One money, one market? Exchange rate variability and the decision to segment markets

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Abstract

We examine how the decision to segment markets depends on exchange rate variability for a monopolist selling on two national markets. Sunk costs of market segmentation implies that there is an option value associated with market segmentation, a monetary union may then lead to market integration when a fixed exchange rate did not. We also etablish that average profits are increasing in exchange rate variability under market segmentation. Results are robust to inclusion of a competitor (Bertrand in differentiated goods). General equilibrium implications are explored.

Keywords: Exchange rate variability, exchange rate exposure, exchange rate pass-trough, law of one price, EMU, price discrimination, real options

JEL classification:

1 Introduction

Much recent evidence establishes large deviations from the law of one price (LOP) for traded goods and that many firms react to exchange rate variability by "Pricing-to-market", stabilizing prices in the consumer's currency (see Goldberg and Knetter, 1997, for a survey). Understanding the mechanisms that hinder arbitrage and thereby support deviations from LOP is central for

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many issues in international economics - for predicting the effects of dismantling of formal trade restrictions and other institutional changes, for understanding the high correlation between real and nominal exchange rates (see for instance Engel, 1999) and for the study of trade under imperfect competition (market segmentation is a key assumption in for instance Brander and Krugman, 1983 and much subsequent work). Unfortunately, we have a very limited understanding of the mechanisms that support observed deviations from LOP across national borders. One branch of the literature has examined the variability of relative prices of goods. This is highly correlated with exchange rate variability, also after accounting for distance (Engel and Rogers, 1996, 1999). In the words of Engel and Rogers we know that the border is wide but we do not know why.

One path to try understanding the border effect is to theoretically model and empirically examine various frictions that segment markets - different cultures, languages, difficulties in enforcing contracts and informational asymmetries are but some pickings from a very long list of potential frictions.

This paper explores another path. We examine the decision to create frictions. To a considerable degree the mechanisms which segment markets are influenced by firms' own decisions and the mechanisms are likely to be costly to establish and maintain. By its control of distribution, marketing and product design a firm may increase the price differential needed to make arbitrage attractive. The closest in spirit to the analysis are Baldwin (1988), Baldwin and Krugman (1989) and Dixit (1989) who view the decision to be present on a foreign market as a sunk cost but ignore a second market.[1]

In particular we are interested in if different currencies can contribute to our understanding of why the border is wide. Nominal price rigidities and exchange rate variability may partly explain deviations. Even if LOP held on average, sticky prices and volatile exchange rates would create the pattern documented by Engel and Rogers (1996, 1999). There is also the issue if using the same currency will make the levels of prices in different locations more equal. It is claimed by many that when prices are expressed in the same currency, price transparency is larger and that this forces LOP to hold to a much greater extent.[2] Indeed, an explicit purpose of the Economic and Monetary Union (EMU) in Europe is to increase market integration.

We take as starting point for our analysis the high correlation between real and nominal exchange rates - the estimated half-lives of deviations from purchasing power parity are typically on the magnitude of several years (see for instance Rogoff, 1996). An implication is that many of the fluctuations in purchasing power are associated with nominal exchange rate fluctuations. The key insight is that if there are less fluctuations in purchasing power between two similar markets, the benefits of market segmentation will be lower. To highlight

[1] They focus on hysterisis in prices and the exchange rate. Since large exchange rate changes induce entry and exit of firms, prices and quantities will not return to pre-shock values just because the exchange rate returns to its original value.

[2] For instance the Financial Times (Guide to Economic & Monetary Union, July 1998), The Economist in various surveys. Asplund and Friberg (1999) provide an empirical investigation of this claim using data from duty-free stores that price in several currencies.

the issues, we examine the decision for a monopolist of whether to segment two national markets - that is to engage in third degree price discrimination. We assume that the exchange rate may vary and prices are set after the current period's exchange rate is observed.

Let us provide some further discussion of the costs of market segmentation before proceeding to the analysis. Having national product specifications, bundling with non-traded goods (service agreements, financing and warranties for instance), having national brand names and exclusive territories for dealers are all mechanisms that increase the potential for market segmentation.[3] They do so by increasing the price differential needed to make arbitrage profitable. Further market segmentation may be achieved by lobbying for barriers to arbitrage. These are all mechanisms that are likely to be associated with some costs. For instance there are in many cases likely to be scale economies in marketing, it is cheaper to use one in many locations than one in each. There is a strong flavor of irreversibility associated with many of the mechanisms and it is in many cases realistic to think of the costs for these hinders to arbitrage as sunk - if the firm decides to integrate markets it can not fully recoup the cost of the segmenting investment. For example assume that a firm has built a brand name in a country - the resources devoted to this are typically not recoupable should it decide to integrate. As long as exchange rates can exhibit large changes there is thus an option value associated with having segmented markets. The option is to segment markets in the future at a lower cost. Since the value of an option is increasing in the variability of the underlying asset (difference in profits between segmented and integrated markets) markets may be segmented even though there is little exchange rate variability today if there is sufficiently high potential variability tomorrow. This presents a mechanism by which a monetary union would imply greater market integration. The mechanism would not be increased price transparency, but the very low probability of future exchange rate variability.

We should point out that the analysis is specific neither to exchange rates nor to an international setting. It can be applied to other situations where a firm contemplates third degree price discrimination with fluctuations in the demand of the groups. With respect to international policy the mechanisms in the current paper for instance imply that there is an option value associated with market segmentation as long as sales taxes can differ between locations. Given the very high volatility of real and nominal exchange rates in comparison with other demand shifters it is nevertheless the perhaps most natural setting for the analysis.

Before proceeding with the analysis let us exemplify with the case of cars

[3] Some of these mechanisms have recieved formal attention: Gandal and Shy (1996) examine the role of differing technical standards and Horn and Shy (1996) analyze bundling of traded goods with non-traded goods. Ganslandt (1999a) analyzes how fixed and variable costs of arbitrage interact to allow deviations from LOP. Friberg (1999) examines the role of exclusive territories and information assymetries on arbitrage markets in allowing deviations from LOP. Somewhat related are also Ganslandt (1999b) and Malueg and Schwartz (1994) who analyze welfare effects of market segmentation and arbitrage.

on European markets. Goldberg and Verboven (1998) show wide price differences (up to 30 percent) between five European car markets between 1980 and 1993. In keeping with the claim in this paper they note that (p.2) car manufacturers actively seek to keep European markets geographically segmented by for instance maintaining the selectivity of the distribution system. Exchange rate fluctuations have been important in driving the price differentials. In 1990 United Kingdom and Italy were the most expensive (pre-tax hedonic prices) countries and by 1996 they were the cheapest - "the major exchange rate realignments seem to have played an important role in this reversal" (p. 5). The price differentials seem to be largely related to local currency price stability and exchange rate fluctuations. The mechanisms analyzed in this paper would lead to more equal prices in Europe, both because of lower differences in markups across national markets and because of a lower share of total costs being local (a non-negligible share of local costs should be connected to measures that segment markets, such as costs of tailoring marketing to that national market or extensive after-sales agreements).

