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ENTRY, DUMPING, AND SHAKEOUT

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ABSTRACT

This paper investigates the relationship between entry, demand, and dumping in the context of a two country Ricardian model of international trade. Dumping - the export of goods at a price below average cost - can arise in the free trade equilibrium if the two countries differ in their initial stock of technological knowledge. As in Jovanovic (1982), I assume that firms in one of the two countries can only acquire knowledge about the technology for producing one of the goods by actually producing that good. Because all firms are ex ante identical in one of the countries, and ex post efficient firms earn positive rents in equilibrium, competition for these rents can result in entry to the point that the equilibrium price is driven below average cost. If world demand is high enough, entry among ex ante identical firms can push down the world price below the opportunity cost of production of new entrants in one country, and that country can in fact initially export the dumped good in equilibrium. Interestingly, and in contrast to models of dumping in cyclical downturns, dumping will not occur with endogenous entry if world demand is too low. Despite the fact that high world demand induces so much entry that price is driven below opportunity cost, welfare in both the dumping (exporting) country and the importing country improve in the free trade dumping equilibrium relative to autarky.

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[Between 1981 and 1986] the number of [dumping] petitions resulting in interventions . . . increased 258% [relative to the 1975 through 1980 period]. It is difficult to believe . . . that dumping has risen to more than two and one-half times its previous level especially since the strong dollar during the latter period made selling in the United States easier for foreigners rather than harder.

The Economic Report of the President, 1988, p. 159.

1. Introduction

In this paper, I investigate the phenomenon of dumping in the context of a simple - but potentially rich - two country model in which entry and the terms of trade are endogenous. In this endeavor, I follow Ethier's (1982) suggestion that "an efficient modern theory of dumping" should incorporate the law of one price, factor markets, rational expectations, and should be able to account for the export of goods at a common world price below the average cost of production.[1]

[1] This is not to say that international price discrimination on the part of exporters with market power, Viner's (1923) definition of dumping, is uncommon or unworthy of study. Rather, formal dumping complaints, at least in the US, are increasingly often based upon allegations of "pricing below cost" regardless of transactions prices in home markets (Gruenspecht (1988)). Furthermore, "in testing for the presence of dumping, the foreign transactions price cannot be used for comparison with the American sales price if the former is less than the cost of production . . . [which] must include general expenses equal to at least 10 percent of manufacturing costs plus a profit margin of at least 8 percent (Ethier (1982))."

The novel feature of the two-sector, two country Ricardian model developed in this paper - which is similar in spirit to (but much simpler than) Jovanovic (1982) - is that, while entry is endogenous, firms can only learn about their production function for producing one of the goods by actually producing that good. Furthermore, production functions, as indexed by a Ricardian labor productivity parameter, differ across firms. However, because producers are ex ante identical, they share a common entry decision rule based upon their knowledge of the distribution of productivities across firms, the terms of trade, and their rational expectation of the future terms of trade. In turn, the equilibrium terms of trade depend upon the entry decisions made by firms, so that in a rational expectations equilibrium, entry decisions and the terms of trade are mutually consistent functions of the parameters that describe technology and demand.

In policy discussions, dumping, increasingly defined as the sale of goods at a price below the average cost of production, is often attributed to a situation in which too many producers are chasing too few consumers.[2] In a cyclical downturn, considerations such as exit costs and implicit labor contracts may very well make it optimal and ex ante rational for *existing* firms to continue to produce at a price that falls short of average total cost.[3] However, as the opening quote suggests and the <u>Annual Report on the Operation of the Trade Agreements Programs</u> documents, there has been an explosion in the number of dumping findings in the US during the 1980s. Although the severity of the 1981-

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[2] For a superb account of the political economy of dumping, see Bhagwati (1986).

[3] This was first shown rigorously by Ethier (1982), although the idea of cyclical dumping dates back to at least Viner (1923). In the conclusion I briefly discuss the recent literature on strategic duopoly models of dumping.

1982 worldwide recession no doubt can account for some of the surge in dumping findings during this decade, the fact that the number of preliminary findings of dumping by the United States Department of Commerce approached all time highs in 1985 and 1986 indicates that cyclical factors, as they are normally understood, cannot provide a complete explanation of dumping during the 1980s.[4]

Endogenizing entry substantially enriches the conditions under which dumping can occur under perfect competition and rational expectations. Intuitively, dumping can arise because the present value of entry includes the value of information about future profitability. Such knowledge is valuable because the most productive producers earn positive current and future rents in equilibrium. Competition among ex ante identical producers for these present and future rents can drive down the price below the opportunity cost of the ex post efficient and inefficient firms who enter in search of the rents that accrue to the most efficient among them. I model a world of two countries that differ only in their initial stock of knowledge about the technology for producing one of the goods: the countries do not differ in the availability or distribution of this technology among firms, nor do they differ in size, nor in tastes. Nonetheless, I show that if world demand is sufficiently high, dumping can occur in equilibrium. Interestingly, I also show that if world demand is sufficiently low, dumping cannot occur.

High demand induces entry of firms seeking to capture the rents accruing to most efficient (ex post) among them. Entry among ex ante identical firms pushes down the world price below the opportunity cost of new entrants, and these firms will in fact initially export in equilibrium. Ex post high cost

[4] Annual Report on the Operation of the Trade Agreements Program, The US International Trade Commission, various issues.

producers recognize their losses and exit. The rents that accrue to the remaining producers in the dumping country exactly equal the net losses incurred as a result of dumping. Despite the fact that high world demand induces entry to the point that price is driven below private opportunity cost - which is the output per entrant foregone by, or average cost of entry to, the economy - I show that welfare in both the dumping (exporting) country and the importing country improve in the free trade dumping equilibrium relative to autarky.

The plan of the paper is as follows. In Section 2, I set up the model, and derive the optimal entry decision rule. In Section 3, I specialize the model and obtain a closed-form expression for the autarky ex ante entry price in terms of the parameters of demand and technology. In Section 4, I provide explicit sufficient conditions for the existence of a dumping equilibrium in a two country world in which the countries differ only in their initial stock of technological knowledge, not their technological capability, their size, nor their preferences. In this equilibrium, positive trade flows arise from the (intertemporal) profit maximizing efforts of firms in one of the two countries to accept a price below opportunity cost in exchange for the option of earning positive rents that accrue to the ex post most efficient among them. I also show that, while dumping coincides with excessive entry (excessive in that new entrants on average suffer losses), the entry that does occur maximizes social surplus subject to constraint that productivity must be learned via production. Section 5 explores some of the implications of the analysis and surveys some recent dumping cases in which technology and/or a surge in world demand for the dumped product appeared to play a prominent role. Section 6 provides concluding remarks and relates the results to those obtained elsewhere in the literature.

2. The Entry Decision Rule

There are two goods z and y, two periods, two countries, one inelastically supplied factor - labor, and N + M agents in each country. z and y are produced with constant returns to scale production functions. In both countries, all N + M agents are endowed with one unit of labor and a technology that can be used to produce w units of y. N agents in each country are endowed not only with one unit of labor and a technology for producing y, but also with a technology that can be used to produce z. Either w units of y or ξ^i units of z, but not both, can be produced in a given period by each potential entrant, $i = 1, \ldots, N$, to the z sector.[5] ξ^i is differs among agents, and is distributed according $G(\xi)$, which is common across both countries. Each agent knows this distribution, *but cannot learn the value of his particular* ξ^i *without first producing z.*

To keep things simple(r), I rule out borrowing and lending so that consumption must be financed by the value of current output. Let p (p') denote the present (future) price of z in terms of y. p and p' are endogenous in equilibrium, but are taken as given by firms. Finally assume that preferences are time separable and Cobb-Douglas, and let α (αn) denote the share of spending that falls on z by the M (N) agents who produce y (who can produce z or y) in each country .[6]

To derive the optimal entry decision rule followed by the N potential entrants to the z sector, begin by observing that the static utility gained by entering sector z in the present is $(p^{1-\alpha n})\xi^i$ while the static utility obtained

[5] Production of z or y by agent i in the present in no way changes the parameters of the of technologies available for producing either z or y in the future; i.e. ξ^i in the present $= \xi^i$ in the future and w in the present = w in the future.

