forthcoming in *Open Economics Review*

Market Power, Uncertainty and the Level of Trade

Winand Emons*
University of Bern and CEPR

Revised October 1993

Abstract

We consider a set of home firms each of which has a stochastic requirement for a particular input. High-cost home firms can produce the input themselves. Low-cost foreign firms produce the input to sell it to home firms through an international market. Efficiency requires the input to be produced by foreign firms and traded in the market. Yet, home firms will always engage in inefficient home production. By producing some of its own input needs, a home firm cuts down on aggregate input demand thus depressing prices in the market.

Keywords: stochastic input demand, oligopsony, international trade.
Journal of Economic Literature Classification Numbers: F12.

*Universität Bern, Volkswirtschaftliches Institut, Abteilung für Wirtschaftstheorie, Gesellschaftsstraße 49, CH-3012 Bern, Switzerland, winand.emons@vwi.unibe.ch, http://www-vwi.unibe.ch/theory/emons03.htm. I thank Aymo Brunetti, Martin Hellwig, and Eric Scheidegger for helpful discussions and the Schweizerischer Nationalfonds for financial support.

I. Introduction

The welfare theorems of international trade state with some qualifications that free trade enhances efficiency; see, e.g., Dixit and Norman (1980) or Helpman and Krugman (1985). Nevertheless, it is a well known empirical observation that goods are often produced in a high-cost country although they could be produced in a low-cost country and exchanged internationally—making both countries better off.

Such departures from efficiency enhancing international trade are typically attributed to some form of protection. The traditional theory proposes the infant industry and optimum tariff arguments as justifications for the pursuit of protectionist policies. The infant industry argument states that it may be unprofitable to start up certain industries in a situation of free trade. Yet, if those industries were given time to develop behind tariff protection, they would eventually become profitable and the tariff could later be dropped.

The argument for an optimum tariff is the application of monopoly/monopsony power in the international market to improve a country's terms of trade. While a country would like its firms to behave competitively at home, it would be beneficial for the country to behave as a monopolist when selling and as a monopsonist when buying abroad. If individual home firms are competitive, there is scope for the government to move in and, essentially, make the country behave as a monopolist/monopsonist. For example, an export tax causes the country to restrict its exports like a monopolist while an import tariff causes the country to restrict its imports like a monopsonist. Both forms of protectionist policies move the terms of trade in the country's favor. See, e.g., Markusen and Melvin (1988).

The more recent strategic trade policy arguments are based on increasing returns and imperfect competition. Suppose, for example, foreign and home firms face decreasing marginal costs and act as Cournot competitors. If the government protects the home market, the domestic firm gets an advantage in scale over foreign rivals. This scale advantage translates into lower marginal costs and a competitive advantage even in unprotected markets (Krugman (1984)). See Brander and Spencer (1985) for a related analysis where an export subsidy by the domestic government increases the home country's welfare.

A final argument falls under the heading of political economy of protection. Free trade increases a country's aggregate welfare. Appropriate lump-sum compensating transfers (Samuelson (1962)) or tax-subsidy policies (Dixit and Norman (1980), (1986)) ensure a gain in an efficient free trade equilibrium for all individuals in an economy relative to any protectionist alternative. Nevertheless, in the absence of such compensatory income adjustments, some individuals gain from free trade at the expense of others. Accordingly, the question of whether a policy of free trade is to be pursued becomes an issue of income redistribution rather than efficiency. Protectionist policies evolve because the losers of free trade seek protection via the political process. See, e.g., Hillman (1989).

Nevertheless, it is fairly unclear why there should be inefficient departures from international trade in the absence of protectionist policies. For instance, profit maximizing home firms should try to minimize the costs of obtaining their inputs. Therefore, they should purchase from foreign suppliers given that the latter offer the best deal. In this paper we show that this need not be so. High-cost home firms inefficiently produce the input themselves. Thereby, they make use of their oligopsony power. They engage in inefficient home production to depress prices on the international market, which is supplied by competitive low-cost foreign firms. Any equilibrium trade pattern involves inefficient home production, making home firms worse off than if they relied on the supply of foreign firms.

We consider a partial equilibrium framework for an intermediate product.[1)] A finite set of home firms needs the intermediate product as an input to produce their outputs. Each home firm has a stochastic requirement for the input—less when demand for its output is low than when it is high. Home firms either produce the input themselves or purchase it via an international market from foreign firms with no market power. Foreign and home firms have access to a similar input technology. To produce the input, either firm has to build up capacity at a fixed cost. If either firm has a certain capacity level, it can produce any quantity of the input not exceeding capacity at a constant marginal cost. The cost differential between foreign and home firms is reflected by different fixed costs. Foreign firms encounter a (slightly) lower fixed cost than home firms when they build up capacity. To simplify the analysis, we assume that a home firm producing the input itself does not sell it. Foreign and home firms simultaneously pick capacity levels. Nature then determines each home firm's input requirement. If a home firm's input requirement exceeds its own capacity, it shows up on the input market with positive demand. If market demand exceeds market supply, a high price prevails and vice versa so that the input market clears. Foreign and home firms are risk neutral.

To begin with, we show that no trade always constitutes an equilibrium trade pattern. That is, all home firms have a capacity level that permits to produce the maximum input requirement when demand for their output is high and that is partly idle when demand is low. Foreign firms are inactive. This equilibrium, however, is inefficient. First, foreign firms can build up any capacity level at a lower cost than home firms. Second, since home firms do not sell the input, they cannot pool their input requirements. Risk pooling can only be achieved if the input is produced by foreign firms and traded in the international market. The maximum trade situation where home firms do not produce the input at all and purchase their needs on the international market realizes further welfare gains through efficient risk pooling. This maximum trade situation is thus the only efficient trade pattern: capacity costs are minimized and all gains from risk pooling are realized. Nevertheless, this efficient maximum trade situation *never* constitutes an equilibrium trade pattern. If a home firm starts producing some of its own input needs, it cuts down on aggregate demand, thus depressing prices in the intermediate good market. This favorable price effect outweighs the additional fixed costs through inefficient home production as well as the risk of idle capacity when output demand is low, given that the home firm's capacity is not too large. It follows from this result that the input market will *always* be characterized by inefficient home production.

