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Two monies, two markets? Variability and the option to segment

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Abstract

This paper examines the decision to create barriers to arbitrage for a firm selling on two national markets. Real exchange rate changes affect the incentives to create such barriers since they influence the optimal prices. Sunk costs of market segmentation imply that the option to segment markets is more valuable the greater the variability of the real exchange rate. If a monetary union reduces future real exchange rate variability it could thus stimulate market integration. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Why does arbitrage exert so weak equalizing pressure on prices across national borders? Large deviations from the law of one price (LOP) for traded goods are pervasive and many firms are able to react to exchange rate variability by ‘‘Pricing-to-market’’, stabilizing prices in the consumer's currency (see Engel and Rogers, 1996 and Goldberg and Knetter, 1997). One path to understanding why the border matters so much for prices is to study the frictions that segment markets, such as different cultures, languages, difficulties in enforcing contracts and informational asymmetries.

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This paper explores another path. We examine the decision to create frictions. By its control of distribution, marketing and product design a firm may increase the price differential needed to make arbitrage attractive. Vertical restraints having different brand names in different locations and bundling with non-traded goods are examples of practices that facilitate segmentation. Such measures allow the firm to charge different prices to different groups of consumers – this is known as third degree price discrimination and is profitable if demand elasticities or marginal costs differ across markets.[1] However, the mechanisms that segment are likely to be associated with some costs for the firm. In a one period problem the firm will segment markets if the gain in profit from segmenting outweighs the cost. In addition, it is often realistic to think of the costs for these hinders to arbitrage as sunk. For example, the resources devoted to building a separate brand name in a country are typically not recoupable should the firm decide to integrate and use the same brand name as in other countries. By segmenting today the firm then buys an option to segment tomorrow at a lower cost – an option that increases the value of segmenting today.

The lower the probability that the optimal prices will differ much between markets in the future, the less is the option to segment worth. Thus, less potential for fluctuations in purchasing power between two similar markets leads to a lower value of being able to segment those markets.[2] To the extent that lowering the nominal exchange rate variability lowers the real exchange rate variability, the mechanism in this paper implies greater market integration as a result of a monetary union.

Close in spirit to the analysis are Baldwin and Krugman (1989) and Dixit (1989) who view the decision to be present on a foreign market as a sunk cost but ignore the Home market. Related is also Broll and Eckwert (1999) who show that for a price taking firm, active on two segmented markets, increasing exchange rate volatility increases the value of the option to export.

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[1] Gould (1977) analyzes price discrimination as a motivation for vertical control. In an international context Horn and Shy (1996) analyze bundling of traded goods with non-traded goods and resulting deviations from LOP. Somewhat related is also Malueg and Schwartz (1994) who analyze welfare effects of market segmentation and arbitrage.

[2] 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 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 exchange rate thus appears to play an important role in a story of price discrimination on European car markets, and therefore for the incentives to segment markets.

2. The model

This section sets out a stylized partial equilibrium model to analyze the decision to segment markets. Examine the maximization problem facing a firm which produces a good that it sells on two markets denoted Home and Foreign. Let there be two periods $i = 1,2$. Each period has the following sequence of events: first the real exchange rate, e, for period i is observed, the firm then decides whether to separate or integrate markets in period i, sets price(s) for period i, and period i profits are realized. Let e denote the Home currency price of Foreign currency such that an increase in e signifies a depreciation of the Home currency. The real exchange rate in period 2, e_2, is assumed to be a random variable with a continuous probability density function $f(e_2)$. Assume that the firm is owned by Home residents and maximizes expected real profits measured in Home currency. To simplify the analysis we choose to disregard issues of how the prices of the owners' consumption or their discount rate vary with the exchange rate. Therefore assume that the Home aggregate price index is fixed and let the discount rate equal 1.

