Exchange Rates and Product Variety

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Abstract

We investigate how variability in the exchange rate affects a firm's choice of number of varieties to offer. We consider a monopoly firm with the possibility to offer one or two varieties of the same good. We show that when markets are relatively similar, exchange rate variability induces the firm to vertically segment markets. This happens because exchange rate variability affects income dispersion and hence the firm's incentives to extract consumer surplus. To better extract surplus, the firm needs to "sort" consumers so that high valuation consumers can be made to pay more without "pricing out" too many consumers. The firm can sort by offering two price-quality menus, high quality variant (priced high) for top-end surplus extraction and a low quality variety (priced low) to address market coverage concern and let consumers self select.

Keywords: exchange rate variability, income dispersion, surplus extraction, product variety

JEL Classification codes: F23, L12

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1 Introduction

The literature on firm behavior under variable exchange rates has focussed on how exchange rate changes affect *pricing policies*: Dornbusch (1987), Goldberg and Knetter (1997); *profits behavior*: Baum et al (2001); Bodnar et al (2002) and *firm strategy*: Friberg (1999, 2001). A common feature of these studies is that the firm's product range is taken as given. In other words, the firm never contemplates changing the output mix as exchange rate variability increases or decreases. But, is export variety independent of exchange rate variability? According to the Economist (November 2001), the launch of the Euro has seen some firms cutting the number of varieties they produce. In an empirical study, Addison (2003) finds a significant effect of a depreciation on export variety[1]. With regard to the article in the Economist, why would a firm find it optimal to reduce the number of varieties when exchange rate variability is reduced to zero? To answer these questions calls for a systematic analysis of the link between exchange rate variability and output variety and that is the focus of this paper.

We study how variability in the exchange rate affects a firm's choice of the number of varieties to produce. In the context of the EMU, will the adoption of the Euro, by eliminating exchange rate variability in the Euro zone, lead to shrinking of product variety across Euroland? If so, why? What is the mechanism by which exchange rate variability affects product variety?

A number of papers have studied whether a vertically differentiated monopoly has an interest to adopt a multi-product strategy under a variety of assumptions about costs and consumer distribution (Gabszewizc et al, (1986); Bonnisseau and Lahmandi-Ayed, (2001); among others. This paper provides an application of these studies by considering how exchange rate variability affects the firm's choice of number of products. We consider a monopoly firm selling in two countries, Home and Foreign. The firm can not observe each individual consumer's type, but knows the distribution from which types are drawn in each country. The monopolist's problem is to choose whether to produce a single brand or two brands.

[1]Baldwin and Krugman (1989) have shown that the level of the exchange rate matters for the firm's decision to enter or exit a foreign market.

Our main result is that exchange rate variability engenders product variety. The main reason is that changes in the exchange rate not only affect the purchasing power of consumers but, more importantly, they affect the dispersion of income and hence incentives to extract surplus. Greater exchange rate variability gives rise to large depreciations which in turn lead to higher income dispersion and this makes it more difficult for the firm to extract surplus with a single product. A single quality (product) forces the firm to *price out* too many consumers but at the same time fails to extract much surplus from the top end of the market. Clearly, these two concerns (market coverage and surplus extraction) are irreconcilable when the firm offers a single product. Hence exchange rate variability induces the firm to choose the two product strategy. This is a classic case of second degree price discrimination. We also find that as market asymmetry increases, it becomes more profitable to offer multiple varieties and when the Foreign market is sufficiently rich, exchange rate variability becomes irrelevant for the firm's choice of product range.

Closely related to the present study is Friberg (2001), who studies how exchange rate variability affects a monopoly firm's decision to "horizontally" segment (international) markets. He shows that with a volatile exchange rate, there is an "option value" to segmenting markets – the ability to third degree price discriminate when it is profitable to do so. This paper blends the literature on vertical product differentiation and that on firms and exchange rates in order to understand how exchange rate variability affects the decisions of exporting firms with respect to the choice of number of varieties.

The paper is organized as follows: In section 2 we set out the model and derive the optimal profits under the alternative strategies. We state and discuss our results in section 3 and section 4 concludes.

2 The Model

2.1 Basic setup

We borrow heavily from Lambertini (2000). Consider a monopoly firm based in Home country (H) and selling in Home country and the Foreign country

(F). The firm has two choices; either the firm sells a single product or the firm sells a vertically differentiated product (two brands) in both countries[2]. In the first case, the firm produces a good of quality q while in the second case the firm produces a high quality good, q_2 and a low quality good, q_1. Quality is chosen from the interval $(0, \infty)$. Total production cost for any variety q_ℓ is $\Gamma_\ell = tq_\ell^2 x_\ell$; $t > 0$ is a constant and x_ℓ is the output of variety ℓ. Thus marginal cost of producing a unit of variety q_ℓ is $c_\ell(q_\ell) = tq_\ell^2$. The firm pays a fixed cost K for every additional brand it produces.

Consumers are uniformly distributed on $[\eta\underline{\theta}, \eta\overline{\theta}]$; $\underline{\theta} = \overline{\theta} - 1 > 0$; where θ denotes the marginal willingness-to-pay for quality[3] and η is a constant measuring the level of affluence. $\boldsymbol{\eta \equiv 1}$ **for Home consumers (throughout the paper)** and $\eta \geq 1$ for Foreign consumers. A generic consumer's net utility takes the form;

$$U(\theta) = \begin{cases} \eta\theta q_i - P_{ij}; i \in \{1,2\}; j \in \{H,F\} \\ 0 \text{ otherwise} \end{cases} \tag{1}$$

where P_{ij} is the price of quality i in market j. We restrict $\overline{\theta}$ so that markets are partially covered, that is, the firm prices out the poorest consumers[4].