The next section presents the model. We proceed with an illustration using simple functional forms before we tackle the issue of whether to segment markets or not. The difference in operating profits between integrated and segmented markets will be important in driving results and we therefore examine this in some detail in Section 5. So far, the analysis is partial equilibrium and in the "pricing-to-market" tradition - the exchange rate is exogenous and prices of other goods are fixed. The final Section relaxes this and extends the analysis to include a competitor and discusses general equilibrium implications. In particular some implications for the "new open economy macroeconomics" are pointed out.

2 The model

Examine the maximization problem facing a firm which produces a good which it sells on two markets which we call Home and Foreign. Let there be two periods $i = 1, 2$. Each period has the following sequence of events: first the exchange rate, e, for period i is observed, the firm then decides whether to separate or integrate markets in period i, sets price for period i, and period i profits are realized. We will typically suppress the timescript. Let e denote the units of the firm's home currency needed to buy one unit of the Foreign currency. The exchange rate in period 2 is stochastic with a continuous probability distribution (but known with certainty at beginning of period 2). We will focus the most attention on $e_1 = E(e_2) = 1$, which we will call the equilibrium exchange rate.

Demand for the good in Home is given by $q(p)$ where p is the price charged on the Home market. Foreign demand is a function of price expressed in the foreign currency, $q^*(p^*)$.[4] Denote the price when markets are integrated with

[4] In assuming that demand in each country is a stable function of the nominal price in that respective currency we assume that a nominal exchange rate changes leaves other prices unchanged. Thus a change in the nominal exchange rate e, will imply a corresponding change

$\overline{p}$. The cost of production is given by a cost function $C(q,q^*)$. Assume that cost and demand functions are twice continuously differentiable, that demand is decreasing in price, and that profits on each market are strictly concave in price so that there for every point on the marginal cost curve exists a unique profit maximizing price on each market.

We examine profits under segmented and integrated markets respectively. By segmented markets we mean that demand on each market is independent of price on the other market. By integrated markets we mean that prices are set so that LOP holds.[5] If markets are segmented profits are given by Π and if markets are integrated profits are given by π defined as

$$\begin{aligned} \Pi &\equiv \max_{p,p^*} pq(p) + ep^*q^*(p^*) - C(q,q^*) \qquad (1) \\ \pi &\equiv \max_{p,p*} pq(p) + ep^*q^*(p^*) - C(q,q^*) \text{ s.t. } p = ep^* \\ &\equiv \max_{\overline{p}} \overline{p}q(\overline{p}) + \overline{p}q^*(\overline{p}/e) - C(q,q^*) \end{aligned}$$

For simplicity let the discount rate equal 1. The firm faces a decision of whether to segment the two national markets. If it is costless to segment markets the firm will never strictly prefer to integrate markets. The observation follows from noting that constrained profits can not dominate unconstrained. Assume that segmenting markets is associated with a cost M if markets were segmented in the last period and a cost N otherwise. Assume that $N > M$.

Consider the decision problem faced by a firm at the beginning of period 1 which enters this period with segmented markets. The firm will segment in period 1 if the gain from segmenting is higher than the gain from integrating. There will exist critical levels of the exchange rate at which a firm integrates or segments - to ensure that these thresholds are uniquely determined we assume that there is a unique exchange rate which minimizes the difference in profits and that the difference in profits increases as the exchange rate moves away from this point.[6]

Assumption A: $\frac{d^2(\Pi-\pi)}{de^2} > 0$.

Now turn to a simple example to establish some intuition.

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in the real exchange rate. We discuss this assumption in Section 6.2, for now view it as a convenient way to model the stylized fact that there is a very high correlation between real and nominal exchange rates.

[5] There are some subtleties associated with how to assume that markets are integrated and how the costs of production for the two markets interact; Assume for instance that all customers buy in the cheaper country and $\frac{\partial^2 C}{\partial q \partial q^*} = 0$: if there were economies of scale the firm would set price such that LOP did *not* hold under integrated markets, wanting to produce only for the Home or the Foreign market. A motivation for the assumptions made is that we focus on the impact of LOP holding rather than on the precise way that arbitrage forces LOP to hold.

[6] This is a version of the LeChattelier-Samuelson principle - in the words of Dixit (1990, p. 113) - "the fewer variables are held fixed, the more convex should the maximum value function be". Profits where the relative price is free to vary should be more convex than profits where the relative price $\frac{p}{ep^*} = 1$. Thus, assumption A will cleary hold under some regularity conditions, we have not pursued the exact nature of those regularity conditions.

3 An illustration

Assume there are constant marginal costs of production (c) and that the firm faces demand that is linear in price in each country $(1-p)$ and $(a-p^*)$ respectively. At the equilibrium exchange rate 1 the markets thus differ in size and thereby in optimal price if a differs from 1. The linear case is attractive not only because it yields transparent expressions but also because the predictions from this simple model matches observed pass-through behavior well.[7] We first examine the per period profit maximization before proceeding to the market segmentation decision.

3.1 Segmented markets

Under the assumptions, the maximization problem under segmented markets is given by

$$\max_{p,p^*} (p-c)(1-p) + (ep^* - c)(a-p^*)$$

Solving for the optimal prices yields

$$p = \frac{1+c}{2} \tag{2}$$

$$p^* = \frac{a + c/e}{2} \tag{3}$$

When $a = e = 1$ the optimal price will be the same on both markets, otherwise they differ. The profits from sales at the optimal prices is given by

$$\Pi = \frac{(1-c)^2}{4} + \frac{e(a-c/e)^2}{4}$$

Figure 1 illustrates optimal price and profits under the mean exchange rate and the effect on price and profits of a depreciation of the Home currency (a move in e to e'). Since marginal costs are constant and markets are segmented the optimal price on the Home market is unaffected by the depreciation. On the Foreign market the depreciation is equivalent to a decrease in the marginal costs for the firm and this induces a decrease in the foreign currency price of the good. A depreciation of the firm's profits increases foreign currency earnings by the area marked with diagonal lines and decrease them by the area marked with vertical lines - implying an increase in profits.