If markets are segmented, operating profits are given by Π_S and if markets are integrated operating profits are given by Π_I. Under integrated markets prices (p and p^* respectively) must be set so that LOP holds whereas under segmented markets the firm is free to set the optimal price to each market. Costs of production are given by $C(q,q^*)$ where q and q^* are quantities sold in Home and Foreign, respectively. The per period profit maximization problems are given by (time index suppressed):[3]

$$
\begin{aligned}
\Pi_S &\equiv \max_{p,p^*} pq(p) + ep^*q^*(p^*) - C(q,q^*) \\
\Pi_I &\equiv \max_{p,p^*} pq(p) + ep^*q^*(p^*) - C(q,q^*) \text{ s.t. } p = ep^*
\end{aligned}
\tag{1}
$$

The firm faces a decision of whether to segment the two national markets. Assume that segmenting markets is associated with a maintenance cost M if markets were segmented in the last period and a cost N otherwise, with $N > M$.

By operating under segmented markets the firm gains an additional degree of freedom so that clearly $\Pi_S \geq \Pi_I$ for all levels of the exchange rate. By shifting the relation between the optimal prices, changes in e will affect $\Pi_S - \Pi_I$. To establish results we make the very weak assumptions that operating profits are higher under price discrimination than without, that $\Pi_S - \Pi_I$ has a unique minimum (which may be 0) and that the loss of not being able to price discriminate increases as e moves

[3] In principle one could let demand in each location explicitly depend on other variables which may change over time – tastes, technology and prices of other goods. The high variability of exchange rates relative to other demand shifters and the weak links between exchange rates and fundamentals (see Obstfeld and Rogoff, 2000 b) serve as motivation for the focus chosen.

away from this minimum.[4] Assumptions A imply that $\Pi_S - \Pi_I$ is a U-shaped function of e.

Assumptions A. (i) In each period there is a unique exchange rate which minimizes $\Pi_S - \Pi_I$, denoted e_{min}. (ii) $\infty > d(\Pi_S - \Pi_I)/d|e - e_{min}| > 0$.

Before proceeding let us point out one very special case which is ruled out by Assumptions A, that of constant marginal costs and constant elastic demand which is equal in both countries. Optimal prices under segmented 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 $[(dp^*/de) e/p^* = -1]$ – optimal prices on the two markets will always be equal since demand elasticities are equal and market integration poses no restriction on profits.

In the following we consider the firm's decision of whether to segment at the beginning of period 1. Assume that it enters period 1 with segmented markets, so that the cost of segmenting in period 1 is M. If the firm wishes to segment in period 2 it does so at a cost M if it segmented in the first period, and at a cost N otherwise. Since the decision to segment in period 2 depends on what was done in period 1, this has to be taken into account in the period 1 decision. We therefore start by analyzing the decision in period 2.

3. The decision to segment markets

3.1. Period 2

To examine the choice of whether to segment markets begin by finding the threshold values of e_2 at which a firm that segmented in period 1 will continue to segment in period 2. The firm will continue to segment if

$$\Pi_S(e_2) - M \geq \Pi_I(e_2) \quad (2)$$

[4]The assumptions are implied by the LeChatelier 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 thus be more convex than profits where the relative price $p/ep^* = 1$. Thus, Assumption A will hold under some regularity conditions, we have not pursued the exact nature of those regularity conditions (see Roberts, 1999, for a discussion of such conditions). Importantly we make no assumptions as to competitive structure (except that the difference in profits should be differentiable, and thereby continuous).

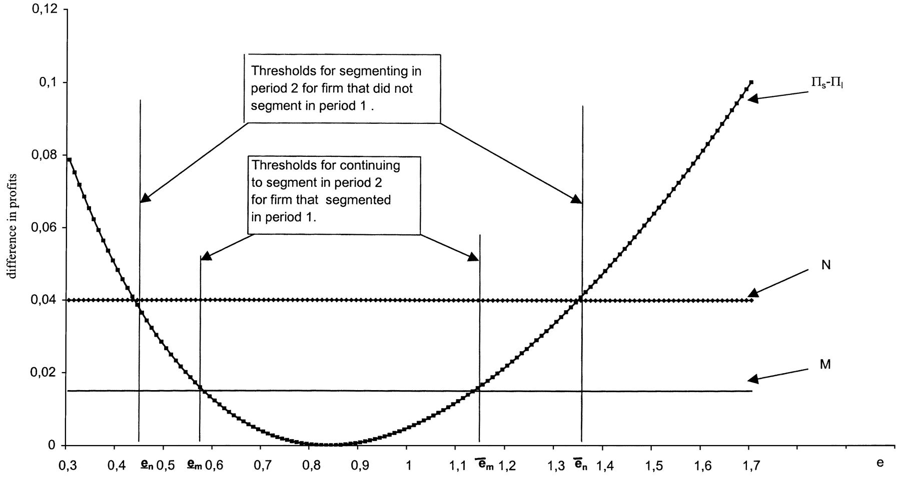

Fig. 1. Difference in profits between segmented and integrated markets with costs of segmenting and threshold values of the exchange rate.