We define the exchange rate S as the number of units of the Home currency needed to buy one unit of the Foreign currency. We assume that the exchange rate is independently and identically distributed with mean of unit and variance σ^2, that is, $S \sim \text{iid}(1, \sigma^2)$. We assume that markets are perfectly integrated (in the sense that $P_{iH} = SP_{iF}$).

Given the above preference structure, we can easily solve for the demand functions. Let $\widehat{\theta}$ ($\widehat{\theta}_1$) define the marginal willingness to pay for quality of the individual indifferent between buying one unit of the good and not buying at all when the firm offers a single quality (two qualities) respectively. Then $\widehat{\theta} = P_j/\eta q$ ($\widehat{\theta}_1 = P_{1j}/\eta q_1$). Similarly, let $\widehat{\theta}_2 : \eta\widehat{\theta}_2 q_1 - P_{1j} = \eta\widehat{\theta}_2 q_2 - P_{2j}$,

[2]We do not model the optimal product range here but instead simply assume that the technology is such that the firm can produce either one or two brands.

[3]We implicitly assume that the willingness to pay is highly (if not perfectly) correlated with income, see Gabszewicz et.al, (1986).

[4]For the derivation of the upper bound to $\overline{\theta}$ see the section on partial market coverage in the appendix.

Then $\widehat{\theta}_2 = (P_{2j} - P_{1j})/\eta(q_2 - q_1)$. In the single product case, individuals for which $\theta \in (\widehat{\theta}, \overline{\theta}]$ buy a unit of the good while those with $\theta < \widehat{\theta}$ do not buy. In the two products case, individuals with $\theta \in (\widehat{\theta}_1, \widehat{\theta}_2)$ purchase the low quality good while those with $\theta \in (\widehat{\theta}_2, \overline{\theta}]$ purchase the high quality variety. Demands are thus given by

$$x_j = \overline{\theta} - \frac{P_j}{\eta q} \tag{2}$$

in the single product case and

$$(x_{1j}, x_{2j}) = \left(\frac{P_{2j} - P_{1j}}{\eta(q_2 - q_1)} - \frac{P_{1j}}{\eta q_1}, \overline{\theta} - \frac{P_{2j} - P_{1j}}{\eta(q_2 - q_1)} \right) \tag{3}$$

when the firm offers two varieties.

2.2 Firm's Profits

We derive here the firm's profit functions under the alternative strategies – the single and the two product strategies. We model the firm's decision as a two step process. In the first step, before the realization of the exchange rate, the firm decides on the quality level q. To simplify the analysis, we suppose that the choice of quality is based on the expected exchange rate[5]. The exchange rate is revealed and the firm makes a second move, the choice of price(s). As is standard in this kind of setting, we solve the problem backwards, starting with the second step decision.

Let $n \in \{1, 2\}$ be the number of products offered. Given the qualities chosen in the first stage, the firm chooses prices to solve,

$$\prod = \max_{P_{iH}, P_{iF}} \sum_{i=1}^{n} \left(\left(P_{iH} - tq_i^2 \right) x_{iH} \; + \left(SP_{iF} - tq_i^2 \right) x_{iF} \right) \text{ s.t. } P_{iH} - SP_{iF} = 0 \tag{4}$$

Solving (10) for prices as functions of the quality level, q, and then substituting back into the objective function, we get the reduced form profit function which we can easily solve (letting $S = 1$) for the optimal qualities. Substituting the optimal qualities into the price equations derived in the first

[5] This amounts to assuming that the quality level is independent of the exchange rate.

step we get the optimal prices which we substitute back into the objective function to get the optimal profit. The optimal qualities and prices are[6]:

$$q_i^* = \frac{2i\eta\overline{\theta}}{t\left(2n+1\right)\left(1+\eta\right)} \tag{5}$$

$$P_{iH}^* = \frac{2i\left(\left(1+S\eta\right)i + S\left(2n+1\right)\left(1+\eta\right)\right)\eta^2\overline{\theta}^2}{t\left(1+S\eta\right)\left(2n+1\right)^2\left(1+\eta\right)^2} = SP_{iF}^* \tag{6}$$

The profit functions in the single and two product(s) cases are respectively;

$$\pi_I^* = \frac{2\left(\left(2\eta+3\right)S-1\right)^2\eta^2\overline{\theta}^3}{27St\left(1+\eta S\right)\left(1+\eta\right)^3} \tag{7}$$

$$\pi_{II}^* = \frac{\left(1-\left(4+2\eta\right)S+\left(5+6\eta+2\eta^2\right)S^2\right)4\eta^2\overline{\theta}^3}{25St\left(1+\eta\right)^3\left(1+S\eta\right)} - K \tag{8}$$

where the subscript denotes the number of varieties offered.

From (5) through (8), we see that qualities, prices and profits are increasing in market affluence $(\overline{\theta}, \eta)$ but decreasing in the cost of quality (t). Also, a depreciation of the domestic currency $(\uparrow S)$ raises the domestic price, P_H, but lowers the foreign price, P_F and an appreciation $(\downarrow S)$ has the opposite effect. Thus, a depreciation is tantamount to an increase in the wealth of Foreign consumers and the opposite is true for an appreciation.

Remark 1 *Relative to the qualities when the firm offers two distinct products, a single product monopoly produces a good of intermediate quality. That is,* $q \in (q_1, q_2)$.

Remark 1 follows from (5). High end surplus extraction calls for a high quality whereas greater market coverage calls for a low quality[7]. When the firm offers a single product, these two objectives are mutually incompatible.

