NBER WORKING PAPER SERIES

THE EFFECTS OF INDUSTRY STRUCTURE ON ECONOMIC EXPOSURE

Richard C. Marston

Working Paper 5518

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 1996

The author is grateful to Gordon Bodnar, Bernard Dumas, Alan Deardorf and Anant Sundaran as well as participants in the International Economics Seminar at the University of Michigan for helpful comments on an earlier draft. This paper is part of NBER's research program in International Finance and Macroeconomics. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

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ABSTRACT

A firm is subject to "economic exposure" if changes in exchange rates affect the firm's value, as measured by the present value of its future cash flows. This paper shows that in many forms of competition, including the most commonly studied case of monopoly, the economic exposure of an exporting firm is simply proportional to the firm's net revenues based in foreign currency. So the firm's hedging strategy is simple: sell foreign currency futures equal to the value of its net revenues in foreign currency. This simple result breaks down under some, but not all, forms of competition between the exporting firm and local firms. In that case, the exporting firm needs to know about the price elasticity of its product demand and its marginal cost in order to assess its exposure to exchange rates. So its hedging strategy also requires detailed knowledge of demand and cost conditions. The key determinant of economic exposure, therefore, is the competitive structure of the industry in which a firm operates.

Richard C. Marston
Wharton School
University of Pennsylvania
Philadelphia, PA 19104
and NBER

THE EFFECTS OF INDUSTRY STRUCTURE ON ECONOMIC EXPOSURE

A firm is subject to "economic exposure" if the firm's value, as measured by the present value of its expected future cash flows, is sensitive to unexpected changes in exchange rates.[1] For example, the value of an exporting firm may fall if the domestic currency appreciates, while the value of an importing firm may rise with that same appreciation. But even a purely local firm which neither exports nor imports may be exposed to changes in exchange rates if it competes with foreign firms in the domestic market or purchases inputs whose prices are sensitive to exchange rates. This paper explores the determinants of economic exposure by investigating how the structure of an industry affects the exposure of firms to exchange rates.

Previous studies of economic exposure such as Adler and Dumas (1984), Hekman (1985), Shapiro (1975), Flood and Lessard (1986), von Ungern-Sternberg and von Weizsacker (1990), and Levi (1994) have investigated various determinants of exposure or the hedging policies to mitigate it.[2] Several of the studies emphasize the importance of supply and demand conditions in determining economic exposure, but none of these studies have focused on a remarkably simple fact about economic exposure: that in many forms of competition, including the most commonly studied case of monopoly, the economic exposure of an exporting firm is simply proportional to the firm's ***net revenues based in foreign currency***. In such cases, the firm does not need to know about the price elasticity of its product demand or its marginal costs in order to assess its

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[1] The definition is often expressed in real terms in which case it is unexpected changes in real exchange rates that are relevant. The distinction between real and nominal values will be ignored in this study, since inflation is assumed to be zero.

[2] There is also a parallel empirical literature on economic exposure including studies by Jorion (1990) and Bodnar and Gentry (1993).

exposure to exchange rates.

The study will examine competition between firms producing distinct products, including purely local firms whose only economic exposure is due to competition from foreign firms that export to the local market. This emphasis on the microeconomic structure of an industry has been at the forefront of the closely-related subject of exchange-rate pass-through, but has been largely ignored in studies of economic exposure.[3] Industry structure is an important determinant of economic exposure because the type of competition between firms determines how exchange rates affect their cash flows. An industry dominated by one monopolist may have very different economic exposure than an industry with both local and foreign firms. And an industry with multiple firms may have very different exposure if one of the firms is dominant than if all firms compete in a symmetric fashion. This paper will show that the form of competition between exporting firms and local firms determines whether economic exposure takes a simple or complex form.

To develop a measure of economic exposure, we must start with an operational definition of a firm's value. The value of a firm can be expressed in terms of a stream of present and future cash flows as

$$V = \sum_{t=1}^{\infty} \frac{CF_t}{(1 + \rho)^t} \tag{1}$$

[3] See, for example, Dornbusch (1987), Krugman (1987), and Froot and Klemperer (1989). Among studies of economic exposure, only the paper by von Ungern-Sternberg and von Weizsacker (1990) examines industry structure. They examine industries where all firms produce a single homogeneous product or where competition follows the spatial model developed by Salop (1979), whereas in this paper, products are differentiated and demand functions take a general form.

where CF_t represents the cash flows of the firm which are equal to after-tax profits plus net investment and where ρ is the discount rate. The simplest measure of economic exposure is dV/dS, where S is the exchange rate.[4] In order to keep the model tractable so that the effects of market structure can be examined, I assume that the net investment of the firm is equal to zero and that cash flows are constant from year to year. In that case, the present value can be written

$$V = \frac{CF}{\rho} = \frac{(1 - \tau)}{\rho} \pi \tag{2}$$

where τ is the tax rate and π is profit before taxes. With taxes and the discount rate constant, economic exposure can be measured by the derivative

$$dV/dS = [(1 - \tau)/\rho]\, d\pi/dS. \tag{3}$$

So economic exposure is proportional to the derivative of current profits with respect to the exchange rate. It is this latter derivative, dπ/dS, that will be explicitly measured below.