Figure 1 about here

[7] Pass-through of an exchange rate change onto import prices equals one half in this model, an estimate that is close to the median estimate of pass-through on shipments to the US (Goldberg and Knetter, 1997).

3.2 Integrated markets

When markets are integrated the maximization problem is given by

$$\max_{\overline{p}} (\overline{p} - c)(1 - \overline{p}) + (\overline{p} - c)(a - \overline{p}/e)$$

yielding the optimal price

$$\overline{p} = \frac{(1+a)}{2} \frac{e}{1+e} + \frac{c}{2}$$

and profits

$$\pi = \left(\frac{(1+a)e}{2(1+e)} - \frac{c}{2} \right) \left(\frac{1+a}{2} - \frac{c(1+e)}{e} \right)$$

The effect of not being able to segment markets is that the optimal price for the integrated markets will not be optimal for any one of the markets individually. A depreciation of the home currency still yields an increase in profits, but the positive effect is tempered by that the optimal price will be "too high" on the home market and "too low" on the foreign market compared to what would have been the case under separated markets.

3.3 Market segmentation

To examine the choice of whether to segment markets begin by finding the threshold values in period 2. The firm will continue to segment if $\Pi - \pi \geq M$ or specifically if

$$\Pi - \pi = \frac{1}{4(1+e)} (1 + ea(ea - 2)) \geq M \tag{4}$$

Rewrite (4) as a quadratic equation in e and solve for the two roots at which (4) holds with equality. We thus establish the critical levels of the exchange rate at which (4) holds with equality

$$\begin{aligned} \underline{e}_m &= 1/a + 2M - 2\sqrt{1/4a^2 - 1/4 + M(2+M)} \\ \overline{e}_m &= 1/a + 2M + 2\sqrt{1/4a^2 - 1/4 + M(2+M)} \end{aligned}$$

where clearly $\overline{e}_m > \underline{e}_m$. In the same manner we calculate the critical values of the exchange rate at which a firm which did not segment in period 1 will choose to segment in period 2.

$$\begin{aligned} \underline{e}_n &= 1/a + 2N - 2\sqrt{1/4a^2 - 1/4 + N(2+N)} \\ \overline{e}_n &= 1/a + 2N + 2\sqrt{1/4a^2 - 1/4 + N(2+N)} \end{aligned}$$

Figure 2 illustrates the case where $a = 1.2$, $M = 0.02$ and $N = 0.03$ and $c = 0.1$.

Figure 2 about here

At the equilibrium exchange rate 1 the markets are in this case similar enough that the firm chooses not to segment them. The Home market is smaller than the Foreign and the optimal price on the Home market is lower than the optimal price on the Foreign market. An appreciation of the Home exchange rate increases the purchasing power of Home market relative to the Foreign, and for a sufficiently appreciated exchange rate there is no difference in profits between the integrated and segmented markets cases. As e appreciates even more prices again diverge, the optimal price on the home market is now greater than price on the foreign market. We see that $\Pi - \pi$ is convex in e, the farther from the minimum difference e is, the greater is the difference in profits between segmented and integrated markets. This ensures that there are only two values where the difference in profits equals M.

For period 2 levels of the exchange rate between $\underline{e}_m$ and $\overline{e}_m$ the firm will integrate markets since the difference in operating profits between integrated and segmented markets is small enough for it not to be profitable to pay the fixed cost of segmenting markets. When e in Period 2 is larger than $\overline{e}_m$ but lower than $\overline{e}_n$ a firm that segmented in period 1 will continue to do so whereas a firm that did not will not do so (since $N > M$). The segmenting firm will thus have higher operating profits in this region. If the exchange rate is more depreciated than $\overline{e}_n$ a firm will segment no matter what it did in period 1, but the firm that did not segment in period 1 will have a higher cost of segmenting. So the decision in period 1 of whether to integrate markets or not will hinge on the probabilities of where the period 2 exchange rate will be in relation to the thresholds. If the exchange rate probability function has sufficient mass in the tails it will pay to segment markets in period 1. We examine this idea formally in the next section in the general setting.

4 The decision to segment markets

4.1 period 2

As in the Illustration the first step in the analysis is to find the threshold values in period 2 at which the firm will discontinue segmenting markets and the thresholds at which it will commence market segmentation. In period 2 a firm that segmented markets in period 1 will choose to continue segmenting if

$$\Pi(e_2) - M \geq \pi(e_2) \tag{5}$$

This will yield two thresholds where (5) holds with equality, $\overline{e}_m$ and $\underline{e}_m$ with $\overline{e}_m > \underline{e}_m$. To make the analysis interesting we want the exchange rate at which $\Pi - \pi$ reaches its minimum is sufficiently close to 1 so that the firm would integrate if there were no exchange rate uncertainty:

Assumption B: $\underline{e}_m < 1 < \overline{e}_m$.

Similarly

$$\Pi(e_2) - N \geq \pi(e_2)$$

yields two thresholds at which a firm that integrated in period 1 will choose to segment in period 2, $\overline{e}_n$ and $\underline{e}_n$ where $\overline{e}_n > \underline{e}_n$. The ranking of the thresholds is such that $\underline{e}_n < \underline{e}_m < 1 < \overline{e}_m < \overline{e}_n$.

4.2 Period 1

In period 1 the firm will keep segmenting markets if the benefit from segmenting exceeds the benefit of integrating, that is if

$$\begin{aligned} &\Pi(e_1) - M + \int_{\underline{e}_m}^{\overline{e}_m} \pi(e_2) f(e_2) de_2 + \int_{0}^{\underline{e}_m} [\Pi(e_2) - M] f(e_2) de_2 + \int_{\overline{e}_m}^{\infty} [\Pi(e_2) - M] f(e_2) de_2 \\ \geq\ & \pi(e_1) + \int_{\underline{e}_n}^{\overline{e}_n} \pi(e_2) f(e_2) de_2 + \int_{0}^{\underline{e}_n} [\Pi(e_2) - N] f(e_2) de_2 + \int_{\overline{e}_n}^{\infty} [\Pi(e_2) - N] f(e_2) de_2 \end{aligned} \quad (6)$$

The first line of the expression is the value of segmenting markets in period 1. Period 1 profits are then given by operating profits when markets are segmented ($\Pi(e_1)$) minus the cost of segmenting markets, M. If the period 2 exchange rate, e_2 lies between $\underline{e}_m$ and $\overline{e}_m$ the firm will integrate in period 2 and gain profits $\pi(e_2)$. This is the third term. If e_2 is lower than $\underline{e}_m$ the firm will continue segmenting markets gaining operating profits $\Pi(e_2)$ and paying the cost of continuing to segment, M. This is the fourth term. The last term on the first line similarly gives the expected value of profits for when $e_2 > \overline{e}_m$. We may rewrite Equation (6) so as to arrive at the following Proposition.

