INEFFICIENT TRADE PATTERNS: EXCESSIVE TRADE, CROSS-HAULING AND DUMPING

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Abstract

I study an example of a competitive environment in which trade occurs in a sequential manner. In this example, a country with a stable demand may suffer from trade with a country with unstable demand, there may be too much trade, a country may import and export the same good in the same period (cross-hauling) and dumping may occur. The timing of delivery is important. When delivery occurs before trade (delivery to stocks) trade improves welfare, there is dumping but no cross-hauling. When delivery occurs after trade (delivery to order), trade may reduce welfare and cross-hauling may occur.

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1. INTRODUCTION

Uncertainty about demand and supply conditions is an important feature of the environment. Yet the standard formulation of a competitive environment does not offer an explicit description of the resolution of uncertainty about market conditions. Instead we have a Walrasian auctioneer who resolves the uncertainty about supply and demand and announces the market-clearing price before the beginning of actual trade.

Monopolistic competition of the type pioneered by Dixit and Stiglitz (1977) is one possible remedy to this well-known problem. It has been widely used in the new Keynesian economics literature and in the international trade literature (see for example, Helpman and Krugman [1985], Obstfeld and Rogoff [1996] and Woodford [2003]).

But for many problems the price-taking assumption is a useful abstraction. I therefore investigate here the Prescott (1975) "hotels" model, studied by, among others, Bryant (1980), Rotemberg and Summers (1990), Deneckere, Marvel and Peck (1996), Dana (1998, 1999) and Deneckere and Peck (2005). Here I use the flexible price version in Eden (1990, 2005) and Lucas and Woodford (1993). This version offers an explicit description of the resolution of uncertainty about market conditions and at the same time abstracts from monopoly power and strategic behavior.

In the Prescott (1975) model a lower price promises a higher probability of making a sale and sellers are indifferent among all prices in the support of the equilibrium distribution. As a result the model determines the equilibrium price distribution but is silent about individual sellers' prices.

Here I assume increasing marginal cost and take explicit account of transportation costs. This allows for sharp predictions about individual sellers' price offers and trade patterns. I focus on the issues of gains from international trade, dumping and cross-hauling. In the example analyzed, a stable demand country suffers from trade with an unstable demand country, there may be too much trade, a country may export and import the same good in the same period (cross-hauling) and a country may export at a price that is lower than the price it charges at home (dumping).

The timing of delivery is important. When delivery occurs ex-ante before the arrival of buyers (delivery to stocks as in food items delivered to supermarkets) trade improves welfare, there is dumping but no cross-hauling. When delivery occurs ex-post (delivery to order as in internet trading), trade may reduce welfare, cross-hauling may occur but dumping does not occur.

In the delivery to stocks case, goods must be on display before the beginning of trade. Since the probability of making a sale is higher in the stable demand country, the price in the stable demand country is lower than the price in the unstable demand country and exporters from the unstable demand country may be accused of dumping.

In the delivery to order case, buyers are treated symmetrically. In the high demand state some buyers from each country arrive early and buy at a cheap price and some arrive late and buy at a higher price. When sellers in the home country supply at the cheap price there will therefore be some export at the low price and some import at the high price (cross-hauling). Trade may reduce welfare in the stable demand country because in the high demand state buyers from the stable demand country may not be able to buy at the cheap price. In general, increasing the uncertainty about demand is "bad" because it leads to more price dispersion and lower average capacity utilization. A country with a relatively stable demand may therefore suffer from trade if as a result of trade there is more demand uncertainty.

The model has elements in common with Newbery and Stiglitz (1984). In both models trade in a single good arises as a result of uncertainty about demand (or supply) and markets are incomplete. But there are important differences. In Newbery and Stiglitz there is a single market clearing price in each period and capacity is always fully utilized. In their model fluctuations in prices provide insurance to farmers against bad crops and are therefore “good” from the social point of view. Trade in their model may reduce welfare because it smoothes prices. In our model price dispersion is “bad” from the social point of view and trade may reduce welfare if it increases the dispersion in prices.

The model is also related to the modern theory of cyclical dumping initiated by Ethier (1982). As in the peak-load-pricing model of Williamson (1966), the competitive price in Ethier’s model is equal to the short run marginal cost when demand is low and capacity is not fully utilized. Ethier demonstrates that firms with high fixed cost due to labor contracts that promise secure employment may sell below average cost in downturns. In his model there is a single price that clears the international market (for steel in his example) and therefore the accusation of dumping will not be supported if the same period home price is used to define the “fair price”. In our model a seller may export at a lower price than the same period home price and therefore an accusation of dumping may be supported even when there are enough data to compute the same period home price. The analysis of dumping here is also different from the traditional price discrimination view because here sellers do not have monopoly power.

Our model is also related to the Cournot type model considered by Brander (1981) and Brander and Krugman (1983). In their model there is a single firm in each country that delivers its output to two markets: the home and the foreign market. The firm takes the quantities delivered to the two markets by the other firm as given and chooses quantities to maximize profits. Cross-hauling and reciprocal dumping may occur and if transportation costs are high, trade may reduce welfare. In our model the environment is competitive and firms take prices as given. Cross-hauling in our model occurs only in the delivery to order case while the Brander and Krugman game suggests segmented markets and delivery to stocks.

