

Contracts, delivery lags, and currency risks

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This paper presents a competitive model in which exchange rate uncertainty has real effects on how trade contracts are written and executed. In this model, exporting firms have an incentive to delay delivery on trade contracts whenever they can sell their products on the domestic market for a higher price than the domestic currency value of the price specified by the trade contracts. In general, it is costly for a firm to offer a credible commitment to the promised delivery date of a trade contract. We demonstrate that under certain conditions a firm can costlessly commit to a policy of no delivery lags by the appropriate choice of the currency of denomination of trade contracts.

This paper provides a model of the choice of the currency of denomination of international trade contracts in an economy with perfect capital markets. While earlier models with perfect capital markets conclude that the currency of denomination of trade contracts is indeterminate, our model is capable of explaining the main empirical regularities.¹ In particular, it predicts

1. That trade contracts for manufactured goods are more likely to be denominated in the currency of the exporter.²
2. That contracts involving raw materials are most often denominated in vehicle currencies.³
3. That contracts are not denominated in the currency of the exporter when the price level of the exporter's country is highly volatile.⁴

We consider contracts defined in terms of price, currency of denomination, quantity, and promised delivery date. While earlier papers assume that trade contracts are perfectly enforceable, we assume that contracts are costly to enforce.⁵ With this assumption, exporters cannot in general credibly commit to the promised delivery date without incurring the costs of bonding or establishing a reputation. In

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a stochastic environment where there is exchange rate uncertainty and uncertainty in domestic demand, exporters have an incentive to delay delivery on export contracts and divert output to the domestic market whenever the domestic market price exceeds the domestic currency value of the contract price. If the contract is denominated in the currency of the importer (exporter), then the importer's (exporter's) price is fixed in the foreign (domestic) currency and the domestic (foreign) currency value of the contract price is variable. It is only when the contract is denominated in a third currency that both the domestic and foreign currency values of the contract price are variable. Since delivery delays occur when the domestic market price exceeds the domestic currency value of the contract price, the expected delivery lag is minimized (maximized) when contracts are denominated in the currency that minimizes (maximizes) the probability that the domestic market price exceeds the domestic currency value of the contract price. Fully informed, rational traders designate the currency of denomination and, within the constraints placed by competition, adjust the contract price to balance at the margin the cost to importers and the option value to exporters of the strategic delivery policy.

Earlier papers explain the choice of the currency of denomination of trade contracts by appealing to capital market imperfections and emphasizing the role of risk aversion in the presence of such imperfections.⁶ This paper provides a theory of the currency of denomination that differs from earlier theories in three useful ways. First, our results hold for value-maximizing firms regardless of the cost of forward coverage. Second, while earlier models effectively solve for the currency of denomination of a firm's aggregate cash flows, we provide a theory of the currency of denomination that applies to individual contracts. Third, our results depend on observable variables, including price, delivery lag, and exchange rate uncertainty, rather than unobservables, such as the degree of relative risk aversion of the trading firms, and, consequently, are in principle testable.

This paper is organized as follows. Section I presents the structure of the model. Section II solves for the market equilibrium. Section III analyzes the model's empirical implications for the choice of the currency of denomination of export contracts. Section IV discusses how our results are affected when some of our assumptions are relaxed. Section V offers concluding comments.

I. The Model

In this section, we develop a model to demonstrate the impact of the currency of denomination of trade contracts on the realized delivery policy of the exporting firm. We assume that production takes place in the domestic country by risk-neutral firms.⁷ Producing firms can sell either on the domestic market or on long-term contracts with foreign firms, called importers, on competitively determined terms. The domestic market is a market for short-term or spot contracts. Although we refer to this market as a spot market, it is not an organized spot market on which a homogeneous product is sold through an auction.⁸ To simplify the analysis, we assume that firms hold no inventories and that there is no domestic demand for long-term contracts. Therefore, all goods sold under contract are exported.

A long-term contract is defined as an agreement reached in period t in which the exporting firm promises to deliver a specified quantity in period $t + 1$ in return for a

specified per unit price. In reaching an agreement about the contract terms, the trading firms must agree on a currency in which to define the price. We call this currency the currency of denomination. At time t , the exchange rate and the domestic spot price in period $t+1$ are random variables. The domestic currency price of the foreign currency, e , is assumed to be an i.i.d. random variable with compact support.⁹

Although exporters promise delivery in the period immediately following the establishment of contract terms, delivery can be delayed. Delivery lags can occur as the result of deliberate action taken by the exporter or for some reason beyond the control of the exporting firm.¹⁰ In an international setting, it is costly for the importer to prove that an exporter has deliberately chosen to delay delivery. Even if the importing firm can prove that a delay was intentional, it is unlikely that the importer will be able to recover damages in excess of enforcement costs. As pointed out by Carlton (1979), it is even difficult to recover these damages in a domestic setting. To reflect the high costs of monitoring and enforcing contracts internationally, we assume that exporting firms can intentionally delay delivery without suffering a direct cost.¹¹ To focus the analysis, we assume that opportunism is the only cause of delivery lags and that firms can delay delivery for only one period.¹² Neither bonding mechanisms nor reputational considerations can be used to mitigate the exporter's incentives to engage in post-contractual opportunism.

