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Strategic flexibility and exchange rate uncertainty

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Abstract. We examine the implications of exchange rate swings in international markets, paying particular attention to the importance of firm flexibility. We use the term *flexibility* to refer to the ease with which firms can respond to exchange rate swings. There are two kinds of flexibility that we consider: (1) flexibility in the timing of output and sales allocation decisions relative to the exchange rate realization; and (2) flexibility in the number of sales outlets available to the firms. We show that differing degrees of flexibility have important implications for equilibrium prices (i.e., exchange rate pass-through), market shares, and profits.

Flexibilité stratégique et incertitude des taux de change. Les auteurs examinent les implications des fluctuations des taux de change dans les marchés internationaux en portant une attention particulière à l'importance de la flexibilité des entreprises. On définit *flexibilité* comme la facilité avec laquelle les entreprises peuvent répondre aux fluctuations des taux de change. Les auteurs considèrent deux types de flexibilité: (1) la flexibilité dans le moment de décision dans l'allocation de la production et des ventes par rapport à la réalisation du taux de change; et (2) la flexibilité dans le nombre des points de vente ouverts aux entreprises. On montre que des degrés différents de flexibilité ont des impacts importants sur les prix d'équilibre, les parts de marché et les profits.

1. INTRODUCTION

In imperfectly competitive international markets, unanticipated changes in the exchange rate drive a wedge between the value of the revenues earned by firms that are located in different countries but compete in a common market. As has been pointed out by a number of authors, this has important implications for production and pricing decisions. For example, Mann (1986), Dornbusch (1987), and Fisher

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(1990) demonstrate, theoretically and empirically, that the extent of exchange rate pass-through depends on the level and type of competition present in international markets. In addition, Ungern-Sternberg and von Weiszacker (1990) use a variety of industrial organization models to examine hedging behaviour when exchange rates are unpredictable. They argue that in order to determine how to hedge against exchange rate uncertainty, imperfectly competitive firms must possess 'detailed knowledge of the competitive environment they work in.'

Although the nature of competition is important, there are other factors that influence imperfectly competitive behaviour when exchange rates fluctuate. In this paper, we focus on the role played by the flexibility of strategic variables in determining equilibrium prices and market shares. We use the term *flexibility* to refer to the ease with which firms can respond to exchange rate swings. There are two kinds of flexibility that we consider: (1) flexibility in the timing of output and sales decisions relative to the exchange rate realization; and (2) flexibility in the number of sales outlets available to the firms.

In reality, production and sales decisions are rarely made simultaneously. The time lag between planning production and actual sales can be quite long. Therefore, it is important to model them as distinct decisions and pay particular attention to the point at which firms learn the exchange rate. We do so by considering three models of exchange rate uncertainty. In the first two, firms must produce their output before the exchange rate is realized. Only in the second model, however, can they wait and allocate their sales across national markets after the exchange rate has been observed. We refer to these models as the 'no flexibility' and 'sales flexibility' cases, respectively. Finally, in the third model (the 'complete flexibility' case), we assume that the firm can wait and determine both output and sales after observing the exchange rate.

We show that the differing degrees of flexibility in the models have important implications for the extent of exchange rate pass-through. In addition, we show that under exchange rate uncertainty, the number of national markets that firms can supply plays an important role in determining equilibrium market shares and the extent of pass-through. Briefly, the *fewer* the number of outlets that are available to a firm, the greater is its ability to commit to selling a given level of output in each of its markets and thus the greater its strategic advantage over its rival. This strategic advantage translates into a larger market share in each market that it supplies.

The remainder of the paper is divided into six sections. In section II, we present an overview of our model and results. In sections III–V, the three models of exchange rate uncertainty are analysed using a specific example (i.e., non-storable goods with CES demand) in order to highlight the forces that drive our results with as few distractions as possible. Finally, in sections VI and VII, we extend the model to allow for linear demand and storable goods with inventories. While the impact on market shares is somewhat modified, we find that the basic results are unaffected and are even strengthened under some circumstances. We also find that the persistence of the exchange rate across periods is an important factor in determining the strategic environment in which the firms wish to operate.

II. OUR MODEL

Consider a domestic market shielded from entry in which two firms compete. One firm is domestic and produces and sells only in its own home market. The other firm is foreign and produces its output in its own country, exporting some of it to the home country for sale and selling the remainder in its own home market. Thus, the domestic firm supplies output to one market, while the foreign firm services two markets (this assumption will be relaxed later in the paper).¹ We assume that the foreign and domestic markets are segmented and that the foreign firm is perfectly competitive in its own market. While our results do not depend on the latter assumption, it greatly simplifies our analysis. In fact, if we assume that the foreign firm is a monopolist in its own market, our results are stronger (we report these results in footnotes throughout the paper).

The firms compete in the following two-stage game. In the first stage, they simultaneously and independently produce output. Then, in stage two, once the production levels have been revealed, they simultaneously and independently decide how much of their output to supply to the markets in which they are active. Finally, price adjusts to clear the market (the usual Cournot assumption.)

We use e to denote the exchange rate (units of foreign currency per unit of domestic currency), which is assumed to be a random variable. Since our primary focus is on the importance of firm flexibility (i.e., how easy is it for a firm to adjust once e is observed?), we vary the point in the game at which the exchange rate is revealed and compare the equilibria generated by the different assumptions. This is the sense in which we consider exchange rate uncertainty.²

To simplify matters, we use a specific example to illustrate our points. Throughout the paper, we assume that both firms produce output and face convex costs. In addition, in sections III–V we assume that demand in the domestic market is given by

$$D(p) = p^{-\epsilon}, \quad (1)$$

where p denotes the domestic price. We assume that ϵ , the elasticity of demand, is greater than one. The foreign market is assumed to be competitive, with p^* representing the price. Finally, we assume that the good is non-storable (or that the cost of holding inventories is prohibitive).

1 We assume the domestic firm is unable to sell profitably in the foreign market owing to prohibitive costs. Examples of such prohibitive costs might include import tariffs, high costs in terms of time and money to gain access to an essentially closed distribution system, and insurmountable red tape barriers. Similar reasons have been cited by a number of U.S. firms to explain their inability to sell in the Japanese market.

2 It is important to note that we do not allow firms to hedge against exchange rate uncertainty in any of our models. In reality, firms can sometimes hedge against the risk associated with exchange rate swings by using the forward market. However, unlimited hedging is not available, nor is it costless. Moreover, for long-term contracts, the implications of exchange rate uncertainty for the firms' costs can be significant. For more on the extent to which firms hedge, see Collier, et al. (1990), Flicker and Blin (1990), and Cohen and Price (1991).

The CES and non-storable goods assumptions simplify matters, since they imply that all output produced in stage one will be sold in equilibrium. In a recent paper, Anderson and Fischer (1989) argue that when the production and sales decisions are distinct, the form of demand has important implications for the structure of equilibrium.³ Therefore, in section VI we extend our analysis to allow for linear demand, although we retain the non-storable goods assumption. This introduces some complications, but we find that the general qualitative nature of our results continues to hold. Finally, in section VII, we extend the model to allow for inventories and show that with minor modifications our results generalize.

