Technical Note –

Pricing Below Cost under Exchange-Rate Risk

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Pricing below cost is often classified as "dumping" in international trade and as "predatory pricing" in local markets. It is legally prohibited from practice because of earlier findings that it leads to predatory behavior by either eliminating competition or stealing market share. This paper shows that a stochastic exchange rate can create incentives for a profit-minded monopoly firm to set price below marginal cost. Our result departs from earlier findings because the optimal pricing decision is based on a rational behavior that does not exhibit any malicious intent against the competition to be considered as violating anti-trust laws. The finding is a robust result, because our analysis demonstrates that this behavior occurs under various settings such as when the firm (1) is risk-averse, (2) can postpone prices until after exchange rates are realized, (3) is capable of manufacturing in multiple countries, and (4) operates under demand uncertainty in addition to the random exchange rate.

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1. Introduction

This paper demonstrates that the stochastic exchange rate leads to a new rationale for a monopolist to set a price below its cost. In international trade, pricing below (total landed) cost can be classified as "dumping" according to Article VI.1.(b).(ii) of the General Agreement on Tariffs and Trade when there is no domestic price, or an equivalent price in another market. Pricing below cost is also prohibited by predatory pricing laws in many countries (Section 2 of the Sherman Act (1975) in the United States), and firms are often accused of predatory pricing when they price below cost by local authorities. In dumping and predatory pricing, pricing below cost is perceived to be motivated by a firm's desire to eliminate competitors with the intention to monopolize the market. During the practice of pricing below cost, the firm commits to losses in the short term, and once the competition is eliminated, the monopoly firm raises its price and starts accruing profits again (Rosenthal 1981, Ordover and Willig 1981, Cabral and Riordan 1994). Earlier publications have created the intuition that a monopolist does not charge a price below cost. While this assertion is generally true, our paper shows that exchange-rate risk can create an incentive for a monopolist to price below cost, even in the absence of competition, without raising the price. Our finding is characteristically different than earlier publications as our model does not feature competition, but a monopoly firm with the profit-maximizing perspective. Our paper shows that pricing below cost is a robust result as it occurs (1) when the firm is risk averse, (2) regardless of whether the firm determines the price in the presence of exchange-rate uncertainty or after the exchange rate is realized (the latter is referred to as "postponed pricing"), (3) even if the firm has manufacturing capabilities in multiple countries, and (4) when the firm operates under the combination of exchange-rate and demand uncertainty.

Our paper does not advocate that firms should price below cost. Rather, it contributes to the discovery of a rational and profit-minded behavior on behalf of a global manufacturer. This result is meaningful for interpreting international trade laws. We argue that our pricing below cost result does not constitute predatory pricing or dumping as the paper clearly shows that a global firm can engage in pricing below cost in the presence of exchange-rate risk even if it is a monopoly firm. Furthermore, because of reduced prices and increased demand, pricing below cost can also be consumer welfare enhancing.

2. The Model

The firm manufactures a single product and sells it in one domestic and one international market. The selling price in the foreign market is expressed in foreign currency, and the revenues generated in the foreign market fluctuate with the random exchange rate. The model is a two-stage stochastic program with recourse where the firm makes the following two decisions in the presence of exchange-rate uncertainty, corresponding to the beginning of Stage 1 in our model:

(1) Price p_i where $i = H$ represents the selling price in the home market denominated in the home-country currency and $i = F$ represents the foreign market price expressed in foreign currency.

(2) Manufacturing quantity X where the firm pays a manufacturing cost c denominated in the home-country currency for each unit. Manufacturing can take place in any country, and the unit manufacturing cost c can be converted at the spot exchange rate at the beginning of the planning horizon.

