ELSEVIER

Economics Letters 55 (1997) 61–67

economics letters

Exchange rate expectations and market shares

Luís M.B. Cabral[a,*], António S. Mello[b]

[a]London Business School, Univ. Nova de Lisboa and CEPR, London, UK
[b]University of Wisconsin–Madison and CEPR, Wisconsin, USA

Received 15 October 1996; accepted 5 December 1996

Abstract

We consider an asymmetric duopoly comprised of a domestic and a foreign firm. We derive optimal collusion equilibria and examine how market shares vary in response to changes in the exchange rate. Our analysis implies some surprising results. First, a temporary depreciation has a greater impact on market shares than a permanent depreciation. Second, if the change in the expected future rates is of sufficient magnitude, then the domestic firm's market share may decrease following a depreciation of the home currency—a "seemingly perverse effect." © 1997 Elsevier Science S.A.

Keywords: Exchange rates; Repeated games

JEL classification: C73; F12; L13

1. Introduction

In a seminal paper, Rotemberg, Saloner (1986) considered a joint-profit-maximizing dynamic duopoly subject to demand shocks. They showed that, in order to maintain the incentive not to deviate from collusion, the maximum sustainable price has to be lower in periods of high demand—thus the title "price wars during booms."[1]

In this paper, we consider an asymmetric, international duopoly comprised of a domestic and a foreign firm. Like Rotemberg, Saloner (1986), we derive optimal collusion equilibria. However, instead of shocks to demand, we consider shocks affecting both the spot exchange rate and the expected future spot exchange rate.

Our analysis implies some surprising results. First, a temporary depreciation has a greater impact on market shares than a permanent depreciation. Second, if a change in the expected future exchange rate is of sufficient magnitude, then the market share of the domestic firm may decrease following a depreciation of the home currency—a "seemingly perverse effect."

*Corresponding author. Tel.: 44-171-2625050; fax: 44-171-7247875; e-mail: lcabral@lbs.lon.ac.uk
[1]For a generalization of these results, see Kandori (1991).

PII S0165-1765(97)00043-8

2. Assumptions

Two firms compete in a given market (the domestic market), a domestic firm and a foreign firm. In each of an infinite number of periods, firms choose output quantity, q and q^*, respectively.[2] The fact that firms compete repeatedly creates the possibility of non-cooperative equilibria yielding higher profits than the short-run, or static, equilibrium. Low output levels that would not be sustainable in a static equilibrium, because each firm would prefer to produce a higher output, can be equilibria in the dynamic game, because deviating imposes the cost of future retaliation.

Specifically, we model tacit collusion by assuming that firms maximize joint profits subject to the constraints that neither firm prefers to deviate from the agreed-upon equilibrium. In addition, throughout the paper we assume that such no-deviation constraints are binding for both firms.[3] Finally, we make the technical assumption that the inverse demand function is (weakly) concave and the cost function is (weakly) convex. As noted later in the paper, these conditions are sufficient for our results, although not necessary.

The central aspect of the paper is the role played by the exchange rate, both the current spot rate (e) and today's expectation of the future rate ($\hat{e}_t$, $t > 1$). For simplicity, we assume that firms expect the exchange rate for $t = 3, 4, \ldots$ to be equal to the value at $t = 2$. This simplification allows us to focus on the contrast between changes in the current exchange rate ($\mathrm{d}e$) and changes in the expected future exchange rate ($\mathrm{d}\hat{e}$).[4]

Let E, E^* be current profit along the equilibrium path for the domestic and for the foreign firm, respectively. Similarly, let F, F^*, be future expected profits along the equilibrium path. Define M, M^*, to be the one-period maximum profit each firm attains if it unilaterally deviates. Finally, P, P^* denote expected payoffs in case firms revert to punishment. The no-deviation constraints are then given by[5]

$$E(q, q^*) + \frac{\delta}{1-\delta} F(\hat{e}) = M(q^*) + \frac{\delta}{1-\delta} P(\hat{e}), \tag{1}$$

$$E^*(q, q^*; e) + \frac{\delta}{1-\delta} F^*(\hat{e}) = M^*(q; e) + \frac{\delta}{1-\delta} P^*(\hat{e}). \tag{2}$$

3. Results

In this section we analyze the case of deviations that are followed by extreme punishments, so that

[2]The stage game may be interpreted as one in which firms first set production capacities and then simultaneously set prices. Kreps, Sheinkman (1983) show that the equilibrium of this two-stage game is such that both firms set the same price, the price that exactly clears total production capacity. Likewise, the assumption that the game is repeated "infinitely" should not be taken literally. The idea is simply that the termination date is uncertain and incorporated into the discount factor. Assuming that the probability of termination at the end of each period is bounded away from zero, then the game ends in finite time with probability one.