The remainder of the paper is organized as follows. In the next section we describe the model. In section III we derive our results of the equilibrium patterns of trade. In the concluding section we relate our findings to optimum tariffs and discuss how in our setup the efficient trade pattern can be implemented by various trade policies. All proofs are relegated to the Appendix.

II. The Model

We consider the market for an intermediate good. The intermediate good is produced according to the following constant returns to scale technology: For each unit a firm wishes to produce, it must employ one unit of a "fixed input bundle" at a cost F. Furthermore, it needs a unit of a "variable input bundle" costing c. As is suggested by their names, the two input bundles differ in the way they can be adjusted to unexpected changes in production. A firm can avoid the cost c for the variable input bundle if it chooses not to produce ex post. In contrast, if a firm wants to have the capability of producing one unit ex post, it must invest F in capacity ex ante; F is sunk even if at a later stage the firm decides not to produce.

More specifically, a firm has to build up capacity $y \in I\!N_0$ at a unit cost $F > 0$. If a firm has capacity y, it can produce any quantity of the intermediate good $\upsilon \leq y,\ \upsilon \in I\!N_0$ at a constant marginal cost $c > 0$. It is not possible to produce $\upsilon > y$. The technology for the intermediate good is thus given by the cost function

$$C(\upsilon, y) = \begin{cases} Fy + c\upsilon, & \text{if } \upsilon \leq y; \\ \infty, & \text{otherwise.} \end{cases} \tag{1}$$

In the low-cost foreign county there are m firms indexed by $f = 1, \ldots, m$. Foreign firms produce the intermediate product according to the technology (1). Foreign firms encounter a fixed cost F^f. They sell the intermediate product via an international market to home firms which use it as an input to produce their outputs. We want to make international trade as attractive as possible for home firms. Therefore, our foreign firms are competitive. That is, foreign firm f chooses capacity $y^f \in \{0, 1\}$, $f = 1, \ldots, m$; foreign firms are thus "small". Under this assumption a foreign firm cannot make positive profits by reducing its capacity. Foreign firms are either in or out of the market. They are, essentially, strategic dummies. In particular, under this assumption foreign firms are happy with expected zero profits.

Besides being competitive, we want the foreign sector to be large enough to satisfy whatever the home firms might need. Therefore, let m be sufficiently large (in a sense to be made more precise below) so that there are enough foreign firms to be able to produce the maximum amount of the intermediate good that might be required. To summarize the foreign sector: There is a large pool of foreign firms. Foreign firms become active on a small scale so that they have no market power. The foreign sector is thus modeled as the most favorable source of supply imaginable for home firms.

Let us now turn to the home sector that uses the intermediate good we consider as an input to produce their outputs. The home sector consists of n firms indexed by $h = 1, \ldots, n$. Each home firm produces a distinct product. To focus on the intermediate good market, we assume away any competition between home firms on their output markets. As an example, think of the intermediate product as memory chips which are used as input in the computer, the auto electronics, the machine–tool, the telecommunications, the consumer electronics industries, etc.; other examples of the intermediate product include the transportation business and certain bulk chemicals which are used as inputs by a plethora of firms not competing on their output markets.

We explain inefficient home production by vertical integration, therefore, as a phenomenon that results solely from input market considerations. This distinguishes our approach from the literature on vertical foreclosure (see, e.g., Hart and Tirole (1990), Ordover, Saloner, and Salop (1990), Salinger (1988), and, in an international trade context, Spencer and Jones (1991), (1992)). In this literature a home firm integrates upstream to foreclose its home rivals from input supplies. This puts the rivals in the product market at a disadvantage, allowing the home firm to raise its market share. In other words, in this literature the motive for vertical integration is to foreclose product market competition by raising rivals' costs (Salop–Scheffman (1988)).

Each home firm faces stochastic demand for its output that can be either high or low. A home firm's requirement for the intermediate good is, therefore, also random: if output demand is low, i.e., in bad times, a home firm needs less of the intermediate good than in good times when its output demand is high. To simplify the analysis, let the home firms' input requirements be identically distributed. Formally, denote home firm h's, $h = 1, \ldots, n$, input requirement by

$$\tilde{x}_h = \begin{cases} \underline{x}, & \text{with probability } Pr(\underline{x}) \in (0,1); \\ \overline{x}, & \text{with probability } Pr(\overline{x}) = 1 - Pr(\underline{x}). \end{cases}$$

Let $\underline{x}, \overline{x} \in I\!N$, i.e., there is a smallest unit of account for the input and a home firm always needs some of the intermediate good. Furthermore, $\overline{x} > \underline{x} \geq \overline{x} - \underline{x}$. That is, measured in input terms, good times are strictly better than bad times and, more importantly, *the high demand state is not more than twice as good as the low demand state.* As we will see later, the second inequality is crucial to our results. It implies that the riskless part of a home firm's input requirement $\underline{x}$ is large enough so that taking $\underline{x}$ out of market demand by vertical integration is sufficient to depress prices on the international market.