The random exchange rate is represented by $\tilde{e}$, where e is the realization, $f(e)$ is the probability density function (pdf) defined on a support $[e_l, e_h]$ such that $e_h > e_l \geq 0$, $F(e)$ is the cumulative distribution function (cdf), and its mean is $\bar{e} = E[\tilde{e}]$. We make no assumptions regarding the distribution of $f(e)$, except that we scale it such that $\bar{e} = 1$ without loss of generality. Demand is described with $d_i(p_i)$ in each market $i = H, F$, and it decreases in price p_i. We assume that revenue $pd_i(p_i)$ is concave, i.e., $2d_i'(p_i) + pd_i''(p_i) \leq 0$ in each market $i = H, F$ where $d_i'(p_i)$ and $d_i''(p_i)$ represent the first- and second-order derivatives of the demand function d_i with respect to price. Stage 1 objective function can be expressed as follows:

$$\max_{(p_H, p_F, X)\geq 0} E\left[\Pi(p_H, p_F, X)\right] = -cX + \int_{e_l}^{e_h} \pi^*(p_H, p_F, X, e) f\left(e\right) de \,. \tag{1}$$

where $\pi^*(p_H, p_F, X, e)$ is the optimal second-stage objective function under exchange-rate realization e.

In Stage 2, the firm determines the optimal values of the allocation quantities to home and foreign markets, defined as x_H and x_F respectively, where $x_H + x_F \leq X$.

$$\pi^*\left(p_H, p_F, X, e\right) = \max_{\substack{(x_H, x_F)\geq 0 \\ x_H + x_F \leq X}} \left(p_H - t_H\right) \min\left\{x_H, d_H\left(p_H\right)\right\} + \left(p_F - t_F\right) e \min\left\{x_F, d_F\left(p_F\right)\right\} \tag{2}$$

where t_H and t_F designate the sum of expenses associated with transportation, localization, and duties as in Kouvelis and Gutierrez (1997) and Munson and Rosenblatt (1998).[1]

[1] Our model assumes that the shipping cost t_F is paid in foreign currency as in a Free on Board scheme. While not presented here, pricing below cost continues to be a feature of a similar model when t_F is paid in domestic currency.

According to Article VI.1.(a) of the anti-dumping laws, the firm sets a selling price in the foreign market such that the return at the expected exchange rate ($\bar{e} = 1$) equals the return from the home market, i.e., $(p_F - t_F)\,\bar{e} = p_H - t_H$. As a result, at the time of determining prices, the (expected) return from each market is equal. As the random exchange rate fluctuates, the actual return from a sale in the foreign market differs from that of the home market. This is legally allowed because the selling price is determined in the presence of exchange-rate uncertainty, the firm's pricing decision is not subject to dumping on the basis of Article VI.1.(a), even if the firm does not adjust its selling price in the foreign market instantaneously with exchange-rate fluctuations.

If the realized exchange rate is below its mean (i.e., $e < 1$), then the revenue per unit from the foreign market is less than the domestic revenue per unit, and the firm prioritizes its allocation of products to the home market. If the firm has any leftovers after satisfying the home market demand, then they are sold in the foreign market. If $e \geq 1$, however, the revenue from the domestic market is less than the foreign revenue; the firm prioritizes the foreign market in its allocation decisions. If the firm has any leftovers after satisfying the foreign market demand, then they are sold in the domestic market.

It is important to note that our main result associated with pricing below cost is not an artifact of the anti-dumping law. Our main finding continues to hold when the firm can set prices independently in each market, i.e., $p_F - t_F \neq p_H - t_H$ (can be verified through numerical examples). The consequence of setting $(p_F - t_F)\,\bar{e} = p_H - t_H$ is that the objective function in (1) can be expressed in terms of only two decision variables (one price and one quantity) rather than three decision variables. In what follows, we express all functions using the domestic price p_H; the foreign price can be obtained from the domestic price.