To complete the description of the model, let x and x^* denote domestic and foreign production, respectively. We use s to represent sales by the domestic firm. Finally, foreign output is divided into sales for the common domestic market (s_d) and its own home market (s_f). Under the CES assumption, $s = x$ and $s_d + s_f = x^*$; that is, all output is sold. As we show in sections VI and VII, however, this need not be true in general.

Expected profits for the two firms (π and π^*) in terms of their own currency can be written as

$$E(\pi) = E[x(x + s_d)^{-1/\epsilon} - c(x)] \quad (2)$$

$$E(\pi^*) = E[\bar{e}s_d(x + s_d)^{-1/\epsilon} + p^*s_f - c^*(x^*)], \quad (3)$$

where the expectations operator refers to the random variable \bar{e} . Changes in the exchange rate affect the foreign firm's profits by altering the foreign currency value of revenue earned in the domestic market. When the firms can react to exchange rate swings, the domestic firm is also affected, but only through changes in the strategic variables. Note that foreign costs, $c^*(x^*)$, are independent of the exchange rate, since the foreign firm produces output in its own country and then (costlessly) ships the good to be sold in the domestic market.

III. NO FLEXIBILITY

When both output and sales must be determined before the exchange rate is observed, the equilibrium is easy to characterize. First, we use the fact that $s = x$ and $s_d + s_f = x^*$ to substitute for x and x^* in (2) and (3). We differentiate (2) with respect to s and (3) with respect to s_d and s_f to obtain the following first-order conditions:

$$E(MR_s) = c'(x) \quad (4)$$

$$E(MR_{s_d}^*) = p^* \quad (5)$$

$$p^* = c'^*(x^*), \quad (6)$$

3 Anderson and Fischer (1989) considered issues that are fundamentally different from those considered in this paper. In particular, their goal was to determine conditions under which the equilibrium in a two-stage game in which output is produced prior to allocating sales differs from the equilibrium generated when the production/sales decisions are made simultaneously. Their model differs from ours in two respects: there is no exchange rate or uncertainty in their model.

where MR and MR^* denote marginal revenue in the domestic and foreign market, respectively.⁴ Each condition states that output is produced until its expected marginal revenue equals marginal cost. Of course, the domestic-market marginal revenue for each firm depends on the amount of output it expects its rival to sell. Thus, MR_s depends on s_d and MR_{s_d} depends on s . Given our assumptions concerning demand, the reaction functions defined by (4) and (5) are downward sloping and the unique Nash equilibrium is defined by their intersection.⁵

In this model, the extent of exchange rate pass-through is zero (we define the extent of pass-through as the change in the domestic price caused by a change in the exchange rate, dp/de).⁶ Since p and p^* are not affected by the ex post realization of e , changes in the exchange rate are not reflected in the domestic price. This follows trivially from the assumption that firms cannot react once the exchange rate is observed. In a sense, this appears to make this equilibrium uninteresting. As we show in the next section, however, by using this equilibrium as a reference point, we can infer how different levels of flexibility affect pass-through.⁷

IV. SALES FLEXIBILITY

In this section, we assume that the foreign firm distributes its output for sale after it observes the exchange rate. As above, however, both firms must complete production before the exchange rate is revealed.

We solve for equilibrium by backward induction, focusing first on the sales decision, given output. As noted above, the constant elasticity of demand assumption makes the sales decision easy to characterize. With elasticity greater than one, marginal revenue is always positive. Since the output has already been produced when the sales decision must be made, the marginal cost of increasing sales is zero

4 Formally, we have $MR_s = p[1 - s/\epsilon(s + s_d)]$; and $MR_{s_d}^* = ep[1 - s_d/\epsilon(s + s_d)]$.

5 If the foreign market were monopolistic, (5) and (6) would be replaced by a condition stating that expected marginal revenue in each market equals the marginal cost of output. Details of this case may be found in Krupp and Davidson (1993).

6 There are at least two definitions of exchange rate pass-through in the literature. The first refers to the degree to which foreign exporters alter their foreign currency-denominated export price in response to an exchange rate change in order to minimize the net impact on the domestic currency price of the foreign good in the domestic market. The firms are typically monopolistically competitive and produce differentiated products. This behaviour is referred to as 'pricing-to-market.' See Krugman (1987), Giovannini (1988), Froot and Klemperer (1989), Fisher (1990), Marston (1990), and Knetter (1993). The second definition concerns the impact of an exchange rate change on the domestic *equilibrium price* when domestic and foreign firms produce a homogeneous product, compete in quantities, and their costs are denominated in their home currencies. See Dornbusch (1987) and Dixit (1989). It is this second definition to which our discussion of pass-through refers.

7 Recent discussions of pass-through (as defined by the pricing-to-market definition) have focused on the strategic pricing by foreign sellers in the face of exchange rate changes. Specifically, foreign sellers attempt to hold down price increases in their export markets despite appreciation of their currency relative to the export country's currency (see Mann 1986; Froot and Klemperer 1989; Marston 1990; Knetter 1993). In our model, the degree of pass-through (defined as the impact of a change in e on the equilibrium domestic price) is affected not only by the foreign firm's reaction to changes in e , but, as we discuss in the text, the extent to which the firms have the flexibility to react to such changes.

until all output is sold, at which point it becomes infinite. Therefore, both firms sell all of their output. The foreign firm distributes its output such that marginal revenue is equated across the two markets. Formally, given x and x^* , $s = x$. For the foreign firm, optimal sales are given by

$$MR_{s_d}(x, e) = p^* \tag{7}$$

$$s_d + s_f = x^*. \tag{8}$$

Equations (7) and (8) are two equations in two unknowns, s_d and s_f .

Note that an increase in e (a domestic-currency appreciation) or a decrease in x increases the foreign firm's marginal revenue in the domestic market. To restore equality in (7) keeping s_d fixed, s_f must fall. Intuitively, a domestic-currency appreciation or lower sales by the domestic firm makes the domestic market more attractive for the foreign firm. Therefore, s_d is increasing in e and decreasing in x , while s_f is increasing in x^* and x and decreasing in e .

We are now in a position to describe how production is determined. Let $s_d(x, e)$ and $s_f(x^*, x, e)$ denote the solutions to (7) and (8). Then expected profit for the domestic firm is given by

$$E(\pi) = E[x(x + s_d(x, e))^{-1/\epsilon} - c(x)]. \tag{9}$$

Expected profit for the foreign firm is given by

$$E(\pi^*) = E[es_d(x, e)[x + s_d(x, e)]^{-1/\epsilon} + p^*s_f(x^*, x, e) - c^*(x^*)]. \tag{10}$$

Differentiating (9) with respect to x yields the first-order condition:

$$E[MR_x - (p/\epsilon)(x/(x + s_d))(\partial s_d/\partial x) - c'(x)] = 0. \tag{11}$$

This is the domestic firm's reaction function which defines the optimal value of x given its conjecture concerning x^* . Differentiating (10) with respect to x^* yields the foreign firm's reaction function:

$$p^* - c^{*'}(x^*) = 0. \tag{12}$$

Since the foreign market is competitive, foreign output is independent of x . As in the no flexibility case, the foreign firm produces output until the non-stochastic marginal revenue it earns in its own market equals the marginal cost of production. Given x^* as defined by (12), the equilibrium can be found by solving (11) for x (see figure 1).