Let $\pi > 0$ denote the home firms' reservation price per unit of the intermediate good. Accordingly, at price π a home firm is indifferent between obtaining and forgoing a unit of the input. As an interpretation, think of π as the price of a backstop substitute for the input, i.e., an expensive yet still profitable substitute available in abundant supply. In terms of our transportation example, think of π as the price the mail service charges for shipping goods around; if we think of the input as 128 K memory chips, 2π would be the price of a 256 K chip.

Home firms can produce the intermediate good themselves according to the technology (1) but at a higher cost than foreign firms. The cost differential between the home and the foreign country is reflected by different fixed costs. Home firms have a unit fixed cost F_h. Let $F_h - F^f > \epsilon$ with $\epsilon > 0$ and small. That is, home firms have a slightly worse technology or the "fixed input bundle" is cheaper in the foreign country.[2)] Home firm h chooses capacity $y_h \in I\!N_0,\ h = 1, \ldots, n$. We identify the amount of international trade by the home firms' capacity choices. We will call a home firm non-integrated if $y_h = 0$ and fully integrated if $y_h \geq \overline{x}$. Accordingly, if all home firms are fully integrated, there is no international trade. Conversely, if all home firms are non-integrated, they rely completely on foreign supplies and we observe maximum trade.

We assume that home firms producing the intermediate product do not sell it. It might, e.g., not be profitable for home firms to digress from marketing their outputs by additionally selling the input.[3)] Note that we do *not* need this assumption to establish our result that there will always be too little international trade.

Let

$$Pr(\overline{x}) \geq F_h/(\pi - c), \tag{2}$$

i.e., the probability of good times is higher than the input technology's cost-benefit ratio for home firms. More specifically, assumption (2) implies the following: If there is no market for the intermediate product, a home firm holds capacity $y_h = \overline{x}$ to be able to produce the maximum requirement $\overline{x}$ itself rather than forgo some input.[4)]

Let us now turn to the formulation of the game which is a simultaneous move game in capacities. Home firms strategically pick capacity $y_h \in IN_0,\ h = 1, \ldots, n$. All home firms exhaust their own input capacity and purchase the remaining requirement on the market should this be necessary.[5)] Home firm h's input demand is thus a random variable $\tilde{d}_h = \max[0, \tilde{x}_h - y_h],\ h = 1, \ldots, n$. Denote aggregate input demand by $\tilde{D} = \sum_{h=1}^{n} \tilde{d}_h$.

Simultaneously with home firms, foreign firm f chooses as a strategic variable the capacity $y^f \in \{0, 1\},\ f = 1, \ldots, m$. Call a foreign firm that picks capacity 1 active and inactive otherwise. Foreign firms tell an auctioneer their capacity $y^f,\ f = 1, \ldots, m$. Denote foreign firms' aggregate capacity by $Y = \sum_{f=1}^{m} y^f$. Call Y market capacity.

Nature then determines each home firm's input requirement. Home firms tell the auctioneer their input demand. The auctioneer clears the market by the following pricing rule

$$p = \begin{cases} c, & \text{if } \tilde{D} \leq Y; \\ \pi, & \text{otherwise.} \end{cases}$$

If the market is slack, i.e., if aggregate demand does not exceed market capacity, price equals marginal production cost. At the rockbottom price $p = c$ active foreign firms are indifferent between producing and not producing the input. Accordingly, in a buyers' market, each active foreign firm makes a loss F^f.

If the market is tight, i.e., if aggregate demand exceeds market capacity, price equals the home firms' reservation price. At the sky-high price $p = \pi$ home firms are indifferent between obtaining and forgoing the intermediate good. In a sellers' market active foreign firms make a profit $(\pi - c - F^f)$. Note that the pricing rule clears the market. Consequently, no rationing occurs.[6)]

Foreign- and home firms are risk neutral. Foreign firm $f,\ f = 1, \ldots, m$ maximizes with respect to y^f expected profits

$$G^f(y_1,\ldots,y_n,y^1,\ldots,y^m)=\begin{cases}(\pi-c)\sum_{\tilde{D}>Y}Pr(\tilde{D})-F^f, & \text{if } y^f=1;\\ 0, & \text{otherwise,}\end{cases}$$

where $Y=\sum_{f=1}^m y^f$.

Home firm $h,\ h=1,\ldots,n$ minimizes with respect to y_h the expected costs $K_h(\cdot)$ of obtaining the intermediate product. To determine $K_h(\cdot)$ we have to specify the stochastic properties of the aggregate input requirement and aggregate input demand in some more detail.

Once nature has picked each home firm's input requirement, a state of the world can be described by the $n\times 1$ vector $(\tilde{x}_1,\ldots,\tilde{x}_n)'$ whose hth component denotes home firm h's input requirement $\underline{x}$ or $\overline{x}$. Denote the possible states of the world by $\Xi_{ij},\ i=0,\ldots,n;\ j=1,\ldots,\binom{n}{i}$. The index i denotes the number of components of Ξ_{ij} that equal $\overline{x}$. Call a state of the world where i firms have input requirement $\overline{x}$ of order i. The index j denotes the number of states of order i. Accordingly, the state of the world is a random variable $\tilde{\Xi}$ distributed according to

$$\tilde{\Xi}=\Xi_{ij}\quad\text{with}\quad Pr(\Xi_{ij}),\quad i=0,\ldots,n;\ j=1,\ldots,\binom{n}{i}.$$

The random variable $\tilde{\Xi}$ is assumed to have full support, i.e., $Pr(\Xi_{ij})>0\ \forall i,j$.