[4]A more elaborate assumption about expected future values of e_t would complicate the derivations considerably without adding much to the results.

[3]This will be the case if the duopoly is not too asymmetric and if the discount factor is not too high.

[5]The following equations result from the recursive problem of finding optimal q, q^* today given the future payoffs along as well as off the equilibrium path. Therefore, F, F^* and P, P^* are written as a function of $\hat{e}$ only. Notice that only the foreign firm's current profit functions, E^* and M^*, depend on e. The domestic firm's profits also depend on e, but only indirectly.

$P(\hat{e}) = P^*(\hat{e}) = 0$. In the next section, we argue that our results extend to other cases of behavior off the equilibrium path.

To explore the response of firms to fluctuations in the exchange rate, we consider three alternative specifications of shifts in the exchange rate:

1. A *permanent* depreciation, which corresponds to $de = d\hat{e} = 0$.
2. A *purely temporary* depreciation, which corresponds to $de > 0$, $d\hat{e} = 0$.
3. A *purely anticipated* depreciation, which corresponds to $de = 0$, $d\hat{e} > 0$.

Proposition 1. A purely temporary depreciation of the home currency leads to an increase in the domestic firm's market share.

Proof. See Appendix A. ■

The intuition for this result is the following. A depreciation of the home currency increases the foreign firm's cost (expressed in domestic currency). An increase in cost decreases the incentives to deviate: deviation implies producing a large quantity, which now costs more. Since the foreign firm has now less incentive to deviate, under tacit collusion it should produce less. Meanwhile, a lower output by the foreign firm increases the benefits from deviation by the domestic firm. In order to keep the equilibrium intact, it is therefore necessary that the domestic firm be allowed to produce more. Together, these effects imply that the domestic firm's market share increases.[6]

Proof: The total effect of de_τ, $\tau = t, \ldots$ is additive. The result therefore follows immediately from Propositions 1 and 2. ■

4. Remarks

1. A number of papers have previously considered models of static international oligopoly under exchange rate variability. In these models, exchange rates and market shares move according to intuition, although the exchange rate "pass-through" is, in general, less than complete.[7] In contrast with this literature (see, however, point 2 below), several empirical studies have reported some form of "perverse effect" of changes in the exchange rates.[8]
2. The possibility of "perverse effects" (cf Corollary 2), as predicted by our model, can be evaluated by looking at actual exchange rate data. Suppose that the prevailing forward exchange rate is an unbiased forecast of the future value of the exchange rate. Then, under specific assumptions about

[6]Note that these comparative statics have the same signs as in a static Cournot equilibrium, although for very different reasons. In a Cournot equilibrium, a depreciation would shift the foreign firm's reaction curve downwards, causing a decrease in its output level. But, since reaction curves are negatively sloped, a decrease in the foreign firm's output would also imply an increase in the domestic firm's output. Again, the end result would be an increase in the domestic firm's market share.

[7]See, for example, Dornbusch (1987) and Fisher (1989).

[8]See Mann (1986); Knetter (1989); Marston (1990) and Luehrman (1991), among others.

market structure, the observed quarterly exchange rates between the US$ and the DM would lead to "seemingly perverse effects" in 5 out of 15 quarters during the period 1980–1983.[9] If, instead, the rates between the US$ and the Yen are used, then "seemingly perverse effects" appear in 4 out of 15 quarters during the period 1992–1995.
The periods we consider are periods of high instability of the forward rates. In particular, the "seemingly perverse effects" occur in periods when e decreases (appreciation of the dollar) but $\hat{e}$ decreases much faster (expected future appreciation of the dollar).
3. The results in the previous section also extend to patterns of punishment for deviation other than the extreme punishments considered. In particular, it can be shown that the results also apply, in the linear case, when punishments consists of reversion to the one-shot Cournot equilibrium.
4. The possibility of "perverse effects" resulting from changes in the exchange rate has also been explained by Froot, Klemperer (1989) in a dynamic setting (see Tivig (1996) for an extension). Our model contrasts with theirs in that it does not require any "physical" link between periods, neither through demand nor through costs; all of the dynamic effects in our model result entirely from the firms' strategies.