I. Economic Exposure for a Simple Monopoly

To illustrate the effects of market structure and to clarify the concept of economic exposure, the paper will begin with a simple example of a monopolistic firm which exports its product and imports some of its inputs for production. Let the domestic currency be the dollar and the foreign currency the mark, with the exchange rate measured as $S^\$ =$ \$/DM. The firm produces output of X units at a price in foreign currency of P. Some costs are incurred in both

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[4] Strictly speaking, economic exposure measures the effects of *unexpected* changes in exchange rates on cash flows, but in this paper all changes in exchange rates will be treated as unexpected.

currencies with total costs equal to $C^\$ + S^\$ C^{DM}$. If the inverse demand function is given by P = D(X), then the profit of this firm is measured in dollars as follows:

$$\pi^\$ = S^\$ X D(X) - C^\$ - S^\$ C^{DM}. \tag{4}$$

The first-order condition for profit maximation is given by:

$$d\pi^\$/dX = S^\$ D(X) + S^\$ X D_1 - C_1^\$ - S^\$ C_1^{DM} = 0, \tag{5}$$

where the derivative of each function with respect to the first argument, output, is denoted with a subscript 1.

As explained above, economic exposure in this static model is proportional to the derivative of profits with respect to the exchange rate:

$$d\pi^\$/dS^\$ = [S^\$ D(X) + S^\$ X D_1 - C_1^\$ - S^\$ C_1^{DM}] (dX / dS^\$) + X D(X) - C^{DM}. \tag{6}$$

If the firm is at a profit-maximizing equilibrium, however, the term in square brackets is equal to zero by the first-order condition. So (6) simplifies to:

$$d\pi^\$/dS^\$ = X D(X) - C^{DM} \tag{7}$$

That is, the derivative of profits with respect to the exchange rate is simply equal to the initial level of mark-based net revenue.[5] If there is a depreciation of the mark ($dS^\$ < 0$), then profits *fall* in proportion to this net revenue. Note that this result does not change if the monopolist also

[5] As Adler and Dumas (1984) emphasize, economic exposure is measured in currency units (in this case, the foreign currency).

sells to its domestic market.[6]

This derivative of profits with respect to the exchange rate, $d\pi^{\$}/dS^{\$}$, provides the basis for a hedging strategy designed to shield profits from changes in the exchange rate. This hedging strategy is simple in the case of monopoly: to hedge the year's profit, sell mark futures equal to the value of the ***mark-based net revenue***. The hedge need not be based on detailed knowledge of the demand elasticities facing this firm or its cost structure. To hedge the firm's value rather than this year's profit, the hedge has to be a multiple of the one-year hedge: $(1/\rho)\ d\pi^{\$}/dS^{\$}$ where ρ is the discount rate.[7]

Similarly, if profits are measured in marks as $\pi = \pi^{\$} / S^{\$}$ and if the exchange rate is measured in DM/$ as $S = 1/S^{\$}$, then the derivative of profits with respect to the exchange rate is given by:

$$d\pi/dS \;=\; [D(X) \;+\; X D_1 \;-\; S\, C_1^{\$} \;-\; C_1^{DM}]\,(dX/dS) \;-\; C^{\$} \tag{8}$$

This expression likewise simplifies once the first-order conditions are substituted in:

$$d\pi/dS \;=\; -\; C^{\$} \tag{9}$$

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[6] In that case, there are two first-order conditions (with respect to output in the domestic and export markets) which are used to simplify $d\pi^{\$}/dS^{\$}$; the exposure expression still simplifies to equation (7).

[7] The static model specified above, however, is really not appropriate for determining long-term hedging strategies. For studies of long-term hedging, see Dumas (1992), Froot (1993), and Brealey and Kaplanis (1994).

So the economic exposure measured in DMs is proportional to the dollar-based costs of the firm.[8] All that matters to economic exposure, therefore, is the level of DM-based net revenues or the level of dollar-based costs, depending on how profits are measured.