Let e be the $1\times n$ unit vector. For each state of order i define $X_i=e\Xi_{i1}=(n-i)\underline{x}+i\overline{x},\ i=0,\ldots,n$. The number X_i denotes aggregate input requirement in a state of order i (note that $e\Xi_{i1}=e\Xi_{ij},\ j=1,\ldots,\binom{n}{i},\ i=0,\ldots,n$). Aggregate input requirement is thus a random variable $\tilde{X}=\sum_{h=1}^n \tilde{x}_h$ that is distributed according to

$$\tilde{X}=X_i\quad\text{with}\quad Pr(X_i)=\sum_{j=1}^{\binom{n}{i}}Pr(\Xi_{ij}),\ i=0,\ldots,n.$$

The maximum aggregate input requirement is $X_n=n\overline{x}$; the assumption that there are enough foreign firms to be able to produce the maximum input requirement thus means $m \geq X_n$.

Finally, recall that home firm h's input demand $\tilde{d}_h$ is jointly determined by the random variable $\tilde{x}_h$ and its strategic capacity choice y_h, i.e., $\tilde{d}_h = \max[0, \tilde{x}_h - y_h],\ h = 1, \ldots, n$. Denote the random variable of $n \times 1$ vectors $(\tilde{d}_1, \ldots, \tilde{d}_n)'$ of individual demands by $\tilde{\Delta}$. With this notation we may denote aggregate input demand by $\tilde{D} = e\tilde{\Delta} = \sum_{h=1}^{n} \tilde{d}_h$.

Having set up the necessary machinery we may now specify home firm h's, $h = 1, \ldots, n$, expected cost $K_h(\cdot)$ of obtaining the input which is given as

$$K_h(y_1, \ldots, y_n, Y) = F_h y_h + c\left[\underline{x}Pr(\underline{x}) + \overline{x}Pr(\overline{x})\right] +$$

$$(\pi - c)\left[\max[0, \underline{x} - y_h] \sum_{\substack{e\tilde{\Delta} > Y \wedge \\ \tilde{d}_h = \max[0, \underline{x} - y_h]}} Pr(\tilde{\Delta}) + \max[0, \overline{x} - y_h] \sum_{\substack{e\tilde{\Delta} > Y \wedge \\ \tilde{d}_h = \max[0, \overline{x} - y_h]}} Pr(\tilde{\Delta})\right].$$

First, the home firm incurs capacity costs $F_h y_h$. Second, it has to pay marginal cost c in any case, whether producing the intermediate good itself or purchasing it on the market. Third, it pays the amount $(\pi - c)$ in excess of marginal cost on the market whenever the market is tight, i.e., if $\tilde{D} = e\tilde{\Delta} > Y$; it pays the surcharge on its demand in bad or good times, resp. Home firms minimize with respect to y_h the expected cost $K_h(\cdot)$ of obtaining the input, $h = 1, \ldots, n$. We focus on Nash–equilibria of our simultaneous move game in capacities.

III. Trade Patterns

Let us now derive some results on trade patterns for our intermediate good market. We will identify the degree of international trade by the amount of capacity that home firms have. We want to start with no trade which is always an equilibrium market pattern.

Proposition 1: *There exists an equilibrium in which home firms pick capacity $\hat{y}_h = \overline{x},\ h = 1, \ldots, n$ and foreign firms choose capacity $\hat{y}^f = 0,\ f = 1, \ldots, m$.*

The existence of the no trade equilibrium is an immediate consequence of assumption

(2). This assumption says that the probability of good times is sufficiently high to make it worthwhile to have capacity $y_h = \overline{x}$ given that there is no input market. The capacity $\overline{x}$ is only partly used in bad times. Yet the cost of forgoing some input when output demand is high outweighs the cost of idle capacity when output demand is low. Conversely, given that all home firms choose capacity $\overline{x}$, there is no demand for the intermediate product. Foreign firms thus never sell anything. If a foreign firm becomes active, it incurs a fixed cost without obtaining any revenue. Consequently, no trade is a Nash equilibrium for our intermediate good market.

Nevertheless, the no trade equilibrium in which all home firms are fully integrated is inefficient. Home firms build up the aggregate capacity $n\overline{x}$ at a cost $F_h n\overline{x}$. If foreign firms build up the same capacity level, they incur a cost $F^f n\overline{x}$. Consequently, $\epsilon n\overline{x} > 0$ are wasted because of the inefficient production in the high-cost home country.

Moreover, home firms do not sell the input. Accordingly, they cannot pool their input requirements.[7)] In our setup, risk pooling can be achieved only if the input is produced by foreign firms and traded in the international market. Typically, risk pooling through international trade leads to further efficiency gains.

To be more specific, consider an example. Suppose $n = 3,\ \underline{x} = 1,\ \overline{x} = 2,\ Pr(\underline{x}) = 2/3,\ c = 1,\ \pi = 3,\ F_h = 2/3,\ F^f = 14/27$ and let the home firms' input requirements be stochastically independent. In the no trade equilibrium home firms' cost $K_h(2,2,2,0) = 8/3,\ h = 1,2,3$.

Now consider the *maximum trade situation* where all home firms are non-integrated. In the maximum trade situation all home firms thus have capacity $y_h = 0$ so that their demand and their requirement coincide, i.e., $\tilde{\Delta} = \tilde{\Xi}$ and $\tilde{D} = \tilde{X}$. To clarify notation, recall that the support of $\tilde{X}$ is aggregate input requirement in a state of order i, $X_i,\ i = 0,\ldots,n$ (in a state of order i, i home firms have high input requirement). It thus follows that in the maximum trade situation the support of aggregate demand $\tilde{D}$ is $D_i = X_i,\ i = 0,\ldots,n$.