2. THE MODEL

I assume a single period economy, two countries (1 and 2), two goods (X and Y with lower case letters denoting quantities) and two states of nature (1 and 2) that occur with equal probability. In each country there are two types of agents: Sellers (producers) and buyers. All agents are risk neutral and get a large endowment of good Y.

Sellers in both countries are the same and derive utility only from Y. Their utility function is: $u^s(x,y)$ = y. They can use their endowment of Y to produce X. The cost of producing x units of X is

C(x) = $(\frac{1}{2})x^2$ units of Y. Production must occur before the beginning of trade.

Buyers differ in the probability that they want to consume X. The buyers in country 1 always want to consume X and their utility function is: $u^{b,1}(x,y)$ = y + U(x), where U(x) = ln(x). Buyers in country 2 want to consume X only in state of nature 2 and have a random utility function: $u^{b,2}(x,y)$ = y in state 1 and $u^{b,2}(x,y)$ = y + U(x) in state 2.

There is one potential buyer per seller in each country. This assumption arises naturally when the economy lasts for many periods and agents change roles: they sometimes act as sellers (producers) and sometimes act as buyers.[2] For convenience, I normalize the number of sellers (buyers) in each country to 1. This assumption about the absolute size of the two countries is not important for the main results.

A buyer who wants to consume and faces the price p, solves $\max_x$ U(x) - px. The first order condition for this problem is:

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[2] This is the standard assumption in overlapping generations (OG) and cash in advance models. In Eden (2006) I study an OG monetary version of this model where young agents use Y (labor) to produce X. In the second period of their life they use the proceeds from selling their output to buy X if they want to consume (in state 2) and pass it as accidental bequest if they do not want to consume. The results in this paper will not change if we adopt this OG framework but since this paper is not about the choice of assets, I simplify by assuming a single period economy.

$U'(x) = 1/x = p$. The demand function of an individual who wants to consume is thus: $D(p) = 1/p$. A seller who can sell with probability q at the price p solves: $\max_x qpx - C(x)$. The first order condition for an interior solution to this problem is: $C'(x) = x = qp$.

Under <u>autarky</u> there is no uncertainty about demand in country 1, the probability of making a sale is q = 1 and therefore in equilibrium:

$$U'(x) = C'(x) = p. \qquad (1)$$

The solution to (1) is: x = p = 1. Profits in the autarkic equilibrium are: $px - \frac{1}{2}x^2 = 0.5$. The buyer's utility is: $\ln(x) + \bar{y} - xp = \ln(x) + \bar{y} - 1$, where $\bar{y}$ is the buyer's endowment of Y. The buyer's surplus is: $\ln(x) - 1 = -1$. Welfare in country 1 is measured by total surplus: 0.5 - 1 = -0.5.

In country 2 demand (under autarky) is positive only in state 2, the probability of making a sale is $q = \frac{1}{2}$ and therefore in equilibrium: $C'(x) = (\frac{1}{2})p$, where p is the price posted by sellers in country 2. (Note that no transactions occur at this price in state 1). The equilibrium condition for country 2 is thus: $U'(x) = 2C'(x) = p$. The solution to these equations is: x = 0.707 and p = 1.414. Expected profits are: $(\frac{1}{2})(px - x^2) = 0.25$. The buyer's surplus is: $(\frac{1}{2})[\ln(1/p) - 1] = -0.673$. Welfare is: 0.25 - 0.673 = -0.423. On average only $\frac{1}{2}$ of the quantity produced in country 2 is sold and therefore average capacity utilization in country 2 is $\frac{1}{2}$.

Outputs and marginal costs are different across countries. This is essential for trade. It requires the assumption that the marginal cost is increasing (rather than constant as in the original Prescott and

Brander models) and that the number of potential buyers per seller is the same in both countries.[3] As was said before, the assumption that there is one potential buyer per seller arises naturally in multi-periods economies in which agents change roles. We may think of the comparative advantage in this model as resulting from differences in average "consumption productivity": The buyers in country 1 can derive utility from X in both states while the buyers in country 2 can derive utility from X only in state 2.[4]

I now turn to the discussion of international trade.

2.1 DELIVERY TO STOCKS (SEGMENTED MARKETS)

I start with the assumption that merchandise must be displayed on location before the beginning of trade as in food products displayed in a supermarket. I assume that it costs τ units of Y to transport a unit of X from one country to another and use the following notation:

x_{jm} = supply to counrty j by a seller who resides in country m

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[3] If in country 2 there were 2 buyers (and one seller) the equilibrium quantity produced by the seller in country 2 would be unity and the only difference between the countries will be in the price charged for this unit.

[4] A dynamic model that allows for the accumulation of capital may prove useful. I expect that since in our example the producer surplus is lower in country 2, adding capital will not change the main results: the equilibrium quantity of both inputs and the marginal cost will be lower in country 2.

(seller m); p_j = the price in country j.