It is interesting to point out what factors *do not matter* to economic exposure if the firm is a pure monopoly. Consider the case where profits are measured in dollars. Economic exposure is not dependent on the price elasticity of the product demand or on marginal cost *once the level of net revenues is taken into account.*[9] It is true that net revenues themselves are dependent on these two factors. Consider, for example, the effects of price elasticity on the initial level of revenues. If two firms face the same marginal costs selling to different markets, the firm with the lower price elasticity (a) will have a higher markup of price over marginal cost (MC) since P/MC = a/(a-1).[10] So the firm with the lower price elasticity will have higher revenues, and hence greater economic exposure. But once the initial level of net revenues is given, the derivative of profits with respect to exchange rates is independent of the price elasticity and marginal cost. As the next section will show, however, this result is very dependent on the industry structure assumed.

The second point to emphasize is that the firm's economic exposure would disappear if

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[8] Measuring profits in marks and the exchange rate in DM/$, a depreciation of the mark raises S and lowers profits in proportion to the dollar-based costs.

[9] Levi (1994) derives an expression for exposure which depends on the elasticity of demand, but this expression can be further simplified by using the first-order condition so that exposure is a function of net revenues only.

[10] Since $a > 1$ for the markup to be positive, the derivative of the markup with respect to a is negative.

this firm ceased to export its product and import some of its input. Yet we know that firms can be exposed to exchange rates even if they are purely "local" in their operations. The missing element is competition between the local firm and internationally-oriented firms, an element which can be introduced if a more complex market structure is introduced.

It should be apparent that this model of a monopoly firm is unable to capture some important features of economic exposure. The next section introduces a richer model which allows for different types of competition between firms.

II. A Model with Local and Internationally-Oriented Firms

In studying economic exposure for firms competing in an industry, two features seem important. First, the goods produced by firms in the industry should be heterogeneous so that substitutibility between the goods can play an explicit role. Second, the industry should include both local firms and internationally-oriented firms. The model chosen is that of a duopoly consisting of a *dollar-based exporter* and a *local firm* in the foreign (export) market (referred to as the "*local firm*"). The basic model of duopoly is taken from Dixit (1986).[11] For simplicity, each firm has costs based only in its own currency; the exporter's costs are in dollars and the local firm's in marks.

The exporting firm (firm 1) produces X_1 units of its good at a price *in marks* of P_1, while the local firm (firm 2) produces X_2 units at a price of P_2. Their respective inverse demand

[11] According to Dixit, any model with heterogeneous products becomes unwieldy once more than two firms are introduced.

functions are given by:[12]

$$P_1 = D^1(X_1, X_2), D_1^1 < 0 \quad (10a)$$

$$P_2 = D^2(X_1, X_2), D_2^2 < 0 \quad (10a)$$

The two goods are assumed to be substitutes, so $D_2^1, D_1^2 < 0$. The total cost for the exporting firm measured in *marks* is given by $S\ C^1(X_1)$ where as before S is the DM/$ exchange rate. The total cost for the local firm is $C^2(X_2)$. So profits can be measured *in marks* as follows:

$$\pi_1 = X_1 D^1(X_1, X_2) - S\ C^1(X_1) \quad (11a)$$

$$\pi_2 = X_2 D^2(X_1, X_2) - C^2(X_2) \quad (11b)$$

If profits are measured in marks, the exchange rate explicitly enters only the profit function of the exporting firm.

In formulating the first-order conditions for profit maximization, it is important to allow for possible interaction between the decisions of the two competing firms. If firm i believes that its output decision will affect the decision of the other firm, then its first-order condition will include a "conjectural variations" term of the form

$$dX_j/dX_i = v^i(X_1, X_2), \quad j \neq i \quad (12)$$

The first-order conditions of the two firms will therefore take the form

$$D^1() + X_1 D_1^1 + X_1 D_2^1 v^1 - S C_1^1 = 0 \quad (13a)$$

[12]The partial derivative of D^i with respect to its jth argument is denoted by D_j^i.

$$D^2() + X_2 D_2^2 + X_2 D_1^2 v^2 - C_2^2 = 0 \tag{13b}$$

The exact form of the conjectural variations term will depend on the nature of competition between the two firms. In the case of Cournot competition where each firm takes the other firm's output as given, these v^i terms are equal to zero.