Assumptions A assure that (2) yields two thresholds at which the relation holds with equality, $\bar{e}_m$ and $\underline{e}_m$ with $\bar{e}_m > \underline{e}_m$.

Similarly

$$\Pi_S(e_2) - N \geq \Pi_I(e_2)$$

yields two thresholds at which a firm that integrated in period 1 will choose to segment in period 2, $\bar{e}_n$ and $\underline{e}_n$ where $\bar{e}_n > \underline{e}_n$. The ranking of the thresholds is such that $\underline{e}_n < \underline{e}_m < \bar{e}_m < \bar{e}_n$. Fig. 1 illustrates $\Pi_S - \Pi_I$ as a function of the exchange rate and the thresholds.[5]

For period 2 levels of the exchange rate between $\underline{e}_m$ and $\bar{e}_m$ the firm will integrate markets since the difference in operating profits between integrated and segmented markets is too small to motivate segmentation. For $\bar{e}_m < e_2 < \bar{e}_n$ a firm that segmented in period 1 will continue to do so and gain higher profits than a firm which integrated in period 1 (which will continue to integrate since $N > M$). If the exchange rate is more depreciated than $\bar{e}_n$, translating into a higher e, a firm will segment no matter what it did in period 1, but the cost of doing so will depend on its history.

3.2. Period 1

In period 1 the firm will segment markets if the benefit from segmenting

[5] Friberg (2000) derives this Fig. from an examination of a specific example, discussed at some length, with linear demand functions and constant marginal costs.

exceeds the benefit of integrating, that is if

$$\Pi_{\mathrm{S}}(e_1) - M + \int_{\underline{e}_m}^{\bar{e}_m} \Pi_{\mathrm{I}}(e_2) f(e_2)\,\mathrm{d}e_2 + \int_0^{\underline{e}_m} [\Pi_{\mathrm{S}}(e_2) - M] f(e_2)\,\mathrm{d}e_2 + \int_{\bar{e}_m}^{\infty} [\Pi_{\mathrm{S}}(e_2) - M] f(e_2)\,\mathrm{d}e_2 \geq \Pi_{\mathrm{I}}(e_1) + \int_{\underline{e}_n}^{\bar{e}_n} \Pi_{\mathrm{I}}(e_2) f(e_2)\,\mathrm{d}e_2 + \int_0^{\underline{e}_n} [\Pi_{\mathrm{S}}(e_2) - N] f(e_2)\,\mathrm{d}e_2 + \int_{\bar{e}_n}^{\infty} [\Pi_{\mathrm{S}}(e_2) - N] f(e_2)\,\mathrm{d}e_2 \quad (3)$$

Rewriting (3) establishes

Proposition 1. *Under assumptions A the firm will segment markets in period* 1 *if and only if*

$$-M + (\Pi_{\mathrm{S}}(e_1) - \Pi_{\mathrm{I}}(e_1)) + (N - M)\left(\int_0^{\underline{e}_n} f(e_2)\,\mathrm{d}e_2 + \int_{\bar{e}_n}^{\infty} f(e_2)\,\mathrm{d}e_2\right) + \int_{\underline{e}_n}^{\underline{e}_m} [(\Pi_{\mathrm{S}}(e_2) - \Pi_{\mathrm{I}}(e_2)) - M] f(e_2)\,\mathrm{d}e_2 + \int_{\bar{e}_m}^{\bar{e}_n} [(\Pi_{\mathrm{S}}(e_2) - \Pi_{\mathrm{I}}(e_2))) - M] f(e_2)\,\mathrm{d}e_2 \geq 0.$$