We next introduce a new measure of the downside risk and the upside potential in exchange-rate fluctuations. We define θ as the difference between the cdf and the partial expectation until the switching point for the allocation preference in the second stage:

$$\theta = \int_{e_l}^{1} f(e)\,de - \int_{e_l}^{1} ef(e)\,de = \int_{1}^{e_h} ef(e)\,de - \int_{1}^{e_h} f(e)\,de\,. \tag{3}$$

As shown in the middle expression of (3), θ can be regarded as the "expected loss" for each dollar revenue from selling in the less-desirable foreign market as opposed to the revenue that can be generated from selling in the more-desirable domestic market. For several common distributions (e.g., normal, uniform, exponential), θ is proportional to the standard deviation. Thus, the value of θ increases with uncertainty in the exchange rate. As shown in the far-right expression of (3), θ can also be regarded as the upside potential corresponding to the expected gain from selling in the foreign market. Thus, we see that θ is a rather illuminating measure: (1) it is an indicator of exchange-rate volatility; (2) it is an indicator of downside risk because the larger the value of θ, the larger the value of the flexibility to not serve the foreign market when the exchange rate is low; and, (3) it is an indicator of the upside profit potential of the foreign market over the home market when the exchange rate is high.

We next identify the optimal policies consisting of price and quantity decisions in (1)–(2) (all proofs are located in the online appendix).

Proposition 1. *The optimal manufacturing quantity for a given price, expressed as* $X^*(p_H)$*, is:*

$$X^*(p_H) = \begin{cases} 0 & \text{when } p_H < c/(1+\theta) + t_H \\ \min\{d_H(p_H), d_F(p_H)\} & \text{when } c/(1+\theta) + t_H \le p_H < c + t_H \\ \max\{d_H(p_H), d_F(p_H)\} & \text{when } c + t_H \le p_H < c/(1-\theta) + t_H \\ d_H(p_H) + d_F(p_H) & \text{when } p_H \ge c/(1-\theta) + t_H \end{cases}. \tag{4}$$

Proposition 1 shows that the optimal production choice can be less than the total demand. The firm's optimal policy can be characterized through the following four policies:

1. Total Demand (TD) policy: $X = d_H(p_H) + d_F(p_H)$
2. Production Hedging Maximum (PHX) policy: $X = d_x = \max\{d_H(p_H), d_F(p_H)\}$
3. Production Hedging Minimum (PHN) policy: $X = d_m = \min\{d_H(p_H), d_F(p_H)\}$
4. No Production (NP) policy: $X = 0$

Policies PHX and PHN are described as production hedging policies where the firm manufactures less than its total demand. In these policies, the firm benefits by adjusting the allocation of its limited number of products to the higher revenue generating market. The expected profit from each policy are as follows:

$$E[\Pi^{TD}(X = d_m + d_x)] = (p_H - c - t_H)(d_m + d_x) \tag{5}$$

$$E[\Pi^{PHX}(X = d_x)] = (p_H - c - t_H)d_x + (p_H - t_H)d_m\theta \tag{6}$$

$$E[\Pi^{PHN}(X = d_m)] = (p_H - c - t_H)d_m + (p_H - t_H)d_m\theta \tag{7}$$

Proposition 2. a) *Expected profit functions under policies* TD, PHX *and* PHN *as expressed in* (5) – (7) *are concave in* p_H; *b*) *The optimal price is never less than* $[c/(1+\theta)] + t_H$*, and thus, policy* NP *is never optimal*; *c) The optimal price for the three potentially optimal policies are as described in Table 1:*

Policy	Optimal Price, p_H^*
PHN	$p_H^{PHN} = \min\left\{\dfrac{c}{1+\theta} - \dfrac{d_m}{d_m'} + t_H, c + t_H\right\}$
PHX	$p_H^{PHX} = \max\left\{c + t_H, \min\left\{\dfrac{d_x + \theta d_m - c d_x'}{-(d_x' + \theta d_m')} + t_H, \dfrac{c}{1-\theta} + t_H\right\}\right\}$
TD	$p_H^{TD} = \max\left\{c + t_H + \dfrac{d_x + d_m}{-(d_x' + d_m')}, \dfrac{c}{1-\theta} + t_H\right\}$

Table 1. Optimal price expressions for the potentially optimal policies.