Now suppose the first 4 foreign firms are active so that market capacity $Y = 4$. Thus, if $\tilde{D} \in \{D_0 = 3,\ D_1 = 4\},\ p = c$ and if $\tilde{D} \in \{D_2 = 5,\ D_3 = 6\},\ p = \pi$. Active foreign firms' aggregate expected profits

$$\sum_{f=1}^{4} G^f(\cdot) = 4\left[(\pi - c)(Pr(D_2) + Pr(D_3)) - F^f\right] = 4\left[(\pi - c)(6/27 + 1/27) - F^f\right] = 0.$$

An active foreign firm has a fixed cost F^f. If the market is slack, $p = c$ and active firms do not recover their overheads. Yet if the market is tight, $p = \pi$ and each active foreign firm earns a contribution margin $(\pi - c) > 0$. If $Y = 4$, $F^f = (\pi - c)\sum_{\tilde{D}>Y} Pr(\tilde{D})$, i.e., the expected contribution margin equals overheads and active foreign firms make expected zero profits. Accordingly, all foreign firms are indifferent between the maximum trade situation and the no trade equilibrium.

A home firm's cost of obtaining the input in the maximum trade situation is

$$K_h(0,0,0,4) = c\underline{x}2/3 + c\overline{x}1/3 + (\pi - c)\underline{x}2/27 + (\pi - c)\overline{x}5/27 = 20/9,\ h = 1, 2, 3,$$

i.e., all home firms are better off in the efficient maximum trade situation than in the no trade equilibrium. The cost reductions of 8/27 are due to the foreign firms' lower fixed cost and 4/27 arise from efficient risk pooling.

This Pareto-improvement through risk pooling can be explained as follows. Home firms pay the markup $(\pi - c)$ with probability $\sum_{\tilde{D}>Y} Pr(\tilde{D})$. Now suppose whenever home firm h has high demand $\overline{x}$ there is a sellers' market, i.e., $\sum_{\substack{e\tilde{\Delta}>Y\wedge \\ \tilde{d}_h=\underline{x}}} Pr(\tilde{\Delta}) = 0$. The home firm then always pays the surcharge for the large quantity, i.e., it pays $(\pi - c)\overline{x}\sum_{\tilde{D}>Y} Pr(\tilde{D}) = F^f\overline{x}$ in excess of marginal costs. Accordingly, there are no gains from risk pooling in this case. If, however, as in our example, a tight market coincides with $\tilde{d}_h = \underline{x}$, i.e., $\sum_{\substack{e\tilde{\Delta}>Y\wedge \\ \tilde{d}_h=\underline{x}}} Pr(\tilde{\Delta}) > 0$, the home firm pays less than $F^f\overline{x}$ in excess of marginal costs, i.e.,

$$(\pi - c)\underline{x}\sum_{\substack{e\tilde{\Delta}>Y\wedge \\ \tilde{d}_h=\underline{x}}} Pr(\tilde{\Delta}) + (\pi - c)\overline{x}\sum_{\substack{e\tilde{\Delta}>Y\wedge \\ \tilde{d}_h=\overline{x}}} Pr(\tilde{\Delta}) < (\pi - c)\overline{x}\sum_{\tilde{D}>Y} Pr(\tilde{D}) = F^f\overline{x}.$$

The market charges the fair expected price $(\pi - c)\sum_{\tilde{D}>Y} Pr(\tilde{D}) = F^f$ to recover active foreign firms' overheads. If a home firm is lucky and has low input demand $\tilde{d}_h = \underline{x}$ in a sellers' market, it is strictly better off in the maximum trade situation than in the no trade equilibrium.[8)]

Given that the maximum trade is efficient, it seems worthwhile to investigate under what conditions the efficient maximum trade situation constitutes an equilibrium. In the next Proposition we will show that the maximum trade situation *never* constitutes an equilibrium trade pattern. It follows from this result that in any equilibrium trade pattern we observe inefficient home production.

Proposition 2: *There does not exist an equilibrium where home firms pick capacity* $y_h = y,\ h = 1, \ldots, n$ *with* $y \in [0, 2\underline{x} - \overline{x}],\quad y \in I\!N_0$.

Let us explain this result by means of the example. If, say, $\hat{y}_h = 0,\ h = 1, 2, 3$, a foreign firms' best response entails $\hat{Y} \in \{3, 4\}$. Suppose $\hat{Y} = 4$ so that 4 foreign firms are active. This best response of foreign firms is the most favorable one for home firms because active foreign firms make expected zero profits, i.e., $F^f = (\pi - c)\sum_{\tilde{D}>\hat{Y}} Pr(\tilde{D})$.

Suppose home firm 1 switches from $\hat{y}_1 = 0$ to $y_1 = 1$ so that its demand reduces from $\tilde{d}_1 = \tilde{x}_1$ to $\tilde{d}_1' := \tilde{d}_1 - \underline{x}$ and aggregate demand changes from $\tilde{D} = \tilde{X}$ to $\tilde{D}' := \tilde{D} - \underline{x}$. Then we have $p = c$ if $\tilde{D}' \in \{D_0' = 2, D_1' = 3, D_2' = 4\}$ and $p = \pi$ if $\tilde{D}' = D_3' = 5$. The probability of a tight market thus decreases from 7/27 to 1/27. If home firm 1 unilaterally deviates to $y_1 = 1$ we have $K_1(1, 0, 0, 4) = F_h\underline{x} + c\underline{x}2/3 + c\overline{x}1/3 + (\pi - c)(\overline{x} - \underline{x})1/27 = 56/27 < 20/9 = K_1(0, 0, 0, 4)$. Consequently, the home firm is strictly better off if it picks capacity $y_1 = 1$ instead of capacity $\hat{y}_1 = 0$.