It will be profitable for the firm to continue segmenting 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 $(\Pi_{\mathrm{S}}(e_1) - \Pi_{\mathrm{I}}(e_1))$ 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 $e_2 > \bar{e}_n$ the firm will segment in period 2 no matter what it did in period 1. The larger the difference between N and M the more important will this term be. For exchange rates that are between thresholds, $\underline{e}_n < e_2 < \underline{e}_m$ (and conversely for a depreciated exchange rate) the firm will operate with segmented markets only if it segmented in period 1. The model thus exhibits hysterisis in the sense that whether the firm segments markets or not depends on history. All terms except the first are non-negative and the last three will be positive if some of the probability mass of the exchange rate distribution falls outside the thresholds. This points us to the following corollary:

Corollary 2. *A redistribution of the probability mass of* e_2 *from the region where the firm would integrate, to the region where it would segment, increases the value of segmenting markets in period* 1.

Proof. See Appendix A □

Note that the corollary does not hinge on a belief that the exchange rate should move in a certain direction – it is the possibility of real exchange rate changes in either direction that creates the option value. For instance, with $\underline{e}_m > E(e_2) > \bar{e}_m$, a mean preserving spread would promote market segmentation. The financial option equivalent to our real option is then a combination of an out-of-the-money call option and an out-of-the-money put option. In analogy with the real option in this paper that combination will be valuable if the price of the underlying asset moves sufficiently in either direction.

Much evidence is consistent with the notion that lowering nominal exchange rate variability leads to lower real exchange rate variability (see Engel, 1999 or Obstfeld and Rogoff, 2000b). If this is the case, a monetary union would promote market integration by diminishing the potential for real exchange rate variability and thereby reducing the option value of segmenting markets. A fixed exchange rate would have the same implication, however a fixed exchange rate is typically associated with a significant probability of future realignments – and thereby with a larger probability of discrete future changes in the real exchange rate. However, following Friedman (1953), one could argue that limiting nominal exchange rate flexibility may simply increase risk in other variables since the nominal exchange rate may facilitate adjustment to real shocks. If this mechanism is important a monetary union would do little to promote market integration.

The fixed costs of segmenting markets also influence the decision. For instance anti-dumping laws and European rules against market segmentation can be seen as affecting the costs of maintaining and starting segmentation. It is easily shown that increasing M decreases the value of segmenting markets, whereas increasing N raises the value of segmenting markets. In the limiting case where $N = M$ the option value of segmenting vanishes.

3.3. Transport costs and imperfect segmentation

The previous analysis assumed that investing in market segmentation made arbitrage impossible, no matter how large the price differential. We also assumed that under integrated markets price must be set so that LOP holds. This section discusses how the intuition carries over when these assumptions are relaxed, Appendix B contains a more detailed discussion.[6] Use the same framework as in the previous section but assume that there is an exogenous transport cost t for consumers and that the firm may increase this transport cost by an amount F by

[6]Little attention has previously been paid to price discrimination when segmentation is imperfect. Anderson and Ginsburgh (1999) appear to be the first to theoretically examine price setting with imperfect leakage in an international setting. They assume that consumers differ in their transport costs and their model yields both third and second degree price discrimination.

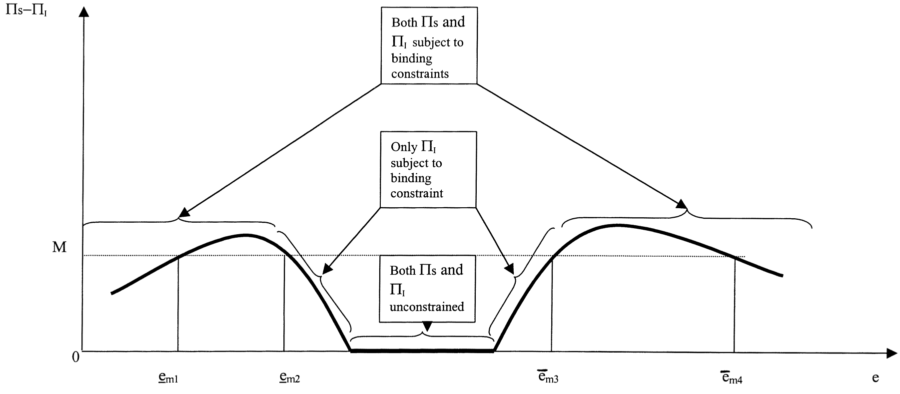

Fig. 2. Difference in operating profits between high and low transport cost cases as a function of the exchange rate in period 2.