[6] We adopt the following convention: If $n = 1$,then $i \equiv 1$ and we drop the *subscript* i whereever it appears. Otherwise $i \in \{1, 2\}$ and we maintain the subscripts.

[7] $\frac{\partial^2 P_{ij}}{\partial q^2} > 0$, that is, price increases in quality at an increasing rate.

Greater market coverage can only be achieved at the expense of high-end surplus extraction and vice-versa. To minimize this incongruence, the firm settles for an intermediate quality – a compromise that permits modest surplus extraction without pricing out too many consumers. On the contrary, with two brands, the firm can tailor qualities to willingness to pay – high quality for high valuation consumers and a low quality for low valuation consumers. This is incentive compatible[8].

Remark 1 contrasts sharply with Gabszewicz et al. (1986) and Bonnisseau and Lahmandi-Ayed (2001) who show that when the firm produces a single product, it pools all consumers on the top quality. In their models, quality is costless and markets are always fully covered. In the present model, however, quality is costly to produce. Thus higher quality necessarily means higher price and hence partial market coverage[9]. Consequently, bunching all consumers on the top quality is not feasible.

By plotting[10] π_I and π_{II} (for $\eta = 1$), we see (figure 1) that π_I and π_{II} diverge as the Home currency depreciates. In other words, π_I is more concave than π_{II}.

Figure 1 about here.

When markets are integrated, profit functions are (strictly) concave in the exchange rate, meaning that the firm looses more in bad times (appreciations) than it gains in good times (depreciations). In other words, the slopes of the profit functions are decreasing in the exchange rate. Hence, greater exchange rate variability leads to lower expected profits. A depreciation lowers profits from Home sales but raises profits from Foreign sales more. However, because LOP binds more as the Home currency depreciates, profit from Foreign sales increases at a decreasing rate and so does the total profit.

What is most interesting about Figure 1 is the fact that π_I is more concave than π_{II}. This means that greater exchange rate variability hurts the

[8] Demands are derived from Individual Rationality and Incentive Compatibility Constraints.

[9] Unless if markets are very rich.

[10] From here on we assume $\overline{\theta} = \frac{8}{5}$ and $t = \frac{256}{375}$. For the calibration of parameters ($\overline{\theta}$ and t), see Appendix A1 and A2.

firm more if it offers a single variety (quality). In other words, offering two varieties allows the firm to reduce the exposure of profits to exchange rate changes (i.e., it makes profits less concave). Another way of looking at this is to note that the profits gap widens as the Home currency depreciates. Hence, we may conjecture that higher exchange rate variability, by allowing for strong depreciations, may induce the firm to choose a multiproduct strategy. In the next section, we show that this is actually the case.

3 Variability and the firm's product range

In this section we analyze the relationship between the **net profit** (the difference between the profit when the firm offers two brands and the profit when the firm offers a single brand) and the exchange rate. In section 3.1 we consider the case where H and F are equally affluent and state our main result. In section 3.2 we relax the symmetry assumption. Section 3.3 considers some robustness checks.

Let $\triangle\pi \equiv \pi_{II} - \pi_I$ denote the *net* profit. Then;

$$\triangle\pi\left(S;\eta\right) = \frac{\left(29 - 66S - 8S\eta + 45S^2 + 24S^2\eta + 8S^2\eta^2\right)2\eta^2\overline{\theta}^3}{675St\left(1+\eta\right)^3\left(1+S\eta\right)} - K \qquad (9)$$

3.1 Symmetric markets $(\eta = 1)$

Let $[\widetilde{S}, \widehat{S}] = [0.806\,36, 1.19364]$. Independent of $\overline{\theta}$ and t; $\triangle\pi\left(S\right)$ is convex for $S \leq \widehat{S}$ and concave thereafter. Figure 2 plots the *net* profit function.

Figure 2 about here.

Let $\varphi = \sup \sigma^2_{\widetilde{S},\widehat{S}}$; where $\sigma^2_{\widetilde{S},\widehat{S}}$ is the variance when draws of S are restricted to the interval $[\widetilde{S}, \widehat{S}]$. Then we have;

Proposition 1 *Suppose* $\triangle\pi(1) = 0$. *For* $0 < \sigma^2 \leq \varphi$, *a monopoly firm with the possibility to offer one or two products will always offer two products.*

Sketch of Proof: $\triangle\pi$ is convex for $S \in [\widetilde{S}, \widehat{S}]$. Thus for $0 < \sigma^2 \leq \varphi$, $E[\triangle\pi(S)] > \triangle\pi(1)$. Hence the firm offers two products.

The intuition is as follows: Exchange rate variability affects the purchasing power of consumers, but more importantly here, it affects the dispersion of income[11]. It is this effect (effect on income dispersion) that matters for the firm's choice of product range[12]. For example, a depreciation makes the Foreign market richer but also generates greater dispersion in willingness to pay. This confronts the firm with a dilemma: On one hand, as the Foreign market gets richer, the firm finds it more costly to price out many consumers (by charging a higher price) but on the other hand, the higher spread in willingness to pay creates incentives for the firm to want to charge a higher price so as to extract more surplus from the top end of the market. These two can not be reconciled with the firm offering a single product. The firm thus needs to offer both high and low quality products. Offering two products is more profitable because it enhances surplus extraction at the top and at the same time permits greater market coverage[13].