[6] That is, agents maximize $z^a y^{1-a} + z'^a y'^{1-a}$ for $a = \alpha, \alpha n$

by entering sector y is $(p^{-\alpha n})w$. Entry into sector z will maximize expected current utility whenever

$$(p^{1-\alpha n})E\xi^{i} > (p^{-\alpha n})w; \qquad (1)$$

otherwise, static utility is maximized by entering sector y. Of course, to the extent that the entry decision in the present impacts upon expected utility in the future, (1) is not the optimal first period entry decision rule. However, by substituting p′ for p, (1) <u>does</u> describe the optimal second period decision rule for agents who did not enter sector z in period 1. Rearranging terms we obtain:

Proposition 2.1: For all firms that produce y in period 1, entry to sector z in period 2 will occur if

$$p > w/E\xi^{i}; \qquad (2)$$

where $w/E\xi^{i}$ is the ex ante static break even price of z, the price at which agents achieve the same expected utility in either sector z or sector y.

What is the expected second period utility of an agent who entered sector z in period 1? Such an agent learns his productivity in producing z. With this knowledge he can attain utility $(p'^{-\alpha n})w$ if he switches to sector y, and he can attain utility $(p'^{1-\alpha n})\xi^{i}$ if he stays in sector z. Note that, as of the beginning of period 2, ξ^{i} is not random, so that

$$E\max[(p'^{1-\alpha n})\xi^{i};\ (p'^{-\alpha n})w]; \qquad (3)$$

is the expectation in the present of the utility in the future of an agent who enters the z sector in the present.

By contrast, it is easily seen from (1) and Proposition 2.1, that the expectation in the present of the utility in the future of an agent who enters the y sector in the present is given by

$$\max[(p'^{1-\alpha m})E\xi^{i};\ (p'^{-\alpha m})w]. \tag{4}$$

The difference between (3) and (4) reflects the net expected value of information about the ability to produce z. Is this value positive? Since max[ ] is a convex function, by Jensen's inequality:

Proposition 2.2:

$$E\max[(p'^{1-\alpha m})\xi^{i};\ (p'^{-\alpha m})w] \geq \max[(p'^{1-\alpha m})E\xi^{i};\ (p'^{-\alpha m})w]. \tag{5}$$

The non-negative value of information is easily understood. Knowledge of ξ^i allows the agent to avoid, in period 2, entering the z sector when he should be producing y.

Pulling together (1), (4), and (5), we are now in a position to obtain a general expression for the entry price at which firms are ex ante indifferent between entering sector z and entering sector y in period 1. Letting β denote the static ex ante break even price, $\beta = w/E\xi^i$, and e denote the (forward looking) ex ante entry price, we have

Proposition 2.3: The rational, ex ante entry price at which firms are indifferent between entering the z sector and entering the y sector is given by

$$e = \beta - (1/E\xi^{i})E\max[p'\xi^{i};w] + (1/E\xi^{i})\max[p'E\xi^{i};w]; \tag{7}$$

where $\beta = w/E\xi^i$. Furthermore, $e \leq \beta$, with strict inequality whenever the net value of information is positive.

For future reference, note that (7) can be re-written as

$$e = \beta - (1/E\xi^{i})E\max[p'\xi^{i}-w;0] + (1/E\xi^{i})\max[p'E\xi^{i}-w;0]. \qquad (8)$$

We conclude this section by observing that the ex ante entry price is related to the variance, or more generally, the dispersion of the probability distribution of productivities across agents. Indeed, a sufficiently large mean-preserving spread of G around $E\xi^{i}$ must drive the ex ante entry price below the static break even price.[7] For completeness we have:

Corollary 2.4: Given p', β, and $E\xi^{i}$ there exists a mean preserving spread of G such that

$$E\max[p'\xi^{i}-w;0] > \max[p'E\xi^{i}-w;0]; \qquad (9)$$

- the value of learning about productivity is positive; and

$$e < \beta; \qquad (10)$$

the ex ante entry price is less than the static break-even price.

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[7] Proof: If $\max[p'E\xi^{i}-w;0] > 0$, a sufficiently low realization of $\xi > 0$ will make any new z entrant in period 2 regret ex post this decision; ie $E\max[p'\xi^{i}-w;0]$ will exceed $\max[p'E\xi^{i}-w;0]$. If $\max[p'E\xi^{i}-w;0] < 0$, a sufficiently high realization of $\xi > 0$ will make any y producer regret ex post the decision not to enter z.

3. Entry and Demand

Proposition 2.3 provides a general expression for the ex ante entry price in terms the opportunity cost of resources, w, the moments of the distribution of productivity across agents, $G(\xi)$, and the expected future price of z, p'. In any interesting model of dumping, p' must be endogenous. In the present model, entry decisions in period 1 depend upon the expected future price of z. However, the future price of z depends upon the future supply of z, *which depends upon entry decisions in period 1*. In a rational expectations equilibrium, second period prices and first period entry must be mutually consistent.

Although my primary interest is in providing an account of dumping in international trade, I begin by solving the model for the autarky equilibrium in each country. Later, these results are used to derive the conditions under which dumping - the export of goods at a common world price below the average cost of production - can occur. Moreover, if the two countries are identical in all respects and none of the potential z entrants in either country knows its firm specific productivity in producing z, autarky will be the free trade equilibrium.

To solve for the rational expectations equilibrium under autarky, it is useful to make several assumptions. First, I assume (A1) that $\alpha n = 0$, the share of spending by potential z entrants that falls on z is zero. This assumption insulates the position of the demand curve for z from the entry and exit decisions made by the producers of z. Entry and exit will have a decisive influence on price, but only because these decisions shift the supply curve along a given demand curve.[8] The second assumption (A2) I shall make is that there are three productivity parameters, and that these are distributed among the N potential z entrants in each country according to the following distribution G:

$$\begin{aligned} \xi &= 1, \text{ shared by } (1 - 2\pi)N \text{ agents;} \\ \xi &= 1 + \varphi, \text{ shared by } \pi N \text{ agents;} \\ \xi &= 1 - \varphi, \text{ shared by } \pi N \text{ agents;} \end{aligned} \tag{11}$$

with $0 < \varphi < 1$ so that,

$$\begin{aligned} E\xi &= 1; \\ \text{var } \xi &= 2\pi\varphi^2. \end{aligned} \tag{12}$$

The third assumption I shall make is that N and M are large enough so that the frequency distribution of productivities among firms that actually enter the z sector in period 1 is given by the population distribution.[9] It follows that the equilibrium p' is a function of the number of firms that enter in period 1, the population distribution of productivities, and the parameters of the demand

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[8] Jovanovic (1982) also assumes that the position of the demand curve is invariant to entry and exit decisions. Jovanovic's model is much more general in that he allows for normally distributed shocks, Bayesian learning over time about the production function, and an infinite planning horizon. What I purchase with my simple set up is the ability to obtain closed-form expressions for price, industry profits, and output, and to show how dumping - the export of goods at a price below average cost - can occur in a two country world.

[9] This assumption is in no way essential to the paper's main results, because all of these results go through in the special case in which demand for z at the ex ante entry price exceeds the maximum supply of z, N. Of course in this case, the distribution of productivities among entrants is equal to the population distribution.

curve for z which, for the Cobb-Douglas preferences, is given by

$$d_z(p) = M\alpha w/p. \tag{13}$$

These assumptions are sufficient to solve the model. We begin with:

Corollary 3.1: Under assumptions (A1) - (A3), the ex ante entry price is given by

$$e = \beta - \pi(1 - \varphi)\max[(w/(1 - \varphi)) - p';0]; \tag{14}$$

so long as $p' \geq \beta - w$. *A sufficient condition for* $p' \geq \beta$ *that*

$$\varphi \leq 1/2.\text{[10]} \tag{15}$$

A key implication of Corollary 3.1 is that

$$w \leq p' \leq w/(1 - \varphi); \tag{16}$$

is a sufficient condition for potential entrants to the z sector to be willing to incur expected losses in period 1. Note that $w/(1 - \varphi)$ is the price of z at which even the least productive producers can break even.[11] When p' falls short of $w/(1 - \varphi)$, there is a positive value to learning about one's productivity in the first period, because a fraction π of all new entrants in period two will regret having entered (but knowing this probability, will enter anyway since,

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[10] The proof of (14) just requires plugging the distribution (12) into equation (7) and cancelling terms. If $p' < w$, it is easy to show that (7) and (12) imply that $e = \beta - \pi(1+\varphi)\max[p' - w/(1+\varphi);0]$. (15) is the condition that $d_z(w) > \pi(1+\varphi)d_z(e)$; i.e. that demand at the break even price $p' = w$ exceeds the output of the most efficient firms that entered in period 1. (15) follows from (13) and the fact that (7) and (12) imply that $e \geq w(1 - \pi\varphi)$.