Propositions 1 and 2 together indicate that there are only three optimal policies (PHN, PHX, and TD), and they produce a unique pair of price and quantity decisions.

Pricing below cost is the prevailing behavior when PHN is optimal. Table 1 indicates that the optimal price is below cost when $-(d_m/d_m') < c[\theta/(1+\theta)]$; however, it does not guarantee that policy PHN is optimal. The online appendix provides the set of necessary and sufficient conditions that warrant the optimality of the PHN policy. We define the price-elasticity of demand functions evaluated at price p_H as $\varepsilon^{TD}(p_H) = -p(d_x' + d_m')/(d_x + d_m)$ and as $\varepsilon^{PHX}(p_H) = -p(d_x' + \theta d_m')/(d_x + \theta d_m)$, and develop sufficient conditions for pricing below cost.

Proposition 3. *Policy* PHN *is optimal when* $\varepsilon^{TD}((c/(1-\theta)) + t_H) > (c + t_H(1-\theta))/(c\theta + t_H(1-\theta))$ *and* $\varepsilon^{PHX}(c + t_H) > 1 + [d_x'(c + t_H)/(\theta d_x'(c + t_H))]$.

The first condition in Proposition 3 guarantees that the TD policy cannot be optimal and is dominated by policy PHX. The second condition assures that the PHX policy is not optimal and is dominated by PHN. Considering that price-elasticity of many demand functions exhibit increasing behavior, these conditions can be satisfied with higher levels of exchange-rate uncertainty and manufacturing cost.

Introducing uncertainty often causes the firm to charge a higher price in order to negate the potential losses. The increase in price is referred to as "risk premium" in pricing literature. One might intuit that the inclusion of exchange-rate risk should lead to a positive risk premium for the global firm. We next show that when exchange-rate uncertainty is introduced to the model (comparing with the deterministic exchange rate), production policies such as PHN and PHX lead to a price discount (or negative premium). Let us refer to the optimal domestic price under deterministic exchange rate as p_H^0 (the optimal riskless price):

$$p_H^0 = c + t_H + [(d_H + d_F)/(-(d_H' + d_F'))] > c + t_H \tag{8}$$

is greater than the total landed cost (obtained from p_H^{TD} in Proposition 2 with $\theta = 0$). We denote the risk discount as r_H^j for j = PHN, PHX policies, and define the optimal selling price in terms of the riskless price and the risk discount:

$$p_H^j = p_H^0 - r_H^j \quad \text{for } j = \text{PHN, PHX}. \tag{9}$$

From Proposition 2, the value of the risk discount for the PHN policy is:

$$r_H^{PHN} = \max\left\{ c\left[\frac{\theta}{1+\theta}\right] + \left[\frac{d_H + d_F}{-(d_H' + d_F')} - \frac{d_m}{-d_m'}\right], \frac{d_H + d_F}{-(d_H' + d_F')} \right\} \geq 0 . \tag{10}$$

Proposition 4. *a*) *The risk discount r_H^{PHN} is increasing in the exchange-rate uncertainty measure θ; b*) *The optimal price p_H^{PHN} is decreasing in the exchange-rate uncertainty measure θ; c*) *The expected profit of the PHN policy as expressed in* (7) *is increasing in the exchange-rate uncertainty measure θ.*

We next show that higher values of the unit manufacturing cost leads to pricing below cost. Proposition 1 indicates that PHN is preferred when the price is in the range $[c/(1 + \theta)] + t_H \leq p_H < c + t_H$, and thus, a higher value of the unit manufacturing cost c makes pricing below cost (as well as the total landed cost) more desirable.