Another model consistent with perverse effects is that of Hens et al. (1991). However, when marginal costs are constant (as in our model), their model predicts that market shares always move in the "right" direction.

Appendix A

Proof of Proposition 1. A purely temporary depreciation corresponds to $\mathrm{d}e>0$ and $\mathrm{d}\hat{e}=0$. We assume the equilibrium is determined by the binding no-deviation constraints (1)–(2). Differentiating, we get

$$\begin{bmatrix} \frac{\partial E}{\partial q} & \frac{\partial E}{\partial q^*} - \frac{\partial M}{\partial q^*} \\ \frac{\partial E^*}{\partial q} - \frac{\partial M^*}{\partial q} & \frac{\partial E^*}{\partial q^*} \end{bmatrix} \begin{bmatrix} \mathrm{d}q \\ \mathrm{d}q^* \end{bmatrix} = \begin{bmatrix} 0 \\ \left(\frac{\partial M^*}{\partial e} - \frac{\partial E^*}{\partial e}\right) \end{bmatrix} \mathrm{d}e. \tag{3}$$

Denote by Δ the determinant of the matrix on the left-hand side. By the envelope theorem,

$$\frac{\partial E^*}{\partial e} = c^* \frac{\partial E^*}{\partial q},$$

$$\frac{\partial M^*}{\partial e} = c^* \frac{\partial M^*}{\partial q},$$

where c^* is the foreign firm's marginal cost. The system (3) can then be solved into

[9] The specific assumptions are that the demand and the cost functions are linear and that the discount factor is close to the value leading to full collusion. Complete calculations are available from the authors upon request.

$$\frac{\partial q}{\partial e}=\left(\frac{\partial M}{\partial q^*}-\frac{\partial E}{\partial q^*}\right)\left(\frac{\partial M^*}{\partial q}-\frac{\partial E^*}{\partial q}\right)\frac{c^*}{\Delta}, \tag{4}$$

$$\frac{\partial q^*}{\partial e}=\frac{\partial E}{\partial q}\left(\frac{\partial M^*}{\partial q}-\frac{\partial E^*}{\partial q}\right)\frac{c^*}{\Delta}. \tag{5}$$

We now establish the signs of the terms on the right-hand side of (4)–(5). First, notice that

$$\frac{\partial E}{\partial q^*}=qP'(q+q^*),$$

$$\frac{\partial M}{\partial q^*}=\bar{q}P'(\bar{q}+q^*),$$

where $P(\cdot)$ is the inverse demand function and $\bar{q}$ is the optimal deviation from q given q^*. If the demand function is (weakly) concave, then $|\bar{q}P'(\bar{q}+q^*)|>|qP'(q+q^*)|$.[10] By similar arguments, it follows that the terms in parentheses in (4)–(5) are all negative.

By definition of $\bar{q}$,

$$\left.\frac{\partial M}{\partial q}\right|_{q=\bar{q}}=\bar{q}P'(\bar{q}+q^*)+P(\bar{q}+q^*)-C'(\bar{q})=0.$$[11]

Since $\bar{q}>q$ and marginal cost is nondecreasing, the following sequence of inequalities results:

$$\begin{aligned}P(q+q^*)-C'(q)&>P(\bar{q}+q^*)-C'(\bar{q})\\ qP'(q+q^*)+P(q+q^*)-C'(q)&>qP'(q+q^*)+P(\bar{q}+q^*)-C'(\bar{q})\\ qP'(q+q^*)+P(q+q^*)-C'(q)&>qP'(q+q^*)-\bar{q}P'(\bar{q}+q^*)\\ \frac{\partial E}{\partial q}&>\frac{\partial E}{\partial q^*}-\frac{\partial M}{\partial q^*}.\end{aligned}$$

Likewise,

$$\frac{\partial E^*}{\partial q^*}>\frac{\partial E^*}{\partial q}-\frac{\partial M^*}{\partial q}.$$

It follows that $\Delta>0$. We have therefore established that

$$\frac{\partial q}{\partial e}>0,$$

$$\frac{\partial q^*}{\partial e}<0,$$

and the result follows. ■

[10] Notice that concavity of the demand function is a sufficient, but not necessary, condition. The necessary and sufficient condition would be that the demand function be not too convex.

