Informational aspects of foreign direct investment and the multinational firm

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Abstract

This paper explores the informational role of plant location decisions for the multinational enterprise. When information about costs is incomplete, the location of a plant will be chosen not only for its impact on actual production costs, but also for its impact on the perception of costs as held by foreign rivals. We show that the desire to transmit cost information can itself give rise to the multinational firm, and characterize the country-specific and firm-specific attributes that are most likely to yield such multinational activity. Hence, the informational role of plant location decisions is a potentially important element in understanding the behavior of the multinational firm.

Keywords: Plant location; Production cost; Multinational firm

1. Introduction

The multinational firm is generally thought to arise as a result of three ingredients.[1] A firm must first possess an *ownership* advantage (patent, expertise, etc.) which it wishes to exploit in foreign markets. Second, *locational* considerations (tariffs, transport costs, etc.) must dictate that supplying foreign markets is best achieved with foreign production. Finally, the firm must choose *internalization* over an arms-length transaction (e.g. open its own plant abroad rather than licensing its technology).

Ethier (1986) has argued that the internalization decision is the least well-understood of these three ingredients, and that the decision between internalization and arms-length

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[1] The existing literature on multinationals, both empirical and theoretical, is vast, and we do not attempt to review it here. For a review of this literature see, for example, Caves (1982) and Markusen (1995).

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transactions is largely an issue of the international economics of information. As such, to understand the internalization decision, one must analyze the exchange of information between agents.

We argue in this paper that the analysis of information exchange between agents is also important in understanding the location decision. In particular, when there exists strategic interaction between the firms of different countries serving a foreign market, the transmission of information about production costs becomes crucial.[2] If the location of production facilities in the foreign market can serve to *directly* inform rival firms of an entrant's production costs, or if the *decision* to locate production facilities there *signals* the costs of the entrant, then multinationalization can arise as a way of transmitting cost information to foreign rivals. Consequently, in the presence of asymmetric information about costs, the role of locational considerations takes on a new dimension. In this paper, we explore this new dimension of the foreign locational decision.

Specifically we show that, when cost information is incomplete among rival firms for a foreign market, the choice of plant location will potentially have *two* effects on a firm's profits: it will affect the firm's *actual* production costs to the extent that factor price differentials exist between countries, and it may affect the *perception* of the firm's production costs as held by rival firms. While the former effect leads plants to locate where actual costs are lowest, the latter effect need not. Taking the two effects together, a firm may be led to multinationalize in order to transmit cost information to foreign rivals, even though its actual costs of serving the foreign market are higher as a result. Such multinational equilibria, which arise solely as a result of incomplete information about costs, are the focus of this paper.

The remainder of the paper proceeds as follows. Section 2 lays out the general model and derives necessary and sufficient conditions for multinationalization to take place solely as a result of the desire to transmit cost information to foreign rivals. Section 3 then explores several specific cases in which the general conditions derived in Section 2 are met. Section 4 concludes.

2. The game and general properties

Our ideas are most easily expressed in a general setting. We therefore provide in this section a characterization of the game in terms of general reduced-form profit functions. In later sections, we evaluate these functions under specific assumptions about demand and cost conditions.

Consider two countries, one (the foreign country) with a new market for a good in which the entry decisions of $N-1$ foreign firms (labeled $j = 1, 2, \ldots, N-1$) are just being made, and the other (the home country) with a single established domestic firm (labeled N)

[2] The incentive to share cost information with rival firms has been explored by Shapiro (1986), for example, under the assumption that cost reports are verifiable. When verification is impossible, direct information exchange is itself impossible. In such cases, observable signals such as price or advertising may be used to transmit cost information, say, to a potential entrant, as in Milgrom and Roberts (1982) and Bagwell and Ramey (1988). The signal we explore here is the location decision, a theme that we first took up in Bagwell and Staiger (1988). Related themes are explored in a recent paper by Haucap et al. (2000).

who serves the home market and is currently considering entry into the foreign market as well. For simplicity, we assume constant cost technologies, that entry is prohibited in the domestic market, and that there exists a prohibitive tariff on imports of the good into the home country as well, so that the domestic firm can make its entry decision into the foreign market without regard to the domestic market.

With regard to the (new) foreign market, all relevant demand information is assumed to be common knowledge to the N firms. In addition, all relevant information concerning the production costs of the $N-1$ foreign firms is assumed to be common knowledge among all N firms. For simplicity, we assume that variable costs of the $N-1$ foreign firms are identical, and that they take the form of a wage w^* times a unit labor requirement α. However, the domestic firm has production costs which, at least initially, are known to it alone. The source of this one-sided informational asymmetry can be either *firm-specific* or *country-specific*.[3] We consider each case in turn.

In the case of *firm-specific* one-sided asymmetric information, we assume that prevailing wages at home and abroad differ but are common knowledge to all N firms, that the domestic wage w is less than the foreign wage w^*, and that the $N-1$ foreign firms use a commonly known technology α. However, the domestic firm has available to it a new technology with unit labor requirements θ known to it alone. The domestic firm must now decide whether to ''stay'' (produce its export good domestically, facing the commonly known (low) domestic wage w) or to ''go'' (open a plant abroad and operate its technology in the presence of the commonly known (high) foreign wage w^*).[4] The latter option corresponds to the choice of multinationalization. Once the domestic firm has made its (observable) location decision, the N firms engage in Cournot quantity competition for the foreign market, with the sequence of play represented graphically in Fig. 1.[5]

Thus, in the case of firm-specific private knowledge, the home firm's decision to locate a plant abroad (multinationalize) does nothing to directly communicate its costs to rivals in the foreign market. However, the locational decision may communicate something about costs indirectly, and it is this signal that, in our firm-specific model, provides the link between location and communication.