[11] Since $p'(1 - \varphi)$ is the ex post utility of the least efficient z producers, and w is the utility of producing in y.

from Proposition 2.1, $p' > w$ is sufficient for entry). When $p' > w/(1 - \varphi)$, there is no *incremental* value to learning the productivity parameter. This is because both new entrants and existing producers of z in period two will make the same entry decision. To summarize, firms will be willing to incur expected losses in period 1 when the rents accruing to experienced producers in period 2 exceed the expected rents accruing to new entrants in period 2.

This is the intuition behind the result that, for p' satisfying (16), the ex ante entry price is increasing in p'. This result depends crucially on the assumption that entry is allowed in period two. If entry to z is only possible in the first period, equation (8) becomes

$$e = \beta - (1/E\xi^{i})E\max[p'\xi^{i}-w;0]; \tag{17}$$

which is nonincreasing in p'. All of the methods of analysis in this paper may be applied to a model in which entry must take place in the first period. In such a model, dumping is even more likely to occur.

Corollary 3.1 does not pin down the conditions under which the price of z in period 1 is driven below the ex ante break even price $\beta = w$. The following Propositions do.

Proposition 3.2: Given w, α, π, $\varphi < 1/2$, and M, a sufficient condition for the ex ante entry price to be driven below the break even price, $e < \beta$, is given by

$$\alpha M(1 - \varphi)/(1 - \pi(1 - \varphi)) < N.^{12} \tag{17}$$

By Proposition 3.2, there exists a sufficiently large number of potential entrants to the z sector such that the ex ante period 1 entry price is driven

[12] I establish below that if ex ante identical producers can sign an Arrow-Debreu insurance contract, that contract will specify a first period entry price of $p = e$.

below opportunity cost for any level of demand, αMw, and for all parameters π and $\varphi < 1/2$ of the distribution, G, of productivities across entrants. We now provide sufficient conditions for the equilibrium period 1 price to be driven below opportunity cost. This means that a fraction $1 - \pi > 1/2$ of the firms that enter suffer losses in period 1, and these losses exceed the rents earned by the ex post most efficient producers. Producers are willing to take expected losses in period 1 because the ex post most efficient among them obtain higher rents in period 2, when the price of z is pushed up by the exit of inefficient firms.

Proposition 3.3: There exists an N_1 such that, for $N > N_1$, $p < \beta$. N_1 is given by

$$N_1 = \max[1;(1 - \varphi))/(1 - \pi(1 - \varphi))]\alpha M. \qquad (19)$$

Furthermore, there exists an $N_e > N_1$ such that, for all $N > N_e$, the period 1 price is driven down to its minimum value $p = w(1 - \pi\varphi)$, so that the average loss in terms of opportunity cost suffered by a new entrant to the z sector is given by

$$(p - \beta)/\beta = - \varphi\pi < 0 \qquad (20)$$

where $\beta = w$. Furthermore, N_e is given by

$$N_e = \alpha M/(1 - \pi(1 - \varphi))). \qquad (21)$$

Proof: Appendix.

Since all firms share the identical entry decision rule, the aggregate supply curve is perfectly elastic at the ex ante entry price e, until $z = N$ at which point it is completely inelastic. Recalling that e is the price at which firms are *indifferent* between entering the z sector or the y sector in period 1, nothing guarantees that all firms that are indifferent between producing z or y will actually produce z. In particular if $d_z(e) < N$, all N producers cannot produce at e. If producers are rational, they take into account this possibility when forming their decision rule. However, if, when $d_z(e) < N$, firms are chosen randomly from among the N potential entrants so that a fraction $d_z(e)/N$ is selected, the optimal entry decision rule is the same.[13]

Before showing how a free trade equilibrium with dumping can arise, I first briefly explore the relationship between the ex ante entry price, the number of firms that enter the market for z, and the number of firms that would have entered the market for z - and the price they would have received - had each firm known ex ante its particular productivity in producing z. I define a *destructive (deficient) competition equilibrium* as an equilibrium in which, because firms

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[13] However the interpretation is slightly different (cf. Dixit and Shapiro (1986). e becomes the price at which firms are indifferent between entering a lottery with probability $d_z(e)/N$ of winning in which the winners produce z and the losers produce y and not entering the lottery and just producing y. The proof of this result is just algebraic manipulation of (8). However, one insight is required. The probability of winning the lottery in the second period, θ', for firms that did not enter in the first period is endogenous and influences e according to

$$e = \beta - (1/E\xi^i)E\max[p'\xi^i - w;0] + (1/E\xi^i)\,\theta'\max[p'E\xi^i - w;0].$$

Recall from Proposition 2.1 that firms will be indifferent between newly entering z in period 2 and staying in y when $p'E\xi = w$. This can be shown to imply that, when $p'E\xi > w$, θ' must equal 1, and that when $\theta' < 1$, $p'E\xi - w = 0$. Thus, without loss of generality, equation (8) defines the entry decision rule. This is not to say that expected utility is invariant to θ' or θ given p and p', but rather that utility is changed in such a way that entry decisions are unaffected.

are ex ante identical but ex post different, too many (too few) firms enter, driving the price below (keeping the price above) the level that would have prevailed had each firm known ex ante its particular productivity in producing z. In a destructive competition equilibrium, price is driven below average (opportunity) cost in period 1. Perhaps surprising, I also show that for certain parameter values, not only does a deficient competition equilibrium exist in this model, but that price is driven below opportunity cost in a deficient competition equilibrium.

Proposition 3.4: A destructive competition equilibrium exists if

$$\alpha M/(1 - \pi(1 - \varphi)) \leq N \leq \alpha M/(1 - \pi\varphi)\pi(1 + \varphi). \tag{21}$$

Furthermore, $p < \beta$ in a destructive competition equilibrium. A deficient competition equilibrium exists if

$$\alpha M/(1 - \pi\varphi))\pi(1 + \varphi) \leq N. \tag{22}$$

Furthermore, $p < \beta$ in any such deficient competition equilibrium.[14]

How can aggregate losses occur when the price of z is higher and fewer firms enter than under ex ante knowledge of firm-specific productivities? In this model, price is driven below opportunity cost in the first period because

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[14] Proof: The number of producers who, under full information, would produce at the ex ante entry price $e = w(1-\pi\varphi) < w$, is πN. Their total output would be $\pi N(1 + \varphi)$. $\alpha Mw/(\pi N(1 + \varphi))$ is the price they would receive. When $e = w(1 - \pi\varphi)$, the second inequality in (21) implies that total output and entry are greater at e (and e itself is less than the price that would prevail under full information) than with ex ante knowledge about firm-specific productivities. Since $\pi(1 + \varphi) < (1 - \pi(1 - \varphi))$ for $\pi < 1/2$, the set of N that satisfies (21) is nonempty. By Proposition 3.3, $p < \beta$. When $e = w(1 - \pi\varphi)$, (22) implies that total output and entry are less at e (and e itself is higher) than under ex ante knowledge of firm-specific productivities. By Propositions 3.3, $p < \beta$.

ex ante identical firms are willing to accept expected losses in the present in exchange for the future profits that will accrue to the most productive among them. The fact the number of firms that actually enter in period 1 - recall that all N are ex ante indifferent as discussed in footnote 13 - is less than would be the case under ex ante knowledge of firm-specific productivities is irrelevant.

4. Dumping in a Free Trade Equilibrium

With the results obtained in Section 3, it is now straightforward to provide sufficient conditions for dumping to occur in a free-trade equilibrium. Dumping will be said to occur when z is *exported* at a common world price that falls below the opportunity cost of production in the exporting country. For positive trade flows - and thus dumping - to occur, it must be the case that the two countries not be identical. As discussed earlier, the results in Section 2 characterize the autarky equilibrium in each country, which is the free trade equilibrium when the two countries are identical. By Propositions 3.2, 3.3, and 3.4, the price of z may be driven below opportunity cost in period 1. However, since the two countries are identical, no trade flows between them will arise in equilibrium, and no dumping can be said to occur.