Proposition 1 *Assume that assumptions A and B hold. The firm will segment markets in period 1 if and only if* $-M+(\Pi(e_1) - \pi(e_1))+(N-M)\left(\int_0^{\underline{e}_n} f(e_2)de_2 + \int_{\overline{e}_n}^{\infty} f(e_2)de_2\right)$
$+\int_{\underline{e}_n}^{\underline{e}_m} [(\Pi(e_2) - \pi(e_2)) - M] f(e_2)de_2 + \int_{\overline{e}_m}^{\overline{e}_n} [(\Pi(e_2) - \pi(e_2))) - M] f(e_2)de_2 \geq$
$0.$

It will be profitable for the firm to continue to segment markets if the cost of doing so (M in the first period) is lower than the gain. The gain consists of the difference in operating profits in period 1 ($\Pi(e_1) - \pi(e_1)$) plus the expected value of entering the next period with segmented markets. There are two parts to this expected value, if $e_2 < \underline{e}_n$or $> \overline{e}_n$ the firm will segment in period 2 no matter what it did in period 1, if it segmented in period 1 it will however only pay M instead of N to do so. The larger the difference between N and M the more important will this term be. For exchange rates that are between thresholds, $\underline{e}_n < e_2 < \underline{e}_m$ (or conversely for a depreciated exchange rate) the firm will operate with segmented markets only if it segmented in period 1. All terms except the first are non-negative and will typically be positive.

For the purpose of the analysis take as reference a firm for which the condition in Proposition 1 holds with equality. Denote the difference in profits in period 1 for which Equation (6) holds with equality by $\Delta_{crit} = \Pi(e_1) - \pi(e_1)$ for some given distribution of e_2. It turns out to be convenient to center a discussion around how Δ_{crit} is affected by changes in the underlying parameters. First observe that

Remark 2 Δ_{crit} *is decreasing in the variance of the exchange rate*

Lower potential for future variability in exchange rates leads a firm to integrate that would otherwise have segmented. By segmenting in period 1 the firm not only increases operating profits from the current period, it also buys an option to segment markets at a lower cost tomorrow. Since the value of the option decreases as variability decreases the firm will need a larger gain today to continue segmenting. For a firm such as this there is thus a fundamental difference between a fixed exchange rate and a monetary union. A fixed exchange rate entails the possibility of large future exchange rate changes - making the option valuable. If demand differs sufficiently between consumers a firm will segment markets also within countries, the presence of variability makes the incentives for doing so stronger.

Most starkly the intuition is brought out if we assume that $e_1 = E(e_2) = 1$ and that the markets are identical such that $\Pi(e_1) - \pi(e_1) = 0$. For sufficiently high future variability the firm will pay the cost of segmenting even though it gains nothing in current operating profits from doing so.

Remark 3 Δ_{crit} *is increasing in* M *and decreasing in* N*.*

Increasing the maintenance cost of segmenting will lead a firm that segmented to integrate. There is a trivial direct effect since increasing M increases the cost of segmenting in period 1. There will be a further effect since $\underline{e}_m$ will decrease and $\overline{e}_m$ will increase. The value of entering period 2 with segmented markets is lower when the cost of maintaining segmentation is high. Many institutional and other details can be seen as affecting M. In the context of price equalization in Europe it should be noted that a common currency comes at the same time as other moves to create a common market are taken. Harder enforcement of competitive rules[8] and elimination of border controls can be seen as making M larger. Clearly, the larger N is the more is the option worth to be able to segment in the future at the lower cost M. Both through the cost of segmenting $(N - M)$ and through shifting the bounds $\underline{e}_n$ and $\overline{e}_n$ closer to the equilibrium exchange rate.

Some observations as to how price equalization based on the present mechanism differs from the more common assumptions of arbitrage making prices equal in all locations after controlling for transport costs deserve to be pointed out. In principle transport costs would affect the cost of M, the lower transport costs between two locations the more would it cost a firm to segment markets. MORE

[8] Volkswagen for instance were fined more than 100 million Ecu in 1997 for (threats of) revoking licences of Italian dealers that sold to Austrian or German customers.

The quite general nature of Proposition 1 deserves to be emphasized. Since the mechanisms behind price discrimination under competition are only beginning to be explored for simplicity we assumed that the firm acted as a monopolist. However, all that is required for results to hold is that profits are higher under price discrimination than without, that the more the demand of the groups differ, the greater is the difference in operating profits and that profits in period 2 are a deterministic function of the exchange rate. The firm does not know the realization of the exchange rate in period 2, it knows however for every possible realization what profits it would achieve - if this were not the case the thresholds would also be stochastic. We used only two periods, extending the analysis to more periods would not change the thrust of results.[9] Previous analysis of sunk costs in conjunction with exchange rates has focused on hysterisis - dependent variables that do not return to pre-shock values after a large shock. Extending the present model to more periods would produce this as well but otherwise offer insufficient insights to motivate the additional complications for our purposes. The flavor of that type of analysis can be seen by the following: assume that in a period 0 $e = 1$ and the firm has integrated markets, then in period 1 there is a large shock to the exchange rate such that segmentation is induced and in period 2 the exchange rate is again 1. If potential variability in e in subsequent periods is sufficiently high the firm will continue to segment markets even though the exchange rate has returned to its original value.

5 Average profits and market segmentation

As noted above the difference in profits between the integrated and segmented case will be important in driving results. Note that in Figure 2 profits in the separated case are strictly convex[10] in the exchange rate whereas they are strictly concave when markets are segmented. The difference between operating profits under integrated and segmented markets is important not only for the thresholds. It will also be of interest to directly examine how profits respond to exchange rate changes. Are exchange rate fluctuations good or bad for profits? For the linear Illustration profits were convex in the exchange rate under segmented markets but concave under integrated. Since we allow prices to be set after the exchange rate is known we focus on longer movements in the exchange rate rather than on daily or monthly variability. Think for example of a Canadian firm selling on the Canadian and US markets during the dollar "swing" of the mid 1980s - how would profits be affected under market segmentation relative to under market integration?