Proposition 5. *a*) *The optimal price under the PHN policy, p_H^{PHN}, is increasing in the unit manufacturing cost c; b*) *The risk discount r_H^{PHN} is increasing in the unit manufacturing cost c; c*) *The increase in p_H^{PHN} is greater than the increase in r_H^{PHN} with higher values of the unit manufacturing cost c.*

The analysis in this section has shown that pricing below cost is potentially optimal for a profit-seeking and risk-neutral monopoly firm. The result stems from the firm's conservative behavior by manufacturing only the minimum of the demand values (and less than the total demand) and relying on the benefits of allocation flexibility. It is enabled by higher levels of exchange-rate uncertainty and total landed cost. One would naturally wonder whether pricing below cost continues to be the prevailing behavior if the firm is risk averse. Does a risk-averse firm price its product below cost?

3. Risk Aversion

This section demonstrates that even a risk-averse firm can price below cost and that the firm's behavior is persistent under risk aversion. We utilize the VaR measure to limit the risk associated with the realized returns from sales in two markets after observing the random exchange rate: β represents the loss (value at risk) that the firm is willing to tolerate at probability α, where $0 \leq \alpha \leq 1$. For a given α, if VaR is more than the tolerable loss β, then first-stage decisions correspond to an infeasible solution. We incorporate the firm's VaR concern into the model in (1)–(2) by supplementing it with the following constraint:

$$P\left[-cX + \pi^*\left(p_H, X, \tilde{e}\right) < -\beta\right] \leq \alpha . \tag{11}$$

Constraint (11) states that the probability that the realized loss exceeds β should be less than or equal to α. Incorporating risk aversion through (11) introduces three new potentially optimal policies:

1. Production Hedging Interior (PHI) policy: $d_x < X < d_x + d_m$
2. Production Hedging Interior less than Maximum (PHIX) policy: $d_m < X < d_x$
3. Production Hedging Interior less than Minimum (PHIN) policy: $X < d_m$

The expected profit from each policy can be expressed as follows:

$$E[\Pi^{PHI}(d_x < X < d_x + d_m)] = (p_H - c - t_H)X + (p_H - t_H)(d_x + d_m - X)\theta \quad (12)$$

$$E[\Pi^{PHIX}(d_m < X < d_x)] = (p_H - c - t_H)X + (p_H - t_H)d_m\theta \quad (13)$$

$$E[\Pi^{PHIN}(X < d_m)] = ((p_H - t_H)(1 + \theta) - c)X \quad (14)$$

Adding policies PHI, PHIX and PHIN to TD, PHX and PHN policies create six potentially optimal policies for the risk-averse firm. We let e_α denote the realized value of the exchange rate corresponding to α probability, i.e., $P[\tilde{e} \le e_\alpha] = \alpha$. Proposition A1 of the online appendix provides a comprehensive set of derivations for all six potentially optimal policies, and their optimal price and quantity expressions. Because our interest is in pricing below cost, we focus on PHN and PHIN policies in the rest of this section. The following proposition prescribes the conditions that lead to PHN and PHIN under the VaR constraint.

Proposition 6. *a*) *For a given price level below cost, there are two potentially optimal production policies:*

i) $[c/(1+\theta)] + t_H \le p_H < \min\{\max\{[c/(1+\theta)] + t_H, c + t_H - (\beta/d_m)\}, c + t_H\}$, *then* $X^* = \beta/(c + t_H - p_H) < d_m$ $\Rightarrow$ PHIN

ii) $\min\{\max\{[c/(1+\theta)] + t_H, c + t_H - (\beta/d_m)\}, c + t_H\} \le p_H < c + t_H$, *then* $X^* = d_m \Rightarrow$ PHN.

b) *The optimal price and manufacturing quantity choices under the PHN and PHIN policies are:*

$p_H^{PHIN} = c + t_H - (\beta/d_m)$ *and* $X^{PHIN} = \beta/(c + t_H - p_H)$, *and*

$p_H^{PHN} = \min\{[c/(1 + \theta)] + t_H + [d_m/(-d_m')], c + t_H\}$ *and* $X^{PHN} = d_m = [p_H - (c/(1 + \theta)) - t_H](-d_m')$.