Let \bar{x} and \bar{x}^* denote equilibrium production in the no flexibility case and let \hat{x} and \hat{x}^* denote equilibrium production in the sales flexibility case. In addition, let $\bar{\pi}$, $\bar{\pi}^*$, $\hat{\pi}$, and $\hat{\pi}^*$ play the same role for expected equilibrium profits in the two cases. Then, if we compare the equations defining equilibrium in the sales flexibility case

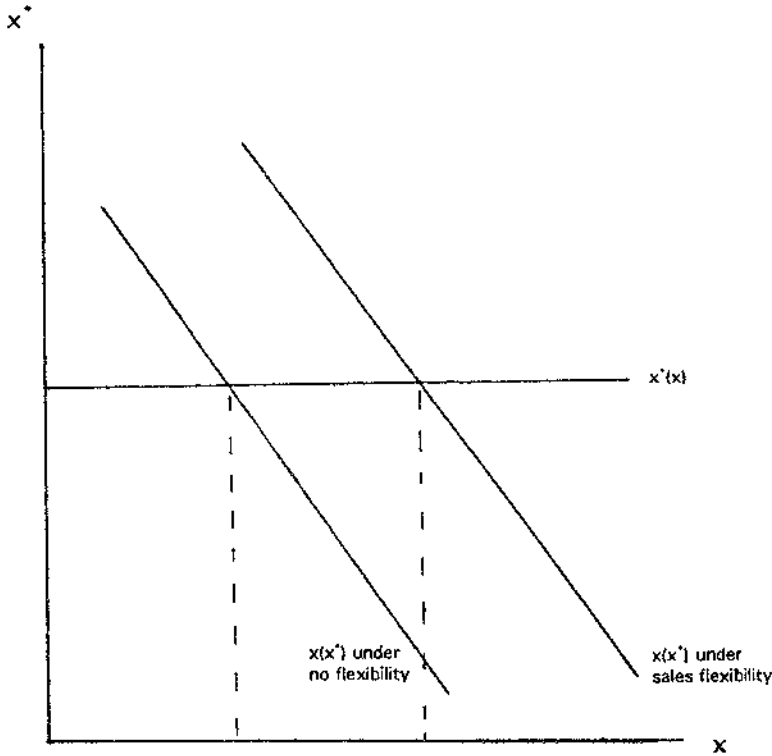


FIGURE 1

(equations (11) and (12)) with those in the no flexibility case (equations (4)–(6)), we obtain the following result:

PROPOSITION 1. *The domestic firm produces more in the sales flexibility equilibrium than it does in the no flexibility equilibrium (i.e., $\bar{x} < \hat{x}$). The foreign firm's output is the same in the two cases (i.e., $\bar{x}^* = \hat{x}^*$). Moreover, the domestic firm earns larger expected profits in the sales flexibility equilibrium than it earns in the no flexibility equilibrium (i.e., $\hat{\pi} > \bar{\pi}$).⁸*

Proof. Using (4) and the properties of s_d described above, we conclude that the left-hand side of (11) is greater than zero when evaluated at the no flexibility equilibrium values of \bar{x} and \bar{x}^* . By the second-order conditions, (11) is decreasing in x . Therefore, in order to restore equality in (11), x must rise. It follows that the domestic firm's reaction function shifts to the right when we move from the

⁸ In the case where the foreign firm is a monopolist in its own home market, the result is even stronger, since the foreign firm produces less in the sales flexibility case than it does in the no flexibility case. See Krupp and Davidson (1993) for details of this case.

no flexibility case to the sales flexibility case (see figure 1). The first part of the proposition follows immediately.

To prove that the domestic firm is better off in the sales flexibility equilibrium, suppose that the firms are initially in the no flexibility equilibrium, with the domestic firm earning $\bar{\pi}$. Now, to move to the sales flexibility equilibrium, allow the foreign firm's sales in the domestic market to drop from their no-flexibility levels to the sales-flexibility levels. Since this increases the domestic price, it benefits the domestic firm. Now, let the domestic firm adjust its output from \bar{x} to \hat{x} . Since \hat{x} maximizes π given the foreign firm's behaviour, this adjustment also benefits the domestic firm. Thus $\hat{\pi} > \bar{\pi}$. \square

The intuition behind this result is as follows: the foreign firm knows that higher domestic output leads to greater domestic-firm sales in the common market (since the domestic firm has no other outlet for its goods). So, by producing more output, the domestic firm can lower the foreign firm's domestic-market marginal revenue. This implies that by producing more output, the domestic firm can induce the foreign firm to direct its sales away from the common market once production levels have been revealed. This ploy would not work in the case without sales flexibility, since the foreign firm would not be able to react to the higher output export. In this sense, the foreign firm's flexibility provides the domestic firm with a strategic advantage. As a result, the foreign firm's market share is reduced and the domestic firm earns higher profits.

The fact that the domestic firm's lack of a second market works to its advantage while the foreign firm's flexibility works to its disadvantage may seem counter-intuitive, but it really should not come as a surprise. The lack of a secondary market guarantees that any increase in output in stage one (by the domestic firm) translates into increased sales in stage two. Thus, the domestic firm can precommit to selling more by increasing output. The ability to allocate sales after the exchange rate is revealed and the existence of a secondary market make it impossible for the foreign firm to precommit in the same manner. It is this ability to commit to higher sales that gives the domestic firm its strategic advantage.⁹ In section VI, we show that this result holds even if we drop the CES assumption (so that the firms may choose *not* to sell everything they produce).

According to proposition 1, the domestic firm always prefers the sales flexibility equilibrium to the no flexibility equilibrium. However, Proposition 1 does not tell us which equilibrium the foreign firm prefers. The reason is that in moving from the sales flexibility equilibrium to the no flexibility equilibrium, there are two forces at work that have opposite implications for the foreign firm's expected profits. On the one hand, the foreign firm's flexibility places it at a strategic disadvantage in the sales flexibility equilibrium and leaves it with a smaller market share. On the other hand, the foreign firm is able to allocate sales once it knows the exchange rate in the sales flexibility equilibrium, and therefore it never over- or undersupplies

⁹ Commitment plays an important and similar role in the literature on entry deterrence. See, for example, the discussion in Tirole (1989, ch. 9, especially 367-74).

a market. As a result, the foreign firm's expected profits could rise or fall as we move from the no flexibility equilibrium to the sales flexibility equilibrium.