Home firms pay the fair expected markup $F^f = (\pi - c)\sum_{\tilde{D}>\hat{Y}} Pr(\tilde{D})$ on the international market. A home firm needs $\underline{x}$ for sure and an additional $(\overline{x} - \underline{x})$ when its output demand is high. If a home firm purchases its entire input needs on the market, the amount it pays in excess of marginal costs equals $(\pi-c)\underline{x}\sum_{\tilde{D}>\hat{Y}} Pr(\tilde{D})+(\pi-c)(\overline{x}-\underline{x})\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\overline{x}}} Pr(\tilde{\Delta}) =$ $F_h\underline{x} + (\pi - c)(\overline{x} - \underline{x})\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\overline{x}}} Pr(\tilde{\Delta}) - \epsilon\underline{x}$. Accordingly, if the probability of a tight market coinciding with home firm 1's high demand did not change by the switch to $y_1 = \underline{x}$, the firm would not increase capacity because it has a worse technology than foreign firms. But this probability decreases.

Recall that $D_i - D_{i-1} = \overline{x} - \underline{x},\ i = 1, \ldots, n$. Since $\underline{x} \geq \overline{x} - \underline{x}$, we have $D'_i \leq D_{i-1},\ i = 1, \ldots, n$; increasing capacity makes demand in a state of order i lower than demand was before the switch in a state of order $i-1$. Therefore, $\sum_{\tilde{D}'>\hat{Y}} Pr(\tilde{D}') < \sum_{\tilde{D}>\hat{Y}} Pr(\tilde{D})$. By building up capacity $y_1 = \underline{x}$, the home firm cuts down aggregate demand by an amount large enough to increase the probability of a glut. Furthermore, the states of the world in which the market changes from tight to slack includes contingencies where the deviating home firm has high demand. Since all states of the world have positive probability, $\sum_{\substack{e\tilde{\Delta}'>\hat{Y}\wedge \\ \tilde{d}'_1=\overline{x}-\underline{x}}} Pr(\tilde{\Delta}') <$ $\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\overline{x}}} Pr(\tilde{\Delta})$. That is, by the switch to $y_1 = \underline{x}$ home firm 1 decreases the probability of a sellers' market coinciding with its own high demand. Consequently, if the cost differential is not too large, home firm 1 is strictly better off by unilaterally deviating to $y_1 = \underline{x}$ and the maximum trade situation cannot be an equilibrium.

We have thus shown that we will *always* observe inefficient home production, or, put differently, too little international trade. A home firm building up capacity has to take into account the following effects: The first unfavorable effect is that building up capacity has a per unit fixed cost F_h. The second unfavorable effect is that the home firm may run the risk of idle capacity. The first favorable effect is that the home firm can produce the input itself at marginal cost c. The second favorable effect is that the home firm cuts down on aggregate demand and may thus decrease the probability that high will prices prevail on the intermediate good market.

Now consider a home firm switching from, say, capacity 0 to capacity $\underline{x}$. If foreign firms make expected zero profits given that all home firms pick capacity 0, the first unfavorable and first favorable effect add up to the additional fixed cost $\epsilon\underline{x}$.[9)] The second unfavorable effect is zero because the home firm needs $\underline{x}$ for sure. Yet, the second favorable effect is strictly positive. The switch to $\underline{x}$ decreases aggregate input demand by an amount large enough to decrease the probability of high prices prevailing on the intermediate good market. If the foreign firms' cost advantage ϵ is not too large, the favorable price effect outweighs the home firms' higher capacity cost. Overall then, it is attractive for home firms to build up positive capacity which in turn implies an inefficiently low level of trade.

IV. Conclusions

We have shown that although an international market for an intermediate product is characterized by flexible prices and competitive foreign firms, home firms will always engage in inefficient home production. If a home firm starts producing some of its own input needs, it cuts down on aggregate input demand thus depressing prices in the market. This favorable price effect outweighs the risk of idle capacity when the output demand is low given that the home firm's capacity and cost disadvantage are not too large. This result of too little trade does not hinge on the assumption that home firms do not sell the input. We only need this assumption to establish the existence of the no trade equilibrium. If we drop this assumption, home firms might start to trade among each other to pool their risks. Yet this kind of home production is still inefficient because foreign firms have a cost advantage.

Our result of too little international trade is driven by the home firms' oligopsony power. By inefficient home production a home firm restricts demand to lower prices on the international input market. By an optimum tariff a home country also restricts its imports like a monopsonist and moves the terms of trade in its favor, thus making the home country better off. In our framework, not only is there too little international trade, but the home country is also worse off than if it relied entirely on foreign supplies. The input is produced by a constant returns to scale technology. If the expected price falls below foreign firms' costs, they opt out of the market. Accordingly, any attempt by home firms to depress prices below costs leads to a market breakdown. Nevertheless, home firms have the described incentive to depress prices. The game between home and foreign firms thus has the flavor of a prisoner's dilemma.

The governments can implement the efficient maximum trade situation as an equilibrium trade pattern by, e.g., increasing the cost differential between the two countries. If home firms' capacity costs are sufficiently higher than foreign firms' capacity costs, the unfavorable fixed costs outweigh the favorable effect of depressing prices. There are several ways to increase the cost differential: The foreign government could subsidize capacity in the foreign country; the home government could subsidize imports or tax the home production of the intermediate product. Under the latter policy, in equilibrium taxes are a mere threat to home firms because in equilibrium there is no home production. Therefore, with sufficiently high taxes on home production no resources are required to implement the efficient trade pattern.

Endnotes

1) We take up an idea from Emons (1993) developed in the context of the theory of the firm. The analysis of an intermediate product seems appropriate given their share of international trade. For example, Yates (1959) argues that 70% of world trade comprise intermediate goods. Sanyal and Jones (1982) even claim "that international trade takes place in middle products."

2) See Spencer and Jones (1991) for more elaborate explanations of the cost differential between home and foreign firms.

3) This assumption is quite common in the transactions cost literature; see, e.g., Williamson (1985).