Seller m takes the prices p_j as given and chooses the quantities x_{jm} to maximize his expected profits:

$$p_1 x_{1m} + (½)p_2 x_{2m} - (½)(x_{1m} + x_{2m})^2 - I(j \neq m)\tau x_{jm}, \qquad (2)$$

where $I(j \neq m) = 1$ if $j \neq m$ and zero otherwise. Note that transportation costs are paid regardless of whether the unit is sold or not and only for units supplied to the foreign country.

The first order conditions for (2) are:

$$C'(x_{1m} + x_{2m}) + I(j \neq m)\tau \geq q_j p_j \text{ with equality if } x_{jm} > 0, \qquad (3)$$

where q_j is the probability of making a sale in country j. Condition (3) says that the marginal cost of production, $C'(\ )$, plus the transportation cost must be greater than the expected revenue if the supply is zero and must equal to it if the supply is strictly positive.

Market clearing requires:

$$x_{j1} + x_{j2} = D(p_j) \quad \text{for } j = 1,2. \qquad (4)$$

Note that (3) and (4) is a system of six equations in six unknowns: x_{11}, x_{12}, x_{21}, x_{22}, p_1, p_2. In Appendix A I show that there exists a unique equilibrium in which seller 2 supplies to both countries while seller 1 supplies only to his home country ($x_{21} = 0$).

Since under autarky the marginal cost of seller 2 is lower than the marginal cost of seller 1 we expect that seller 2 will increase production and export it to country 1. This will reduce price and production in country 1 and will work in the direction of lowering the difference in the marginal cost. Table 1 illustrates. It uses Appendix A to calculate the equilibrium magnitudes for three levels of transportation costs: 0, 0.1 and prohibitively large (the autarkic case discussed above). For the sake of comparison with subsequent cases I use e_s to denote the amount of export in state s and $Av = (|e_1| + |e_2|)/2$ to denote the average amount of trade.

The last row in Table 1 is the autarkic case in which the marginal cost of seller 2 is lower than the marginal cost of seller 1. We then lower transportation costs and this works to reduce the difference between the marginal costs by increasing the marginal cost of seller 2 and reducing the marginal cost of seller 1. As a result the price in country 1 goes down and the price in country 2 goes up. Thus, unlike the standard international trade model, here reducing transportation costs increases price dispersion. Note that since $p_2 \leq 2p_1$, seller 1 has no incentive to export to country 2.

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Table 1 about here

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Table 2 calculates the surplus for each of the four agents and their sum in each country. Not surprisingly, the profits of seller 1 go down with the decline in transportation costs while the profits of seller 2 go up. But total welfare goes up in each country as a result of lowering transportation costs.

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Table 2 about here

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Note that seller 2 exports at a price that is lower than the price in his country. The intuition is clear: capacity utilization (fraction of output sold) is higher in country 1 and therefore the price is lower in country 1. Seller 2 may therefore be accused of dumping. I now turn to a brief discussion of this issue.

<u>Dumping:</u> A seller may be accused of dumping whenever he exports at a price that is less than the "fair price". According to Blonigen (2003) the "preferred" method of calculating the "fair price" is the price of the product before it leaves the factory in the home country. But since this is inherently unobserved, final consumer prices are used after various adjustments. When the investigated foreign firm does not have "sufficient" sales of the product in its own market, sales in a third country are used. If there are no "sufficient" sales to a third country, estimated average cost is used.

In our model (Table 1) exports in the high demand state occur at a lower price than in the home country and therefore seller 2 may be accused of dumping. In the low demand state, a high price is quoted in country 2 but there are no transactions at this price and therefore the accusation of dumping may not be supported.[5]

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[5] In an Appendix that is on my web page, I worked out an example in which there are two strictly positive realizations of demand in country 2. In this example, there are always transactions in country 2

2.2 DELIVERY TO ORDER (FULL INTEGRATION)

Ethier (1979) and Sanyal and Jones (1982) emphasize the fact that much of international trade is in intermediate inputs and not in final goods. The assumption that goods must be displayed on location before the beginning of trade does not seem realistic for wholesale trade in intermediate inputs. I therefore consider now the case in which goods can be ordered on the internet.

It is assumed that buyers' orders arrive sequentially and delivery occurs at the end of the arrival process. Transportation costs are paid only if actual delivery takes place. As before production must occur ex-ante before the beginning of trade.[6]

In the previous delivery to stocks case the buyers in country 1 bought at the low price and (in state 2) the buyers in country 2 bought

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but in the low demand period the export price is the same (after taking transportation costs into account) as the price at home. Only in the high demand state can an accusation of dumping be supported. An accusation of dumping can also be supported if an average over time or average quoted prices (rather than actual transaction prices) is used to calculate the "fair price".

[6] Of-course, in the real world the distinction between delivery to stocks and delivery to order is not always sharp. Sometimes it is possible to order in the store an item that is stocked out. The analysis of stock-outs and inventories requires a multi-period framework and will not be attempted here.

at the high price. Here I treat all buyers symmetrically and assume that all buyers who want to consume have the same chance of buying at the low price. (See Dana [1998], for alternative possible assumptions.) This makes a big difference both for the welfare analysis and for the trade patterns that may emerge.