We consider a competitive export industry composed of n independent firms. For each firm there is a production lag of one period between the time that inputs are committed and the time output is forthcoming. The one period discount factor is β . The per unit production cost of producing a generic product is

$$\langle 1 \rangle \quad c.$$

Since the technology is constant returns to scale, the exporter's decision about the quantity to produce for new contracts does not depend on the quantity of output yet to be delivered on existing contracts. For convenience, the word 'production' is taken to mean production for new contracts. Without being explicit, we take it for granted that in any actual sense production is the sum of existing obligations and new commitments.

Once a good is produced, the firm can either use it to deliver on long-term contracts or sell it on the spot market. The firm delivers a specialized product rather than the generic product. The specialized product has some buyer specific characteristics that, if known at the beginning of the production period, can be incorporated costlessly. However, if the firm chooses to sell on the spot market, the firm incurs an additional cost of ϕ when it incorporates the buyer specific characteristics, which are unknown at the beginning of the production period, at the end of the period. Consequently, the present value of the total cost of producing one unit of output for the domestic spot market is

$$\langle 2 \rangle \quad c + \beta\phi,$$

where β is the discount factor.

If the firm chooses to divert a unit of the product to the spot market from delivery on a long-term contract, it also incurs the cost ϕ . There is an additional per unit cost λ that reflects the cost of cancelling shipping arrangements and other reorganization costs. The total cost of producing one unit of output for the export

market and then switching delivery to the spot market is

$$\langle 3 \rangle \quad c + \beta(\phi + \lambda).$$

In this model, buyers who can forecast their demand for the product one period ahead will always purchase on long-term contracts if there are no delivery lags, as it is cheaper for firms to produce for such contracts than for the spot market.¹³ Buyers on the spot markets have less predictable demands and find it unprofitable to commit themselves to future purchases, provided the difference between the expected contract and spot prices is not too large. We assume that there is no third party with access to the technology by which the generic product is transformed into a specialized product with buyer specific characteristics. In short, there is no market for middlemen or wholesalers in our model.

With our approach, competitive value maximizing importing firms are indifferent to the currency of denomination *per se*. While the demand of importing firms for a given contract type could be derived as the solution of an optimization problem, we simply assume that the demand for contracts is a function of the expected prices evaluated in the foreign currency, *i.e.*, the currency of the importers, and of the expected delivery lags on the two contract types available to them.¹⁴ Delivery lags affect the demand for contracts because importers incur additional costs when delivery does not occur on the promised date.¹⁵ The demand of importing firms does not depend on the spot price, as we assume that the cost to foreign buyers of shopping on an unorganized domestic spot market is prohibitive.¹⁶

If firm i promises to deliver

$$\langle 4 \rangle \quad x'_i, \quad j = d, f,$$

units on long-term contracts denominated in the domestic (d) and foreign (f) currencies, aggregate sales are

$$\langle 5 \rangle \quad X^j = \sum_{i=1}^n x'_i, \quad j = d, f.$$

Recall that, given our definition of a long-term contract, X^d (X^f) is the aggregate quantity that firms promise to deliver in the subsequent period for a per unit price denominated in the domestic (foreign) currency. However, the quantity that firms promise in one period to deliver in the next period is only an upperbound on what they will actually deliver. Since the delivery date is stochastic, we assume that payment is made on delivery.

After firm i has made long-term commitments and after uncertainty has been resolved, it may be profitable for the firm to delay delivery on one or both types of long-term contracts.¹⁷ The delivery policy of firm i ,

$$\langle 6 \rangle \quad d'_i, \quad j = d, f,$$

is the quantity diverted from delivery on its long-term commitments and sold on the spot market. For simplicity, we assume that output cannot be diverted from long-term commitments of one contract type to long-term commitments of the other contract type. Alternatively, we could assume that firms specialize in only one contract type.

A delivery policy must satisfy

$$\langle 7 \rangle \quad d'_i \leq x'_i, \quad j = d, f.$$

The aggregate quantity diverted from each contract type for sale on the spot market is

$$\langle 8 \rangle \quad D^j = \sum_{i=1}^n d_i^j, \quad j = d, f.$$

It must hold that

$$\langle 9 \rangle \quad D^j \leq X^j, \quad j = d, f.$$

If firm i plans to sell a minimum of

$$\langle 10 \rangle \quad x_i^j$$

units on the domestic spot market, the minimum aggregate quantity that is sold on the spot market is

$$\langle 11 \rangle \quad X^j = \sum_{i=1}^n x_i^j.$$

The actual quantity that firm i sells on the spot market is

$$\langle 12 \rangle \quad s_i = x_i^j + d_i^d + d_i^f.$$

Therefore, aggregate sales on the spot market are

$$\langle 13 \rangle \quad S = \sum_{i=1}^n s_i.$$

The inverse demand functions assumed for long-term contracts are

$$\langle 14 \rangle \quad P^j = P^j(X^j, E(P^d/\epsilon), E(D^j/X^j), E(D^d/X^d))$$

and

$$P^d = P^d(X^d, E(1/\epsilon), P^j, E(D^d/X^d), E(D^f/X^f)),$$

where P^j (P^d) is the price in the foreign (domestic) currency on contracts denominated in the foreign (domestic) currency, $E(1/\epsilon)$ is the expected value of the inverse of the exchange rate, and $E(D^j/X^j)$ ($E(D^d/X^d)$) is the expected delivery lag on contracts denominated in the foreign (domestic) currency.