We begin with the symmetric case in which countries 1 and 2 differ in only one respect: each potential z producer in country 1 knows its firm-specific productivity in producing z, while no potential z entrant in country 2 knows its firm-specific productivity. Otherwise, the distribution, $G(\xi)$ of productivities across firms, the number of producers of y and potential producers of z, M and N respectively, and their preferences, are identical. Thus it can be said that countries 1 and 2 differ only in their initial stock of technological knowledge, but not in their initial stock of technological capability. Interestingly, not only will such a difference in the initial stock of technological knowledge induce trade flows between the two otherwise identical countries but, under sufficient conditions to be established now, dumping will occur in the free trade equilibrium. That is, country 2 will in period one export z to country 1 at a common world price that is driven below the average cost of production in country 2. In period 2, following the excessive entry and resulting destructive competition that transpires in period 1,[15] a rationally expected shakeout occurs: inefficient country 2 firms, discovering their inability to cover opportunity cost, exit the z sector. This exit of country 2 producers drives up the period 2 price of z, and acts to reduce or eliminate country 1's trade deficit in z.

Proposition 4.1: Given π, φ, M, and α, there exists a symmetric free trade dumping equilibrium if

$$N_1 < \max[2/(1 + \pi(1+\varphi)); (1 - \varphi)/(1 - \pi(1 - \varphi))]\alpha M < N < \alpha M/\pi(1+\varphi). \quad (23)$$

In this dumping equilibrium, country 1 imports z from country 2 in period 1 at a price p that falls below average cost w.

Proof: Appendix.

This is a striking result. It says that for any values of the distribution parameters π and φ, the expenditure share $\alpha > 0$, the "wage" (opportunity cost)

[15] I show formally below that if dumping occurs in the symmetric case, the equilibrium must be a destructive competition equilibrium.

w, and the position of the world demand curve as indexed by M (the number of z consumers in each country), there exists a number, N, of potential z producers in each country such that country 1 is net importer of z at a price that is driven below the break even point for country 2 exporters. This is despite the fact that the two countries differ only in their initial stock of technological knowledge - but not capability. Additional properties of this symmetric free trade dumping equilibrium are easily obtained.

Corollary 4.2: The symmetric free trade dumping equilibrium is a destructive competition equilibrium.[16]

Corollary 4.3: If world demand is too low relative to potential supply, dumping cannot occur. Specifically, given N, M, π, and φ, there exists a value of α, $\underline{\alpha}$, such that if $0 < \alpha < \underline{\alpha}$, country 1 exports z to country 2 in period 1 and dumping does not occur. $\underline{\alpha}$ is given by

$$\underline{\alpha} = (1-\pi\varphi)\pi(1+\varphi)N/M < 1.^{17} \tag{24}$$

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[16] Proof: If country 1 is to be a net importer of z, it must be the case that per country demand at p exceed country 1 supply $\pi(1+\varphi)N$. Since country 1 supply is the supply of z in country 2 that would be forthcoming if country 2 producers had knowledge of firm-specific productivities, $\alpha Mw/p - \pi(1+\varphi)N$ "too many" country 2 firms enter the z sector in period 1. If country 2 is larger than country 1, it is straightforward to show that a deficient competition free trade equilibrium can exist in which dumping can occur. However, since the symmetric case is more interesting, a formal treatment will be omitted.

[17] Alternatively, given N, π, φ, α, there exists a value of M, $\underline{M}$, such that if $0 < M < \underline{M}$, country 1 exports z to country 2 in period 1 and dumping does not occur. $\underline{M}$ is given by

$$\underline{M} = (1-\pi\varphi)\pi(1+\varphi)N/\alpha. \tag{25}$$

To see this, note that since $p \geq w(1 - \pi\varphi)$ by Proposition 3.3, $d_z(p) \leq 2\alpha M/(1-\pi\varphi)$. Thus, if $2\alpha M/(1-\pi\varphi) \leq 2\pi(1+\varphi)N$ country 1 is a net exporter of z in period 1. (24) and (25) follow immediately.

Corollary 4.4: The exit of inefficient country 2 producers drives up the period 2 price of z to $p' \geq w$ and acts to shrink the country 1 trade deficit in z. Furthermore, if

$$N \geq \alpha M/(1 - \pi(1-\varphi)); \tag{26}$$

such a shakeout in country 2 completely eliminates the country 1 trade deficit in z in period 2.[18]

We now examine the welfare implications of dumping in a free trade equilibrium. For concreteness we focus on the case in which

$$\max[2/(1 + \pi(1+\varphi)); 1/(1 - \pi(1 - \varphi))]\alpha M < N < \alpha M/\pi(1+\varphi). \tag{27}$$

As can be seen by comparing (23) and (27), any N that satisfies (27) will satisfy Proposition 4.1. Furthermore, such an N will insure that $p' = w$ in autarky in both countries, that $p = w$ in autarky in country 1, and that $p = e = w(1-\pi\varphi)$ in country 2.[19] Under autarky, welfare as measured by the sum of consumer and

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[18] This is not to say that country 2 cannot run a trade surplus in z in period 2. However, the conditions for this to occur will not be presented although they are straightforward, if tedious, to derive. To see (26), note that if (23) is satisfied, $w \leq p' < w/(1-\varphi)$ so that αM is the maximum period 2 demand for z in country 1. $N(1 - \pi(1-\varphi))$ is the country 1 supply of z at any $w \leq p' < w/(1-\varphi)$. Thus, if (26) is satisfied, domestic production in country 1 can meet demand. Note finally that $\alpha M/(1 - \pi(1-\varphi)) < \alpha M/\pi(1+\varphi)$, so that the set of N that satisfies (26) and (23), and thus Proposition 4.1 and Corollary 4.4 is nonempty.

[19] Proof: The country 2 results follow immediately from Proposition 3.3. $[1/(1 - \pi(1 - \varphi))]\alpha M < N < \alpha M/\pi(1+\varphi)$ is just the condition that per country demand exceed the supply of the most efficient producers, but fall short of the total supply of all but the least efficient producers.

producer surplus in the market for z, is given by:

$$2(\int_{w}^{\infty}(\alpha Mw/P)dP + (w - w/(1+\varphi))\pi(1+\varphi)N); \tag{28}$$

in country 1, while welfare in country 2 is just

$$\int_{e}^{\infty}(\alpha Mw/P)dP + \int_{w}^{\infty}(\alpha Mw/P)dP. \tag{29}$$

Note that the most efficient producers in country 1 earn positive rents in autarky, while the net producer surplus in country 2 in autarky is zero. This is a direct implication of the fact that the period 1 autarky price is driven down to the ex ante entry price in country 2, and that the equilibrium period 2 price of z is pushed up to the ex ante break-even level w.

Under the conditions of Proposition 4.1, a free trade dumping equilibrium exists in which $e \leq p < w$ and, by (27), $p' = w$. The change in welfare in country 1 is given by

$$\int_{p}^{w}(\alpha Mw/P)dP - (w - p)\pi(1+\varphi)N > 0; \tag{30}$$

Despite the fact that dumping occurs in the free trade equilibrium, country 1 unambiguously benefits from free trade. The loss in producer surplus resulting from the fall in the price of z represents a transfer from the most efficient producers to consumers. Since country 1 demand for z exceeds the output of the most efficient z producers, the gain in consumer surplus must exceed the loss in producer surplus. Note that, relative to autarky, employment in the z sector is lower by $\alpha M - \pi(1+\varphi)N$, as less efficient z producers, unable to cover their opportunity cost, shift to the y sector. Thus, both employment and profits in the country 1 z sector shrink in period 1 in a free trade dumping equilibrium.

The change in welfare in country 2 is given by:

$$\int_{p}^{e}(\alpha Mw/P)dP + (p - e)N \geq 0. \tag{31}$$

Welfare rises in country 2 if world demand is sufficiently strong to pull up $p > e$. Otherwise, *country 2 welfare is unchanged in the free trade dumping equilibrium*. How can this be? The supply of z in country 2 is completely elastic at the ex ante entry price e. Country 2 producer's ex ante expected and ex post average rents are driven to zero at e. Although employment and production in the z sector increase in a free trade dumping equilibrium (relative to the autarky equilibrium), only a fraction π of these exporters will obtain positive producer surplus ex post; the remaining fraction $1 - \pi$ will suffer losses that exactly offset these gains. Obviously, country 2 consumers lose if world demand pushed p above e. But this loss must fall short of the gain to producers because country 2 supply at $p > e$ is equal to N, while country 2 demand at e - and thus p - is less than N. Thus, we have now established:

Proposition 4.5: Consider the free trade dumping equilibrium that satisfies (27). Then relative to autarky,

(a) The welfare of country 1 consumers improves; the welfare, rents, and period 1 output of country 1 z producers contract; and the gain in country 1 consumer surplus exceeds the loss in country 1 producer surplus.

(b) The welfare of country 2 consumers does not improve; the welfare, rents, and period 1 output of country 2 z producers do not contract; and the gain, if any, in country 2 producer surplus exceeds the loss, if any, of country 2 consumer surplus.