To examine the issue make the additional assumptions that $\frac{\partial^2 C}{\partial q \partial q^*} = 0$ and

[9] The related literature on hysterisis in trade also finds that results are robust. Baldwin (1988) examines Cournot competition and one time shocks to the exchange rate, Baldwin and Krugman (1989) examine a monopoly firm subject to iid exchange rate shocks, Dixit examines perfect competition and models the real exchange rate as a Brownian motion. They all find similar results.

[10] The strict convexity is easier to see if you put a ruler under the curve.

$\frac{\partial C}{\partial e} = 0$.[11]

Proposition 4 *Under segmented markets average profits are increasing in exchange rate variability (if* $\frac{\partial C}{\partial q^*} \neq 0$*).*

Proof. Average profits are increasing in the variability of the exchange rate if profits are strictly convex in the exchange rate, if $\frac{d^2\Pi}{de^2} > 0$. $\Pi = pq(p) + ep^*q^*(p^*) - C(q, q^*)$. Totally differentiating profits yields (using that $\frac{\partial^2 C}{\partial q \partial q^*} = 0$ and thus that $dp = 0$ and evaluating around optimum) $\frac{d^2\Pi}{de^2} = \frac{\partial^2\Pi}{\partial p^{*2}}\left(\frac{dp^*}{de}\right)^2 + \frac{\partial^2\Pi}{\partial e^2} + 2\frac{\partial^2\Pi}{\partial p^*\partial e}\frac{dp^*}{de}$. Totally differentiating the first order condition for profit maximization yields $\frac{dp^*}{de} = -\frac{\partial^2\Pi/\partial p^*\partial e}{\partial^2\Pi/\partial p^{*2}}$. Use this and that $\frac{\partial^2\Pi}{\partial e^2} = 0$ to establish that $\frac{d^2\Pi}{de^2} = \frac{\left(-\partial^2\Pi/\partial p^*\partial e\right)^2}{\partial^2\Pi/\partial p^{*2}} - 2\frac{\left(\partial^2\Pi/\partial p^*\partial e\right)^2}{\partial^2\Pi/\partial p^{*2}} = -\frac{\left(\partial^2\Pi/\partial p^*\partial e\right)^2}{\partial^2\Pi/\partial p^{*2}}$. Second order conditions for profit maximization require that $\frac{\partial^2\Pi}{\partial p^{*2}} < 0$. $\frac{\partial^2\Pi}{\partial p^*\partial e} \neq 0$ (marginal revenue measured in Foreign currency) if $\frac{\partial C}{\partial q^*} \neq 0$. This establishes that $-\frac{\left(\partial^2\Pi/\partial p^*\partial e\right)^2}{\partial^2\Pi/\partial p^{*2}} > 0 \; iff \; \frac{\partial C}{\partial q^*} \neq 0$. ■

The intuition for this result is straightforward - if prices on the two markets are unchanged the relation between the exchange rate and profits will be linear, which means that average profits are unaffected by exchange rate variability. By pursuing an optimal policy the monopolist will do better and achieve profits that are convex in the exchange rate, increasing in the variability of the exchange rate.[12]

The result corresponds closely to the result of Oi (1961) that the profits of a price taker are convex in the variability of the price. By setting quantity (price) optimally in each period the firm makes the best of the good times (high price, depreciated exchange rate) and by cutting back in unfavorable conditions it limits the effects of adverse movements in the price or exchange rate. Indeed, it can be seen as corollary to results in Friberg and Martensen, 1999, which analyzes the impact on profits from variability of input costs.

Now turn to the integrated markets case, the reason for why profits can be concave is that as the exchange rate moves and markets are integrated the price that consumers face on the two markets will differ from the optimal price on that market. A depreciation of the firm's home currency will be equivalent to having a lower cost of producing for the Foreign market - something that will increase profits. When markets are integrated this positive effect is tempered

[11] Both these assumptions could be relaxed without changing the flavor of results. The first assumption is convenient since it implies that optimal quantity on the Home market is unaffected by an exchange rate change when markets are segmented. The second assumption catches that costs tend to be rigid in the producers currency (we may for instance think of labor as the only input in production and let nominal wages be fixed). Allowing for some direct effect on costs from an exchange rate change would complicate the analysis (what share, what pass-through) without changing exchange rate pass-through.

[12] The reason why profits are linear in the exchange rate when marginal costs are 0 is that the exchange rate then cancels from the first order condition. Thus foreign price and quantity do not change and changes in the exchange rate will shift profits linearly.

by that the price set will be an unhappy compromise between the prices that would be optimal on each market. If the first effect is sufficiently low profits will increase at a decreasing rate when the exchange rate depreciates, profits will be concave in the exchange rate and variability will lower average profits.

Average profits are decreasing in variability of the exchange rate if profits are strictly concave in the exchange rate, if $\frac{d^2\Pi}{de^2} < 0$. Totally differentiate $\pi(\overline{p}(e), e)$ twice yields (evaluating around optimum) $\frac{d\pi^2}{de^2} = \frac{\partial^2\pi}{\partial\overline{p}^2}\frac{d\overline{p}^2}{de^2} + \frac{\partial^2\pi}{\partial e^2} + 2\frac{\partial^2\pi}{\partial e\partial\overline{p}}\frac{d\overline{p}}{de}$. The first term will be negative and so will the second for a broad class of demand and cost functions.[13] The last term however will be positive, a depreciation of the home currency leads to a higher optimal price in home currency terms and the cross-effect will be the same sign. The more concave that demand is as a function of price and the more convex that costs are, the more likely are profits to be concave in the exchange rate.

6 Extensions

We will in the following briefly explore the sensitivity of the conclusions to extensions and discuss some additional results that emerge from an analysis of the issues in this paper. We start with the case when the firm faces competition and proceed to sketch an analysis of general equilibrium.

6.1 Competition

Only recently has the literature on price discrimination started to examine the case of competition (see for instance Corts, 1998). General results on the mechanisms above when the firm faces competition is left for future research. We know from the literature on multi-market contact that originated with Bernheim and Whinston (1990) that results are sensitive to the set-up of the game, such as the sequencing of moves and the form of competition. We also know that whether markets are segmented or not is crucial for competition in a international duopoly.[14] In this section we will contend ourselves with examining a simple case, the same as in Section 3 but with a competing firm. We thus examine the case of two firms (a, b) from the Home country that compete on both markets. Let the two firms each produce a good which is an imperfect substitute for the other firm's good and let demand functions in the two countries be linear in prices. Let cost functions be identical with constant marginal costs and assume that firms have Nash conjectures on price responses (Bertrand). As before let Π denote profits when of a firm that segments markets and π of a firm that integrates markets. Let a $'$ signify that the other firm segments. Let x denote the price of firm b. The maximization problems facing firm a in period

[13] The corresponds to the case with pre-set prices see for instance Donnenfeld and Zilcha (1991) or Friberg (1998).