In section VII, we show that while our results with respect to output need to be modified when the good is storable and the firms hold inventories, our results with respect to profits do generalize. In addition, we show that whether the foreign firm prefers the sales- or no-flexibility equilibrium depends upon the degree of persistence in the exchange rate.

Because the foreign firm can direct sales towards (away from) the domestic market when the domestic currency appreciates (depreciates), the domestic price varies with the exchange rate – there is a non-zero rate of pass-through. When comparing the sales flexibility and no flexibility cases, we can therefore conclude that sales flexibility leads to a greater degree of pass-through. However, proposition 1 implies that comparing intermediate levels of flexibility is more difficult for the following reason.

Imagine a model in which the firms must produce output and make an initial sales allocation decision prior to observing the exchange rate. Once e is observed, however, we now allow the foreign firm to redirect its sales at a per unit cost of g . Lower values of g would then reflect greater firm flexibility, with $g = \infty$ making the model identical to the no flexibility case and $g = 0$ making the model identical to the sales flexibility case. As g falls, proposition 1 indicates that the foreign firm's presence in the domestic market would be reduced. Since only the foreign firm reacts to exchange rate changes, the fact that the foreign firm's presence in the domestic market is diminished as g falls reduces the extent of pass-through. Since lowering g results in the foreign firm's reacting to a greater degree (i.e., increasing (decreasing) its sales allocation to the domestic market when the domestic currency appreciates (depreciates)), however, there is a second force at work that increases the amount of pass-through. That is, as g falls, the foreign firm becomes smaller but more active in the domestic market, and this has an ambiguous impact on the extent of pass-through.¹⁰

Finally, suppose that we now reverse our assumption concerning the number of markets that the firms supply. That is, suppose that we now assume that the domestic firm serves two markets while the foreign firm simply exports all of its output to the domestic market. Then the foreign firm would possess a strategic advantage in the sales flexibility case, which would result in a smaller market share for the domestic firm (and lower domestic firm profits). The implications for exchange rate pass-through would not be altered; the domestic firm would be smaller and more active when there is some degree of sales flexibility, which would have an ambiguous impact on the extent of pass-through.

10 The introduction of g changes the model in the following way. First, suppose there is a domestic currency appreciation that results in the foreign firm's desiring to increase its sales in the domestic market. Then (7), the equal marginal revenue condition, would be replaced by $MR_{SD}(x, e) - g = p^*$. Thus, the level of sales redistribution would be decreasing in g . Moreover, by similar logic, it also follows that $\partial s_d / \partial x$ would be decreasing in g . Combining this with (11), we conclude that increases in g shift the domestic firm's reaction function down towards the no flexibility reaction curve. As g tends to infinity, the reaction curve converges to its no flexibility counterpart.

V. COMPLETE FLEXIBILITY

If the firms can observe the exchange rate before producing output, then the model reduces to the complete information Cournot case examined in Dornbusch (1987). In this case, the firm's profits and first-order conditions are given by equations (2)–(6) without the expectations operator. As in the other two cases, foreign output is set such that its marginal cost equals the foreign-market price. In terms of sales, let $s(e)$ and $s_d(e)$ denote the complete flexibility equilibrium domestic sales by the domestic and foreign firms, respectively. Then, since higher values of e increase the foreign firm's domestic-market marginal revenue, it follows that the foreign firm's domestic-market sales are increasing in e (i.e., $s'_d(e) > 0$). Furthermore, since Cournot reaction curves are downward sloping, the domestic firm's sales are decreasing in e (i.e., $s'(e) < 0$). Finally, by stability, the increase in the foreign firm's domestic-market sales always dominates the fall in the domestic firm's sales so that aggregate domestic market sales are increasing in e (i.e., $s'_d(e) + s'(e) > 0$).

To compare the degree of pass-through in this case with that under sales flexibility, define \hat{e} to be the value of e such that $s_d(e) + s(e) = \hat{s}_d + \hat{s}$ where \hat{s}_d and \hat{s} denote foreign and domestic firm domestic-market sales in the sales flexibility equilibrium. It follows that for $e > \hat{e}$ (appreciated domestic-currency case), the domestic firm will overproduce in the sales flexibility case, while for $e < \hat{e}$ (depreciated domestic-currency case), it will underproduce (relative to the complete flexibility case). That is, for low values of e , the domestic firm will regret not having more output, while for high values of e , it will regret having produced as much as it did. In terms of aggregate domestic-market sales, for $e > (<) \hat{e}$, aggregate production will be higher (lower) in the complete flexibility case. Of course, higher (lower) domestic-market aggregate sales results in a lower (higher) domestic price. Thus, the extent of pass-through is greater (lower) in the complete flexibility case when the exchange rate is greater (less) than \hat{e} .

VI. RELAXING THE CES ASSUMPTION

Our constant elasticity of demand assumption greatly simplifies our analysis by ruling out the possibility that a firm will choose not to sell all of the output it produces. This is particularly important for our comparison of the no flexibility and sales flexibility cases; with a CES demand function, the foreign firm knows that a unit increase in domestic-firm output translates into one extra unit of domestic-firm sales in the common market, and this causes the foreign firm to direct some of its sales away from the common market. In fact, this is the source of the domestic firm's strategic advantage.

Suppose instead that demand were linear. Then there would be cases in which it would be in the domestic firm's interest to throw output away rather than offer it for sale. For example, suppose that (1) the domestic firm produces a large amount of output; and (2) there is a large domestic-currency appreciation, so that the foreign firm's domestic-market sales are high. Then, if the domestic firm were to offer all

of its output for sale, the domestic price would be so low that its marginal revenue would become negative. Thus, it would be optimal for the domestic firm to offer only part of its output for sale. In this case, an increase in x would *not* translate into an equal increase in domestic-firm sales, and the domestic firm's strategic advantage would be reduced.

In this section, we argue that our results do generalize to other demand curves. We illustrate our argument by sketching the linear demand case and showing that the equilibrium possesses the general properties outlined in sections III–V.¹¹

We assume that the domestic demand curve is given by $D(p) = 1 - p$, and that $c(x) = 0.5x^2$ and $c^*(x^*) = 0.5x^{*2}$. With this demand curve, it is necessary to assume that $p^* < 1$; otherwise the foreign firm would sell only in its own home market. In addition, for simplicity, we assume that e may take on one of two values, 1 or \bar{e} , where $\bar{e} > 1$. We use π to denote the probability that $e = 1$. Thus, $E(e) = \pi + (1 - \pi)\bar{e}$. Finally, we continue to assume that the foreign market is perfectly competitive.¹² Therefore, expected profits are

$$E(\pi) = E[(1 - s_d - s)s - 0.5x^2] \quad (13)$$

$$E(\pi^*) = E[e(1 - s_d - s)s_d + p^*s_f - 0.5x^{*2}]. \quad (14)$$

1. No flexibility

Here, the firms must make both their output and their sales allocation decisions prior to the realization of the exchange rate. Straightforward differentiation of (13) and (14) yields the following first-order conditions:

$$x = (1 - s_d)/3 \quad (15)$$

$$s_d = [1 - x - (p^*/E(e))]/2 \quad (16)$$

$$x^* = p^*. \quad (17)$$

Solving (15) and (16) for x and s_d yields the no flexibility equilibrium values.¹³

$$x = [1 + (p^*/E(e))]/5 \quad (18)$$

$$s_d = [2 - (3p^*/E(e))]/5. \quad (19)$$

11 We choose to focus on the case of linear demand because of its tractability and because, like any demand curve less convex than the CES case, it has the property that marginal revenue becomes negative at some point. This second feature ensures that at some point it becomes optimal to discard output that has already been produced rather than sell it.