We assume that the demand for each contract type falls with its own price and shifts out with increases in the price of contracts denominated in the other currency. As importers expect to pay $E(P^d/\epsilon)$ in their own currency on contracts denominated in the domestic currency, an increase in $E(1/\epsilon)$ is equivalent to an increase in the expected price on contracts denominated in the domestic currency evaluated in the foreign currency. By analogy, demand for each contract type shifts down with increases in its own expected delivery lag and shifts out with increases in the expected delivery lag on contracts denominated in the other currency. We assume that importers have rational expectations regarding delivery lags, which means here that importers expect exporters to delay delivery when it is profitable for them to do so.

We close the model by assuming that the inverse demand for spot sales is

$$\langle 15 \rangle \quad P^s = P^s(S, \epsilon),$$

where P^s is a decreasing function of the actual spot sales and an increasing function

of ε which is an i.i.d. random variable that represents shocks to the spot demand. Note that spot market buyers have characteristics which make it unprofitable for them to enter long-term contracts, at least for the relevant prices in our model. Therefore, contract prices and expected delivery lags on contracts do not enter the spot demand function.

II. Market Equilibrium and the Currency of Denomination

In this section we describe the equilibrium conditions for the model defined by equations (1)–(15).¹⁸ The intuition behind our analysis involves a comparison of the benefits to exporting firms of following a delivery policy that exploits post-contractual profit opportunities with the benefits to importers of a non-stochastic delivery policy. If the spot price minus the incremental cost of selling on the spot market exceeds the realized contract price, *i.e.*, the price after exchange rate uncertainty has been resolved, evaluated in the domestic currency, then exporters have an incentive to divert to the spot market that quantity of output promised for export which either exhausts existing supplies or equates the spot price to the realized contract price. This is because, by acting opportunistically, they sell the product at its highest price first and hence make a greater profit now and postpone the smaller profit to later. Such a strategy is profitable because of the discounting of future profits that takes place.

Rational importers recognize that post-contractual profit opportunities may arise and expect exporters to exploit them. Therefore, if exporters and importers have access to the same information set, the importers' expectations about the distribution of delivery lags is consistent with the observed distribution of delivery lags. The cost of a higher probability of delivery lags to exporters in the aggregate is the downward shift in the demand for long-term contracts.

The first step in characterizing the conditions for competitive equilibrium is to establish the equilibrium aggregate delivery policy. Clearly, any individual price-taking firm will divert output to the spot market from promised delivery on long-term contracts denominated in the domestic currency whenever the spot price minus the incremental cost of diverting output to the spot market exceeds the contract price, *i.e.*,

$$P^s - \phi - \lambda > P^d.$$

Likewise, any individual price-taking firm will divert output to the spot market from promised delivery on long-term contracts denominated in the foreign currency whenever the spot price minus the incremental cost of selling on the spot market exceeds the contract price evaluated in the domestic currency, *i.e.*,

$$P^s - \phi - \lambda > P^f e.$$

Profit seeking by individual price-taking firms results in aggregate delivery policies on contracts denominated in the domestic and foreign currencies, D^{*d} and D^{*f} respectively, that satisfy

$$\begin{aligned} \langle 16 \rangle \quad & P^s(X^s + D^d + D^f, \varepsilon) - \phi - \lambda > P^d \Rightarrow D^d = X^d \\ & P^s(X^s + D^d + D^f, \varepsilon) - \phi - \lambda < P^d \Rightarrow D^d = 0 \\ & P^s(X^s + D^d + D^f, \varepsilon) - \phi - \lambda > eP^f \Rightarrow D^f = X^f \end{aligned}$$

$$\begin{aligned}
 P^i(X^i + D^d + D^f, \varepsilon) - \phi - \lambda < eP^f &\Rightarrow D^f = 0 \\
 P^i(X^i + D^d + D^f, \varepsilon) - \phi - \lambda = P^d &\Rightarrow 0 < D^d < X^d \\
 P^i(X^i + D^d + D^f, \varepsilon) - \phi - \lambda = eP^f &\Rightarrow 0 < D^f < X^f.
 \end{aligned}$$

It follows from <16> that if $P^d = eP^f = P^i - \phi - \lambda$, there are an infinite number of solutions for D^d and D^f . To complete the specification of the delivery policies and to resolve this indeterminacy we assume that in this case producers adopt the same delivery policy for both types of long-term contracts.