A depreciation of the Home currency has a stronger total effect than an equal appreciation under symmetric markets. To see this, note that an appreciation of $\triangle S$ has the same (in absolute terms) *total demand effect*[14] as a depreciation of $\triangle S$. Hence, since S is iid, exchange rate variability is neutral with respect to total demand. However, a depreciation has a stronger conversion-effect[15] *(The effect of the level of the exchange rate on Foreign earned profits expressed in terms of the Home currency).* Put simply, the firm gains relatively more from selling two products (compared to a single product) under a favorable exchange rate than it looses under a less favorable

[11] Consumers have unit demands, so an increase in income will not translate into a corresponding increase in demand by an individual consumer.

[12] Gabszewicz et al. (1986), page. 284.

[13] There is a monotone relationship between market coverage and the number of varieties. The more varieties the firm offers, the greater the degree of market coverage.

[14] How much total demand changes following a marginal change in the exchange rate.

[15] When Home currency depreciates, you convert Foreign earned profits at a more favourable rate.

exchange rate. However, the ability to extract surplus is somewhat curtailed by arbitrage concerns. On one hand, a "strong" depreciation of the Home currency weakens top-end surplus extraction in the (richer) Foreign market but on the other hand it mitigates the inability to extract surplus through the conversion effect. It is the interplay of these two that determines the curvature of the *net* profit function. The stronger the depreciation, the more LOP binds and the less convex the *net* profit function becomes.

Conjecture *A monopoly firm offers at least as many varieties under a floating exchange rate regime compared to a fixed exchange rate regime.*

A floating exchange rate regime allows for exchange rate variability leading to proposition 1 whereas a fixed exchange rate regime *may* not. Even if variability were permitted under a fixed exchange rate regime, expected profits are at least as high under a floating exchange rate regime. Thus the upper bound to the number of varieties must be determined by the more profitable regime – the floating regime.

Broadly interpreted, our results say that other things equal, if a country moves from a floating exchange rate regime to a fixed exchange rate regime, we should observe firms in the exporting sector reduce the number of varieties they sell. Interestingly, we find some support for such restructuring in Euroland following the launch of the Euro (The Economist, November 2001).

We have shown here that exchange rate variability matters for firms' decisions with regard to the number of varieties to produce. We find some support, albeit anecdotal, for our findings. The Economist (November, 2001) has a discussion on how multiproduct firms selling in the EU are responding to the launch of the Euro. Some firms, for example, Unilever and Procter & Gamble have started trimming the number of brands they offer so that they can concentrate on a few brands[16]. Other manufacturers, for example, Nestle', Henkel and Danone are homogenizing (using same brand name on) their products across Euroland. These observed responses are very much in line with our findings. Elimination of exchange rate variability diminishes

[16] The reasons advanced by the Economist for these actions are somewhat different from those proposed in this paper.

product variety because it takes away (expected) future dispersion in income and hence the incentive to crowd the product space.

3.2 Asymmetric markets

We assume now that the Foreign market is richer[17], that is, $\eta > 1$. Will variability in the exchange rate still engender product variety? Figure 3 plots $\triangle\pi\left(S;\eta\right)$ for different values of η.

Figure 3 about here.

Proposition 2 *As η increases, (i) it becomes more profitable to offer two brands, and (ii) the net profit function becomes less convex.*

Proof (sketch): Differentiate $\triangle\pi\left(S;\eta\right)$ and respectively $\frac{\partial^2(\triangle\pi(S;\eta))}{\partial S^2}$ with respect to η to get the results for (i) and (ii) respectively.

The intuition is as follows: When the Foreign market gets richer, the firm responds by raising the quality level (and hence price). When the firm sells two products, the quality gap increases with the wealth in the Foreign market (so does the price gap) and this augurs well for surplus extraction. Moreover, the profit margin increases with quality – hence profit increases with affluence in Foreign market. As before, LOP binds more as the Foreign market gets richer and this makes the *net* profit function less convex.

Remark 2 *For a given level of fixed cost, K, there exists a level of market asymmetry, $\widetilde{\eta}$, beyond which the exchange rate becomes irrelevant for the firm's choice of number of products.*

Remark 2 follows directly from proposition 2 (i). Because the net profit is increasing in the affluence of the Foreign market, if the cost of carrying a second brand is fixed or only increases slowly, it follows that for some η large enough, the exchange rate will cease to matter.

[17]It makes no (qualitative) difference whether the Home market or the Foreign market gets richer.

3.3 Some robustness checks

3.3.1 Importance of the result, a quantitative assessment

How much does a variable exchange rate raise expected profits relative to profits when the exchange rate is fixed at unit? Is this increase quantitatively important? As we can see (figure 2), the *net* profit function is rather flat. We calculate the percentage increase in *net* profits (gross of the fixed cost) for chosen realizations of the exchange rate[18].

We find a progressive effect of exchange rate variability on percentage increase in profits. For variability within 0.05, 0.15 and 0.18 units from the mean, expected profits increase by as much as 0.1%, 1% and 1.5% respectively.

These numbers are not huge, but are they also non-trivial. For example, if the *net* profits under a "fixed" exchange rate were SEK 10 000 000, then a one percent increase in expected profits (due to exchange rate variability) would mean a SEK 100 000 increase in expected profits. This (at least to me) is not insignificant. Moreover, numbers of the same order of magnitude have been considered non-trivial elsewhere. In assessing costs and benefits of the Euro, the following were considered non-trivial. Emerson *et al.* (1992) estimated that exchange transactions costs for the entire EU were as high as 0.5% of EU GDP and as high as 1% of GDP for the case of smaller EU countries whose currencies are less internationally traded[19].

3.3.2 Relaxing LOP assumption

As Goldberg and Knetter (1997) points out, LOP holding requires the following; costless transportation, distribution and resale. These three requirements are difficult (if not impossible) to satisfy practically, hence markets

[18] Remember, $S \in [\widetilde{S}, \widehat{S}] \sim iid\left(1, \sigma^2_{\widetilde{S},\widehat{S}}\right)$. That is, a depreciation of $\triangle S$ is as likely as an appreciation of $\triangle S$.