12 We have also worked out the linear demand case in which the foreign firm is a monopolist in its own market. The results are qualitatively similar and can be found in our working paper (Krupp and Davidson 1993).

13 For these to represent equilibrium values, p^* must be large enough that it is in the foreign firm's interest to sell in its own market. This requires $p^* \geq 2E(e)/[5E(e) + 3]$.

2. Sales flexibility

In this case, the firms first choose output before e is realized and, once e is known, they allocate their sales. We begin by considering the sales decisions of the two firms, given x and x^* . Since the foreign firm is competitive in its own market, its marginal revenue is always positive and it sells all of its output regardless of e . Thus, as in the CES case, the foreign firm allocates its sales such that (a) marginal revenue is equated across markets; and (b) all of its output is sold. Together, these two conditions imply

$$s_d(e) = 0.5[1 - x - (p^*/e)] \tag{20}$$

$$s_f(e) = x^* - 0.5[1 - x - (p^*/e)]. \tag{21}$$

The domestic firm sells all of its output provided that its marginal revenue is positive when $s = x$. Thus,

$$s(e) = \min [x, 0.5(1 - s_d(e))]. \tag{22}$$

Combining (20) and (22) allows us to identify three cases. First, if $x \leq (1/3)[1 + (p^*/\bar{e})]$, then the domestic firm sells all of its output regardless of the realization of e ; that is, $s(e) = x$ for all e . Second, if $(1/3)[1 + (p^*/\bar{e})] \leq x \leq (1/3)[1 + p^*]$, then the domestic firm sells all of its output if and only if $e = 1$. Thus, $s(1) = x$ and $s(\bar{e}) = 0.5[1 - s_d(\bar{e})]$. Using (20) to substitute for $s_d(\bar{e})$, we find that, in this case, $s(\bar{e}) = 0.25[1 + x + (p^*/\bar{e})]$. Note that in each of these two cases, s is increasing in x just as in the CES case analysed above. Finally, if $x \geq (1/3)[1 + p^*]$, the domestic firm never sells all of its output. Thus, $s(e) = 0.5[1 - s_d(e)]$ for all e . This last case will not occur in equilibrium, however, since producing the extra output is costly.

To determine the equilibrium output levels, we substitute the optimal sales functions into (13) and (14) and optimize over x and x^* , respectively. Optimizing (14) over x^* yields what we would expect: $x^* = p^*$. As before, the foreign firm produces output such that its marginal revenue (p^*) equals its marginal cost (x^*). Optimizing (13) over x yields

$$x = \begin{cases} 0.25[1 + p^*[1 + (1 - \bar{e})/\bar{e}]] & \text{if } p^*[3[1 - (1/\bar{e})] - (1/\bar{e})] \leq 1 \\ [1 + 3 + p^*[4 + (1 - \bar{e})/\bar{e}]]/(9 + 7) & \text{if } p^*[3[1 - (1/\bar{e})] - (1/\bar{e})] \geq 1. \end{cases} \tag{23}$$

For low values of p^* ($p^* \leq 1/[3[1 - (1/\bar{e})] - (1/\bar{e})]$), the foreign firm directs much of its sales to the domestic market, resulting in a low equilibrium value for x . In fact, x is so low that once e has been observed, the domestic firm sells all of its output, even when e is as high as possible. Since both firms sell all of their output, this case is qualitatively identical to the CES example analysed above. A comparison of x in (23) with its no flexibility counterpart in (18) confirms that our result reported in proposition 1 generalizes.

For high values of p^* ($p^* \geq 1/[3[1 - (1/\bar{e})] - (1/\bar{e})]$), the domestic firm does actually discard output if $e = \bar{e}$. Thus, in this case, the linear example differs from the CES example. If we compare the equilibrium value for x in the sales flexibility case, given in (23), with its no flexibility counterpart, given in (18), we find that proposition 1 *fails* if $\lambda^2(\bar{e} - 1)[20p^* + 6 - (5p^*/\bar{e})] + \lambda[19p^* + 2 - 8\bar{e} - (5p^*/\bar{e}) - 20p^*\bar{e}] + 2(\bar{e} + p^*) > 0$. It is straightforward to check that there are no values of $\lambda \in (0, 1)$, $p^* \leq 1$, and $\bar{e} > 1$ that satisfy this condition and $p^* \geq 1/[3[1 - (1/\bar{e})] - (1/\bar{e})]$. Thus, proposition 1 holds for all relevant values of p^* . The reason that our result generalizes is simple: even when the domestic firm discards output (p^* is high and $e = \bar{e}$), domestic sales are still increasing in x (i.e., $s(1) = x$ and $s(\bar{e}) = 0.25[1 + x + (p^*/\bar{e})]$). Even though the domestic firm's strategic advantage is reduced, it is still present.

3. Complete flexibility

In this case, the firms determine both output and sales after the exchange rate has been realized. In section V, we argued that in comparing this case with sales flexibility, there exists a critical exchange rate, \hat{e} , such that if $e > (<)$ \hat{e} , the domestic firm will produce more (less) in the sales flexibility case than in the complete flexibility case. In this subsection, we calculate \hat{e} for low values of p^* for illustrative purposes.

As argued in section V, \hat{e} equates total domestic market sales in the complete and sales flexibility cases. From (20), (22), and (23), when p^* is low, total domestic market sales under sales flexibility is given by

$$s_d(e) + s(e) = (1/8)\{5 + p^*[\lambda + ((1 - \lambda)/\bar{e}) - (4/e)]\}.$$

To calculate aggregate domestic market sales under complete flexibility, we follow the approach outlined in section V to obtain

$$x(e) = s(e) = [1 + (p^*/e)]/4 \text{ and } s_d(e) = (1/8)[3 - (5p^*/e)].$$

Thus, aggregate sales under complete flexibility are given by

$$s_d(e) + s(e) = (1/8)[5 - (3p^*/e)].$$

Equating aggregate sales in the two cases and solving for e yields

$$\hat{e} = \bar{e}/[\lambda\bar{e} + 1 - \lambda].$$

VII. INVENTORIES

In the previous section, we extended the model to allow firms to discard output if marginal revenue becomes negative. Since we assumed the good is non-storable, discarding output is the only option for the firm that does not wish to sell all of its output. If the good is storable, however, the firm has a second option: it can place

unsold goods in inventory. While inventory models are substantially more difficult to analyse, it seems important to know if our results generalize to such a setting.