Let d_i^{d*} (d_i^{f*}) represent the optimal delivery policy of firm i consistent with profit-seeking behavior, the delivery policies of other firms, and the aggregate delivery policy defined by <16>. Define \hat{P}^i ($P^j \hat{e}$) as the realizations of the random variables P^i ($P^j e$). Suppose firms believe that

$$\langle 17 \rangle \quad \Phi(\hat{P}^i, P^j \hat{e}) = Pr((\hat{P}^i, P^j \hat{e}) \geq (P^i, P^j e))$$

is the cumulative joint distribution of the spot price and the price on contracts denominated in the foreign currency evaluated in the domestic currency, conditional on <16>. Under this belief firm i chooses sales on long-term contracts, <4>, delivery on long-term contracts, <6>, and a minimum level of sales on the spot market, <10>, to maximize expected profits:

$$\begin{aligned}
 \langle 18 \rangle \quad \max_{x_i^d \geq 0, x_i^f \geq 0, x_i^s \geq 0} & E((\beta(P^i - \phi) - c)x_i^s + (\beta(P^i - (\phi + \lambda)) - c)(d_i^{d*} + d_i^{f*}) \\
 & + (\beta P^d - c)(x_i^d - d_i^{d*}) + (\beta P^f e - c)(x_i^f - d_i^{f*})) \\
 & + \beta^2(P^d - (1/\beta)c)d_i^{d*} + \beta^2(P^f e - (1/\beta)c)d_i^{f*}.
 \end{aligned}$$

Note that the maximization problem takes into account the fact that the firm delivers in the following period the quantity on which it delays delivery in the current period.

When each firm, perceiving that $\Phi(P^i, P^j e)$ represents the ‘true’ distribution of prices, reacts in a way which confirms the distribution $\Phi(P^i, P^j e)$, we have a rational expectations equilibrium (REE). More formally, a REE is a set of firm decisions on long-term contracts, <4>, a minimum value of sales on the spot market, <10>, and a delivery policy, <16>, that satisfy each firm’s optimization problem, <18>, where the aggregate values of the sales, delivery policies and prices satisfy <5>, <8>, <9>, <11>, <13>–<15>.

A REE is compatible with a multiplicity of individual reactions because of the assumption of constant costs. One solution is the symmetric solution in which all firms make the same decisions and essentially divide the market into $1/n$ symmetric segments. However, in its aggregate variables, the model has, in some cases, a unique equilibrium. The aggregate variables are $X^d, X^f, X^s, D^d, D^f, S$, and e . To economize on notation, let P^{d*} (P^{f*}) represent the equilibrium contract prices implied by the equilibrium values of the quantity variables. Let P^{s*} represent the equilibrium value of the spot price.

The basic result of our paper is that a REE has the following simple characterization.

Theorem: An aggregate rational expectations equilibrium, $X^d = X^{d*}, X^f = X^{f*}, X^s = X^{s*}, D^d = D^{d*}, D^f = D^{f*}, S = S^*$, and the implied prices P^{d*}, P^{f*} , and P^{s*}

satisfy

$$\langle 19 \rangle \quad c \geq \beta E \max(P^{i*} - \phi - \lambda, P^{d*}) + \beta^2 [(P^{d*} - (1/\beta)c) Pr(P^{i*} - \phi - \lambda > P^{d*})],$$

$$\langle 20 \rangle \quad c \geq \beta E \max(P^{i*} - \phi - \lambda, eP^{f*}) \\ + \beta^2 E [(eP^{f*} - (1/\beta)c) Pr(P^{i*} - \phi - \lambda > eP^{f*})],$$

$$\langle 21 \rangle \quad c \geq \beta E(P^{i*} - \phi).$$

The theorem states that, in equilibrium, no firm can produce an additional unit of output for sale on any of the three markets and expect to earn a positive profit. Equations $\langle 19 \rangle$, $\langle 20 \rangle$, and $\langle 21 \rangle$ give the zero profit conditions for sales on, respectively, long-term contracts denominated in the domestic currency, the foreign currency and on the spot market.

The proof of the theorem follows directly from the fact that violation of $\langle 19 \rangle$ – $\langle 21 \rangle$ implies the existence of a profit opportunity, because it insures that expected revenue on at least one market exceeds cost. However, by definition, all profit opportunities are exhausted in a rational expectations equilibrium. Therefore, if $\langle 19 \rangle$ – $\langle 21 \rangle$ do not hold, the definition of a REE, specifically $\langle 18 \rangle$, is violated. Notice that the second term on the right-hand side of equations $\langle 19 \rangle$ and $\langle 20 \rangle$ cannot be positive, otherwise long-term contracts would garner positive profits.

The next section uses the theorem to present results on the choice of the currency of denomination of contracts under different configurations of demand, distributions of the exchange rate, and distributions of the spot demand prices.

IV. Interpretation

The analysis of the previous section is very general. Its purpose is to explain the role of output diversion in the equilibrium of foreign trade contracts. In this section we discuss the determinants of particular equilibria. We do so by introducing two lemmas that describe the conditions under which trade contracts denominated in a particular currency are self-enforcing.

Consider first contracts denominated in the domestic currency. Using the theorem of the previous section, we prove that:

Lemma 1: A necessary and sufficient condition for a trade contract denominated in domestic currency to be self-enforcing is that:

$$\langle 22 \rangle \quad P^{i*} - E(P^{i*}) < \lambda$$

always holds for $D^d = 0$.