[14] See for instance Brander (1995) for a discussion.

$i = 1, 2$ (suppressed) is thus given by

$$\begin{aligned}
\Pi &= \max_{p,p^*} (p-c)(1-p+\gamma x) + (ep^* - c)(1-p^*+\gamma x/e) \\
\Pi' &= \max_{p,p^*} (p-c)(1-p+\gamma x) + (ep^* - c)(1-p^*+\gamma x^*) \\
\pi &= \max_{p} (p-c)(1-p+\gamma x) + (p-c)(1-p/e+\gamma x/e) \\
\pi' &= \max_{p} (p-c)(1-p+\gamma x) + (p-c)(1-p/e+\gamma x^*)
\end{aligned}$$

and equivalently for firm b. We may solve these equations in standard fashion to arrive at profits as a function of underlying parameters. Figure 4 plots Π, Π', π and π' under the same parameter values as in Section 3.

Figure 3 about here

When $e = 1$ all the strategies yield the same profits. As the exchange rate differs from 1 they will yield different payoffs. Segmenting markets always yields higher operating profits, no matter what the other firm does. In this sense segmenting markets is a dominating strategy and for a low enough cost of continuing to segment markets and sufficiently high future potential exchange rate volatility the firms will continue to segment markets even when the exchange rate is equal to its equilibrium value. Therefore Proposition 1 holds also under this form of competition. Under the most natural extension the results from the monopoly analysis thus carry over to the case when the firm faces competition. Further analysis of competition will have to be left for future research.

6.2 General equilibrium

The results presented in this paper are in all likelihood generalizable to general equilibrium. Of particular interest would be the externality associated with market segmentation that should be typically be present. If the firm does not change foreign price proportionally to an exchange rate change (when markets are segmented) it increases the correlation between real and nominal exchange rates by segmenting.

Consider a setup of the following type. Assume that Home is very large in relation to Foreign such that the price under integrated markets would almost exclusively be geared to Home, that there is a continuum of firms in the economy who each produces a differentiated good with labor as only input. Let wages be pre-set. Assume further that the demand function facing firms is such that exchange rate pass-through is less than full ($\frac{dp^*}{de}\frac{e}{p^*} > -1$). Consider now a nominal exchange rate change. If all other firms segment markets the nominal exchange rate change will have a great impact on the real exchange rate since Foreign prices will only respond by half the exchange rate change. Since the real exchange rate varies it will pay for a single firm to segment markets as well (for sufficiently low M).

Consider instead the case where no other firm segment markets. From the assumption that Foreign is small it follows that prices expressed in Home currency will not change when there is an exogenous exchange rate change. There will be complete pass-through onto Foreign prices and consequently the nominal exchange rate change will have no real exchange rate implications. Since the real exchange rate is constant it will not be profitable to segment markets as the relative purchasing power of consumers is constant.

By comparing the decision when no other firm segments with the one where every one else segments we see that there is an externality associated with a firms decision to segment markets, by segmenting markets a firm increases the correlation between real and nominal exchange rates.

Before concluding we should relate to the rapidly expanding literature which has become known as the "new open economy macroeconomics" (see e.g. Obstfeld and Rogoff, 1995, 1999, Betts and Devereux, 1996 or Devereux and Engel, 1998). These models have proven very useful for many purposes and appear at first glance to present an excellent framework in which to examine the current issues - there is monopolistic competition and two countries that are equal in equilibrium (which made the conclusions in Proposition 1 particularly stark). Especially Obstfeld and Rogoff (1999) are close to the setup in the present paper since they allow (labor) costs to be rigid but let prices be set after uncertainty is resolved.

However, this literature employs constant elastic demand and has constant marginal costs. Optimal prices under segmented markets on the two markets are then given by (with ρ denoting the constant demand elasticity and c marginal cost)

$$p = ep^* = \left(\frac{\rho}{\rho - 1}\right) c \;\forall e$$

The pass-through elasticity of an exchange rate change is perfect ($\frac{dp^*}{de}\frac{e}{p^*} = -1$) - optimal prices on the two markets will always be equal and market integration poses no restriction on profits. As soon as optimal prices differ across markets, $\Pi > \pi$, consequently if markets are equal in equilibrium only for a firm that exhibits perfect pass-through will it be of no value to segment markets.

One branch of the literature has assumed that a share of traded goods have prices that are pre-set in the consumers currency and that LOP does not hold on these goods (Betts and Devereux, 1996, Devereux and Engel, 1998). The goal of general equilibrium modeling of the mechanisms in this paper would be to make the share of firms that segment markets endogenous. This is far from straightforward however. Assume, as do Betts and Devereux (1996) that prices are set under certainty. In line with the argument above assume that all other firms "price-to-market" in the sense that they set prices in the consumers' currency and (costlessly) segment markets. What should your firm do? The optimal price in such a setup is given by the constant elastic formula above. The way for the firm to assure that Foreign *actual* ex post prices are equal to *optimal* ex post prices, is to set prices in the Home currency and not segment markets![15] If menu costs were given as the motivation for the rigid prices it

[15]If uncertanty is explicitly introduced as in Devereux and Engel (1998) the first order

would thus be nonoptimal to set price in the foreign currency. Figure 4 (inspired by Romer, 1996) might be clarifying. Profits from sales to the foreign market under two values of the exchange rate ($e = 1$ and $e = e' > 1$) are plotted against the foreign currency price. When $e = 1$ the optimal price is $\widehat{p}^*$and when $e = e'$ the optimal price is $\widehat{p}^{*\prime}$. Since optimal pass-through is unity setting price in the producer's currency implies an optimal adjustment of the Foreign currency price. If price were pre-set in the importers currency the firm would instead end up at point B on the profit curve when its currency depreciates.

Figure 4 about here

Constant elastic demand may be very convenient for many applications but clearly is problematic if we want to endogenize market segmentation. Bergin and Feenstra (1999) extend a model of the Obstfeld-Rogoff type to a demand function yielding less than full pass-through. This could prove a valuable starting point for analysis of endogenous segmentation in a general equilibrium setting. However they rely on linearizations to handle the model which also is problematic in that the greater curvature of profits in the exchange rate under segmented markets is driving results.