The second order conditions can be written in compact form as

$$R_1^1 + v^1 R_2^1 < 0 \tag{14a}$$

$$R_2^2 + v^2 R_1^2 < 0 \tag{14b}$$

where R_j^i is the derivative of the ith first-order condition with respect to j. For firm 1, for example,

$$R_1^1 = 2 D_1^1 + X_1 D_{11}^1 + D_2^1 v^1 + X_1 D_{21}^1 v^1 + X_1 D_2^1 v_1^1 - S C_{11}^1 \tag{15a}$$

$$R_2^1 = D_2^1 + X_1 D_{12}^1 + X_1 D_{22}^1 v^1 + X_1 D_2^1 v_2^1 \tag{15b}$$

In addition to these second-order conditions, stability conditions will be useful in establishing the direction in which outputs and profits change. As Dixit (1986) shows, the duopoly model is stable if $R_1^1 < 0$, $R_2^2 < 0$, and $R = R_1^1 R_2^2 - R_2^1 R_1^2 > 0$.

The analysis will focus on the effects of a depreciation of the mark, dS > 0. The depreciation shifts up the marginal cost of the exporting firm (measured in marks), so it has an asymmetric effect on market equilibrium. The effects on output are examined first by differentiating the first-order conditions with respect to output:

$$\begin{bmatrix} R_1^1 & R_2^1 \\ R_1^2 & R_2^2 \end{bmatrix} \begin{bmatrix} dX_1 \\ dX_2 \end{bmatrix} = \begin{bmatrix} C_1^1 \, dS \\ 0 \end{bmatrix} \tag{16}$$

The changes in output for the two firms are given by

$$d X_1/d S = R_2^2 C_1^1/R \tag{17a}$$

$$d X_2/d S = - R_1^2 C_1^1/R \tag{17b}$$

The stability conditions ensure that $d X_1/d S < 0$. The sign of $d X_2/d S$ depends on the sign of the term, R_1^2.

This duopoly model is conveniently analyzed in terms of two reaction functions whose *slopes* are given by:[13]

$$r_1 = - R_2^1 / R_1^1 \tag{18a}$$

$$r_2 = - R_1^2 / R_2^2 \tag{18b}$$

Since the stability conditions ensure that $R_1^1 < 0$ and $R_2^2 < 0$, the slopes of these reaction functions depend on the cross partial derivatives, R_2^1 and R_1^2. The reaction functions have negative slopes if and only if these two cross derivatives are *negative*. If R_2^1 and R_1^2 are negative, the goods are said to be "strategic substitutes" by Bulow, Geanakoplos, and Klemperer (1985).[14]

By examining the expression for R_2^1 in (15b) it is clear that the cross derivatives are not

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[13] Each slope is defined with respect to that firm's output, so $r_1 = dX_1/dX_2$ for firm 1 and $r_2 = dX_2/dX_1$ for firm 2.

[14] Thus two goods are strategic substitutes if a rise in one firm's output lowers the marginal profit of the other firm. I am grateful to Anant Sundaran for this reference.

necessarily negative even if the two goods are substitutes so that $D^i_j < 0$. In the case of Cournot competition, $v^i = 0$, so the sign of R^i_j depends on $D^i_j + X_i D^i_{ij}$. This measures the effect of an increase in firm j's output on firm i's marginal revenue. Hahn (1962) assumed that marginal revenue would fall, so he viewed the negatively sloped reaction function as the "normal case." This would have to be true if demand curves are linear (so $D^i_{ij} = 0$). But notice that in the general case of non-Cournot competition, positively-sloped reaction functions are possible. For the same reason, it is possible that country 2's output can fall rather than rise when the mark depreciates.

The effects of the mark depreciation on the profits of the two firms are determined by differentiating the profit expressions (11a-b) with respect to S:

$$d\pi_1 / dS = [D^1() + X_1 D^1_1 - S C^1_1] (dX_1/dS) + X_1 D^1_2 (dX_2/dS) - C^1() \\ = - X_1 D^1_2 C^1_1 (R^2_2 v^1 + R^2_1)/R - C^1(). \quad (19a)$$

$$d\pi_2 / dS = [D^2() + X_2 D^2_2 - C^2_2] (dX_2/dS) + X_2 D^2_1 (dX_1/dS) \\ = X_2 D^2_1 C^1_1 (R^2_2 + v^2 R^2_1)/R > 0. \quad (19b)$$

The second equality in each expression is obtained by substituting in the first-order conditions in 13(a-b) and the expressions for d X_1/dS and d X_2/dS in 17(a-b).