Welfare analysis is different because country 1 buyers lost their priority on buying at the low price. As a result buyer 1 may suffer from trade and since the profits of seller 1 goes down as well, country 1 may suffer from trade.

We get cross-hauling when transportation costs are strictly positive. In this case the equilibrium sellers' supplies are not symmetric: Seller 1 supplies only at the low price while seller 2 supplies at both prices. But this asymmetric equilibrium does not economize on transportation costs. To show this we start by describing a symmetric equilibrium that is possible only if transportation costs are literally zero.

<u>Symmetric equilibrium with no transportation costs:</u> Trade occurs sequentially. Buyers who want to consume form a line. The place in the line is determined by a lottery that treats all buyers who want to consume symmetrically. After forming the line they arrive at the market place (go on the internet) one by one in a process that does not take real time (and occurs in meta time). Upon arrival buyers see all price offers and buy at the cheapest available offer.

In this fully integrated world economy either 1 or 2 buyers will arrive. From the sellers' point of view a first batch (of 1 buyer) arrives with certainty and after it completes trade a second batch (of 1 buyer) may arrive (with probability $^1/_2$). Since buyers that want to consume are treated symmetrically, the buyers' composition in each batch represents the worldwide composition of buyers who want to consume. In state 1, only the first batch arrives and all of the buyers in this batch are from country 1. In state 2 two batches arrive and in each batch half of the buyers are from country 1 and half are from country 2.

Sellers are price-takers and expect to be able to sell to the first batch at the price p_1 and to the second batch at the price p_2 if it arrives. Seller m makes a contingent plan that specifies the amount, k_{im}, that he will sell to batch i if it arrives.

It is convenient to talk about two markets. The first market opens with certainty at the price p_1 and the second market opens with probability ½ (if country 2 buyers want to consume) at the price p_2. Note that in the previous delivery to stocks case the first market was in country 1 and the second in country 2. Here markets are an abstract concept and have no specific location.

Seller m chooses the supply to market i, k_{im}, by solving:

$$\max_{k_{im}} p_1 k_{1m} + (½) p_2 k_{2m} - C(k_{1m} + k_{2m}) . \tag{5}$$

The first order conditions for an interior solution to (5) are:

$$p_1 = (½) p_2 = C'(k_{1m} + k_{2m}) = k_{1m} + k_{2m} . \tag{6}$$

Equilibrium requires in addition to (6) the market clearing conditions:

$$k_{11}+k_{12}=D(p_1) \;=\; {}^{1}\!/_{p_1} \quad \text{and} \quad k_{21}+k_{22}=D(p_2) \;=\; {}^{1}\!/_{p_2}\,. \qquad (7)$$

In the symmetric case: $k_{i1} = k_{i2} = k_i$. In state 1 seller 2 exports $e_1 = k_1$ units to country 1. In state 2 the demand in each country is the same and there is no trade across countries. The average amount of trade is thus: Av = $(\frac{1}{2})k_1$. Table 3 compares the symmetric solution to (6) and (7) to autarky. When transportation costs (τ) drop to zero, the difference between the marginal costs ($p_1 - MC^2$) drops to zero, the supply (per seller) to market 1 goes up (from 0.5 to 0.577) and the supply to market 2 goes down (from 0.354 to 0.289).

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Table 3 about here

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Expected profits per seller are: $p_1k_1 + (\frac{1}{2})p_2k_2 - (\frac{1}{2})(k_1+k_2)^2$ = 0.375. The fraction of revenues obtained in market 1 when both markets open is: $\theta = \dfrac{p_1k_1}{p_1k_1+p_2k_2}$ = $\frac{1}{2}$. This is also the probability that a unit of Y will buy in market 1 when both markets open. Since buyer 1 spends a unit of Y in both states, his expected surplus is:

$$(\tfrac{1}{2})\ln({}^{1}\!/_{p_1}) + (\tfrac{1}{2})[\theta\ln({}^{1}\!/_{p_1}) + (1-\theta)\ln({}^{1}\!/_{p_2})] - 1 \;=\; -\,1.029. \qquad (8)$$

The expected surplus of country 2's buyer is:

$$(\tfrac{1}{2})[\theta\ln({}^{1}\!/_{p_1}) + (1-\theta)\ln({}^{1}\!/_{p_2}) - 1] \;=\; -0.601. \qquad (9)$$

Table 4 summarizes the welfare calculations. Relative to autarky, the buyers and the sellers in country 1 are both worse off. And the buyer and the seller in country 2 are both better off.

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Table 4 about here

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Our welfare results are different from the standard result. The standard result is that some individuals in every country gain from trade and if transfers are allowed trade leads to a Pareto improvement. Here all the agents in country 1 lose from trade and all the agents in country 2 gain from trade. To build some intuition note that under autarky average capacity utilization (the fraction of output sold) in country 1 is 1 and in country 2 is $\frac{1}{2}$. In the fully integrated world economy average capacity utilization is:
$\frac{1}{2} + (\frac{1}{2})k_1/(k_1 + k_2) = 0.833$. Thus as a result of trade average capacity utilization went down in country 1 and up in country 2. Roughly speaking we may think of average capacity utilization as a measure of markets performance. Country 1 starts with a perfectly efficient market in which everything that is produced is sold. When it opens to trade only a fraction of what was produced is sold and therefore welfare goes down.

