchange rate need to be accounted for. This paper develops an international oligopoly model that endogenises price and innovation decisions of foreign and domestic firms. The model captures all exchange rate links working through firms' price and cost competitiveness and provides a unified framework for obtaining more informative results for the pass-through.

2. Model

In this section we develop an oligopolistic model, which examines the pricing behaviour of foreign firms that produce a slightly differentiated product and compete with domestic firms in the importer's market. These firms face two kinds of decisions. One relates to their pricing strategy and the other to their investment in process innovation. As for the sequence of decisions, we employ the simplest possible one-period game, i.e. we assume that firms choose simultaneously both their pricing strategy and the amount of real resources directed towards innovative activity, given expectations about the reaction of their rivals to their price changes—these expectations are captured by a non-zero conjectural variation term for price changes.[3] It is also assumed that firms in each country are identical (Yang, 1997) and we can therefore consider a game between two firms—one foreign and one domestic.

The specification adopted in this model introduces process innovation in a way similar to that of Dasgupta and Stiglitz (1980). Specifically, the unit cost of production[4] of the foreign and the domestic firm is defined as:

$$c_j = c_j(x_j), \quad \text{where } x_j = a_j q_j, \quad \text{or} \quad c_j = c_j(a_j q_j) \quad j = 1, 2$$

x_j corresponds to total resources committed to innovative activity and α_j to their proportion to the firm's output q_j.[5] According to this specification, only part of the firm's total output is sold in the market, i.e. $(1 - \alpha_j)q_j$.

This specification assumes that the unit cost of production depends on the amount of cost-reducing investment in process innovation in the sense that a higher commitment of resources to process innovation leads to greater cost reductions for the firms. Thus, output as a determinant of the amount of this cost-reducing investment, is a factor that shifts the unit cost of the production curve downwards.

The demand for the firms' products is derived from a homothetic expenditure function of the translog form (cf. Diewert, 1974, Bergin and Feenstra, 2001, Feenstra, 2003):

$$\ln X = \ln U + \beta_0 + \sum_{i=1}^{n} \beta_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j, \quad \text{with } \gamma_{ij} = \gamma_{ji} \tag{1}$$

where X is the minimum expenditure necessary to obtain a specific utility level at given prices, U is the level of utility and p_i, p_j are the prices of good i and j, respectively. From the logarithmic differentiation of (1) with respect to the price of good i, we can obtain demand functions in budget share form, namely the share of good i in total expenditure.

$$\text{Thus, } s_i = \frac{\partial \ln X}{\partial \ln p_i} = \beta_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j \tag{2}$$

where s_i is the share of good i (see Chung, 1994). The term β_i in Eq. (2) represents the basic market share, the market share that firms could attain if prices where equalised. It depends on tastes, advertising, past market shares and switching costs (Allen, 1998).

Firms, therefore, maximise profits – expressed in the currency of the importer – by choosing their prices and the proportion of R&D investment under the constraint of the above demand structure.

Therefore the profit function of the foreign firm can be defined as follows:

$$\Pi_1 = p_1(1 - \alpha_1)q_1 - ec_1(a_1 q_1)q_1 \tag{3}$$

where p_1 corresponds to the price of the imported good, q_1 to the foreign firm's supply, e to the exchange rate defined as the home currency price of foreign currency, c_1 to the foreign firm's marginal cost and α_1 to the proportion of foreign firm's output devoted to innovative activity—the foreign firm's process-innovation intensity. The term $\alpha_1 p_1 q_1$, represents revenue foregone and could thus be interpreted as the total cost of innovative activity and as such it is subtracted from the firm's total revenue.

If the foreign firm's profit function is rewritten in terms of market share we obtain the following expression for the foreign firm's profits[6,7]:

$$\Pi_1 = \left((1 - \alpha_1) - \frac{ec_1(a_1 q_1)}{p_1} \right) s_1 X \tag{4}$$

where s_1 is the foreign firm's market share and X is total expenditure, as defined above. Since the firm simultaneously chooses its price p_1 and the fraction of output α_1 devoted to innovative activity, the two first-order conditions for profit maximisation are:

$\partial \Pi_1 / \partial p_1 = 0$ and $\partial \Pi_1 / \partial \alpha_1 = 0$.

The first condition can be written as:

$$\left[\frac{ec_1}{p_1^2} - \frac{e\partial c_1(\alpha_1 q_1)}{\partial(\alpha_1 q_1)} \frac{\partial(\alpha_1 q_1)}{\partial p_1} \frac{1}{p_1} \right] s_1 X + \left((1 - \alpha_1) - \frac{ec_1}{p_1} \right) \left[\frac{\partial s_1}{\partial p_1} + \frac{\partial s_1}{\partial p_2} \frac{\partial p_2}{\partial p_1} \right] X = 0 \tag{5}$$

where p_2 is the price of the domestic firm and $\frac{\partial p_2}{\partial p_1}$ is the foreign firm's conjectural variation, i.e. its expectation about the domestic firm's reaction to its own price change.[8]

Assuming that $\eta_{s_{11}} = \frac{\partial s_1}{\partial p_1} \frac{p_1}{s_1}$ and $\eta_{s_{12}} = \frac{\partial s_1}{\partial p_2} \frac{p_2}{s_1}$ are the elasticities of the foreign firm's market share with respect to its price and the price of the domestic firm respectively, and that $\eta_{11} = \frac{\partial q_1}{\partial p_1} \frac{p_1}{q_1}$ and $\eta_{12} = \frac{\partial q_1}{\partial p_2} \frac{p_2}{q_1}$ are the foreign firm's own and cross price elasticity of demand respectively, we get the following expression:

$$\left[\frac{ec_1}{p_1^2} - \frac{e\partial c_1(\alpha_1 q_1)}{\partial(\alpha_1 q_1)} \frac{(\alpha_1 q_1)}{c_1} \frac{c}{p_1^2} \left(\eta_{11} + \eta_{12} \frac{\partial p_2}{\partial p_1} \frac{p_1}{p_2} \right) \right] s_1 X + \left((1 - \alpha_1) - \frac{ec_1}{p_1} \right) \left[\eta_{s_{11}} \frac{s_1}{p_1} + \eta_{s_{12}} \frac{\partial p_2}{\partial p_1} \frac{p_1}{p_2} \frac{s_1}{p_1} \right] X = 0. \tag{6}$$

3 We assume that firms have zero conjectural variations in relation to their competitors' innovation strategies.

4 The unit cost of production is assumed to be constant for every output level and equal to the marginal cost.

5 We assume that firms finance investment in process innovation from their own resources, i.e. using a proportion of their output, and we thus abstract from the analysis of the impact of alternative ways of investment financing.

6 Eq. (4) is derived from Eq. (3) by multiplying the first term of Eq. (3) by $\frac{X}{X}$ and the second term by $\frac{p_1}{p_1} \frac{X}{X}$.

7 The profit function is similar as in Allen (1998) but extended to account for the impact of the exchange rate and of the investment in process innovation.

8 Conjectural variations are assumed to be constant (cf. Boyer and Moreaux, 1983).