Proof. From $\langle 19 \rangle$, the contract is self-enforcing if it is always true that, for $D^d = 0$,

$$\langle 23 \rangle \quad P^{i*} - \phi - \lambda < P^{d*}.$$

If the contract is self-enforcing, $\langle 19 \rangle$ implies that

$$\langle 24 \rangle \quad c = \beta P^{d*}.$$

From $\langle 21 \rangle$

$$\langle 25 \rangle \quad c = \beta E(P^{i*}) - \beta \phi.$$

Using $\langle 24 \rangle$ to eliminate P^{d*} in $\langle 23 \rangle$ and $\langle 25 \rangle$ to eliminate c proves the Lemma.

Lemma 1 has the interpretation that if the volatility of the spot price is small, the contract denominated in the exporters' currency is self-enforcing. A small volatility of the spot price obtains when the price level is stable and the real shocks to the spot demand are small, so that the spot price does not fluctuate too much relative to the cost, λ , of diverting output from delivery on trade contracts to the spot market. This suggests that the domestic currency contract is self-enforcing for goods whose demand is not too volatile in economies in which there is little inflation uncertainty. Our model predicts that, for such goods, contracts are mainly denominated in the domestic currency if importers value timeliness. Further, for such goods, the expected delivery lag is smaller for contracts denominated in the exporters' currency than for those denominated in the foreign currency. Those importers that least value timeliness in delivery may prefer contracts to be denominated in the importers' currency, since these contracts have a lower price.

We now turn to the case in which contracts denominated in the foreign currency are self-enforcing:

Lemma 2: The contract denominated in foreign currency is self-enforcing if and only if, for $D^f = 0$, it is always the case that:

$$\langle 26 \rangle \quad P^f - (e/E(e))E(P^f) + (e/E(e))\phi - \phi < \lambda.$$

Proof. Equation $\langle 20 \rangle$ of the theorem implies that the foreign currency contract is self-enforcing if it is always true that, for $D^f = 0$,

$$\langle 27 \rangle \quad P^f - \phi - \lambda < eP^f.$$

If the contract is self-enforcing, it follows from equation $\langle 20 \rangle$ that

$$\langle 28 \rangle \quad c = \beta E(e)P^f.$$

From $\langle 21 \rangle$,

$$\langle 29 \rangle \quad c = \beta E(P^f) - \beta\phi.$$

Using $\langle 28 \rangle$ to eliminate P^f in $\langle 27 \rangle$ and $\langle 29 \rangle$ to eliminate c proves the Lemma.

It follows from Lemma 2 that if changes in the spot price are driven purely by changes in the price level that are offset by changes in the exchange rate, the contract denominated in foreign currency is self-enforcing. This means that one does not expect trade contracts to be denominated in the domestic currency when there is substantial inflation uncertainty in the exporters' country. Cornell (1980) provides evidence supportive of such an hypothesis. Further, in the absence of domestic nominal shocks, one still expects contracts to be denominated in the foreign currency for goods whose demand is high when the exchange rate is high. An example of such a good is a domestically produced good that competes with substitute goods that are imported. Following a real depreciation of the domestic currency, one expects the demand for the good to increase.

Lemmas 1 and 2 characterize goods for which self-enforcing contracts can be achieved by the appropriate choice of a currency of denomination. The goods that are excluded from Lemmas 1 and 2 are goods whose spot demand is highly volatile and is either uncorrelated or positively correlated with the value of the exporter's currency. For these goods, one expects contracts denominated in the exporters' and the importers' currency to coexist, because contracts denominated in different currencies imply different distributions for the delivery lags. Importers who value

on-time delivery the most choose the contract that has the highest probability of on-time delivery. Since the option to divert production to the spot market is the least valuable with this contract, the contract price is higher than with other contracts that have a lower probability of on-time delivery. This means that our analysis predicts that both contract prices and the volatility of the delivery lag vary across contracts that are denominated in different currencies. Generally, for imports from countries with low price level volatility, one expects that contracts denominated in the currency of the exporter have both a higher price and a lower delivery lag volatility than contracts denominated in the currency of the importer when the volatility of the exchange rate is more substantial than the volatility of the spot price.

Importantly, goods for which Lemmas 1 and 2 do not apply will be sold to importers at a price lower than the cost of producing them. To see that this is true, we can rewrite equation <19> as follows:

$$\begin{aligned} \langle 30 \rangle \quad c/\beta = P^{d*} + E \max(P^{r*} - \lambda - \phi - P^{d*}, 0) \\ + \beta[(P^{d*} - (1/\beta)c)Pr(P^{r*} - \lambda - \phi > P^{d*})]. \end{aligned}$$

The second term on the right-hand side of equation <30> is the value of the option to delay delivery. The value of this option must be positive for there to be a positive probability of a delay in delivery. This means that the last term must be negative. Otherwise the exporter receives more than c/β for sure and hence makes profits. Consequently, P^{d*} is lower than c/β . The same argument can be made for foreign currency contracts. While the difference between price and cost seems to suggest dumping, it is really a compensation to importers for delivery lag uncertainty.