[19] Taken from Micco et al. (2003), page 322

are at best partially covered. Thus, it is interesting to know the extend to which the LOP assumption affects our findings.

Let $\triangle\pi^{seg}(S)$ be the *net* profit when markets are fully segmented. We determine how much net profits would increase if we moved from LOP to segmented markets. To this effect, let $\widetilde{\pi} = \triangle\pi^{seg}(S) - \triangle\pi(S)$. Figure 4 below gives the plot of $\widetilde{\pi}$.

Figure 4 about here.

We get a strengthening of proposition 1;

Proposition 1' *Suppose* $\triangle\pi(1) = 0$. $\forall\sigma^2 > 0$, *a monopoly firm with the possibility to offer one or two products will always offer two products.*

We argued earlier that LOP dampens the positive effect of exchange rate variability on profitability of a multiproduct strategy. Also, LOP becomes even more binding as variability increases, hence we needed to restrict the range over which variability enhances product variety. However, when markets are segmented, there is no dampening effect and greater variability is desirable.

4 Conclusion

We extend the literature on monopoly and product mix by considering how variability in the exchange rate affects the product range offered by a monopoly firm selling in international markets. Starting in a situation where there is no variability in the exchange rate, we show that introducing variability in the exchange rate induces the firm to expand the number of varieties offered. The mechanism works through the effect of exchange rate changes on the dispersion of income in the Foreign market. A higher dispersion of income makes it harder for the firm to significantly extract surplus from the top end of the market under a single product strategy. What is more, because a depreciation of the Home currency makes all Foreign consumers relatively richer, a single product strategy will constrain market coverage at a time when the firm would want to expand market coverage. If markets are symmetric, variability leads to more products being offered. In other words, two countries that

are served by a single monopoly firm can adopt a single currency (currency union) only at a cost of diminished product variety. This is an interesting implication in light of the adoption of the Euro. The result seems to matter quantitatively, that is, the effect on profits is non-negligible. Because the result was derived under some restrictive assumptions (for example, costless arbitrage), the result holds good under more realistic assumptions (partially integrated or fully segmented markets).

As an extension, it would be interesting to introduce competition into the model (a duopoly for instance) and study how variability in the exchange rate affects the firms' incentives to vertically segment markets. If firms can not collude, we conjecture that exchange rate variability puts pressure on prices thereby diminishing firms' incentives to offer multiple varieties, moreso if exchange rate changes have a bearing on firms' costs.

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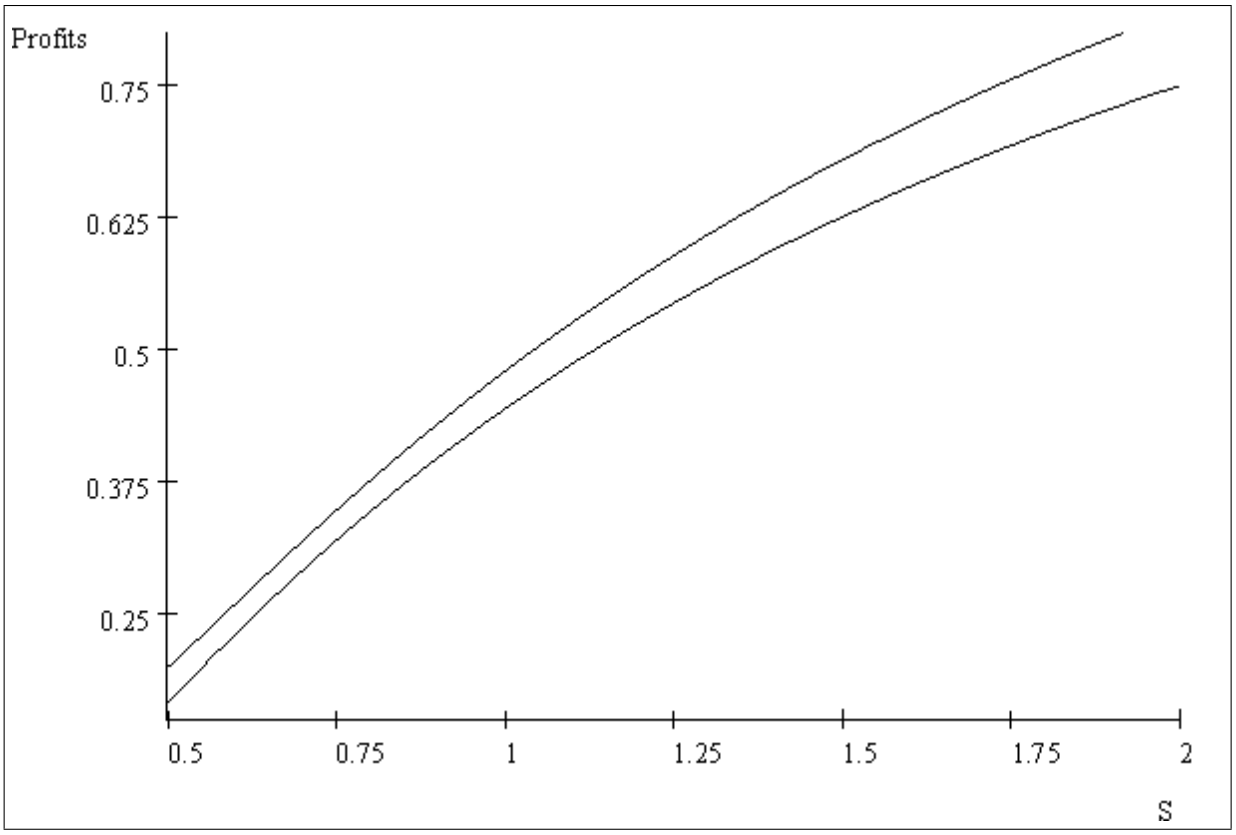

Figure 1. Plot of π_I and π_{II} as functions of the exchange rate, S.