The effect of the depreciation on the profits of the exporting firm is indeterminate in the general case, depending on the exact form of the competition between the two firms. But the effect on the local firm *is* determinant. The second order condition ensures that $R^2_2 + v^2 R^2_1 < 0$ and the stability conditions ensure that $R > 0$. If the demand curve is downward sloping ($D^2_1 < 0$), then $d\pi_2/dS > 0$. The local firm necessarily benefits from the depreciation of its currency. It benefits despite the fact that it is a purely local firm with both its revenues and costs based on its own currency.

To establish the behavior of the exporting firm's profits, it is necessary to become more specific about industry structure. Before discussing individual types of competition, it will be useful to rewrite the profit expressions in terms of the slopes of firm 2's reaction function, $r_2 = -R^2_1 / R^2_2$:

$$d\pi_1/dS = -X_1 D^1_2 C^1_1 R^2_2 (v^1 - r_2) / R - C^1() \tag{20a}$$

$$d\pi_2/dS = X_2 D^2_1 C^1_1 R^2_2 (1 - v^2 r_2)/R. \tag{20b}$$

As noted above, $r_2 < 0$ if and only if $R^2_1 < 0$.

(a) **Cournot Competition**

If each of the firms takes the other firm's output as given, then the conjectural variations terms are equal to zero:

$v^1 = 0$ and $v^2 = 0$ **Cournot Competition**

So the profit expressions (20a-b) simplify to:

$$d\pi_1/dS = X_1 D^1_2 C^1_1 R^2_2 r_2 / R - C^1() < 0 \text{ if } r_2 < 0. \tag{21a}$$

$$d\pi_2/dS = X_2 D^2_1 C^1_1 R^2_2 / R > 0 \tag{21b}$$

The profits of the local firm necessarily rise (as in the general case), while the profits of the exporting firm *fall* as long as the reaction function of the local firm is negatively sloped ($r_2 < 0$).

What does the economic exposure of the exporting firm depend on? As in the case of monopoly, the economic exposure of this firm depends on its dollar-based costs, $C^1(\ )$. But since changes in exchange rates induce changes in the other firm's price and output, the exporting firm's economic exposure also depends implicitly on price elasticities of demand, both own elasticities and cross elasticities. And it depends on marginal costs and other derivatives of the demand and cost functions.[15] Unlike in the case of monopoly, demand and supply behavior has an impact on economic exposure independent of the initial level of dollar-based costs.

It is also useful to examine the profits of the exporter measured in *dollars*. Since $\pi_1^\$ = \pi_1/S$ and $d\pi_1^\$/dS^\$ = d\pi_1^\$/d(1/S) = \pi_1 - S\,(d\pi_1/dS)$,

$$d\pi_1^\$/dS^\$ = X_1 D^1() - S X_1 D_2^1 C_1^1 R_2^2 r_2 / R > 0 \ \ if\, r_2 < 0. \tag{20c}$$

If $r_2 < 0$, then this derivative is positive rather than negative. But since the exchange rate is measured in \$/DM, a depreciation of the mark *lowers* $S^\$$. So the profits of the exporter *fall* in terms of dollars as well as in terms of marks. Because of output and price adjustment by the other firm, in fact, profits fall more than in proportion to the exporting firm's revenues from export sales, $X_1D^1(\ )$.

The expression for $d\pi_1^\$/dS^\$$ suggests the basis for a hedging strategy for this exporter. To shield this year's profit from the exchange rate, it is not enough to sell mark futures equal to the value of this year's revenues from the export market. The sale must be larger by the second term in (20c) involving demand and cost function derivatives. Because it would be difficult to estimate the demand and cost behavior implicit in this term, such a hedging strategy would be

[15] See the expressions for R_i^i and R_j^i in 15 (a-b).

difficult to implement.[16]

(b) **Illustrative Example: Constant-Elasticity Demand**

To illustrate the effects of exchange rates on outputs and profits in this case of Cournot competition, consider the example of a constant-elasticity demand function. This function has several useful properties which simplify the analysis of exchange rate changes: (i) markups of price over marginal cost are constant; (ii) if marginal costs are constant, the "pass-through" of exchange rates into foreign currency prices is complete; and (iii) output responses are a simple function of price elasticities.

Consider the following demand functions for the export and foreign goods written in logarithmic form:

$$\ln X_1 = -a_1 \ln P_1 + b_1 \ln P_2 + e_1 \ln P_3 + f_1 \ln Y + g_1 \tag{22a}$$

$$\ln X_2 = -a_2 \ln P_2 + b_2 \ln P_1 + e_2 \ln P_3 + f_2 \ln Y + g_2 \tag{22b}$$

P_3 is the price of a composite product from other industries in the local market, while Y is the income level of the consumer in this market. If these demand functions are homogeneous of degree one, then each *own* price elasticity is related to the cross elastiticies by $a_1 = b_1 + e_1$ and $a_2 = b_2 + e_2$.