Empirical evidence that imports have more delivery lag uncertainty than domestically produced goods and that, consequently, imports have a lower price than these goods, is provided by Jondrow *et al.* (1982) in a comparison of the price of domestic and imported steel. They find that imported steel is cheaper, but that part of the price differential can be explained by differences in the distribution of delivery lags. Our model suggests that the compensation to importers for delivery lag uncertainty depends on the currency of denomination of trade contracts, so that trade contracts for the same good denominated in different currencies are predicted to have different expected prices in a common currency. The exporters can pay for this compensation because the option to delay is valuable. For contracts denominated in the domestic currency, the value of this option increases with the volatility of the spot price and with the discount rate, while for contracts denominated in the foreign currency, it also increases with the volatility of the exchange rate.¹⁹ Hence, one expects contractual import prices to fall relative to the expected spot prices when the volatility of the spot price or the discount rate increase.

Our analysis has the following empirical implications:

1. If there is little inflation uncertainty in the exporter's country and if importers value timeliness in delivery, one expects most contracts to be denominated in the exporter's currency.
2. The volatility of delivery lags differs across contracts that are denominated in different currencies. In particular, the contract for which the ratio of the price evaluated in the currency of the exporter and the spot price is most volatile exhibits the most volatile delivery lag.

3. The contract-type with the highest delivery lag uncertainty has the lowest expected price in the importers' currency.
4. If contracts denominated in the importers' currency exhibit substantial delivery lag volatility, one expects the delivery lag to be longest when the exporters' currency has appreciated unexpectedly.

These empirical implications are in principle testable with data on the currency of denomination of contracts and on delivery lags of the type used by Magee (1973). The empirical implications of our analysis can be tested even if delivery lags occur for reasons other than the strategic delivery policy. This is because lags induced by the strategic delivery policy are common to all contracts for a particular good denominated in a given currency, while in most cases there is no reason to suspect that lags caused by production difficulties are common to all exporters of one good. If the empirical implications of our analysis do not hold on a particular data set, this may mean that the contracts studied are either for goods where the cost of switching output from delivery on trade contracts to the spot market is too high or for goods where the spot price exhibits too little volatility to enable the exporters to pursue a strategic delivery policy.

V. Qualifications and Extensions

In this section, we first investigate alternative ways of making international trade contracts self-enforcing. We then examine the effects of relaxing some of our key assumptions.

V.A. Alternative Mechanisms to Make Trade Contracts Self-Enforcing

It is important to emphasize that the self-enforcement mechanism discussed in this paper is costless for goods that satisfy the conditions set forth in Lemmas 1 or 2. The fact that the choice of currency of denomination is a costless mechanism explains why it will be preferred to alternative mechanisms that intuitively provide a solution to the problem of post-contractual opportunism by exporters. In particular, any bonding mechanism could solve that problem but it would do so at the cost of establishing a bond.

A frequent solution to the problem of post-contractual opportunism is reputation. In the context of this paper, exporters who deliver on time have a reputation of reliability and lose it if they delay delivery. Hence, by delaying delivery, exporters lose customers. However, there is a cost to building a reputation, since it requires exporters to deliver goods when it is unprofitable to do so in the short run. In our model, for the goods for which there is a costless mechanism to resolve the problem of post-contractual opportunism, firms cannot earn rents for the reputation they have built, which negates the incentive for acquiring a reputation in the first place. Hence, one would expect firms to incur real costs to insure that post-contractual opportunism does not occur only for those goods that do not satisfy the conditions of Lemmas 1 or 2. It is possible, however, that for goods that do not satisfy the conditions of these Lemmas, there exist contingent contracts that are self-enforcing. For instance, the contract price could be a function of some spot price index and of the exchange rate.²⁰

Importantly, if an exporter expends resources to limit its incentives to engage in

post-contractual opportunism, the model developed in this paper can still be used. To see this, suppose that a reputation mechanism is introduced for goods that satisfy neither Lemma 1 nor Lemma 2. In the presence of such a mechanism, there is a cost to the exporter of engaging in post-contractual opportunism in the form of the loss of reputation. The theorem developed in Section III still holds, but now λ is inclusive of the cost to the exporter of the loss of reputation resulting from post-contractual opportunism. Clearly, if the cost of that loss is large enough, it makes contracts self-enforcing that otherwise would not be. Reputation considerations do not mean, however, that the issue of the currency of denomination becomes meaningless. There will be a currency of denomination that implies less expenditures on reputation building than the other. That currency is the one that has the shortest expected delivery lag. Hence, if in the absence of reputation considerations, contracts denominated in the domestic currency have the shortest expected delivery lag, one would expect contracts made self-enforcing by a reputation mechanism to be denominated in the domestic currency.

V.B. Post-Contractual Opportunism by Importers

Because of the use of letters of credit in financing international trade, it is typically harder for importers to engage in post-contractual opportunism than for exporters. It is interesting to note, however, that when this is not true, the choice of a currency of denomination can attenuate the incentives for importers to engage in post-contractual opportunism. In this case, using the importer's currency to denominate the contract stabilizes the price that the importer will have to pay. However, denominating the contract in the importers' currency may exacerbate the exporters' incentives to act opportunistically. In this case, the use of a third currency can help since, when the contract is denominated in a third currency, it is possible for the contract price evaluated in the exporters' currency and in the importers' currency to exhibit too little volatility to make opportunistic actions either by the importer or by the exporter profitable.