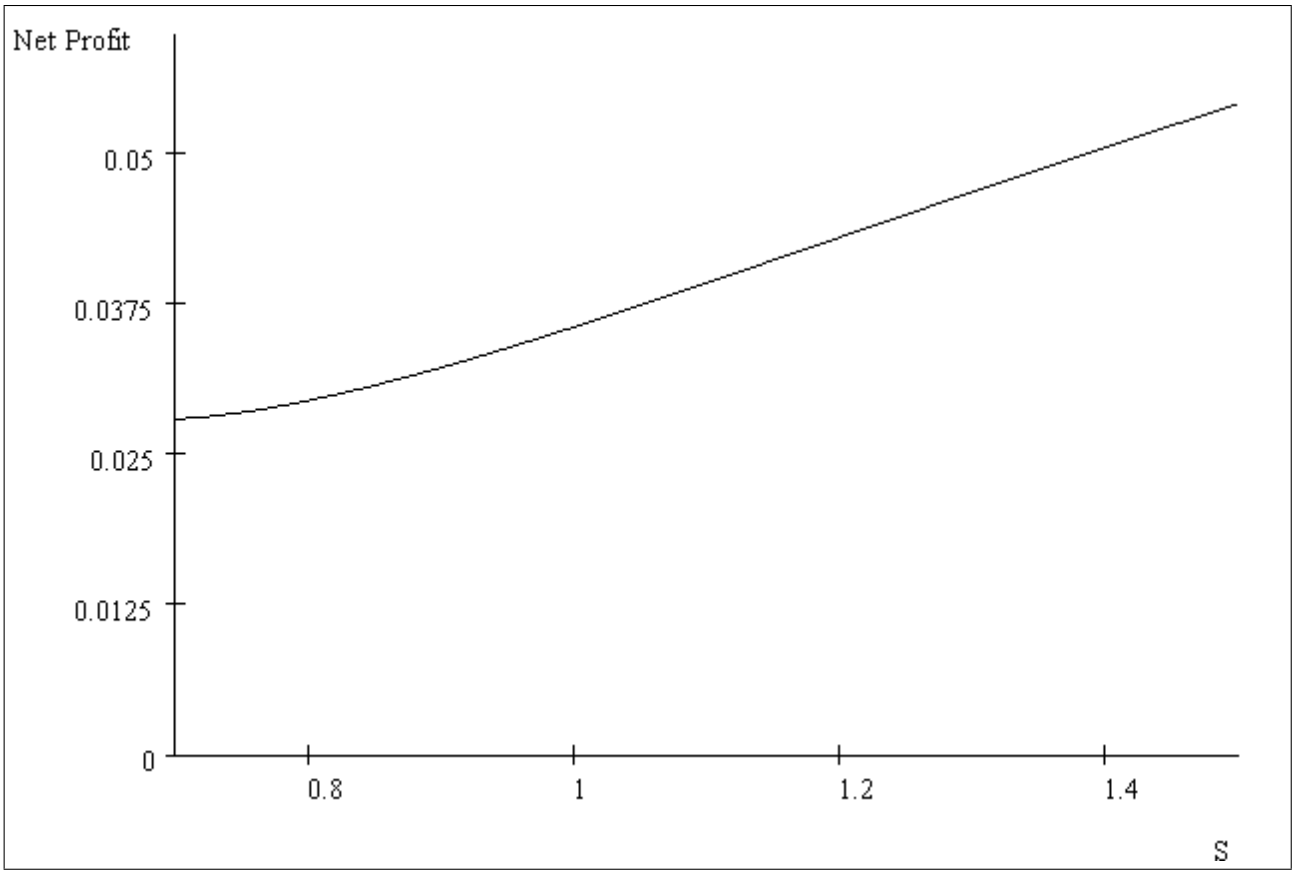

Figure 2. Net profit as a function of the exchange rate.