Note that while less efficient z producers in country 1 are unable to cover their opportunity cost in period 1 of the dumping equilibrium, they only earn w in autarky. Thus the extent of injury in the z sector in country 1 is the loss of pure rents that accrue to the most efficient producers. It is easy to generalize this result. If N satisfies Proposition 4.1 such that

$p = p' > w$ in country 1 autarky, and $p' > w > p_A > e$ in country 2 autarky, then welfare in country 1 still improves in the free trade dumping equilibrium:

$$\int_{p}^{p'} (\alpha Mw/P)dP - (p' - p)\pi(1+\varphi)N - (p' - w)(1 - 2\pi)N > 0$$

which can be shown to be positive if (23) is satisfied. The change in country 2 welfare is given by

$$\int_{p}^{p_A} (\alpha Mw/P)dP + (p - p_A)N \geq 0. \tag{31}$$

which is also positive. In this equilibrium the z producers who cannot cover opportunity cost in the dumping equilibrium actually achieve lower utility than in autarky.

We conclude this section with an investigation of the welfare properties of the autarky equilibrium in a country in which each potential entrant is initially uncertain about its productivity in the z sector. At the beginning of period 1, all potential z producers are ex ante identical. Suppose they sign an Arrow-Debreu insurance contract that guarantees that each z producer will share equally in the total output of all z producers in both periods. Let p* denote the first period price at which such a contract would require entry to the z sector. For any given vector of current and future prices (p, p') such that $w \leq p' \leq w/(1-\varphi)$ and $p \geq p^*$, the utility achieved by each potential z entrant is given by:

$$u(p,p') = \theta(p)p + (1-\theta(p))w + \theta(p)p'[\pi(1+\varphi) + (1-2\pi)] + \theta(p)w\pi + (1-\theta(p))p'; \qquad (32)$$

where $\theta(p) = \min[d_z(p)/N;1]$. Note that a potential z entrant will only agree to such an Arrow-Debreu contract if $u(p,p') \geq w + p'$, the expected value of producing y this period, entering the z sector next period, and keeping the returns which, in expectation, are equal to p'. It follows that the insurance contract will only require entry[20] to the z sector in period 1 if $p \geq p^*$ such that

$$\theta(p)p + \theta(p)p'[\pi(1+\varphi) + (1-2\pi)] + \theta(p)w\pi \geq \theta(p)w + \theta(p)p' \qquad (33)$$

which is just the condition that p* satisfy:

[20] As discussed in Section 3, when $d_z(p) < N$, it is assumed that all potential z entrants in fact enter a lottery in which winners produce z and losers produce y.

$$p^* = w - \pi(1 - \varphi)\max[w/(1 - \varphi) - p';0]. \tag{34}$$

This is exactly the entry decision rule derived in Section 3, equation (14). It follows that, for any given p', the amount of entry and, in a two country world, dumping that occurs is exactly the same irrespective of the presence or absence of an Arrow-Debreu insurance market. The Arrow-Debreu contract will stipulate that all signees enter the z market when $p \geq p^* = e$. When $p = e$, each z producer receives

$$e < \theta(e)e + (1-\theta(e))w < w$$

in period 1 (and of course each of the $(1 - \theta(e))N$ signees who are y producers also receive $\theta(e)e + (1- \theta(e))w$). With insurance, the loss to each z producer is lower in the first period than is the expected loss to each z producer in the absence of insurance. In period 2, each insured z producer receives:

$$\theta(p)p'[\pi(1+\varphi) + (1-2\pi)] + \theta(p)w\pi + (1-\theta(p))p'; \tag{35}$$

which is less than the expected return, in the absence of insurance, of $p'\{\pi(1+\varphi) + (1-2\pi)\} + w\pi$ received by each experienced z producer in period 2. The key point is that, with risk neutrality, the facility to pool risk afforded by an insurance contract does not alter conditions under which it is optimal to enter the z sector in the first period. Such a contract insures that each firm earns the same utility $u(p,p')$. In the absence of such a contract, the expected utility of each potential z entrant is $u(p,p')$.

Having demonstrated in Proposition 4.5 that, relative to autarky, welfare in the free trade dumping equilibrium must improve, we now show that the autarky competitive equilibrium in fact maximizes the sum of consumer and producer surplus. Again, for concreteness we focus on the case in which rents are driven to zero in autarky equilibrium, which by Proposition 3.3 will be true if $N \geq \alpha M/(1 - \pi(1-\varphi))$. Since $p' = w$ in such an equilibrium, producer surplus at any first period price p is given by:

$$ps(p) = (p - w)d(p) + (w(1+\varphi) - w)\pi d(p). \tag{36}$$

Let $p^{\sim} < p$. Then the change in producer surplus may be expressed as:

$$ps(p^{\sim}) - ps(p) = (p^{\sim} - p)d(p) + (p^{\sim} - w(1-\pi\varphi))[d(p^{\sim}) - d(p)]. \tag{37}$$

The change in consumer surplus is just:

$$cs(p^{\sim}) - cs(p) = \int_{p^{\sim}}^{p} (\alpha Mw/P)dP > (p - p^{\sim})d(p). \tag{38}$$

Thus, for all $p^{\sim} < p$, social surplus at $p^{\sim}$ exceeds social surplus at p if:

$$p^{\sim} > e = w(1 - \pi\varphi). \tag{39}$$

Now let $p = e$. If $p^{\sim} < e$, (37) implies that

$$ps(p^{\sim}) - ps(e) = (p^{\sim} - e)d(p^{\sim}); \tag{37'}$$

which means that producer surplus unambiguously contracts. Furthermore, since:

$$cs(p^{\sim}) - cs(e) = \int_{p^{\sim}}^{e} (\alpha Mw/P)dP < (e - p^{\sim})d(p^{\sim}); \tag{38'}$$

social surplus at $p^{\sim} < e$ falls short of social surplus at e. Thus, we have just proven the following proposition:

Proposition 4.6: Consider an autarky equilibrium in which the expected rent to a potential entrant is driven to zero. This equilibrium, which will occur whenever $N \geq \alpha M/(1 - \pi(1-\varphi))$, maximizes the sum of consumer and producer surplus subject to the constraint that all potential entrants to the z sector are ex ante identical.

5. Implications

In this section, we explore some key implications of the model of entry, dumping, and shakeout. In pursuit of this goal, it will be useful to generalize slightly the model of Section 4 to allow for differences between countries in w, productivity of labor in the y sector and thus the opportunity cost of resources in the z sector. In particular, let $\omega < w$ denote the opportunity cost of resources in country 2 and suppose that:

$$w/(1+\varphi) < \omega(1 - \pi\varphi) < \omega < w. \tag{39}$$

We continue to assume that distribution of productivities across firms is identical in the two countries, but that no potential entrant in country 2 knows its firm-specific productivity in the z sector until it has actually produced z. We begin by stating sufficient conditions for a free trade dumping equilibrium to exist in such a world economy.

Proposition 5.1: Given π, φ, ω, w, M, and α, there exists a free trade dumping equilibrium if (39) is satisfied and if:

$$[1/(1 - \pi(1-\varphi) + \pi(1+\varphi))]\alpha M(\omega + w)/\omega < N < \alpha M(\omega + w)/\omega 2\pi(1+\varphi). \qquad (40)$$

In this equilibrium, $p < \omega$, $p' = \omega$, country 1 imports z from country 2 in both periods, and dumping occurs in the first period.[21]

Because $\omega < w$ and the distribution $G(\zeta)$ of productivities across firms in the z sector is the same in both countries, country 2 has a comparative advantage in the z sector, and it will export z to country 1 in both periods. However, notwithstanding its comparative advantage in the z sector, country 2 can still dump in period 1 for the reason outlined in Sections 2 and 3: firms are willing to enter the z sector at a price that fails on average to cover the opportunity costs of resources in period 1 if the most efficient among them earn rents in period 2.

While country 1 continues to import z in period 2, there is shakeout of inefficient country 2 producers and a contraction in country 2 output in period 2 that pushes up the world price of z to $p' = \omega$.[22] We now show that,

[21] Proof: $\alpha M(\omega + w)/\omega$ is the world demand for z at the country 2 break even price ω. The minimum world supply at $p' = \omega$ is just $\pi(1+\varphi)N + (1 - \pi(1-\varphi))N$ since by (39) $\omega < w$. $2\pi(1+\varphi)N$ is the maximum world supply of z at any $p' < w$. Equation (40) follows immediately as the condition for $p' = w$. For dumping to occur, $p < w$, which will be true if $\alpha M(\omega + w)/\omega < N + \pi(1+\varphi)$, as implied by the first inequality in (40). It must also be true that $\alpha Mw/\omega$ exceed $\pi(1+\varphi)N$, as is implied by the second inequality in (40).