On a deeper level the reason for the surprising welfare result is in incomplete markets. Unlike Newbery and Stiglitz (1984), here agents are risk neutral so that there is no lack of insurance markets. But we miss ex-ante markets for allocating capacity.

The above equilibrium solution assumes a symmetric equilibrium in which both sellers allocate identical amounts to the two hypothetical markets. Since sellers are indifferent to the way they allocate output across markets there are many other equilibria. We now show that these other equilibria require a higher volume of trade relative to the symmetric case.

<u>Claim 1:</u> The symmetric equilibrium minimizes expected trade between the two countries.

The proof is in Appendix B.

I now introduce transportation costs to pin down the equilibrium solution.

<u>Transportation costs:</u> The introduction of strictly positive transportation costs ruins the symmetric equilibrium. To see this point, note that the first market price clears the market in the low demand state. Since all the buyers in the low demand state reside in country 1, transportation costs introduce a discrepancy between the first market price that country 1 buyers pay and the first market price that country 2 sellers get. But seller 1 gets the full amount paid by the buyers in the low demand state. As a result, both sellers cannot be indifferent between the two markets: If seller 2 is indifferent, seller 1 will prefer to specialize in market 1. I elaborate on this point later.

I now turn to describe the emerging asymmetric equilibrium in detail. I assume here that the buyer pays transportation costs of τ units of Y per unit of X if actual delivery from a foreign country takes place. The buyer sees the location of the seller at the time he makes his order on the internet and takes transportation costs into account when choosing the best available offer. Seller m assumes that he can sell to the first batch at the (net of transportation cost) price p_{1m} and to the second batch (if it arrives) at the price p_{2m}.[7]

I now modify (5) and (6) to take account of seller specific prices. Seller m chooses the quantities k_{im} to maximize expected profits:

$$p_{1m}k_{1m} + (\tfrac{1}{2})p_{2m}k_{2m} - C(k_{1m} + k_{2m}) \qquad (10)$$

The first order conditions for this problem are:

$$C'(k_{1m} + k_{2m}) \geq q_i p_{im} \text{ with equality if } k_{im} > 0. \qquad (11)$$

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[7] Like in the case of taxes it does not matter who actually pays the transportation costs. An alternative formulation may assume that the seller pays the transportation costs and quotes different prices for home and foreign buyers. Let P_{imf} be the price that seller m charge from foreigners and P_{imh} be the price that he charges from buyers in the home country. In equilibrium $P_{imf} = P_{imh} + \tau$ because otherwise the seller will refuse to sell to some buyers: if, for example, $P_{imf} > P_{imh} + \tau$ he will refuse to sell to buyers in the home country. Since $P_{imf} = P_{imh} + \tau$ we may drop an index and let $p_{im} = P_{imh}$ denote the price that the seller gets. This alternative is adopted here because it is simpler (and it is used in actual internet and commodity trading). The analysis will not change if the second alternative is adopted. In the previous delivery to stock case, transportation costs occurred before the buyers arrive and regardless of whether sale was actually made. It was therefore more natural to assume that the seller quotes prices that include transportation costs.

In the low demand state, only the buyers in country 1 want to consume. For these buyers the relevant price is $\min(p_{11}, p_{12} + \tau)$ because if they import the good they must pay transportation costs. The clearing of the first market therefore requires:

$$k_{11} + k_{12} = D[\min(p_{11}, p_{12} + \tau)]. \qquad (12)$$

In the high demand state there are $1 - \theta$ buyers from each country who could not buy at the first market price and want to buy in the second market. The relevant price is different for the two types of buyers. It is: $\min(p_{21}, p_{22} + \tau)$ for buyers in country 1 and $\min(p_{21} + \tau, p_{22})$ for buyers in country 2. The clearing of the second market therefore requires:

$$k_{21} + k_{22} = (1-\theta)\{D[\min(p_{21}, p_{22} + \tau)] + D[\min(p_{21} + \tau, p_{22})]\}. \qquad (13)$$

In Appendix C I show how the fraction θ is determined and derive the unique solution to (11) - (13). In this solution seller 2 supplies to both markets and seller 1 supplies to market 1 only. Seller 2 quotes two prices: $p_{12} = MC^2$ and $p_{22} = 2MC^2$, where MC^2 is the marginal cost of seller 2. Seller 1 quotes only one price $p_{11} = MC^2 + \tau$. In state 1, buyers from country 1 buy from both sellers and pay $MC^2 + \tau$ per unit. In state 2 only a fraction θ of the buyers in country 1 gets the good at the low price. The remaining $1 - \theta$ gets it at the high price from sellers in country 2. Similarly a fraction θ of country 2 buyers gets the good at the low price (either MC^2 or $MC^2 + \tau$) and the remaining $1 - \theta$

gets it at the high price. Cross hauling occurs in state 2. In this state country 1 exports the good at the low price and imports it at the high price while the opposite is true for country 2.