An interesting case arises when both importers and exporters have access to a spot market. Suppose that the importer pays a cost k' in the foreign currency if delivery is not accepted. With this cost, importers walk away from the contract only if the contract price, evaluated in the foreign currency, exceeds the spot price by more than k' . The availability of a spot market for importers leads to a symmetric situation between importers and exporters. If the spot market for both importers and exporters is an organized market in a third country, a contract denominated in the currency of that country is self-enforcing if the volatility of the spot price is not too large. As long as the spot price does not deviate too much from the contract price, no party has any incentive to act opportunistically. To see this, define e'_j and e'_d to be, respectively, the price of the third currency in the importers' and in the exporters' country. Further, let P'_i be the spot price in the third currency and P' the contract price in that currency. With this notation, a trade contract denominated in the third currency is self-enforcing if:

$$\langle 31 \rangle \quad P' - k'/e'_j < P'_i < P' + (\phi + \lambda)/e'_d$$

for all values of e'_j , e'_d and P'_i . The second inequality in equation $\langle 31 \rangle$ is similar to equation $\langle 27 \rangle$, except for the fact that equation $\langle 27 \rangle$ is expressed in the currency of the exporter, while equation $\langle 31 \rangle$ is expressed in the third currency.

To see why the self-enforcing contract is likely to be denominated in the third currency, we consider the implications of denominating it in the currency of the exporters and in the currency of the importers. If the contract is denominated instead in the currency of the importers, equation <31> changes to:

$$\langle 32 \rangle \quad (P^f - k')/e'_j < P'_i < P^i/e'_j + (\phi + \lambda)e'_d.$$

Unless e'_j and P'_i are positively correlated, <31> is more likely to hold than <32>. If the contract is denominated in the currency of the exporters, equation <31> becomes:

$$\langle 33 \rangle \quad (P^d - k'e)/e'_d < P'_i < (P^d + \phi + \lambda)/e'_d.$$

Again, unless P'_i and e'_d are positively correlated, <31> is more likely to hold than <33>.

Unless the spot price in the third currency is positively correlated with either the exchange rate of the exporters' currency or of the importers' currency with the third currency, one expects the contract to be denominated in the third currency. Consequently, equation <31> defines a class of goods for which one expects a third currency to be used to denominate contracts. These goods have an organized spot market in a third country. To the extent that such spot markets are in the UK and the USA, this analysis provides some support for the use of vehicle currencies to denominate international trade contracts. Goods for which organized spot markets exist are typically raw materials. For raw materials, the empirical evidence is that contracts are usually denominated in vehicle currencies.²¹

VI. Conclusion

In this paper, we present a model in which the currency of denomination of contracts determines the delivery policy associated with the contract, irrespective of the hedging opportunities available to firms. In this model, exchange rate uncertainty and uncertainty in spot demand have real effects on the manner in which contracts are written, executed and enforced. We argue that firms have an incentive to delay delivery on long-term contracts whenever they can sell their products on a spot market for a price in excess of the stipulated contract price. In general, there is a cost associated with a credible commitment to leave unexploited post-contractual profit opportunities. However, we demonstrate that, in some economic environments, a firm can costlessly assure its customers that it will fulfill the terms of its contracts by an appropriate choice of the currency of denomination of long-term contracts.

Notes

1. See Baron (1976) and Magee and Rao (1980).
2. See Grassman (1973).
3. See Magee (1973), Page (1977), and Carse *et al.* (1979).
4. See Cornell (1980).
5. See Wilson (1984). Most of the paper focuses on the effect of this assumption on the behavior of exporters, since the use of letters of credit in the financing of international trade limits the importers' ability to engage in post-contractual opportunism. Section V discusses the effect of costly contracting on the behavior of importers.
6. See Grassman (1973), Baron (1976a, b), Cornell (1980), Magee and Rao (1980), and Bilson (1983).