[22] However, because $w/(1+\varphi) < \omega(1-\pi\varphi) < \omega < w$, the rise in the world price of z does not call forth an expansion in the country 1 output of z, which in both periods is given by $\pi(1+\varphi)N$.

under a mild additional restrictions on the parameter φ - the fraction by which the output of the most and least efficient firms differs from the output of the average firm, it is possible to obtain simple and intuitive expressions for the rate at which inefficient firms exit during the shakeout as well as the average loss incurred by new entrants in period 1.

Proposition 5.2: If $\varphi \leq 1/3$, then in any free trade dumping equilibrium that satisfies Proposition 5.1, the equilibrium price of z in period 1 is driven down to $p = \omega(1 - \pi\varphi)$, the average loss incurred per new entrant in period 1 is equal to $-\pi\varphi\omega$, and the rate at which inefficient country 2 firms exit during the shakeout is constant and equal to π.[23]

Proposition 5.2 highlights an interesting feature of the dumping equilibrium. Namely, given $1-2\pi$, the probability of being a firm of average productivity, the exit rate is independent of the average loss per entrant. The larger is φ, the fraction by which the output of the most - and least - efficient firms differ from the output of the average firm, the smaller will be p, and thus the greater will be the average loss per entrant. Since $p' = \omega$, all low productivity entrants will exit as part of the shakeout. These low productivity

[23] Proof: Letting $D(p) = \alpha M(\omega+w)/p$, $\pi(1-\varphi)[D(\omega(1-\pi\varphi)) - \pi(1+\varphi)N]$ is the output produced by exiting firms at the period 1 price $p = \omega(1-\pi\varphi)$. The contraction in country 2 output between periods 1 and 2 is just $D(\omega(1-\pi\varphi)) - D(\omega)$. The output produced by exiting firms will exceed the contraction in country 2 output if:

$$D(\omega) > \pi(1+\varphi)N(1-\varphi)(1-\pi\varphi)/(1-2\varphi).$$

From (40), this will be true if $(1-\varphi)(1-\pi\varphi)/(1-2\varphi) < 2$. Re-arranging, this is just the condition that $3\varphi < 1 + \pi\varphi - \pi\varphi^2$, which for any $\pi > 0$, will be true if $\varphi \leq 1/3$. If $D(\omega)/(1-\pi\varphi) < N(1 + \pi(1+\varphi))$, $p = \omega(1-\pi\varphi)$. From (40), we know that $D(\omega)/[1-\pi(1-\varphi) + \pi(1+\varphi)] < N$. It is easy to verify that if $\varphi < 1/3$, $(1-\pi\varphi)(1+\pi(1+\varphi)) > [1-\pi(1-\varphi) + \pi(1+\varphi)]$, and thus $p = \omega(1-\pi\varphi)$.

firms represent a fraction π of all period 1 entrants. The condition that $\varphi \leq 1/3$ is just the condition that only low productivity firms exit as part of the shakeout, so that ex post all entrants of average and, of course, high productivity produce in both periods.

Thus, under the conditions of Proposition 5.2, some part of the world demand for z in period 2 will be met by new entry in country 2. This means that the change in country 2 output is the sum of two forces working in opposite directions: the shakeout of inefficient period 1 entrants and the entry of new z producers in period 2. Of course, under the conditions of Proposition 5.2, the reduction in output resulting from the shakeout must, in absolute value, exceed contribution to output arising from the new entry. However, it follows that the contraction in output understates the amount of shakeout and dumping for two reasons. First, because of the entry of new z producers in period 2, the contraction in output must be less than the output produced by inefficient firms that exit during the shakeout. Second, the number of firms that exit as part of the shakeout understates the number of firms that dump in period 1. This follows from the fact that p is driven down to $\omega(1-\pi\varphi)$, so that firms of average quality, $(1 - 2\pi)N$ in number, also dump in period 1. Yet none of these firms exit in period 2. In other words, the fact that a firm does not exit as part of the shakeout does not imply that such a firm did not dump in the first period.

Proposition 5.2 does not rule out a positive correlation between the exit rate and the average loss per entrant. Indeed, given φ, both the exit rate and the average loss per entrant are increasing in π. Thus, the effect of a mean-preserving spread of $G(\zeta)$ is to raise both the exit rate and average loss per entrant. Note finally that if π and φ are negatively correlated, so that sectors with few firms of average productivity are also sectors in which the output of the most and least efficient firms differs little from the output of the average firm, then the exit rate and the average loss per entrant can in fact be negatively correlated. In sum, without rather detailed knowledge of the distribution of productivities among potential entrants, a correlation of either sign or zero between exit rates and average losses is consistent with some version of the model.

For a given world demand curve, we have seen that the contraction in output in the dumping country that follows the initial stage of entry and shakeout <u>understates</u> the amount of shakeout and dumping that actually occurs. We now generalize the model to allow for growth in world demand and show that it is possible for the initial stage of dumping and shakeout to be followed by an expansion in output in the dumping country. To see this, let $\alpha M'(\omega + w)/p'$ denote the world demand for z in period 2, and suppose for concreteness that $M'/M = (1+g)/(1-\pi\varphi)$. With this rate of world demand growth, the demand for z at the period 2 price of $p' = \omega$ exceeds the demand for z at the period 1 price $p = \omega(1 - \pi\varphi)$. If N is such that:

$$[1/(1 - \pi(1-\varphi) + \pi(1+\varphi))]\alpha M'(\omega + w)/\omega < N < \alpha M(\omega + w)/\omega 2\pi(1+\varphi); \qquad (41)$$

is satisfied, then dumping occurs in period 1, inefficient firms exit as part of the shakeout, but output expands after the shakeout in response to the fully anticipated rise in world demand.[24]

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[24] Note that the set of N that satisfies (41) is non-empty if $(1-\pi\varphi)/2\pi(1+\varphi) > [1/(1 - \pi(1-\varphi) + \pi(1+\varphi))]$. For any given π, there exists sufficiently small but positive φ and g such that (41) is satisfied.

In addition to the above-mentioned implications, there are at least three additional insights conveyed by this approach that may be directly compared with the record so as to assess the relevance of the theory. First, following the lead of Gort and Klepper (1982), the model implies that dumping should be observed in younger industries in which new technology - new at least to the dumping country - plays an essential role. Second, the model implies that even in countries in which an existing production base is in place, a surge in demand, to the extent that it attracts new entrants and/or new additions to capacity, may be associated with dumping. Third, the model implies that dumping should be observed in countries whose firms have not yet mastered an existing technology and/or acquired sufficient experience in producing the dumped good. We consider in turn the empirical support for each of these predictions.

Gort and Klepper (1982) develop an evolutionary theory of industry structure following the introduction of a product innovation.[25] According to their theory and the case studies of American industries they report, Gort and Klepper argue that the markets "for most new products appear to pass through at least five distinguishable stages in the course of their evolution. New industries generally pass through a stage (IV) in which the number of producers declines significantly (Gort and Klepper (1982), p. 651)." In Gort and Klepper's descriptive model, a new product is commercially introduced in Stage I, followed by a Stage II in which the entry rate and industry output accelerate

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[25] I would like to thank a referee for bringing the Gort and Klepper paper to my attention. The literature on competitive as opposed to strategic models of selection in industries dates back at least to Alchian (1950) and Nelson and Winter (1982). Following on the seminal work of Jovanovic (1982) and Lippman and Rumelt (1982), recent papers by Pakes and Ericson (1988) and Hopenhayn (1986) have begun to explore the implications of learning, entry, and exit on industry structure in a closed-economy context.

rapidly. In Stage III, the rate of net entry declines dramatically - and ultimately to zero - as a result of "the accumulation of experience by existing firms . . . and a gradual reduction in the population of potential entrants that have not as yet entered the market (Gort and Klepper (1982), p. 633)." In the aforementioned Stage IV, the "less efficient firms who are unable to imitate the leaders . . . are forced out of the market. . . Consequently, the exit rate rises sharply (Gort and Klepper (1982), p. 633)." Finally, in Stage V, the net entry rate returns to zero, where it remains until the eventual shrinkage of the market is brought on, either by product obsolescence or the introduction of a competing product.