These demand functions can be inverted to obtain expressions for each price as a function

[16] For this reason, most empirical studies estimate exposure by indirect methods: regressing share returns on exchange rates. See the Jorion (1990) and Bodnar and Gentry (1993) studies.

of X_1 and X_2 in the same form as 10 (a-b):

$$\ln P_1 = -\alpha_1 \ln X_1 - \beta_1 \ln X_2 + \alpha_1 \ln Z_1 + \beta_1 \ln Z_2 \quad (10a')$$

$$\ln P_2 = -\alpha_2 \ln X_2 - \beta_2 \ln X_1 + \alpha_2 \ln Z_2 + \beta_2 \ln Z_1 \quad (10b')$$

where $\alpha_1 = a_2/h$, $\alpha_2 = a_1/h$, $\beta_1 = b_1/h$, $\beta_2 = b_2/h$, and $h = a_1 a_2 - b_1 b_2 > 0$. The Z_js are exogenous demand variables which are functions of P_3 and Y.[17] The partial derivatives of these inverted demand functions satisfy the conditions outlined above; for example, $D_1^1 = - \alpha_1 (P_1 / X_1) < 0$, and $D_2^1 = - \beta_1 (P_1 / X_2) < 0$.

Given these demand functions, the first-order conditions for the exporting and foreign firms can be written as *markup* equations of the form:

$$P_1 = S\, C_1^1 / (1 - \alpha_1) \quad (23a)$$

$$P_2 = C_2^2 / (1 - \alpha_2). \quad (23b)$$

In order for the markups to be positive, $\alpha_1 < 1$ and $\alpha_2 < 1$. These markup equations are the two-product equivalent of the monopolist's markup equation of the form, $P_1 = S\, C_1^1 / [1 - (1/a)]$, where *a* is the monopolist's own price elasticity of demand.[18]

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[17] The Z_js are defined as follows:

$$\ln Z_1 = e_1 \ln P_3 + f_1 \ln Y + g_1$$

$$\ln Z_2 = e_2 \ln P_3 + f_2 \ln Y + g_2.$$

[18] *a* is defined as a conventional price elasticity, $- d \ln X_1 / d \ln P_1$, rather than the elasticity in an inverse demand function like (10a').

As in the case of monopoly, an exporting firm facing a constant-elasticity demand function keeps its markup ***constant*** if the exchange rate changes. If marginal costs are constant in the exporter's currency, a depreciation of the mark leads to a proportionate change in the exporting firm's marginal costs measured in ***marks***. So it leads to a proportionate change in the mark price of the export product:

$$d \ln P_1 / d \ln S = 1$$

(i.e., the "pass-through" is complete). The local firm, in contrast, keeps its price constant in marks as long as its marginal costs are constant. This same depreciation causes the exporting firm to reduce its output, while the local firm increases its output. In the case of constant marginal costs, the changes in output take particularly simple forms:

$$d \ln X_1 / d \ln S = -\alpha_2 / (\alpha_1 \alpha_2 - \beta_1 \beta_2) = -a_1 < 0 \tag{24a}$$

$$d \ln X_2 / d \ln S = \beta_2 / (\alpha_1 \alpha_2 - \beta_1 \beta_2) = b_2 > 0. \tag{24b}$$

The changes in output are proportional to the conventional own and cross price elasticities of demand defined in equations (22a) and (22b), respectively.

The profit expressions can be written in terms of the elasticities of either the inverted or conventional demand functions:

$$\begin{aligned} d \pi_1 / d S &= -X_1 C_1^1 [\beta_1 \beta_2 h / (1 - \alpha_1)] - C^1() \\ &= -X_1 C_1^1 [b_1 b_2 / (a_1 a_2 - b_1 b_2 - a_2)] - C^1(). \end{aligned} \tag{21a'}$$

$$\begin{aligned} d \pi_2 / d S &= X_2 C_2^2 [\beta_2 \alpha_2 h / (1 - \alpha_2)] / S \\ &= X_2 C_2^2 [a_1 b_2 / (a_1 a_2 - b_1 b_2 - a_1)] / S \end{aligned} \tag{21b'}$$

Since $\alpha_1 < 1$ and $\beta_1, \beta_2 > 0$, the profits of the exporting firm ***necessarily fall*** in response to the depreciation of the mark.[19] So there is no ambiguity in the case of this constant elasticity demand function. As in the general case, the profits of the local firm necessarily rise. The exposure of each firm to exchange rate changes depends on several factors: (i) marginal costs, (ii) the own and cross price elasticities of demand, and (iii) the initial levels of output and the exchange rate.