paying a maintenance cost M. Profits are denoted Π_I and Π_S, respectively. If prices differ by more than t ($t+F$ when the firm has invested in segmentation) all consumers would buy in the cheaper country. Maximization is thus subject to the constraint that $|p-ep^*|\leq t$ ($\leq t+F$ under Π_S). Fig. 2 illustrates the difference in profits in period 2. The flat section is where both Π_S and Π_I are unconstrained and thus $\Pi_S-\Pi_I=0$. Intuitively, if exogenous transport costs are high enough to make arbitrage unprofitable, there is no point in creating additional barriers to arbitrage.

As optimal prices differ by more than t, Π_I is subject to a binding constraint whereas initially Π_S is not. $\Pi_S-\Pi_I$ is then increasing in the deviation of e following the same logic as in Assumptions A, the firm has bought an additional degree of freedom. However as the exchange rate deviates further, both maximization problems are subject to binding constraints and the difference in profits could taper off or even start declining.[7]

Sufficient weight far out in the tails of the exchange rate distribution will lead the firm to integrate if it is indeed the case that the difference in profits between the integrated and segmented cases diminishes as the exchange rate moves sufficiently far. If the firm believes that there is a high probability of moderate exchange rate variability but a low probability of extreme variability, then the firm

[7]An extreme example would be where the Foreign currency depreciates so much that Foreign demand goes to zero, even if price were set at marginal cost. Then the difference in profits between the ''integrated'' and the segmented'' case would be 0. Some intuition for why Π_I could be increasing more rapidly than Π_S as e depreciates comes from noting that the foreign price under Π_S will be lower than the foreign price under Π_I. Consider a further depreciation, if the foreign demand curve is very concave the quantity increase in response to the price change will be larger under integrated than under segmented markets. Profits from foreign sales would be lower under integrated markets since the price to the foreign market is further from its optimum, but the change in profits could well be larger than for segmented markets, leading to a declining gap.

will continue to segment. As before, higher costs of maintaining segmentation, M, makes segmenting less attractive. In conclusion, allowing for transport costs and arbitrage opportunities does not change the fundamental results that variability creates an option value of market segmentation and that the value of this option is decreasing in the cost of maintaining segmentation.

4. Conclusions

This paper has tried to contribute to our understanding of market segmentation by examining a simple model in which the decision to segment markets is endogenous. Given the importance of market segmentation for several issues in international economics it will be interesting to examine the decision to create barriers to arbitrage in more elaborate settings. It should be straightforward to extend the analysis to examine oligopolistic competition – exogenously segmented markets is a crucial assumption in for instance Brander and Krugman's (1983) model of ''reciprocal dumping''. An important task is to study the welfare aspects of endogenous market segmentation. In contrast to popular belief, price discrimination may be welfare enhancing, see for instance Malueg and Schwartz (1994). Further, Obstfeld and Rogoff (2000b) argue that goods market segmentation can explain many of the puzzles in international macroeconomics. To examine endogenous market segmentation in a general equilibrium setting should therefore be worthwhile. Note however that much recent work in international macroeconomics (such as Obstfeld and Rogoff, 2000a) uses a model in which optimal prices are equal on both markets and there would thus be no point in segmenting markets.

A clear prediction of the model is that (the expectation of) lower real exchange rate variability should promote market integration. It will therefore be exciting to observe how price differentials develop within the economic and monetary union in Europe. The mechanisms explored in this paper should show up not only in price differentials but also in issues such as if products differ between markets – is the same product name employed? Does packaging have text in several languages? Where is a warranty honored? What is the extent of vertical integration?