Table 5 describes the equilibrium magnitudes for various τ, using the following notation:

$e_1 = k_{12}$ = export from country 2 in state 1;

$e_{21} = \theta(1/p_{11}) - k_{11}$ = export (Import when the amount is negative) from country 2 in state 2 at the low price;

$e_{22} = (1 - \theta)[1/(p_{22} + \tau)]$ = export from country 2 in state 2 at the high price;

$Av = (|e_1| + |e_{21}| + |e_{22}|)/2$ = average volume of trade.

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Table 5 about here

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As expected, a decline in transportation costs leads to a decline in the ratio of the marginal costs p_{11}/p_{12}; this ratio approaches unity as τ approaches zero. A decline in transportation costs tends to increase the average volume of trade. However, when $\tau \to 0$ we get an asymmetric equilibrium with an average volume of trade of 0.433. In accordance with Claim 1, the average volume of trade is larger than in the symmetric no transportation costs case (0.289). Thus the case of small transportation costs is different from the case of zero transportation cost.

The difference between the average volume of trade in the limiting asymmetric equilibrium and the symmetric equilibrium is due to cross hauling that occurs only in the asymmetric case. The asymmetric equilibrium does not converge to the symmetric equilibrium when $\tau \to 0$

because of the following reason. In the asymmetric equilibrium seller 2 posts the price MC^2 for goods supplied to the first market and the price $2MC^2$ for goods supplied to the second market. Since $MC^2 = (\frac{1}{2})(2MC^2)$ he is indifferent between the two markets. Seller 1 can get from buyers in his own country, $MC^2 + \tau$ for goods supplied to the first market and (if the second market opens) $2MC^2 + \tau$ for goods supplied to the second market.[8] Since $MC^2 + \tau > (\frac{1}{2})(2MC^2 + \tau)$, seller 1 strictly prefer market 1 as long as τ is strictly positive. Therefore the limiting asymmetric equilibrium is not equal to the symmetric equilibrium.

Note also that as in the delivery to stock case, price dispersion is decreasing in transportation costs.[9] This result will be discussed shortly.

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[8] To see why seller 1 can get the price $2MC^2 + \tau$ if the second market opens, note that in the high demand state there are buyers from country 1 who arrived late and did not make a buy in the first market. In the asymmetric equilibrium these buyers buy from seller 2 at the price $2MC^2$ and in addition they pay the transportation cost τ. Seller 1 can therefore sell to these buyers at the price $MC^2 + \tau$.

[9] When $\tau \rightarrow 0$, the standard deviation of prices is SD = 0.408. When τ = 0.1 it is 0.345 and when τ is prohibitively large it is 0.204. I use:

$\phi_{ij} = k_{ij}/(k_{11} + k_{12} + k_{22})$; $AV = \phi_{11}p_{11} + \phi_{12}p_{12} + \phi_{22}p_{22}$

$VAR = \phi_{11}(p_{11} - AV)^2 + \phi_{12}(p_{12} - AV)^2 + \phi_{22}(p_{22} - AV)^2$; $SD = VAR^{.5}$

3. CONCLUDING REMARKS

In the standard Walrasian analysis of economies with uncertain demand, actual trade starts only after the uncertainty about demand is resolved and the auctioneer announces a price that guarantees the making of a sale. Here we studied the implication of a model that permits trade before the complete resolution of demand uncertainty and as a result making a sale is not guaranteed. Our model is competitive in the sense that sellers take the price that they can sell to each batch that does arrive as given and markets that open do clear.

This model has been studied before but the application to international trade is, as far as I know, new. The application to international trade allows for a natural solution to the non-uniqueness problem in the Prescott type models. The Prescott model determines only the equilibrium distribution of prices and not the price charged by each seller. Here we solve this problem by assuming transportation costs and increasing marginal cost.[10]

It is shown that the time of delivery makes a difference. In the delivery to stocks case, we get dumping but no cross-hauling and no adverse welfare implications. Dumping occurs because the probability of making a sale in the exporting country is lower and therefore the price must be higher to yield the same expected revenues per unit.

Delivery to stocks is prevalent in retail trade of final goods. But since much of international trade takes place in intermediate

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[10] In Eden (1990, Theorem 2) and in Dana (1999) the non-uniqueness problem is solved by assuming market power.

inputs, the delivery to order case is likely to be more relevant. In this case buyers are treated symmetrically. In the stable demand country buyers may suffer from trade because in the high demand state some of them will not be able to make a buy at the low price. Since sellers in country 1 also suffer from trade, all agents in country 1 suffer from trade. This is a surprising result. On an abstract level it has to do with incompleteness of markets. But here it comes with a story and a rather realistic "friction" that allow for trade before the complete resolution of uncertainty.

As in many models of trade, reducing transportation costs reduces the difference between the marginal costs of the two sellers. But the results with respect to prices and trade patterns are not standard.