[11] Concavity of the demand function and convexity of the cost function imply that the second-order condition for profit maximization is satisfied.

Proof of Proposition 2. A purely anticipated depreciation corresponds to $\mathrm{d}e=0$ and $\mathrm{d}\hat{e}>0$. Differentiating (1)–(2), we get

$$\begin{bmatrix} \frac{\partial E}{\partial q} & \frac{\partial E}{\partial q^*}-\frac{\partial M}{\partial q^*} \\ \frac{\partial E^*}{\partial q}-\frac{\partial M^*}{\partial q} & \frac{\partial E^*}{\partial q^*} \end{bmatrix} \begin{bmatrix} \mathrm{d}q \\ \mathrm{d}q^* \end{bmatrix} = \begin{bmatrix} \delta \frac{\partial F}{\partial \hat{e}} \\ -\delta \frac{\partial F^*}{\partial \hat{e}} \end{bmatrix} \mathrm{d}\hat{e} \tag{6}$$

.Solving this system, we get

$$\frac{\partial q}{\partial \hat{e}} = \frac{\partial E^*}{\partial q^*}\left(-\delta \frac{\partial F}{\partial \hat{e}}\right)\frac{1}{\Delta} - \left(\frac{\partial E}{\partial q^*}-\frac{\partial M}{\partial q^*}\right)\left(-\delta \frac{\partial F^*}{\partial \hat{e}}\right)\frac{1}{\Delta}$$

$$\frac{\partial q^*}{\partial \hat{e}} = -\left(\frac{\partial E^*}{\partial q}-\frac{\partial M^*}{\partial q}\right)\left(-\delta \frac{\partial F}{\partial \hat{e}}\right)\frac{1}{\Delta} + \frac{\partial E}{\partial q}\left(-\delta \frac{\partial F^*}{\partial \hat{e}}\right)\frac{1}{\Delta}.$$

It can be shown that, following a permanent depreciation, q increases and q^* decreases. It follows that

$$\frac{\partial F}{\partial \hat{e}} > 0 > \frac{\partial F^*}{\partial \hat{e}},$$

and, by an argument, similar to that of the proof of Proposition 1,

$$\frac{\partial q}{\partial \hat{e}} < 0$$

$$\frac{\partial q^*}{\partial \hat{e}} > 0,$$

and the result follows. ■

References

Dornbusch, Rudiger, 1987. Exchange Rate and Prices. American Economic Review 77, 93–106.

Fisher, E., 1989. A Model of Exchange Rate Pass-Through. Journal of International Economics 26, 119–137.

Froot, K., Klemperer, P., 1989. Exchange Rate Pass-Through When Market Share Matters. American Economic Review 79, 637–654.

Hens, T., Kirman A., Philips L., 1991. Exchange Rates and Oligopoly. Working Paper ECO No. 91/42. European University Institute, May.

Kandori, M., 1991. Correlated Demand Shocks and Price Wars During Booms. Review of Economic Studies 58, 171–180.

Knetter, M., 1989. Exchange Rate Fluctuations and Price Discrimination by US and German Exporters. American Economic Review 79, 198–210.

Kreps, D.M., Sheinkman, J.A., 1983. Capacity Precommitment and Bertrand Competition Yield Cournot Outcomes. Bell Journal of Economics 14, 326–337.

Luehrman, T., 1991. Exchange Rates and Intra-Industry Value Redistributions. Journal of International Business Studies 22, 619–649.

Mann, C., 1986. Prices, Profits, and Exchange Rates. Federal Reserve Bulletin 72, 366–379.

Marston, R., 1990. Price Behavior in Japanese and U.S. Manufacturing. Working Paper No. 3364. N.B.E.R., May.

Rotemberg, J., Saloner, G., 1986. A Supergame-Theoretic Model of Price Wars During Booms. American Economic Review 76, 390–407.

Tivig, T., 1996. Exchange Rate Pass-Through in Two-Period Duopoly. International Journal of Industrial Organization 14, 631–645.