Following the lead of Gort and Klepper and their case study approach, we searched the record of dumping cases filed during the last decade to isolate those in which new technology and a substantial shift in world demand might be expected to play a prominent role. We confined our attention to cases in which the Commerce Department ruled that sales "at less than fair value" were in fact made. Within this subset of cases, we examined only those in which the Commerce Department employed the "constructed value" approach to determine fair value. "Constructed value" is the Department's estimate of the average cost of production. It is employed whenever there are insufficient (and many times no) sales in the domestic market that can be used calculate the domestic sales price. Thus, a finding of dumping ("sales at less than fair value") based upon constructed value is a finding that the dumped goods have been exported at a price falling short of the Department's estimate of average cost.

Among the cases we isolated in which technology and robust world demand played a prominent role, two stand out: the dumping of cellular telephones and cellular telephone subassemblies by Japan in 1984; and the dumping of small business telephone systems and small business telephone subassemblies by South Korea in 1988. In 1985, in response to a complaint filed by the Motorola Corporation in November 1984, the Commerce department ruled (Federal Register, v. 50 (1985), p. 24554) that Japanese manufacturers were dumping cellular telephones and cellular telephone subassemblies in the US. In its ruling, the Department noted that, because of *insufficient sales in the domestic market* by at least three firms, the finding of dumping was based on evidence that cellular telephones were being exported at a price that failed to cover average cost. In 1989, in response to a complaint filed by the AT&T and Comdial Corporations, the Commerce department ruled (Federal Register, v. 54 (1989), p. 31980) that South Korean manufacturers were dumping small business telephone systems and subassemblies in the US. Again, the finding of dumping was based on evidence that these business telephone systems were being exported to the US at a price that failed to cover average cost.

Olley and Pakes (1991), in their recent study of the US telecommunications industry, have documented that the demand for communication equipment, and especially imported equipment, surged after the breakup of AT&T in the early 1980's. In 1982, imports represented 4 per cent of new supply in the US market; by 1987 the *share* of imports had more than tripled to 14 per cent. Olley and Pakes also document that this surge in demand for imports accompanied a substantial jump in the entry - and exit - rate of new plants, owned by domestic as well foreign producers, in the US market. They argue that, "entry into the telecommunications equipment market was effectively prohibited . . . prior to the AT&T divestiture [since] Western Electric supplied 90 per cent of AT&T equipment purchases (Olley and Pakes (1991), p. 4)." Furthermore, it was not until 1978 that the Federal Communications Commission even permitted the connection of such private subscriber equipment as telephones and PBX systems to the AT&T network. While we were not able to obtain detailed data on entry and exit rates at the plant level for the Japanese cellular telephone industry or the South Korean business telephone system sector, it is noteworthy that the constructed value definition of dumping was employed by the Commerce Department precisely because of insufficient home market sales of these products; price discrimination was neither alleged nor documented. Furthermore, because of the surge in demand for telecommunications equipment following the AT&T divestiture, these cases would not appear to represent episodes of cyclical dumping.

A second implication of the theory is that, even in countries in which an existing production base is in place, a surge in demand, to the extent that it attracts new entrants and/or new additions to capacity, may induce dumping. To understand this in the context of the model, suppose that at the beginning of period 1, a fraction δ of the N potential country 2 z producers know their productivity in the z sector. It is straightforward to show that if

$$\delta \leq \pi(1 - \varphi)/(1 - \pi\varphi - \pi); \tag{42}$$

Proposition 5.1 implies that country 2 will dump z in country 1, despite the fact that country 2 has in place an existing base of producers who share in common with producers in country 1 a stock of knowledge about the technology for making z.[26] Among the cases we investigated in which dumping was associated with a surge in demand for and a concomitant substantial expansion in the output of the dumped product, we will mention two: the dumping of steel by Brazil in 1983 and 1984, and the dumping of color television sets by Taiwan in 1983.

In October 1982, just before the end of the 1981-1982 recession, the United States placed quota limits on the steel exports of the European Economic Community, and reached an informal agreement with the Japanese to limit their US exports (Destler (1986), p. 130). In 1983, as the US economy began to recover and "in the aftermath of the quota limits placed on EEC steel in October 1982 [and the restraint demonstrated by Japanese producers] . . a large upsurge of developing country steel . . . flowed into the United States (Conybeare (1987), p. 212)." A rash of dumping complaints, especially against Brazilian steel exporters, followed. According to the data compiled by Destler (1986), no fewer than eight findings of dumping steel at less than fair value were issued by the Commerce Department against Brazil in 1983 and 1984. To name just two, the Department, in response to complaints filed by the Bethlehem Steel and US Steel Corporations, ruled that at least four Brazilian producers were dumping hot rolled steel plate and hot rolled steel sheet in the US (Federal Register, v. 48, (1983), p. 40419). Because of insufficient domestic sales, the Department ruled that the US price did not cover the constructed value of the Brazilian steel.

The surge in steel exports from Brazil did not reflect a diversion of a relatively fixed supply to the US market. According to US Iron and Steel

[26] To see this, note that $p < \omega$ if $\alpha M(\omega + w)/\omega < \pi(1+\varphi)N + \pi(1+\varphi)\delta N + (1-\delta)N$. When (42) is satisfied, $[\pi(1+\varphi) + \pi(1+\varphi)\delta + (1-\delta)] > \pi(1+\varphi) + 1 - \pi(1-\varphi)$, so that (40) is sufficient for dumping to occur.

Institute data, exports of Brazilian steel to the US were 432,000 net tons in 1979, 604,000 tons in 1982, 1,257,000 tons in 1983, 1,460,000 tons in 1984, 1,701,000 tons in 1985, and after a quota agreement with the US entered in to effect, only 1,103,000 tons in 1986. Total production of steel by Brazil was 15,300,000 net tons in 1979, 14,324,000 tons in 1982, 16,159,000 tons in 1983, 20,266,000 tons in 1984, 22,546,000 tons in 1985, 23,405,000 tons in 1986. Thus, between 1982 and 1985, the near trebling of Brazil steel exports to the US accounted for less than 12 per cent of the increase in total steel output, which rose by nearly 60 per cent.[27] Nor was this a period in which the total US demand for steel was falling. In fact total US steel demand (imports plus domestic production less exports) was roughly 80,000,000 tons in 1982, 85,000,000 tons in 1983, 100,000,000 tons in 1984, and 96,000,000 tons in 1985.[28]

Consider next the dumping of color television sets by Taiwan. In 1983, in response to a complaint filed by six US firms, the Commerce Department ruled that Taiwan producers were dumping color television sets in the US. In its ruling (Federal Register, v. 48 (1983), p. 48491), the Department noted that, because at least two firms, RCA and Hitachi, had no sales of color television sets in Taiwan or in third markets, the finding of dumping was based upon sales in the US at a price that fell below constructed value; price discrimination was

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[27] I was unable to obtain plant level data on entry and exit in the Brazilian steel industry. However, according to the industry publication American Metal Markets, Brazil continued to add to its steel capacity during the mid 1980s while world steel capacity was shrinking. See, "A Continued Shakeout Among Steelmakers is Probable through the Early 1990's", American Metal Markets, November 1, 1985, p. 1.

[28] Of course, the US steel industry contracted substantially between 1979 and 1982. In 1979 total US demand for steel mill products was approximately 115,000,000 tons and total imports of steel mill products were 17,500,000 tons.

of course neither alleged nor established for these firms. Total US demand for television sets rose by more than 20 percent between 1982 and 1983 to more than 21,000,000 sets, while total US production rose by more than 10 percent, to more than 11,000,000 sets.[29] Total exports of color television sets from Taiwan rose from 600,000 sets in 1982 to 1,500,000 sets in 1983. This did not represent a diversion of a given output level. According to industry trade publications, total output of color television sets in Taiwan was less than 1,300,000 units in 1980; by 1984 total exports alone were approaching 2,000,000 sets.[30]

A third implication of the model is that dumping should be observed in countries whose firms have not yet mastered an existing technology or have not yet acquired sufficient experience in producing the dumped good. An examination of the record reveals several instances in which countries have been found dumping in the US during a cyclical expansion goods for which there is no home market, goods that would appear to be neither capital nor technology intensive. Two will be mentioned here: the dumping of photograph albums by Hong Kong in 1984, and the dumping of thermostatically controlled appliance plugs by Malaysia in 1987.