When the VaR constraint is not satisfied through the PHN policy, the firm switches its policy to PHIN, increases its selling price and decreases its manufacturing quantity; the firm continues to price below the total landed cost under the PHIN policy.

Proposition 7. *a) The optimal price increases and the manufacturing quantity decreases with smaller values of tolerable loss* β (*corresponding to higher risk aversion*) *when the firm does not satisfy* (11) *under the* PHN *policy and adopts policy* PHIN; *b*) *The risk premium for the PHIN policy is:*

$$r_H^{\text{PHIN}} = \frac{\beta}{d_m} + \left[\frac{d_x + d_m}{-(d_x' + d_m')}\right] \ge 0, \quad (15)$$

and its value is decreasing with lower values of tolerable loss β (*higher risk aversion*).

We conclude that while risk aversion is likely to pressure the firm to increase the price (and reduce quantity), pricing below (total landed) cost continues to be a potentially optimal behavior.

4. Potential Extensions

Our study has shown that a monopoly firm can price below cost under exchange-rate risk. In this section, we discuss how the results alter under various extensions.

4.1. Minimum Allocation Requirement

Policy PHN assumes that we can starve a market completely in Stage 2. Would our result change if the firm is forced to satisfy a minimum allocation amount described as y_i in each market $i = H, F$? This requirement incorporates an additional constraint in Stage 2 of the model where $x_i \geq y_i$ for $i = 1, 2$.

Incorporating a minimum allocation requirement alters the PHN policy by manufacturing the sum of the minimum of the two demand values and the maximum of the minimum allocation requirements. If the minimum allocation requirements are extremely high, exceeding the difference between the maximum and minimum demand values, then PHN policy is automatically eliminated from being a potentially optimal policy. Thus, pricing below cost is no longer a feasible solution. However, when the minimum allocation requirement does not exceed the difference between the maximum and minimum demand values, the optimal manufacturing quantity under the PHN policy becomes $X^{PHN} = d_m + \max\{y_H, y_F\}$. This result is formalized in Proposition A2 in the online appendix. The immediate consequence of this result is that the firm continues to engage in pricing below cost. A similar analysis defining the minimum allocation requirement as a percentage of the demand in each market also reveals that pricing below cost is a persistent behavior.

4.2. Postponed Pricing

We next examine whether the firm would continue to price below cost if it can postpone its pricing decisions until after exchange rates are observed. In this scheme, given the realized value of the exchange rate, the firm would set the foreign price as $(p_F - t_F)\, e = p_H - t_H$ in order to comply with the anti-dumping laws. The demand in the foreign market changes with exchange-rate realization, and can be expressed $d_F(t_F + (p_H - t_H)/e)$. In this setting, appreciation in exchange rate results in a lower selling price in the foreign market with higher demand, and depreciation leads to a higher price in the foreign market with lower demand. Price can go below cost in the domestic market when the exchange rate depreciates and in the foreign market when it appreciates (can be verified through numerical examples).

4.3. Plants in Multiple Countries

We have shown that pricing below cost is a robust result when the firm manufactures in a single plant. We next present that pricing below cost can be the optimal strategy when the firm has two plants, one located in the home country and the other in the foreign country. In the first stage, the firm determines X_H and X_F, the amount to manufacture in the domestic and foreign plants respectively, in addition to the selling prices p_H and p_F in the presence of exchange-rate uncertainty. It pays a unit manufacturing cost of c_H and c_F where c_F incurs in the foreign currency using the spot exchange rate at time zero (denoted e_0) which is equal to the expected exchange-rate, i.e., $e_0 = \bar{e} = 1$. The firm continues to comply with the anti-dumping laws, and the foreign price can be expressed in terms of domestic price. Stage 1 objective function can be written as:

$$\max_{(p_H, p_F, X_H, X_F) \ge 0} E\left[\Pi\left(p_H, p_F, X_H, X_F\right)\right] = -c_H X_H - c_F X_F + \int_{e_l}^{e_h} \pi^*\left(p_H, p_F, X_H, X_F\right) f\left(e\right) de . \quad (16)$$