(c) **Stackelberg Leadership by the Exporting Firm**

As an alternative to Cournot behavior, consider the case where the exporting firm (firm 1) dominates the foreign market in the sense that it formulates its output decision only after taking into account the reaction of the local firm. In this case of Stackelberg leadership by the exporter, the local firm (firm 2) continues to pursue a Cournot strategy. But the exporting firm takes into account the local firm's output decision by setting its conjectural variations parameter equal to the slope of the foreign firm's reaction function:

$$v^1 = r_2 \text{ and } v^2 = 0 \qquad \textbf{Stackelberg Leadership by Firm 1}$$

In this case, the two profit functions simplify as follows:

$$d\pi_1/dS = -C^1() < 0 \tag{25a}$$

$$d\pi_2/dS = X_2 D_1^2 C_1^1 R_2^2 / R > 0. \tag{25b}$$

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[19] As noted above, the change in profits is negative if the slope of the reaction function is negative; the reaction function of each firm has a negative slope if and only if $R_j^i < 0$. In the case of a constant elasticity demand function, $R_2^1 = -\beta_1 (1 - \alpha_1)(P_1/X_2) < 0$ and $R_1^2 = -\beta_2 (1 - \alpha_2)(P_2/X_1) < 0$, so both reaction functions have negative slopes.

When the exporting firm is the Stackelberg leader, the response of its profits to the depreciation of the mark is the same as in the case where the exporter is a *monopolist.* Profits fall in proportion to the exporter's dollar-based costs. The reason why there are no terms stemming from the local firm's output response (as in the Cournot case) is that the Stackelberg leader has already taken these output responses into account in its profit-maximizing strategy.

It is interesting to compare the relative economic exposure of the exporting firm if it is a Stackelberg leader and if it is a Cournot competitor. The difference in profit responses is as follows:

$$(d\pi_1/dS)_{COURNOT} - (d\pi_1/dS)_{STACKELBERG} = X_1 D_2^1 C_1^1 R_2^2 r_2 / R.$$

As long as the reaction function of Country 2 is downward sloping so that $r_2 < 0$, the above expression is negative, so

$$(d\pi_1/dS)_{COURNOT} < (d\pi_1/dS)_{STACKELBERG} < 0.$$

That is, the fall in profits is greater in the case of Cournot competition than in the Stackelberg case. So if the exporting firm acts as a Stackelberg leader in the export market, it can mitigate the impact of a depreciation of the foreign currency on its profits.

It can also be shown that the fall in profits is greater in the Cournot case if profits are measured in the exporter's currency (dollars). In the case of Stackelberg leadership by firm 1, the change in profit is given by $d\pi_1^\$/dS^\$ = X_1 D^1(\,)$; that is, the change in profit is proportional to the initial level of export revenue, just as in the monopoly case. So the difference in profit responses for the Cournot and Stackelberg cases is given by:

$$(d\pi_1^\$/dS^\$)_{COURNOT} - (d\pi_1^\$/dS^\$)_{STACKELBERG} = - S\, X_1\, D_2^1 C_1^1 R_2^2 r_2 / R.$$

As long as $r_2 < 0$, this difference is positive, so

$$0 < (d\pi_1^\$/dS^\$)_{STACKELBERG} < (d\pi_1^\$/dS^\$)_{COURNOT}$$

With a depreciation of the mark, $S^\$$ falls, so the fall in profits is greater in the case of Cournot competition whether profits are measured in dollars or marks.[20]

(d) **Stackelberg Leadership by the Local Firm**

If the local firm (firm 2) rather than the exporting firm is the Stackelberg leader, then the local firm sets its conjectural variations parameter equal to the slope of the exporting firm's reaction function:

$$v^2 = r_1 \text{ and } v^1 = 0 \qquad \textbf{Stackelberg Leadership by Firm 2}$$

In this case, the two profit expressions simplify to

$$d\pi_1/dS = X_1 D_2^1 C_1^1 R_2^2 r_2 / R - C^1() < 0 \text{ if } r_2 < 0. \tag{26a}$$

$$d\pi_2/dS = X_2 D_1^2 C_1^1 R_2^2 (1 - r_1 r_2)/R > 0. \tag{26b}$$

As before, profits of the exporting firm fall as long as $r_2 < 0$, while profits of the local firm rise.[21]

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[20] Note also that if the firm is a Stackelberg leader, its hedging strategy is simplified because it can be based on mark-based revenues alone.