In 1985, in response to a complaint filed by Esselte Pendaflex Inc. in February 1985, the Commerce Department ruled (Federal Register, v. 50 (1985), p. 28830) that exports of photograph albums from Hong Kong were being dumped in the US. The Department calculated the constructed value of the albums because

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[29] Although the Census Bureau reports import volumes separately for color and black and white sets, it only reports domestic production by 5 digit SIC Code 36512, "Television Receivers".

[30] For production and export data on Taiwan color television sets see The Japan Economic Journal, June 21, 1981, p. 9, The Journal of the Asian Economics Union, June 1984, p. 16, and Les Echos, November 28, 1983, p. 9.

there was no home market for the goods. In 1988, in response to a complaint filed by the Triplex Inter Control Company in May 1988, the Commerce Department ruled (Federal Register, v. 53 (1988), p. 37827) that exports of thermostatically controlled appliance plugs from Malaysia were being dumped in the US. Again, the Department based its dumping findings on the constructed value calculation because of insufficient or non-existent domestic market sales - price discrimination was neither alleged nor documented. A check of 7 digit SIC data revealed that the US production of photograph albums (SIC 27824 41) actually rose substantially between 1983 and 1984, and was essentially unchanged in 1985, while the US production of "temperature responsive controls for major appliances" (SIC 38220 75) was essentially flat in 1985, 1986, and 1987.

It should be noted that, without rather detailed data on entry and exit data at the plant level in the dumping country, it is not formally possible to confirm the theory of entry, dumping, and shakeout presented in this paper. Only very recently have researchers begun to characterize actual patterns of firm entry and exit in the US economy. As pointed out recently by Dunne, Roberts, and Samuelson (1988), "Despite wide recognition of the important role of entry and exit, surprisingly little is known about the patterns of firm entry and exit in the US economy (p. 495)." Nonetheless, the model presented here does help to provide one explanation for dumping cases in which (i) price discrimination is neither alleged nor documented (ii) there is a surge in total demand for the dumped product (iii) there is a surge in total production of the dumped product in the dumping country, and (iv) the dumping country is among the group of newly industrializing countries whose share of world manufacturing trade has risen so dramatically during the past ten years.

6. Concluding Remarks

This paper has developed a model of dumping - similar in spirit to Jovanovic (1982) - in which entry and exit and the terms of trade are endogenous. The novel feature of the two country Ricardian model developed in this paper is that dumping can arise in the free trade equilibrium even if the two countries differ only in their initial stock of technological knowledge.

Intuitively, dumping can arise because the present value of entry includes the value to the individual producer of learning his productivity parameter. Such information is valuable because the most productive producers earn positive rents in equilibrium. Competition among ex ante identical producers for these present and future rents can drive down the price of the product sufficiently so that the industry suffers losses. Ex post inefficient producers, upon learning their productivity parameter, recognize their losses and exit the sector. The rents earned by the most productive producers offset the opportunity cost previously incurred.

The reason why entry to the z sector is costly for a new entrant is that, for the length of a "production period", that entrant is unable to produce and consume w units of y. In this sense, factor specificity is crucial for this, as well as other, explanations of dumping. However, a specific factors explanation that excludes a role for learning via production would not appear to predict that dumping should be observed in periods of high demand for the dumped product. Specific factor models of the sort developed by Ethier (1982) illustrate why dumping can occur when demand is transitorily low, not permanently high.

In our analysis, we have said that a firm dumps if it exports at a price that fails to cover the opportunity cost w. Of course, with the simple Ricardian entrepreneur set-up of this paper, there is no explicit wage bill paid by a firm. Rather, there is a return that must be earned if the Ricardian entrepreneur is to remain in the z sector. Given the Commerce Department method of constructed value, the use of the static opportunity cost of resources in this world, w, to define dumping does not seem to be at variance with the definition that is actually employed by the Department in dumping cases.

In our analysis, we have abstracted from the durability of dumped goods. It is natural to ask why, if dumped goods can be purchased and stored, are they sold at a price that is expected to increase, either because of the mechanism outlined here, or because of the mechanism outlined in Ethier (1982), or because of the expectation that the Commerce Department will impose dumping duties on the culprits? Does this not violate the an intertemporal arbitrage condition? In the absence of transaction costs, it of course does. In fact, many if not most of the goods that are said by the Commerce Department to be dumped are durable and storable. The fact that we, along with others, ignore this question does not suggest that it is not important.

In the Introduction, I alluded to the literature on cyclical dumping. Two recent papers, by Gruenspecht (1988) and Dick (1988) study the connection between internal scale economies (along a learning curve in the sense of Spence (1981)), an exogenous duopoly market structure, and the resulting Nash equilibrium. The basic message of both papers is that, since the relevant marginal cost of an extra unit of output includes the reduction in future costs that will be forthcoming as a firm moves down the learning curve, observed unit cost can exceed the shadow marginal cost and, depending upon the elasticity of demand, the current price of output. Thus, dumping can result because measured unit cost overstates true marginal cost.

Clearly, the common definition of dumping embodies several related, but distinct phenomenon. The purpose of this paper has most surely not been to argue that all dumping is the result of the process of entry and shakeout that has been outlined above. Rather, the modest goal has been to show one mechanism by which transitory differences in the stock of technological knowledge in otherwise identical countries can result in international trade and, under certain conditions, dumping, and to evaluate some of the implications.

Appendix

Proof of Proposition 3.3: From Corollary 3.1, $e < \beta$ when $p' < w/(1 - \varphi)$. The minimum supply of z in period 2 at a price $p' > w$ is given by $N(1 - \pi(1 - \varphi))$. This is because at most πN firms will be unwilling to produce at $p' > w$. These are the (at most) πN firms that entered in period 1 and found their productivity parameter to be $(1 - \varphi)$. Since total output of z is $NE\xi = 1$, $N(1 - \pi(1 - \varphi))$ is the minimum period 2 output of z at $p' \geq w$. Thus, from (13), $\alpha M(1-\varphi) \leq N(1 - \pi(1 - \varphi))$ is the restriction that insures that $p' \leq w/(1 - \varphi)$. (18) and the second term in the max[] in (19) follow immediately. For $p < w$, demand at a price w must fall short of the elastic supply of z, N, when p equals or exceeds the entry price $e < w$. This will be true when $\alpha Mw/w < N$. The first term in the max [] in (19) follows. By similar reasoning, $\alpha M \leq N(1 - \pi(1 - \varphi))$ is the condition that, along with the condition $\varphi \leq 1/2$ (Corollary 3.1), $p' = w$. When the period 2 price is pushed to the break even price w, the period 1 ex ante entry price e is, from equation (14) equal to $e = w(1 - \pi\varphi)$.

Proof of Proposition 4.1: The proof is similar to that of Proposition 3.3. From Corollary 3.1, $e < \beta$ when $p' < w/(1 - \varphi)$. The minimum world supply of z in period 2 at a price $p' \geq w$ is given by $2N(1 - \pi(1 - \varphi))$. This is because at most πN firms in each country will be unwilling to produce at $p' > w$. These are the (at most) πN country 2 firms that entered in period 1 and found their productivity parameter to be $(1 - \varphi)$, plus the πN inefficient country 1 firms. Since total output of z is $2NE\xi = 2N$, $2N(1 - \pi(1 - \varphi))$ is the minimum period 2 output of z at $p' \geq w$. Thus, f rom (13), $2\alpha M(1-\varphi) \leq 2N(1 - \pi(1 - \varphi))$ is the restriction that insures that $p' \leq w/(1 - \varphi)$. The second term in max[] in (23) follows immediately. For the first period equilibrium price to be driven below break even, $p < w$, world demand at a price w must fall short of the elastic supply of z when p equals or exceeds the entry price $e < w$. This supply is given by $N + \pi(1+\varphi)N$. It is the sum of the elastic country 2 supply at the entry price e and the supply of the most efficient country 1 producers. When $2\alpha Mw/w < N + \pi(1+\varphi)N$, $p < w$ if $p' < w/(1-\varphi)$. The first term in max[ ] in (23) follows. Finally, for dumping to occur in period 1, it must be the case that $d_z(p) > 2\pi(1+\varphi)N$; otherwise country 1 will export z to country 2. Since $p < w$ by the first inequality, this condition will be satisfied if $2\alpha Mw/w > 2\pi(1+\varphi)N$; the second inequality follows. The set of N that satisfies (24) is nonempty for all $\pi < 1/2$, $\varphi < 1$, and positive α since $(1 - \pi(1 - \varphi)) > \pi(1+\varphi)$ and $1 + \pi(1+\varphi)) > 2\pi(1+\varphi)$.

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