In this section, we consider a model in which firms are allowed to carry inventories across periods. The framework is similar to the model examined earlier, but we now allow for two periods of production and sales. In particular, period one is identical to the model we have already analysed, except that we allow firms the option of placing goods in inventory. We then add a second period in which firms decide how much output to produce and sell in each market given their first-period inventories. Exchange rates in the two periods are random variables with the same distribution employed in section VI. For simplicity, we assume $\bar{e} = 2$ and $\sigma = 1/2$. This two-period framework also affords us the opportunity to compare the equilibria under different degrees of exchange rate persistence. We examine two extreme cases: one in which the exchange rates in the two periods are independent random variables, and one in which the exchange rates in the two periods are perfectly correlated (i.e., $e_1 = e_2$). In the first case, we say that changes in the exchange rate are *temporary*, while in the second case, they are *permanent*.

With inventories, there is reason to believe that our results may not generalize. After all, the reason that the domestic firm has a strategic advantage in the sales flexibility case is that once it has produced its output, the foreign firm has a chance to respond and direct sales away from the domestic market. With a second period, the domestic firm has a strategic advantage even in the case of no flexibility, since an increase in its first-period output causes the foreign firm to direct sales away from the domestic market in the *second* period. As we show in this section, however, with some minor modifications our results do generalize. The reason is simple. With inventories, the domestic firm's strategic advantage is stronger in the case of sales flexibility, since an increase in domestic first-period output causes the foreign firm to direct sales away from the domestic market in *both* periods. Thus, it is still the case that the domestic firm's first-period output is higher under sales flexibility.

The same forces that provide the domestic firm with a strategic advantage under sales flexibility in the first period also provide it with a strategic advantage under sales flexibility in the second period. However, this need not imply that the domestic firm's second-period sales are higher under sales flexibility. While this is usually the case, there is at least one important case in which this is not true. To see this, consider the case in which the exchange rate in the first period is extremely low (the foreign currency is very strong). In that case, under sales flexibility the foreign firm will not sell much in the first period in the domestic market and will carry a large inventory into the second period. The fact that the foreign firm begins the second period with a great deal of unsold output will result in the domestic firm's producing and selling very little in the second period. Thus, the domestic firm may sell less in the second period under sales flexibility than it would under no flexibility.

Finally, with respect to profits, we show that our results generalize and, in fact, are strengthened in this extended model. In particular, we show that the domestic firm always earns more in the sales flexibility equilibrium, and that whether the

foreign firm prefers the sales or no flexibility equilibrium depends upon whether the exchange rate changes are temporary or permanent.

Again, demand is assumed to be linear, and for brevity, we consider the case in which all output produced is eventually sold by the end of the second period. As we demonstrated in section VI, for a substantial portion of the parameter space this condition is satisfied in equilibrium. Moreover, even when this condition is not satisfied, the equilibrium does not differ in any qualitatively substantive way from that in which all output *is* sold by the end of the period. It is also indicated in section VI that even when attention is restricted to the one-period model, the linear demand case is rather algebra intensive. When we add a second period of production and sales, the algebra becomes much worse. Thus, since the details of the algebra provide no additional insight, we offer only a cursory discussion of the equilibrium in each case and provide the final results in tables 1 and 2. The values reported in these tables represent the equilibria under the different assumptions concerning firm flexibility and exchange rate persistence *provided that* $p^* \in [0.288, 0.520]$. (For lower values of p^* , there are cases in which the foreign firm sells no output in the foreign market, and for higher values of p^* , there are cases in which the foreign firm sells all of its output in the foreign market.) Interested readers may obtain the detailed calculations from the authors upon request.

Let i and i^* denote inventories held by the domestic and foreign firms, respectively. In addition, we use subscripts on output and sales variables to denote the period in which they occur. In some instances, output and/or sales may depend upon previously observed exchange rates. For example, in the sales flexibility case, sales in the first period will depend on e_1 and sales in the second period will depend on both e_1 and e_2 . Any variable that depends on e_1 will be written as $f(e_1)$, and any variable that depends on both exchange rates will be written as $f(e_1, e_2)$. Thus, $s_{d1}(1)$ denotes the foreign firm's first-period sales in the domestic market when $e_1 = 1$, while $s_2(1, 2)$ denotes the domestic firm's second-period sales when $e_1 = 1$ and $e_2 = 2$.

The equilibria possess the same basic properties of those described in sections III and IV (for brevity, we do not consider the case of complete flexibility). Consider the foreign firm first. Since it can always sell its output for p^* in the foreign market, in each period it produces output such that its marginal cost equals p^* . Thus, given our assumption concerning the cost function, $x_1^* = x_2^* = p^*$. As for sales, if the exchange rate *is not known* when the firm determines its sales allocation across markets, it sets its sales such that *expected* marginal revenue from domestic-market sales equals p^* . If the exchange rate *is known* when sales are determined, the firm equates p^* and *actual* marginal revenue from domestic-market sales. All foreign output that is not sold in the domestic market is sold in the perfectly competitive foreign market at p^* .

For the domestic firm, first-period sales and inventories are determined in much the same manner. If the exchange rate *is not known* when s_1 and i must be determined, then sales are set such that *expected* first-period marginal revenue equals *expected* second-period marginal revenue. On the other hand, if the exchange rate

TABLE 1
Temporary change in the exchange rate

| No flexibility | Sales flexibility |
|--|--|
| <i>First-period output</i> | |
| $x_1^* = p^*$ | $x_1^* = p^*$ |
| $x_1 \cong 0.273 + 0.182p^*$ | $x_1 \cong 0.273 + 0.199p^*$ |
| <i>First-period sales</i> | |
| $s_1 \cong 0.193 + 0.129p^*$ | $s_1(1) \cong 0.193 + 0.206p^*$ |
| $s_{d1} \cong 0.403 - 0.398p^*$ | $s_1(2) \cong 0.193 + 0.081p^*$ |
| | $s_{d1}(1) \cong 0.403 - 0.603p^*$ |
| | $s_{d1}(2) \cong 0.403 - 0.291p^*$ |
| <i>Second-period output</i> | |
| $x_2^* = p^*$ | $x_2^* = p^*$ |
| $x_2 \cong 0.210 + 0.140p^*$ | $x_2(1) \cong 0.210 + 0.191p^*$ |
| | $x_2(2) \cong 0.210 + 0.129p^*$ |
| <i>Second-period sales</i> | |
| $s_2 \cong 0.290 + 0.193p^*$ | $s_2(1, e_2) \cong 0.290 + 0.184p^*$ |
| $s_{d2} \cong 0.355 - 0.430p^*$ | $s_2(2, e_2) \cong 0.290 + 0.246p^*$ |
| | $s_{d2}(1, 1) \cong 0.355 - 0.592p^*$ |
| | $s_{d2}(1, 2) \cong 0.355 - 0.342p^*$ |
| | $s_{d2}(2, 1) \cong 0.355 - 0.623p^*$ |
| | $s_{d2}(2, 2) \cong 0.355 - 0.373p^*$ |
| <i>Expected profits</i> | |
| $\Pi \cong 0.122 + 0.162p^* + 0.054(p^*)^2$ | $\Pi \cong 0.122 + 0.183p^* + 0.073(p^*)^2$ |
| $\Pi^* \cong 0.433 - 0.939p^* + 1.51(p^*)^2$ | $\Pi^* \cong 0.433 - 0.947p^* + 1.58(p^*)^2$ |