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Appendix A

Define a probability density function $g(e_2)$ such that $\int_0^s g(e_2)\,\mathrm{d}e_2 \geq \int_0^s f(e_2)\,\mathrm{d}e_2$ $\forall s < \underline{e}_m$ and $\int_t^\infty g(e_2)\,\mathrm{d}e_2 \geq \int_t^\infty f(e_2)\,\mathrm{d}e_2$ $\forall t > \bar{e}_m$ and where the inequality is strict for at least some values of s and t. Let $\int_{\underline{e}_m}^{\bar{e}_m} f(e_2)\,\mathrm{d}e_2 > 0$. Using the expression in Proposition 1, the value of segmenting when e_2 follows the distribution $g(e_2)$ minus the value of segmenting when e_2 follows the distribution $f(e_2)$ is given by

$$(N-M)\left(\int_0^{\underline{e}_n} (g(e_2)-f(e_2))\,\mathrm{d}e_2 + \int_{\bar{e}_n}^{\infty} (g(e_2)-f(e_2))\,\mathrm{d}e_2\right)$$
$$+\int_{\underline{e}_n}^{\underline{e}_m} [(\Pi_\mathrm{S}(e_2)-\Pi_\mathrm{I}(e_2))-M](g(e_2)-f(e_2))\,\mathrm{d}e_2$$
$$+\int_{\bar{e}_m}^{\bar{e}_n} [(\Pi_\mathrm{S}(e_2)-\Pi_\mathrm{I}(e_2))-M](g(e_2)-f(e_2))\,\mathrm{d}e_2.$$

This expression is positive, therefore the value of segmenting markets is greater when e_2 follows the distribution g than when it follows the distribution f.

Appendix B

Profit maximization problems are given by

$$\begin{aligned}\Pi_\mathrm{S} &\equiv \max_{p,p^*}\; pq(p)+ep^*q^*(p^*)-C(q,q^*)\ \text{s.t.}|p-ep^*|\leq t+F\\ \Pi_\mathrm{I} &\equiv \max_{p,p^*}\; pq(p)+ep^*q^*(p^*)-C(q,q^*)\ \text{s.t.}|p-ep^*|\leq t\end{aligned} \tag{A.1}$$

As in Section 2 examine the period one problem of if a firm should continue to segment or not (for simplicity rule out the possibility of starting segmentation). Denote by $e_{\min}$ the level of the exchange rate at which optimal unconstrained prices are equal, $p = ep^*$. The development of $\Pi_\mathrm{S} - \Pi_\mathrm{I}$ is discussed in Section 3.3.

If indeed $\Pi_\mathrm{S} - \Pi_\mathrm{I}$ declines as e deviates there will now be four thresholds where $\Pi_\mathrm{S}(e_2) - \Pi_\mathrm{I}(e_2) = M$, denote these $\underline{e}_{m1}$, $\underline{e}_{m2}$, $\bar{e}_{m3}$ and $\bar{e}_{m4}$ (if it does not decline but only tapers off there will be only two thresholds, $\underline{e}_{m2}$ and $\bar{e}_{m3}$ and the firm is then faced with the same choice as in the base line model). For e_2 such that $\underline{e}_{m2} < e_2 < \bar{e}_{m3}$ the difference in profits is too small to motivate continuing segmentation ($\Pi_\mathrm{S}(e_2) - \Pi_\mathrm{I}(e_2) < M$). For $e_2$such that $\underline{e}_{m1} < e_2 \leq \underline{e}_{m2}$ (and analogously for e_2 such that $\bar{e}_{m3} \geq e_2 > \bar{e}_{m4}$) the difference in profits is large enough to motivate continuing segmentation. Finally for $e_2 < \underline{e}_{m1}$ and $e_2 > \bar{e}_{m4}$ having the extra degree of freedom in price setting is not worth sufficiently to motivate taking the cost of maintaining segmentation. Following the same logic as in Proposition 1 we can establish that the firm will segment in period 1 if and only if

$$- M + (\Pi_S(e_1) - \Pi_I(e_1)) + \int_{\underline{e}_{m1}}^{\underline{e}_{m2}} [\Pi_S(e_2) - \Pi_I(e_2) - M] f(e_2)\, de_2$$

$$+ \int_{\bar{e}_{m3}}^{\bar{e}_{m4}} [\Pi_S(e_2) - \Pi_I(e_2) - M] f(e_2)\, de_2 \geq 0.$$

The more of the probability mass of the exchange rate distribution that falls between $\underline{e}_{m1}$and $\underline{e}_{m2}$ (and $\bar{e}_{m3}$ and $\bar{e}_{m4}$ respectively), the greater is the option value of segmenting in period 1.

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