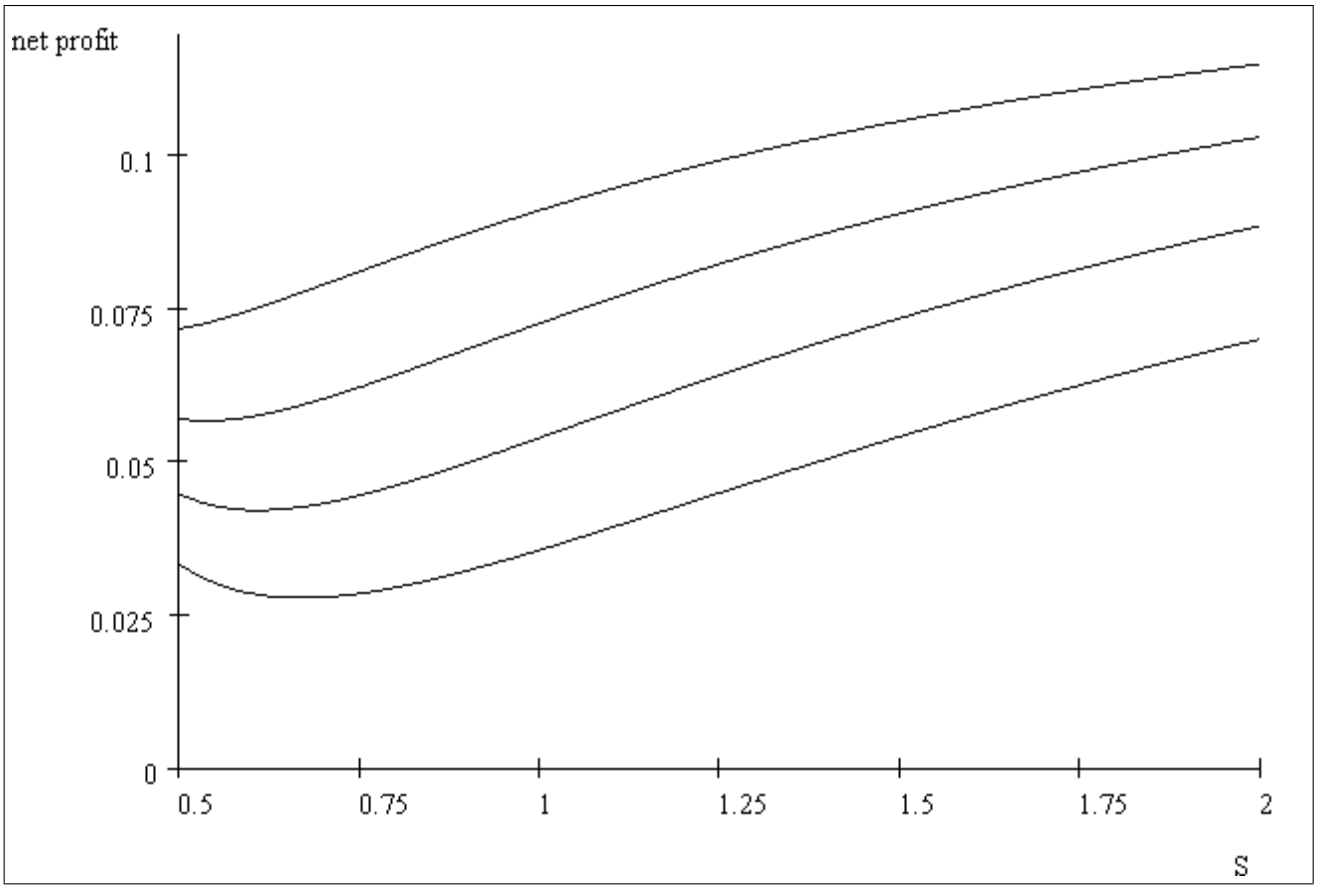

Figure 3. Plot of $\triangle\pi\left(S;\eta\right)$ for different values of η.

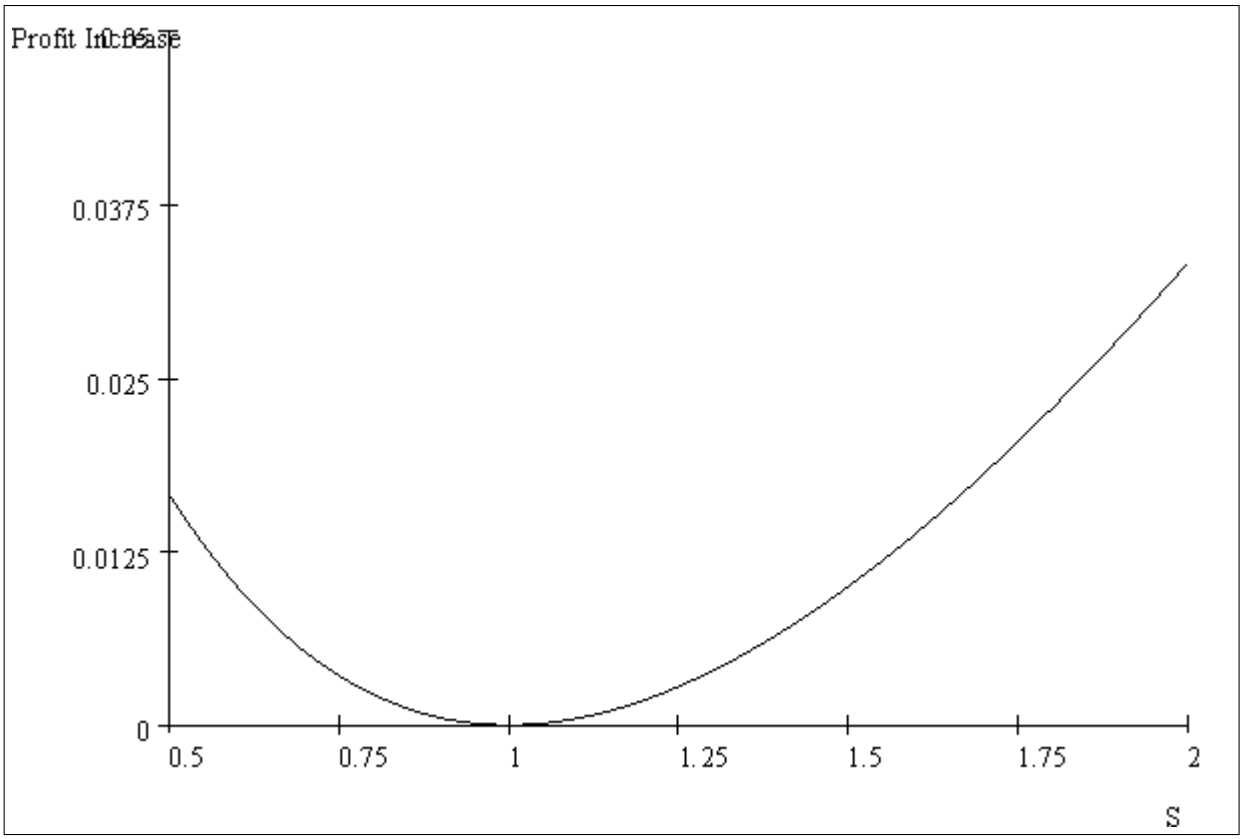

Figure 4. Effect of LOP on expected net profits – plot of $\triangle\pi^{seg} - \triangle\pi$.