4) Note that our setup is related to Prescott (1975). Prescott works with the came constant returns to scale technology as we do. In Prescott's model, the consumers' requirement for the product is uncertain. Since consumers do not produce the good themselves, their requirement and demand coincide. In our model the home firms' input requirement is stochastic. Yet home firms may produce the intermediate good themselves so that in our setup demand may be lower than requirement.

5) It follows from assumption (2) that this behavior is indeed optimal. Withholding input demand ex post costs $Pr(\overline{x})\pi$ in expected terms; if a home firm builds up capacity ex ante and leaves it idle in bad times, it incurs expected costs $F_h + Pr(\overline{x})c$.

6) If $\tilde{D} = Y$, any price $p \in [c, \pi]$ clears the market. The reason why we choose $p = c$ is as follows. Suppose foreign and home firms' capacity choices are such that $\tilde{D} = Y$ with positive probability and, moreover, that $p > c$ in this case. If a home firm increases its capacity by a small amount, it cuts down aggregate demand by the same quantity. Thereby, it turns the event $\tilde{D} = Y$ and $p > c$ into an event $\tilde{D} < Y$ and $p = c$. Accordingly, the home firm gains $(p - c) > 0$ with positive probability. To rule out this incentive to cut down on aggregate

demand at the margin, we set $p = c$ if $\tilde{D} = Y$.

7) Note that we rule out mergers between home firms. If home firms merge, they can pool their input requirements.

8) Note that $(\pi - c) \sum_{\tilde{D}>Y} Pr(\tilde{D}) = F^f$ and $\sum_{\substack{e\tilde{\Delta}>Y\wedge \\ \tilde{d}_h=\underline{x}}} Pr(\tilde{\Delta}) > 0$ (where the second condition is equivalent to $Y < D_{n-1} = X_{n-1}$) are sufficient conditions for risk pooling benefits.

9) If foreign firms make positive expected profits, the net-effect becomes even less unfavorable for the home firm.

Appendix

Proof of Proposition 1: Suppose all foreign firms pick $\hat{y}^f = 0$ so that market capacity $\hat{Y} = 0$. This implies $p = \pi$ whenever $\tilde{D} > 0$. Take $z \in I\!N$ and consider home firm 1. Home firm 1 will never deviate to capacity $y_1 = \overline{x} + z$. It incurs a fixed cost $F_h z$ without ever using the additional capacity. Now take $0 < z \leq \overline{x}$. If home firm 1 deviates to capacity $y_1 = \overline{x} - z$ we have

$$
\begin{aligned}
&K_1(\overline{x} - z, \hat{y}_2, \ldots, \hat{y}_n, \hat{Y}) = \\
&\quad F_h(\overline{x} - z) + c\underline{x}Pr(\underline{x}) + c\overline{x}Pr(\overline{x}) + (\pi - c)\max[0, \underline{x} - (\overline{x} - z)]Pr(\underline{x}) + (\pi - c)zPr(\overline{x}) \geq \\
&\quad F_h\overline{x} + c\underline{x}Pr(\underline{x}) + c\overline{x}Pr(\overline{x}) + (\pi - c)zPr(\overline{x}) - F_h z \geq \\
&\quad F_h\overline{x} + c\underline{x}Pr(\underline{x}) + c\overline{x}Pr(\overline{x}) = K_1(\hat{y}_1, \ldots, \hat{y}_n, \hat{Y})
\end{aligned}
$$

where the last inequality follows from assumption (2). Thus, given $\hat{Y} = 0$, it is optimal for home firms to have capacity $\hat{y}_h = \overline{x},\ h = 1, \ldots, n$.

Conversely, if all home firms have capacity $\hat{y}_h = \overline{x}$, aggregate demand $\tilde{D} = 0$. Foreign firms thus never sell any input. Building up capacity $y^f = 1$ yields losses for a foreign firm because it incurs a fixed cost F^f without obtaining any revenue.

Q.E.D.

Proof of Proposition 2: Suppose, on the contrary, that there exists an equilibrium where home firms pick capacity $\hat{y}_h = y,\ h = 1, \ldots, n,\ y \in [0, 2\underline{x} - \overline{x}],\ y \in I\!N_0$. Then $\tilde{d}_h := \tilde{d}_h(y) = \tilde{x}_h - y,\ h = 1, \ldots, n$, $\tilde{\Delta} := \tilde{\Delta}(y) = \tilde{\Xi} - e'y$, and $\tilde{D} := \tilde{D}(y) = \tilde{X} - ny$.

Let $\overline{Y} := \overline{Y}(y) = \max\{Y \in I\!N_0 | F^f \leq (\pi - c)\sum_{\tilde{D} > \overline{Y}} Pr(\tilde{D})\}$. A foreign firms' equilibrium aggregate capacity $\hat{Y} := \hat{Y}(y)$ must satisfy $\hat{Y} \leq \overline{Y}$. If $Y > \overline{Y}$, $Y \in I\!N$, $F^f > (\pi - c)\sum_{\tilde{D} > Y} Pr(\tilde{D})$. All active foreign firms make expected losses and are better off if they become inactive.

Consider the case where $F^f < (\pi - c)(1 - Pr(D_0))$ so that $\hat{Y} > D_0 = X_0 - ny = n\underline{x} - ny$. That is, there is a buyers' market with positive probability (the converse case is ruled out by assumption (2)). Suppose home firm 1 deviates to $y_1 = \underline{x} > y$ while $\hat{y}_h = y,\ h = 2, \ldots, n$. Home firm 1's input demand thus reduces to $\tilde{d}'_1 := \tilde{x}_1 - \underline{x}$, the vector of individual demands $\tilde{\Delta}' := \tilde{\Delta} - \omega(\underline{x} - y)$ where ω is the $n \times 1$ vector whose first component is 1 and the others are 0, and $\tilde{D}' := \tilde{D} - (\underline{x} - y)$.