One of the surprising results is that a decrease in transportation costs increases price dispersion. To understand this result we must distinguish between quoted prices and expected prices (expected revenues per unit). In our model the expected price is equal to the marginal cost and a decrease in transportation costs decreases the dispersion of expected prices. But the effect on quoted price, which **do** not take into account the probability of making a sale, is in the opposite direction. This occurs in both cases but the intuition is easier for the delivery to stocks case. When transportation costs decline the seller in country 2 move merchandise from the high price market in his country to the low price market in country 1. This increases the price in country 2 and reduces it in country 1. As a result the dispersion of quoted prices increases.

Data used for computing the CPI are about quoted prices. Therefore our model may be useful for understanding some of the price puzzles in the literature. Checchetti et.al (2002) examine the CPI inflation rate in 19 US cities from 1918 to 1995. They found that when looking at ten years periods, the average difference between the city with the highest and the lowest inflation rate does not change much between the 1920s and the 1990s. This is surprising because transportation costs went way down in this period. In our model the dispersion of quoted prices is caused by differences in demand uncertainty and reduction in transportation costs works in the direction of increasing it. Other factors like differences in technology may have worked to reduce the dispersion of quoted prices and therefore we may find no change in it.

According to Crucini et.al (2005) "most economists believe that sticky prices, in their various forms, cannot account for the observed persistence in real exchange rates" (page 736, for other references on this issue see Frankel and Rose [1996] and Rogoff [1996]). Using a model with equilibrium price dispersion may help because permanent shocks to taste may have permanent effect on prices. For example, a permanent change in taste that affects the probability of wanting to consume will have a permanent effect on the real exchange rate in our model.

APPENDIX A: SOLVING FOR THE UNIQUE EQUILIBRIUM WHEN DELIVERY IS TO STOCK

I start by guessing a solution to (3) and (4) in which seller 2 supplies to both countries while seller 1 supplies only to his home country ($x_{21} = 0$). Indeed, an equilibrium in which seller 1 exports the good can be ruled out by the following argument. If country 1 exports, the marginal cost in country 2 must be higher than in country 1 and total supply to country 2 (home production plus import) must be higher in country 2. This says that the price in country 2 must be lower than in country 1. But sellers in country 1 have no incentive to export at a lower price to a country that the probability of making a sale is relatively low. It is also possible to rule out an equilibrium in which both sellers export the good.

I use $P = MC^2$ for the marginal cost of seller 2. Since under the proposed solution seller 2 supplies to both countries we must have:

$$P = p_1 - \tau = (\tfrac{1}{2})p_2 \qquad \text{(A1)}$$

We can now express prices in each country in terms of P:

$$p_1 = P + \tau \text{ and } p_2 = 2P \qquad \text{(A2)}$$

I use $x_1 = x_{11}$ to denote the supply of seller 1 and $x_2 = x_{12} + x_{22}$ to denote the supply of seller 2. Using $C(x) = (\tfrac{1}{2})\,x^2$, leads to:

$$C'(x_1) = x_1 = P + \tau \text{ and } C'(x_2) = x_2 = P. \qquad \text{(A3)}$$

Using (A2) and $e = x_{12}$ to denote export by seller 2, the market clearing conditions are:

$$x_1 + e = D(P + \tau) = 1/(P + \tau) \text{ and } x_2 - e = D(2P) = 1/2P. \qquad \text{(A4)}$$

We now have four unknowns (x_1, x_2, e, P) with four equations (A3) and (A4). After some substitutions we arrive at the following equation for P:

$$F(P) = 2P^2 + 3P\tau + \tau^2 - (\tau/2P) - 3/2 = 0. \quad \text{(A5)}$$

The function F(P) is strictly increasing in P and F(P) < 0 for small P and F(P) > 0 for large P. Therefore, there exists a unique solution to (A5).

APPENDIX B: PROOF OF CLAIM 1

Proof: Suppose seller 1 allocates $k_{11} = k_1 + \varepsilon$ units to market 1 and $k_{12} = k_2 - \varepsilon$ units to market 2 where k_i is the symmetric equilibrium allocation. (Seller 2 allocates $k_{21} = k_1 - \varepsilon$ units to market 1 and $k_{22} = k_2 + \varepsilon$ units to market 2). We assume $|\varepsilon| \leq \min(k_1, k_2)$ so that all the quantities supplied are positive. In the low demand state the buyers in country 1 consume the total supply to market 1. Therefore in state 1 country 2 exports $k_1 - \varepsilon$ units. Since each batch of buyers accurately represents the composition of buyers who want to consume, in the high demand state an equal number of buyers from each country participate in each of the two markets. Therefore in the high demand state country 1 exports ε units in the low price and imports ε units at the high price. Trade in the high demand state is $2|\varepsilon|$ and expected trade over the two states is:

$$(1/2)(k_1 - \varepsilon) + (1/2)2|\varepsilon| = (1/2)k_1 + |\varepsilon| - (1/2)\varepsilon. \quad \text{(B1)}$$

Expected trade is minimized at the symmetric equilibrium when $\varepsilon = 0$.