[21] The sign of (26b) depends on the sign of $(1 - r_1 r_2)$ which seems to require an assumption about the slopes of the two reaction functions (and their relative size). But as shown

Stackelberg leadership by the local firm allows that firm to optimally adjust to changes in the exporting firm's output. But it does not shield that firm from economic exposure because the two firm's demands are still tied together by product substitutibility.

Which firm is the Stackelberg leader clearly makes a difference to the economic exposure of the exporting firm. Compare the profit responses for the exporting firm in the two Stackelberg cases:

$$(d\pi_1/dS)_{STACKELBERG\,2} - (d\pi_1/dS)_{STACKELBERG\,1} = X_1\, D_2^1 C_1^1\, R_2^2\, r_2 / R < 0 \text{ if } r_2 < 0.$$

If the exporting firm is the leader (Stackelberg 1), then its profits fall less than if the local firm is the leader (Stackelberg 2), at least as long as $r_2 < 0$.[22] Stackelberg leadership permits the exporter to mitigate the impact of exchange rate changes on its profits.

(e) **Consistent Conjectures**

In the case of Stackelberg competition, one of the two firms is acting myoptically in assuming that the other firm's output will be unaffected by its output decisions. If neither firm acts myoptically, but instead each firm takes the other firm's output response into account, then the firms are said to have "consistent conjectures":

$$v^1 = r_2 \text{ and } v^2 = r_1 \qquad \textbf{Consistent Conjectures}$$

That is, each firm sets its conjecture about the other firm's output behavior equal to the slope of

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above, the stability assumption are sufficient to ensure that (26b) is positive.

[22] Recall that in non-Cournot cases, the sign of r_2 depends on more than just the response of marginal revenue to the other firm's output.

the other firm's reaction function. In this case, the profit functions take the form:

$$d\pi_1/dS = -C^1() < 0 \tag{27a}$$

$$d\pi_2/dS = X_2 D_1^2 C_1^1 R_2^2 (1 - r_1 r_2)/R > 0 \tag{27b}$$

The depreciation necessarily leads to a fall in the exporting firm's profit and a rise in the local firm's profit.

As in the case of Stackelberg leadership by the exporting firm, it is possible to show that Cournot behavior leads to a larger fall in profit than when the firms follow "consistent conjectures":[23]

$$(d\pi_1/dS)_{Cournot} < (d\pi_1/dS)_{Consistent\ Conjectures} < 0,$$

So if the exporting firm takes into account the other firm's behavior, its profit response is smaller whether or not it is a Stackelberg leader. It is also possible to show that the fall in profit measured in dollars is larger if Cournot behavior is followed.

It is clear from these four cases that the response of profits to the exchange rate varies widely depending on the nature of competition between the exporting and local firm. Thus industry structure is no doubt crucial in determining the economic exposure of the firm. The implications for empirical research on exposure are evident: Without knowing the industrial structure of an industry, it is not possible to know whether data on revenues or costs are sufficient to measure the economic exposure of the firm. In some cases, detailed knowledge of

[23] As in the Stackleberg case, this inequality is based on the assumption that $r_2 < 0$.

demand and cost parameters are required in order to assess this exposure.

III. Summary of Results

This study has shown how the economic structure of an industry helps to determine the exposure of firms to exchange rates. The model examined was that of a duopoly with one firm an exporter and the other firm a purely local firm in the export market. The main results are as follows:

(1) The purely local firm is exposed to exchange rates as long as the demand for its product is substitutable with that of the other firm. This exposure occurs despite the fact that the local firm has no foreign sales or foreign purchases. And it occurs regardless of the form of competition between the two firms.

(2) If both firms follow a myopic (Cournot) strategy where each takes the other firm's output as given, the exporting firm's profits move more than proportionally to its dollar-based costs. Its economic exposure depends on demand and cost parameters which are difficult to estimate.

(3) The exporting firm can mitigate its economic exposure by becoming a Stackelberg leader. Its economic exposure is then simply proportional to its export revenues. The same result holds even if the local firm abandons its myopic strategy; economic exposure is the same in the resulting "consistent conjectures" equilibrium.

Hedging strategies similarly vary depending on the nature of competition between the two firms:

(4) If the exporting firm is a Stackelberg leader, then its hedging strategy is simple: sell mark futures equal to its mark-based revenues.

(5) If the exporting firm is myopic, its hedges have to be larger. But hedging strategy then relies on detailed knowledge of demand and cost behavior difficult to obtain in practice.

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