In Stage 2, the firm determines the best allocation decisions: x_i denotes the number of products manufactured and sold in the same country ($i = H, F$) and is charged a unit transportation cost t_i, and x_{ij} denotes the number of products manufactured in country i ($i = H, F$) and sold in country j ($j = H, F$ and $j \neq i$) and is charged a unit transshipment cost t_{ij}. Stage 2 objective function can be written as:

$$\pi^*\left(p_H, p_F, X_H, X_F, e\right) = \max_{\substack{(x_H, x_F, x_{HF}, x_{FH}) \ge 0 \\ x_H + x_{HF} \le X_H \\ x_F + x_{FH} \le X_F \\ x_H + x_{FH} \le d_H(p_H) \\ x_F + x_{HF} \le d_F(p_F)}} \left(p_H - t_H\right) x_H + \left(p_H - t_{FH}\right) x_{FH} + \left(p_F - t_F\right) e x_F + \left(p_F - t_{HF}\right) e x_{HF} . \quad (17)$$

It can be easily verified that the problem setting with two plants continues to feature the same set of potentially optimal policies where the total production ($X_H^* + X_F^*$) is equal to either the minimum demand d_m (PHN policy), or the maximum demand d_x (PHX policy), or the total demand $d_x + d_m$ (TD policy). Let us describe the unit transshipment cost to be greater than or equal to the unit transportation cost: $t_{ij} = t_j + \Delta$ where $\Delta \ge 0$. The next proposition shows that, under the PHN policy, production is not split between two plants when $\Delta > 0$ and the optimal price is below cost.

Proposition 8. *Under the* PHN *policy with $X_H^* = \delta$ and $X_F^* = d_m - \delta$, a) $\delta = 0$ when $\Delta > 0$, and δ can only be positive when $\Delta = 0$; b) the optimal price is below the total landed cost.*

When the unit transshipment cost is higher than the unit transportation cost, Proposition 8 proves that the manufacturing activity takes place in a single country under the PHN policy with the optimal price below the total landed cost.

4.4. Demand Uncertainty

It is important to observe that when demand is the sole source of uncertainty (i.e., deterministic exchange rate), the problem becomes a Price-Setting Newsvendor Problem (PSNP) with two markets. It is well known that the optimal selling price is never below cost in PSNP (Petruzzi and Dada 1999). The online appendix shows that pricing below cost can occur under the combination of demand and exchange-rate uncertainty; thus, we conclude that it is an artifact of the randomness in the exchange rate.

5. Conclusions

Pricing below cost is prohibited by international and local trade laws. These laws rely on previous findings indicating that firms price below only because they aim to steal market share from its competitors. Earlier publications inherently assume that once the firm becomes a monopoly it will increase price and will not charge a price below its (total landed) cost. Our paper, however, shows that even a rational and profit-minded monopoly firm can charge a price below cost when it operates under exchange-rate risk. Thus, we argue that global firms that operate under exchange-rate risk can engage in pricing below cost, and it should not be classified as an illegal behavior.

While the firm would never price below cost when it operates under demand uncertainty in isolation, it can charge a price below cost in the presence of combined exchange-rate and demand uncertainty. Pricing below cost is enabled through higher levels of exchange-rate uncertainty, unit manufacturing cost, and price-elasticity of the demand functions. Our paper shows that pricing below cost is a persistent behavior under various generalizations: (1) under risk aversion, (2) regardless of whether the firm determines the price before or after exchange-rate uncertainty is resolved, (3) even if the firm has plants in multiple countries, and (4) under the combination of exchange-rate and demand uncertainty. Pricing below cost is not an artifact of complying with the anti-dumping laws; it is a robust result even if the firm does not comply with the anti-dumping laws.

We have considered a setting where marginal production, transportation, localization, and duty costs are fixed. A possible extension is to expand the model to consider strategies for reducing these costs.

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