Since $\overline{x} - \underline{x} \leq \underline{x}$, we have $D'_i \leq D_{i-1},\ i = 1, \ldots, n$; increasing capacity makes demand in a state of order i lower than demand was before the switch in a state of order $i - 1$. Thus $\sum_{\tilde{D} \leq \hat{Y}} Pr(\tilde{D}) < \sum_{\tilde{D}' \leq \hat{Y}} Pr(\tilde{D}')$. That is, if home firm 1 switches to $y_1 = \underline{x}$ there is more often a glut on the input market than if it sticks to $\hat{y}_1 = y$. Moreover, full support of $\tilde{\Xi}$

implies $\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\overline{x}-y}} Pr(\tilde{\Delta}) > \sum_{\substack{e\tilde{\Delta}'>\hat{Y}\wedge \\ \tilde{d}'_1=\overline{x}-\underline{x}}} Pr(\tilde{\Delta}')$. Thus,

$$\begin{aligned}
K_1(\hat{y}_1,\ldots,\hat{y}_n,\hat{Y}) = F_h y + c\underline{x}Pr(\underline{x}) + c\overline{x}Pr(\overline{x}) + \\
(\pi - c)(\underline{x} - y)\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\underline{x}-y}} Pr(\tilde{\Delta}) + (\pi - c)(\overline{x} - y)\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\overline{x}-y}} Pr(\tilde{\Delta}) \geq \\
F_h\underline{x} + c\underline{x}Pr(\underline{x}) + c\overline{x}Pr(\overline{x}) + (\pi - c)(\overline{x} - \underline{x})\sum_{\substack{e\tilde{\Delta}>\hat{Y}\wedge \\ \tilde{d}_1=\overline{x}-y}} Pr(\tilde{\Delta}) - \epsilon(\underline{x} - y) > \\
F_h\underline{x} + c\underline{x}Pr(\underline{x}) + c\overline{x}Pr(\overline{x}) + (\pi - c)(\overline{x} - \underline{x})\sum_{\substack{e\tilde{\Delta}'>\hat{Y}\wedge \\ \tilde{d}'_1=\overline{x}-\underline{x}}} Pr(\tilde{\Delta}') - \epsilon(\underline{x} - y) = \\
K_1(\underline{x},\hat{y}_2,\ldots,\hat{y}_n,\hat{Y}) - \epsilon(\underline{x} - y),
\end{aligned}$$

where the first inequality follows from algebraic manipulations and the observation that $\hat{Y} \leq \overline{Y}$. Consequently, if ϵ is sufficiently small, home firm 1 is strictly better off if it picks $y_1 = \underline{x}$ instead of $\hat{y}_1 = y \in [0, 2\underline{x} - \overline{x}]$.

Q.E.D.

References

1. J. A. BRANDER and B. S. SPENCER: Export Subsidies and International Market Share Rivalry, *Journal of International Economics* **18** (1985), 83 - 100.

2. A. K. DIXIT and V. NORMAN: "Theory of International Trade", Cambridge University Press (1980).

3. A. K. DIXIT and V. NORMAN: Gains from Trade without Lump-sum Compensation, *Journal of International Economics* **21** (1986), 111 - 122.

4. W. EMONS: "Good Times, Bad Times, and Vertical Upstream Integration", mimeo, University of Bern (1993).

5. O. HART and J. TIROLE: Vertical Integration and Market Foreclosure, *The Brookings Papers on Economic Activity, Microeconomics* (1990), 205 - 286.

6. E. HELPMAN and P. R. KRUGMAN: "Market Structure and Foreign Trade ", M.I.T. Press, Cambridge, Mass. (1985).

7. A. L. HILLMAN: "The Political Economy of Protection", Harwood Academic Publishers, London, New York (1989).

8. P. R. KRUGMAN: Import Protection as Export Promotion: International Competition in the Presence of Oligopoly and Economics of Scale, *in*: H. Kierzkowski, ed., "Monopolistic Competition and International Trade", Oxford University Press (1984).

9. J. R. MARKUSEN and J. R. MELVIN: "The Theory of International Trade", Harper & Row, New York (1988).

10. J. A. ORDOVER, G. SALONER, and S. C. SALOP: Equilibrium Vertical Foreclosure, *American Economic Review* **80** (1990), 127 - 142.

11. E. PRESCOTT: Efficiency of the Natural Rate, *Journal of Political Economy* **83** (1975), 1227 - 1236.

12. M. SALINGER: Vertical Mergers and Market Foreclosure, *Quarterly Journal of Economics* **103** (1988), 345 - 356.

13. S. SALOP and D. SCHEFFMAN: Raising Rivals' Costs, *American Economic Review, Papers and Proceedings* **73** (1983), 267 - 271.

14. P. A. SAMUELSON: The Gains from International Trade Once Again, *Economic Journal* **72** (1962), 820 - 829.

15. K. SANYAL and R. JONES: The Theory of Trade in Middle Products, *American Economic Review* **72** (1982), 16 - 31.

16. B. SPENCER and R. JONES: Vertical Foreclosure and International Trade Policy, *Review of Economic Studies* **58** (1991), 153 - 170.

17. B. SPENCER and R. JONES: Trade and Protection in Vertically Related Markets, *Journal of International Economics* **32** (1992), 31 - 55.

18. O. E. WILLIAMSON: "The Economic Institutions of Capitalism", Free Press, New York (1985).

19. 10. P. L. YATES: "Forty Years of Foreign Trade", Allen and Unwin, London (1959).