Appendix

A1: Partial Market coverage (restriction on $\overline{\theta}$)

Partial market coverage obtains whenever $\underline{\theta} < \frac{p}{q}$, where $\frac{p}{q}$ is the MWTP for quality of the individual indifferent between purchasing a unit of quality q at price p and purchasing nothing. Let $\overline{\theta}_j$ be the highest WTP consistent with partial market coverage in market j.

Single product
Home: $\underline{\theta} < \frac{p_H}{q} \implies \overline{\theta}_H = \frac{6(1+S)}{5-S}$;
Foreign: $\underline{\theta} < \frac{p_F}{q} \implies \overline{\theta}_F = \frac{6S(1+S)}{(3S+1)(2S-1)}$

Two products
Home: $\underline{\theta} < \frac{p_{1H}}{q_1} \implies \overline{\theta}_{1H} = \frac{10(1+S)}{9-S}$
Foreign: $\underline{\theta} < \frac{p_{1F}}{q_1} \implies \overline{\theta}_{1F} = \frac{10S(1+S)}{10S^2-S-1}$

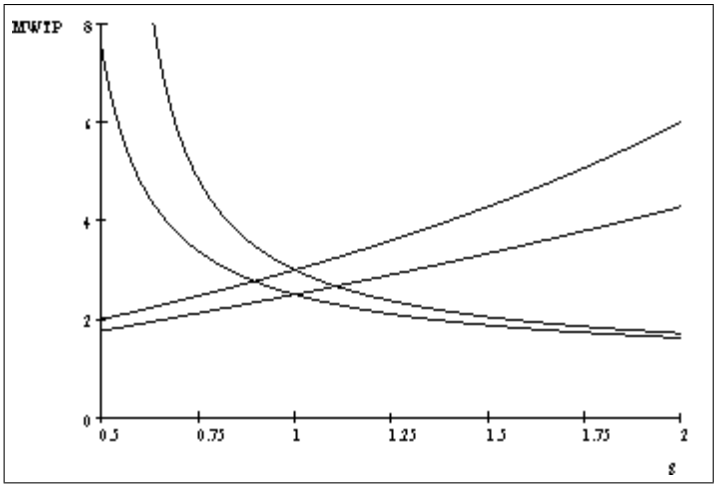

Figure A: Plot of $\overline{\theta}_H, \overline{\theta}_F, \overline{\theta}_{1H}$ and $\overline{\theta}_{1F}$.

We see from the figure above that $\overline{\theta}_H > \overline{\theta}_{1H}$ (upward sloping curves) and $\overline{\theta}_F > \overline{\theta}_{1F}$ (downward sloping curves) for all S. Thus partial market coverage with two products implies partial market coverage with a single product

but not the other way round. We have partial market coverage in both markets with two products (brands) if $\overline{\theta} < \min\left\{\overline{\theta}_{1H}, \overline{\theta}_{1F}\right\}$. Partial market coverage requires that markets be rather poor. More precisely, partial market coverage in both markets require $\overline{\theta} \leq 1.\,621\,6$.

A2: Calibration

For any product to have positive demand, the price must be such that $P_{ik} \leq \overline{\theta}; i = 1, 2;$. If $\overline{\theta}$ is given, we can easily pin down the permissible range of t. If the domestic currency is strongly appreciated, we can pin down t by insisting that $P_{2F} \leq \overline{\theta}$. This gives a lower bound to t, which we can call $\underline{t_F}$. This is so because P_{2F} is the highest price when the domestic currency appreciates. Similarly, if the domestic currency depreciates, P_{2H} is the highest price and we thus pin down t by requiring that $P_{2H} \leq \overline{\theta}$. This gives a lower bound to t which we call $\underline{t_H}$. The permissible t is any t such that $t \geq \underline{t} \equiv \max\left\{\underline{t_F}, \underline{t_H}\right\}$. If the relevant domain for S is $[0.5, 2]$, we can evaluate P_{2F} and P_{2H} at $S = 0.5$ and $S = 2$ respectively to get $\underline{t_F}$ and $\underline{t_H}$ respectively. For $\overline{\theta} = \frac{8}{5}$, we get $\underline{t} \equiv \max\left\{\underline{t_F}, \underline{t_H}\right\} = \max\left\{\frac{256}{375}, \frac{92}{375}\right\} = \frac{256}{375}$.

A3: Segmented markets

The firm chooses prices to solve the problem;

$$\pi_{II}^{seg} = \max_{P_{iH}, P_{iF}} \sum_{i=1}^{n} \left[\left(P_{iH} - tq_i^2\right) x_{iH} + \left(SP_{iF} - tq_i^2\right) x_{iF}\right] \tag{A1}$$

This is analogous to equation (4) except that now we do not require Home and Foreign prices to be equal when expressed in terms of a common currency. Solving as we did before gives

$$\left(\pi_I^{seg}, \pi_{II}^{seg}\right) = \left(\frac{(1 - 2S + 9S^2)}{108St}, \frac{(1 - 2S + 5S^2)}{50St}\right)\overline{\theta}^3$$

Hence

$$\triangle\pi^{seg} = \frac{(29 - 58S + 45S^2)\,\overline{\theta}^3}{2700St} \tag{A2}$$