is known when s_1 and i must be determined, then sales are set such that *actual* first-period marginal revenue equals expected second-period marginal revenue. As for second-period sales, since all output is sold at the end of the second period, $s_2 = x_2 + i$. Finally, at the beginning of each period, the domestic firm chooses output to maximize total future expected profit, taking into account any impact its output may have on its own future sales and those of the foreign firm.

The amount of information available to the firms when they must make their decisions depends not only on whether we are in the no flexibility or sales flexibility cases, but also on whether the exchange rate changes are temporary (i.e., e_1 and e_2 are independent random variables) or permanent (i.e., $e_1 = e_2$). Of the four possible cases, we begin with the one in which the information structure is the easiest to describe: the 'no flexibility - temporary changes' case. In this case, since all first-period decisions must be made before e_1 is observed, inventories and sales are independent of e_1 . In addition, since e_1 and e_2 are independent, observing e_1 at the end of period one will give the firms no new information about e_2 . Thus, all second-period decisions will be independent of e_1 as well. This is indicated in table 1 by the fact that all equilibrium variables are independent of e_1 and e_2 .

TABLE 2
Permanent change in the exchange rate

| No flexibility | Sales flexibility |
|--|--|
| <i>First-period output</i> | |
| $x_1^* = p^*$ | $x_1^* = p^*$ |
| $x_1 \cong 0.295 + 0.209p^*$ | $x_1 \cong 0.301 + 0.226p^*$ |
| <i>First-period sales</i> | |
| $s_1 \cong 0.154 + 0.093p^*$ | $s_1(1) \cong 0.156 + 0.131p^*$ |
| | $s_1(2) \cong 0.156 + 0.103p^*$ |
| $s_{d1} \cong 0.423 - 0.380p^*$ | $s_{d1}(1) \cong 0.422 - 0.565p^*$ |
| | $s_{d1}(2) \cong 0.422 - 0.302p^*$ |
| <i>Second-period output</i> | |
| $x_2^*(1) = x_2^*(2) = p^*$ | $x_2^*(1) = x_2^*(2) = p^*$ |
| $x_2(1) \cong 0.180 + 0.192p^*$ | $x_2(1) \cong 0.178 + 0.203p^*$ |
| $x_2(2) \cong 0.180 + 0.067p^*$ | $x_2(2) \cong 0.178 + 0.064p^*$ |
| <i>Second-period sales</i> | |
| $s_2(1) \cong 0.321 + 0.308p^*$ | $s_2(1) \cong 0.322 + 0.297p^*$ |
| $s_2(2) \cong 0.321 + 0.183p^*$ | $s_2(2) \cong 0.322 + 0.186p^*$ |
| $s_{d2}(1) \cong 0.340 - 0.654p^*$ | $s_{d2}(1) \cong 0.339 - 0.649p^*$ |
| $s_{d2}(2) \cong 0.340 - 0.342p^*$ | $s_{d2}(2) \cong 0.339 - 0.343p^*$ |
| <i>Expected profits</i> | |
| $\Pi \cong 0.114 + 0.163p^* + 0.062(p^*)^2$ | $\Pi \cong 0.114 + 0.171p^* + 0.069(p^*)^2$ |
| $\Pi^* \cong 0.442 - 0.864p^* + 1.55(p^*)^2$ | $\Pi^* \cong 0.439 - 0.945p^* + 1.58(p^*)^2$ |

The next case we consider is the 'no flexibility – permanent changes' case. As above, since all first-period decisions must be made *before* e_1 is observed, all first-period variables must be independent of the first-period exchange rate. Since $e_1 = e_2$ in this case, however, once e_1 is observed at the end of period one, both firms will enter period two with complete information concerning the second-period exchange rate. Thus, *all* second-period variables will be functions of e_1 . This is indicated in table 2 by the fact that all first-period variables are independent of e_1 , while all second-period variables are functions of e_1 .

Similar arguments apply to the two 'sales flexibility' cases. With temporary exchange rate changes, first-period sales and inventories depend on e_1 , since e_1 is observed before sales are set. In addition, knowing e_1 provides no new information about e_2 , so that second-period output depends only on e_1 (since e_2 is not known when output must be produced), while second-period sales depend on both e_1 and e_2 (see table 1). In the case of permanent changes, once the firms learn e_1 , they have complete information about e_2 . Thus, all future decisions can be written as functions of e_1 alone (see table 2).

The equilibrium values reported in tables 1 and 2 indicate that while most of our results continue to hold in this framework, at least one result needs to be modified. We begin our discussion with the output results. As both tables indicate, the do-

mestic firm's first-period output is always higher in the sales flexibility equilibrium than it is in the corresponding no flexibility equilibrium. The logic follows from above: under sales flexibility, the domestic firm has a strategic advantage that results directly from the foreign firm's ability to allocate sales after the exchange rate is observed. This strategic advantage is strongest when the good is non-storable. It is weakened, but does not disappear, when the good is storable and the firms have the option of carrying inventories across periods.

Now, consider the second period. It is tempting simply to compare the domestic firm's second-period output across the sales and no flexibility equilibria. It should be clear, however, that this would not be the right thing to do. What is most important is not second-period output, but rather the total amount that the domestic firm has available for sale in the second period. Thus, the natural way to extend proposition 1 is to compare the sum of the domestic firm's second-period output and first-period inventories, $x_2 + i$, in the two equilibria. Both tables indicate that proposition 1 *does* generalize in that $(x_2 + i)$ is higher under sales flexibility than it would be under no flexibility when the domestic currency is strong in the first period (i.e., $e_1 = 2$). If the domestic currency is relatively weak in the first period (i.e., $e_1 = 1$), however, the proposition fails. The reasoning is as follows. Suppose that $e_1 = 1$. In the sales flexibility equilibrium, the foreign firm reacts to this by selling only a small amount of output in the domestic market in the first period and carrying a large level of inventories into the second period. Such a reaction is not possible under no flexibility, since, in that case, the foreign firm must determine inventories before e_1 is observed. Thus, if $e_1 = 1$, the foreign firm enters period two with larger inventories under sales flexibility than under no flexibility. These larger inventories provide the *foreign firm* with a strategic advantage in the second period that is more than enough to offset the domestic firm's strategic advantage that it gains under sales flexibility. Note that what really causes proposition 1 to fail is the fact that when the domestic currency is relatively weak, the foreign firm carries more inventories into the second period under sales flexibility than it carries under no flexibility. If inventories were always the same in both equilibria, the domestic firm would sell more under sales flexibility than under no flexibility regardless of the exchange rate.