7. The analysis could be extended to risk-averse firms; however, an important contribution of the paper is to derive a theory of the currency of denomination of trade contracts that does not require firms to be risk averse. Further, if one believes that hedging foreign currency risk is cheap, a firm's attitude towards risk will not affect contract prices. Exporters will act strategically as discussed in this paper whether hedged or not.
8. The motivation for this assumption is that we do not want foreign firms to be able to buy on that spot market. It would make little sense to assume that they cannot buy on an auction market.
9. The results of this paper hold for alternative exchange rate distributions as long as the probability that a low value of e is followed by a low value of e does not exceed 0.5 by too much.
10. Our analysis is similar to Carlton (1979) in that we treat delivery lags as a predictable equilibrium phenomenon.
11. The high monitoring and enforcing cost also explains why penalties in the form of price reductions for late deliveries are not substitutes for the proper choice of the currency of denomination. If the penalties are large and exogenous factors can affect the delivery date, the penalties themselves could induce exporters to walk away from contracts. If the penalties are small, there will always be instances in which it pays for exporters to delay delivery.
12. The analysis could be extended to allow for a delivery delay of more than one period. The gain in generality would come at the expense of a substantially more complicated model. However, our main results would remain unchanged. For instance, for contracts denominated in the domestic currency, there would be a threshold spot price greater than the expected spot price such that delivery on these contracts would take place if the spot price is below this threshold spot price.
13. Any other assumption which allows for the possibility that markets for long-term contracts coexist with a spot market would leave our results unaffected. See Carlton (1979) for a discussion of these issues.
14. If the two contracts have different expected prices, evaluated in the foreign currency, and different expected delivery lags, it is possible for markets to be active in both contract types. However, if the expected price adjusted for the implied delivery policy of one contract type is lower than the other, there is no demand for the high-price contract.
15. For instance, they may incur the carrying cost of idle inventories waiting for delivery of the needed input from abroad or the cost of empty shelf space if the imported good is to be sold directly to consumers. See Gould (1978) and DeVany (1976) for models which justify this assumption.
16. This assumption simplifies the analysis without affecting the nature of our results. For analytical convenience, we want spot demand to remain unaffected by delivery lags on contracts.
17. We assume that exporters do not have the opportunity to deliver ahead of time. In a more general model, exporters could deliver early if they chose to divert output from the spot market to deliver on trade contracts. However, given the cost of such a change in plan, the cost of producing and delivering early would exceed the cost of producing and delivering on time. Further, unless exporters can force importers to pay early on early deliveries, exporters would lose interest on the payment until the promised delivery date. Early delivery is therefore unlikely to occur unless the spot price is substantially below the contract price, in which case the distinction between the spot market and the contract market would break down.
18. The structure of this model and its solution are similar to models used to analyze the intertemporal allocation of output with inventories, for example Reagan and Weitzman (1982), as well as models used to analyze temporary layoffs, for example Parsons (1987).
19. The volatility effect follows from Merton (1973). The discount rate effect is straightforward and can be verified by inspection of equations <19> and <20>. As the discount rate increases, the benefit from realizing a higher profit now increases.
20. Note, however, that a contract denominated in the domestic currency but with a price indexed to the price of the foreign currency can be a good substitute for a contract denominated in the foreign currency for the goods that satisfy Lemmas 1 and 2.
21. See Magee (1973), Page (1977), and Carse *et al.* (1979).

References

- BARON DAVID P., 'Fluctuating Exchange Rates and the Pricing of Exports,' *Economic Inquiry*, September 1976, 14: 425-438 (1976a).

- BARON, DAVID P., 'Flexible Exchange Rates, Forward Markets and the Level of Trade,' *American Economic Review*, June 1976, **66**: 252-266 (1976b).
- BILSON, JOHN F.O., 'The Choice of an Invoice Currency in International Transactions,' in Jagdeep S. Bandari and Bluford H. Putnam, eds, *Economic Interdependence and Flexible Exchange Rates*, Cambridge: M.I.T. Press, 1983.
- CARLTON, DENNIS W., 'Contracts, Price Rigidity and Market Equilibrium,' *Journal of Political Economy*, October 1979, **87**: 1034-1062.
- CARSE, STEPHEN, JOHN WILLIAMSON, AND GEOFFREY WOOD, *The Financing Procedures of British Foreign Trade*, London: Cambridge University Press, 1979.
- CORNELL, BRADFORD, 'The Denomination of Foreign Trade Contracts Once Again,' *Journal of Financial and Quantitative Analysis*, November 1980, **15**: 933-944.
- DEVANY, ARTHUR, 'Uncertainty, Waiting Time, and Capacity Utilization: A Stochastic Theory of Product Quality,' *Journal of Political Economy*, June 1976, **84**: 523-542.
- GOULD, JOHN P., 'Inventories and Stochastic Demand: Equilibrium Models of the Firm and Industry,' *Journal of Business*, January 1978, **51**: 1-42.
- GRASSMAN, SVEN, 'A Fundamental Symmetry in International Payment Patterns,' *Journal of International Economics*, May 1973, **3**: 105-116.
- JONDROW, JAMES M., DAVID E. CHASE, AND CHRISTOPHER L. GAMBLE, 'The Price Differential between Domestic and Imported Steel,' *The Journal of Business*, July 1982, **55**: 383-400.
- MAGEE, STEPHEN P., 'Currency Contracts, Pass-through, and Devaluation,' *Brookings Papers on Economic Activity*, 1973, No. 1: 117-168.
- MAGEE, STEPHEN P., AND RAMESH RAO, 'The Currency of Denomination of International Trade Contracts,' in Richard M. Levich and Class Wihlborg, eds, *Exchange Risk and Exposure: Current Developments in International Financial Management*, Lexington: D. C. Heath, 1980.
- MERTON, ROBERT C., 'The Theory of Rational Option Pricing,' *The Bell Journal of Economics and Management Science*, Spring 1973, **4**: 141-183.
- PAGE, S.A.B., 'The Currency of Invoicing in International Trade,' *National Economic Review*, August 1977, **81**: 77-81.
- PARSONS, DONALD O., 'The Employment Relationship: Job Attachment, Work Effort, and the Nature of Contracts,' in O. Ashenfelter and R. Layard, eds, *Handbook of Labor Economics*, Amsterdam: North-Holland, 1987.
- REAGAN, PATRICIA B., AND MARTIN L. WEITZMAN, 'Price and Quantity Adjustments by the Competitive Industry,' *Journal of Economic Theory*, August 1982, **27**: 410-420.
- WILSON, DONALD T., *International Business Transactions*, St. Paul: Publishing Co., 1984.