□

APPENDIX C: SOLVING FOR EQUILIBRIUM IN THE FULL INTEGRATION CASE

I start by guessing that only seller 2 supplies to market 2 ($k_{21} = 0$) and express equilibrium magnitudes as a function of the marginal cost of seller 2 ($P = MC^2$). Seller 1 quotes one price: $p_{11} = P + \tau$. Seller 2 quotes two prices: $p_{12} = P$ and $p_{22} = 2P$. We can now write (11) - (13) as:

$$C'(k_{12} + k_{22}) = k_{12} + k_{22} = P \tag{C1}$$

$$C'(k_{11}) = k_{11} = P + \tau \tag{C2}$$

$$k_{11} + k_{12} = D(P + \tau) = 1/(P + \tau) \tag{C3}$$

$$k_{22} = (1-\theta)D(2P) + (1-\theta)D(2P+\tau) = (1-\theta)\ [(1/2P) + 1/(2P + \tau)] \tag{C4}$$

I now turn to compute the fraction of buyers who could not buy in the first market in state 2. x buyers from country 2 who arrive early buy from the local sellers at the price P, where

$$x(1/P) = k_{12} \tag{C5}$$

Since buyers are treated symmetrically, when sellers in country 2 are stocked out x buyers from country 1 have already bought at the price

$P + \tau$ from their local sellers. The amount that is left in market 1 after the first x buyers are served is therefore: $k_{11} - x/(P + \tau)$. Since buyers from country 2 pay transportation costs on top of the price $P + \tau$ that is charged by sellers in country 1, the number of buyers (y) that will buy this stock is:

$$y/(P + \tau) + y/(P + 2\tau) = k_{11} - x(1/P+\tau) \qquad \text{(C6)}$$

We can now compute the fraction of buyers who did not buy in market 1 by:

$$1 - \theta = 1 - (x + y) \qquad \text{(C7)}$$

We now have 7 equations in 7 unknowns: k_{11}, k_{12}, k_{22}, P, x, y, θ. These equations are solved in Table 5 for various levels of τ.

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Table 1[*]: A delivery to stock case of international trade

τ	MC^2	p_1	p_2	x_1	x_2	e_1	e_2	Av
0	0.866	0.866	1.732	0.866	0.866	0.289	0.289	0.289
0.1	0.809	0.909	1.618	0.909	0.809	0.191	0.191	0.191
prohibitive	0.707	1	1.414	1	0.707	0	0	0

[*] The first column is per unit transportation cost (τ), the second is the marginal cost for seller 2 (MC^2), we then have the prices in countries 1 and 2 (p_1, p_2), the amount produced by sellers 1 and 2 (x_1, x_2), the amount exported by seller 2 in states 1 and 2 (e_1, e_2) and the average amount of trade (Av).

Table 2*: Welfare calculations for the examples in Table 1

τ	seller 1	seller 2	buyer 1	buyer 2	welfare 1	welfare 2
0	0.375	0.375	-0.856	-0.775	-0.481	-0.400
0.1	0.413	0.327	-0.905	-0.741	-0.491	-0.413
prohibitive	0.5	0.25	-1	-0.673	-0.5	-0.423

* The first column is the per unit transportation costs (τ). We then have the expected profits of the seller in country 1 and the seller in country 2. The expected surplus of the buyers follows. We then compute the sum of the seller's expected profits and the buyer's expected surplus in each country.

Table 3: Costless deliver to order and autarky

τ	MC^2	p_1	p_2	k_1	k_2	e_1	e_2	Av
0	0.866	0.866	1.732	0.577	0.289	0.577	0	0.289
prohibitive	0.707	1	1.414	0.5	0.354	0	0	0

Table 4*: Welfare calculations for the allocations in Table 3

τ	seller 1	seller 2	buyer 1	buyer 2	welfare 1	welfare 2
0	0.375	0.375	– 1.029	–0.601	-0.654	-0.226
prohibitive	0.5	0.25	-1	-0.673	-0.5	-0.423

* The first column is the transportation cost. Then we have the expected profits of the seller in country 1 and country 2. A measure of the expected surplus of the buyer in each country follows. The last two columns compute the welfare in each country defined as the sum of the seller's expected profits and the buyer's expected surplus.

Table 5*: Costly delivery to order

τ	p_{11}	p_{12}	p_{22}	k_{11}	k_{12}	k_{22}	e_1	e_{21}	e_{22}	Av
$\tau \to 0$	0.866	0,866	1.732	0.866	0.289	0.577	0.289	-0.289	0.289	0.433
0.1	0.902	0.802	1.605	0.902	0.206	0.597	0.206	-0.341	0.289	0.418
large	1	0.707	1.414	1	0	0.707	0	0	0	0

* The first column is the per unit transportation cost. We then have the producer prices: the first market price that seller 1 gets, the first market price that seller 2 gets and the second market price that seller 2 gets. The next three columns describe the allocation. Seller 1's supply to the first market and seller 2's supplies to the first and the second market. The next three columns describe country 2's export (import with a negative sign). The export in state 1 at the low price, the import in state 2 at the low price and the export in state 2 at the high price. The last column is the average volume of trade.