To summarize our results with respect to output, the strategic advantage conferred upon the domestic firm under sales flexibility results in higher domestic-firm output in the first period and higher domestic-firm sales in the second period if the domestic currency is relatively strong in the first period. However, if the domestic currency is relatively weak in the first period, then the domestic firm sells *less* in the second period under sales flexibility than it would under no flexibility. These results do not depend on the degree of persistence in the exchange rate over the two periods.

As for profits, careful consideration of the results reported in tables 1 and 2 indicate that proposition 1 *does* generalize to this setting. The strategic advantage that the domestic firm enjoys under sales flexibility allows it to earn higher expected profits under sales flexibility regardless of whether exchange rate changes

are temporary or permanent. As for the foreign firm, its profits are higher under sales flexibility if exchange rate changes are temporary, but they are higher under no flexibility if the exchange rate changes are permanent.

To understand this result, remember that in moving from the no flexibility to the sales flexibility equilibrium, there are two effects on foreign profits. On the one hand, the foreign firm faces a strategic disadvantage under sales flexibility that lowers its profits. On the other hand, under sales flexibility the foreign firm can wait and allocate its sales after the exchange rate is observed, so that it never makes sales decisions that it later regrets. This second effect tends to result in larger foreign-firm profits under sales flexibility. Table 1 indicates that when changes in the exchange rates are temporary, the second effect dominates, leading to higher foreign profits under sales flexibility. When exchange rate changes are permanent, however, the second effect is diminished because much of the uncertainty about future exchange rates can be removed by observing the current exchange rate. Thus, the first effect dominates, so that the foreign firm earns more in the no flexibility equilibrium. Since we can now specify the conditions under which foreign profit is higher under sales flexibility (something we could not do in our previous model), there is a sense in which our profit-related results in proposition 1 are strengthened when we allow for inventories.

VIII. CONCLUSION

In this paper, we examined three duopolistic models of domestic- and foreign-firm production and sales decisions with exchange rate uncertainty. In the first two models, production takes place before the exchange rate is revealed. In addition, in the first model sales must be distributed across national markets before the exchange rate is known. In the second model, however, the sales decision is made after the exchange rate has been observed. We referred to the first model as the 'no flexibility case' and the second model as the 'sales flexibility case.' Finally, we considered a third model ('complete flexibility') in which the firms made both production and sales allocation decisions after observing the exchange rate.

We have two sets of results. The first set concerns the nature of the equilibria under the various degrees of flexibility. In particular, we compare output and profits under the sales and no flexibility assumptions. The second set of results concerns the extent of exchange rate pass-through in the three models.

Assuming that the foreign firm sells both in its own market and the domestic market, while the domestic firm sells only in the domestic market, we showed that the greater flexibility in the second model gives the domestic firm a strategic advantage over the foreign firm in that it can credibly precommit to produce and sell more in the domestic market than it would in the first model (i.e., the no flexibility case). This results in the domestic firm selling more and earning more profit in the sales flexibility equilibrium than it would under no flexibility. As for the foreign firm, moving from the no flexibility to the sales flexibility equilibrium has an ambiguous effect on profits. These results hold whether or not the good is

storable and regardless of the degree of persistence of the exchange rate. If the good is storable, however, we showed that the degree of persistence of the exchange rate plays a crucial role in determining the strategic environment in which the foreign firm prefers to operate.

In comparing the extent of exchange rate pass-through across these models, we find that if we compare the sales and no flexibility cases, there are two effects that work in opposite directions. On the one hand, under sales flexibility, the foreign firm has the ability to divert sales from the weaker market. During a domestic currency depreciation (appreciation), the foreign firm shifts sales away from the domestic (foreign) market. This results in a domestic price that is higher (lower) than the one that would be observed under no flexibility and subsequently implies that the impact of the exchange rate change on the equilibrium domestic price is greater (i.e., more pass-through). On the other hand, we showed that under sales flexibility, the lack of a secondary market for its output affords the domestic firm a strategic advantage by allowing it to precommit to greater domestic market sales by increasing output in the first stage of the game. This forces the foreign firm to allocate more of its sales away from the domestic market and leaves the foreign firm with a smaller share of the domestic market. Therefore, since the foreign firm's presence is smaller, the rate of pass-through is reduced.

In the complete flexibility model, all decisions are made after the uncertainty has been resolved, so that this model is equivalent to the complete information model examined by Dornbusch (1987). When we compared this case to our sales flexibility model, we found that the increased flexibility leads to a greater degree of pass-through when the domestic currency appreciates (e is high) and less pass-through when the domestic currency depreciates (e is low). The reasoning is as follows: when the domestic currency appreciates (depreciates), a foreign firm that has already produced its output finds itself regretting that it did not produce more (less). Therefore, sales by the foreign firm in the domestic market are higher (lower) when output can be produced after the exchange rate is observed. The implications for the net impact on the domestic equilibrium price (i.e., pass-through) follow immediately.

REFERENCES

- Anderson, S., and R. Fischer (1989) 'Multi-market oligopoly with production before sales.' *Journal of Industrial Economics* 38, 167-82
- Cohen, F., and R. Price (1991) 'Competitive pricing strategies for exporters.' *Journal of European Business* 2, 46-8
- Collier, P., E.W. Davis, J.B. Coates, and S.G. Longden (1990) 'The management of currency risks: case studies of U.S. and U.K. multinationals.' *Accounting and Business Research* 20(79), 206-10
- Dornbusch, R. (1987) 'Exchange rates and prices.' *American Economic Review* 77, 93-106
- Fisher, E. (1989) 'A model of exchange rate pass-through.' *Journal of International Economics* 26, 119-37
- Flicker, S., and D. Blinle (1990) 'Managing foreign currency exchange risk.' *Journal of Accounting* 170, 128-30

- Froot, K., and P. Klemperer (1989) 'Exchange rate pass-through when market share matters.' *American Economic Review* 79, 637-54
- Knetter, M. (1993) 'International comparisons of pricing-to-market behavior.' *American Economic Review* 83, 637-54
- Krupp, C., and C. Davidson (1993) 'Exchange rate swings, flexibility, and international competition.' Working Paper, Michigan State University
- Mann, C. (1986) 'Prices, profit margins, and exchange rates.' *Federal Reserve Bulletin* June, 366-79
- Marston, R. (1990) 'Pricing to market in Japanese manufacturing.' *Journal of International Economics* 29, 217-36
- Tirole, J. (1989) *The Theory of Industrial Organization* (Cambridge, MA: MIT Press)
- Ungern-Sternberg, T., and C. von Weizsacker (1990) 'Strategic foreign investment management.' *Journal of Industrial Economics* 38, 381-95