7 Conclusions

Whether to think of international markets as segmented or integrated is central to a large number of issues on international economics. Rather than examining the frictions that segment markets we analyzed the incentives for market segmentation and how these incentives depend on the possibility for future shifts in demand of different groups of consumers. It should be stressed that the present paper has not tried to make a welfare analysis of monetary union. Rather we wanted to explore if there could be a basis for beliefs that monetary union could imply goods market integration and to understand a potential mechanism.

A number of extensions present themselves - it should in many cases be straightforward to extend the analysis to other forms of competition. General equilibrium analysis should be very fruitful but has some pitfalls as noted. We examined the case of third degree price discrimination, recently Anderson and Ginsburgh (1999) have examined second degree price discrimination in an international setting. Consumers in the rich country differ in their search costs and a second market may be open only to serve those customers with the lowest search costs. In such a framework exchange rate changes would shift the marginal consumer for which the incentive constraint is binding and we are in a similar fashion likely to observe an option value associated with market segmentation.

The theories also lend themselves well to empirical examination. Further studies of deviations from LOP and PPP under various institutional arrange-

conditions become more complicated and include a term capturing a risk premium stemming from the covariance between firm profits and consumption - here it might be more fruitful to try to endogenize the market segmentation decision but the above example nevertheless suggests that we would like to examine a model where optimal pass-through differs from unity.

ments should be valuable.[16] Tentatively one could also see some connection between hysterisis in a model of the present type and the amazingly long time that the world economy remained more segmented after World War 1 than before. Most notably it will be exciting to observe how price differentials develop within the EMU. The mechanisms explored in this paper should show up not only in price differentials but also in issues as if products differ between markets - is the same product name employed? Does packaging have text in several languages? Where is a warranty honored?

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Figure 1. Profits on the Home and Foreign markets

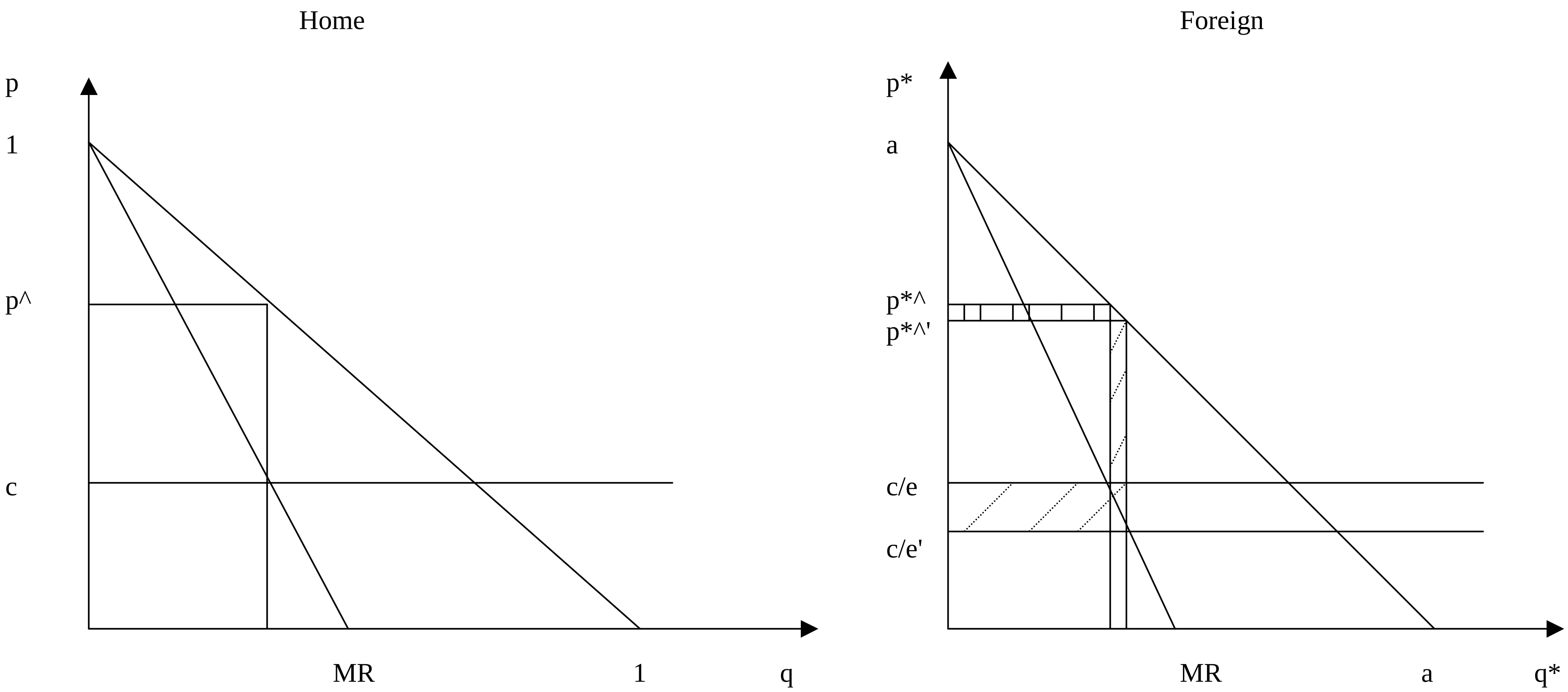

Figure 2. Profits with segmented and integrated markets with costs of segmenting and threshold values of the exchange rate.

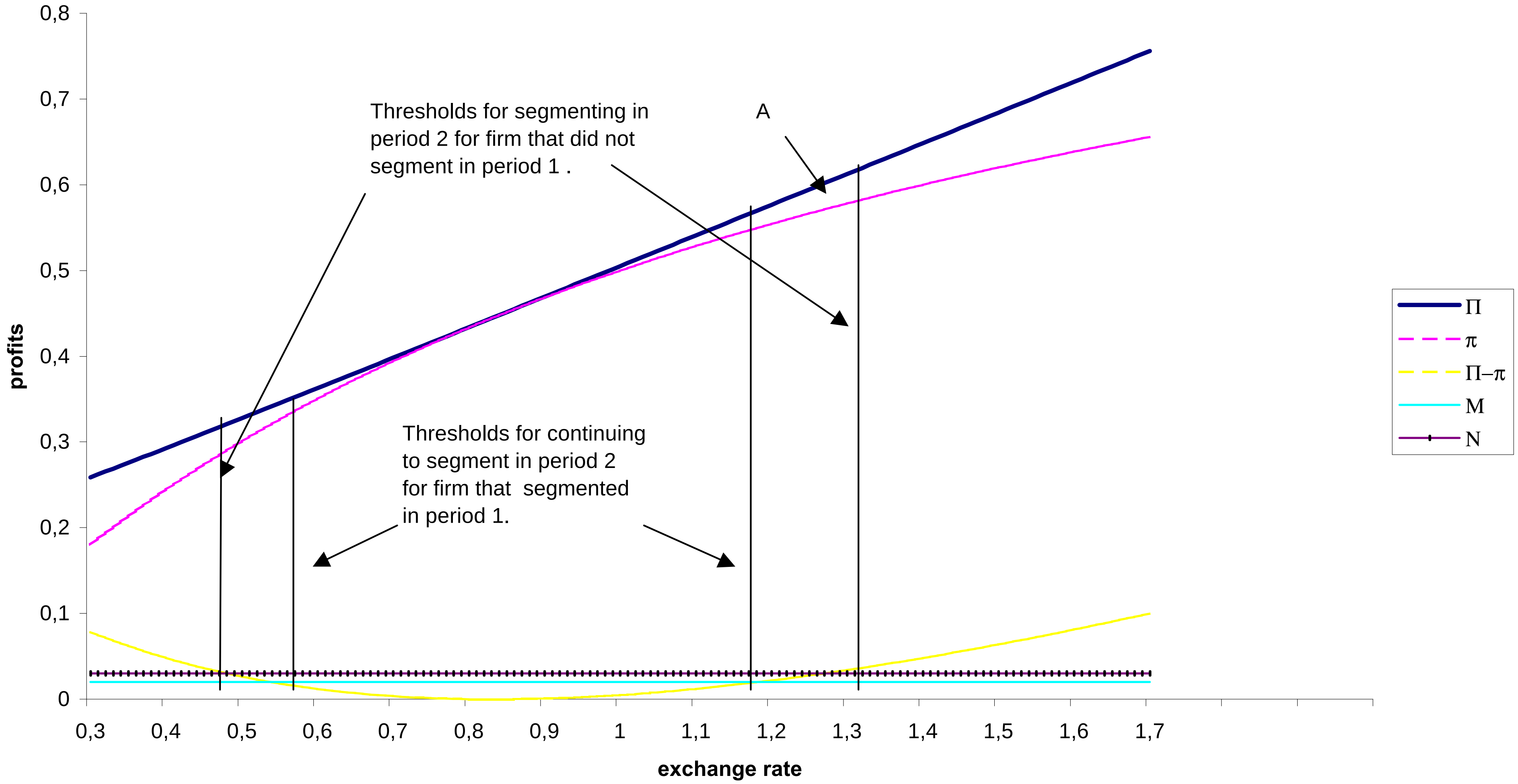

Figure 3 Profits as a function of the exchange rate under competition

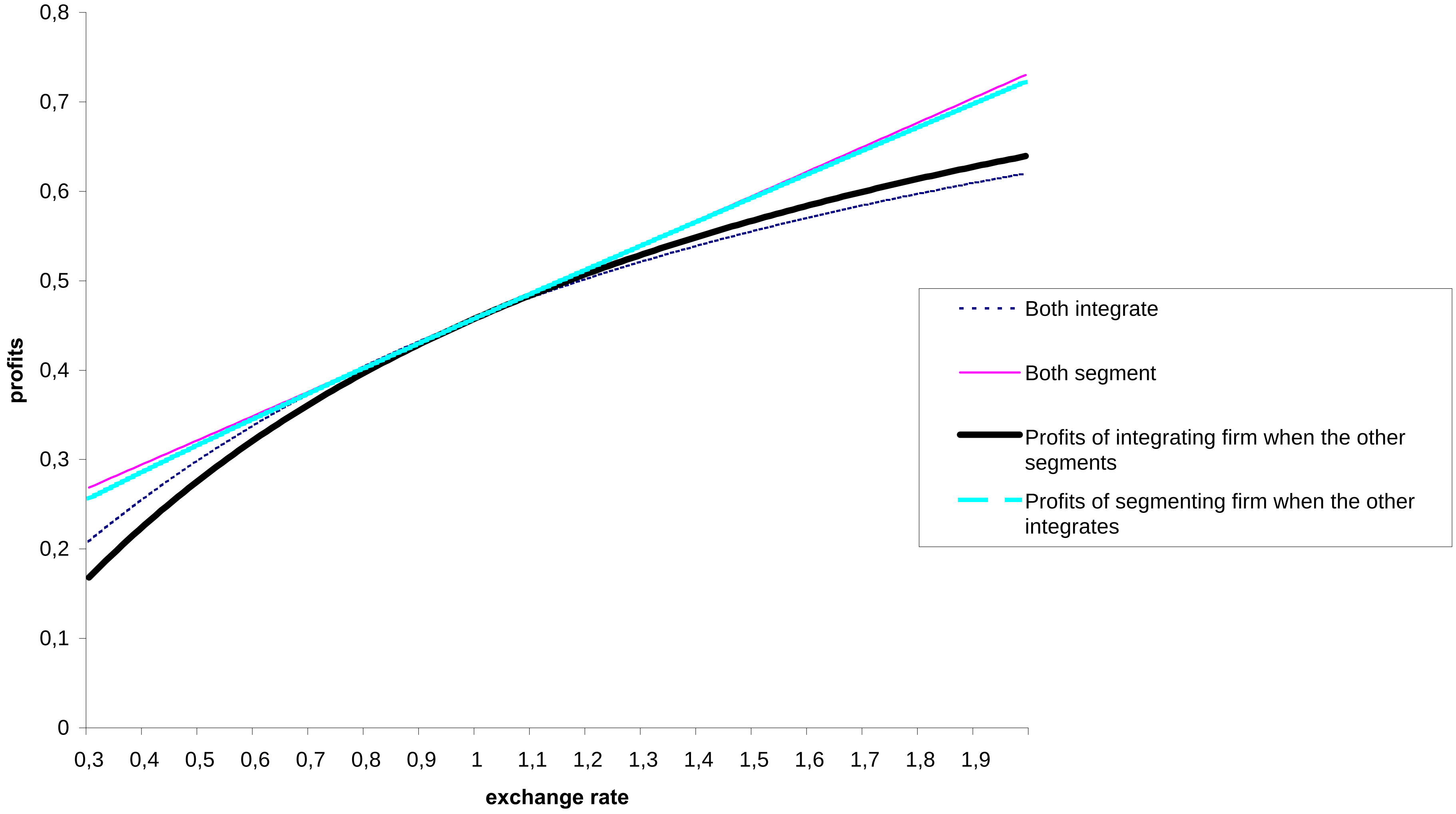

Figure 4. Profits from Foreign market