In the case of *country-specific* one-sided asymmetric information, we assume that all N firms employ the same commonly known technology α, and that the $N-1$ foreign firms face a wage w^* that is assumed to be common knowledge to all N firms. However, the domestic firm alone knows the wage of labor in the home country, w. It must now decide whether to produce its export good in the domestic plant or to multinationalize and open a

[3] In both the firm-specific and country-specific cases, the one-sidedness of the informational asymmetry is not crucial. With risk-neutral firms, nothing would change if the domestic firm were uninformed about the foreign cost parameter, and made its location decision to maximize expected profits. Since this adds nothing to the analysis, we abstract from it and concentrate on the case of one-sided informational asymmetries.

[4] The third option, that of technology licensing, is assumed to be precluded for ''transactional'' reasons. The possibility of contracting to provide the services of firm-specific intangible assets to a foreign firm in the country-specific case is similarly precluded.

[5] Thus, the domestic firm chooses its (observed) wage by choosing a plant location and paying the prevailing wage. Wages paid by the domestic firm in excess of the prevailing wage are assumed to be unobservable to foreign firms. This assumption, which is consistent with the notion that foreign firms know the relevant country-specific but not firm-specific information, eliminates the potential for such behavior to serve as a signaling device.

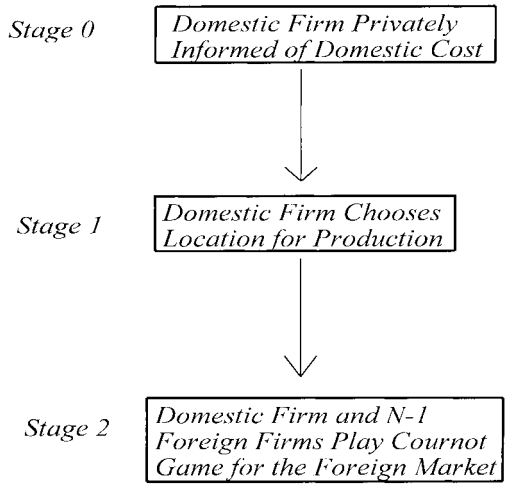

Fig. 1. The sequence of play.

new plant in the foreign country. If the domestic firm decides to "stay" in the domestic country, then it retains some private information about its labor costs, $w\alpha$, through its private knowledge about w. But, if the firm chooses to "go" and build a foreign plant, the N firms all face the commonly known foreign wage w^*, and their unit labor costs $w^*\alpha$ are then common knowledge and identical. In the latter case, we allow for the possibility that a portion of any plant-specific fixed costs of operating a foreign plant, e.g. accounting, are carried out by the home operations, and thus reflect in part the domestic wage w: however, since these are fixed costs, they will affect directly the multinational's profits but not its strategic interaction with rival firms.

Thus, by staying home, the domestic firm pays the domestic wage and faces foreign rivals that are not completely informed about that wage, while by going to the foreign country, the domestic firm faces the well-known foreign wage: the location choice in this case is a choice of information structure for the ensuing oligopolistic rivalry. Hence, in the country-specific case, there is a direct link between location and communication. As before, once the domestic firm has made its (observable) location choice, the N firms engage in Cournot quantity competition for the foreign market. The sequence of play is represented graphically in Fig. 1.

Notice that in both the firm-specific and the country-specific case, the domestic firm's choice of location is important in two respects. First, the choice determines the firm's *actual costs*. Second, foreign firms may (rationally) use the location decision of the domestic firm as a *signal* of its cost type, as certain cost types may be more willing to stay than others. Since the output choices of the $N - 1$ foreign firms depend on their expectation of the domestic firm's output selection, and since the domestic firm's output selection depends on its costs, the quantity of output of foreign firms depends on their perception of the domestic firm's costs. Thus, in making its choice of location, the domestic firm must also consider the affect that its location decision would have on its *perceived production costs*.

We now give a formal representation of the general game. The first player to move is ''nature'', who chooses the unknown cost parameter (θ in the firm-specific case and w in the country-specific case). It is commonly known among all players that nature chooses a high cost parameter with probability $\delta_{\mathrm{H}} \in (0,1)$ and a low cost parameter with probability $1-\delta_{\mathrm{H}}$. The domestic firm is then privately informed about the realized cost parameter, and chooses a plant location. Let $C \equiv \{\mathrm{L},\mathrm{H}\}$ and $Z \equiv \{\mathrm{S},\mathrm{G}\}$ represent, respectively, the set of possible cost parameters ($\mathrm{L} \equiv$ low, $\mathrm{H} \equiv$ high) and the set of possible plant locations ($\mathrm{S} \equiv$ stay, $\mathrm{G} \equiv$ go) for the domestic firm, we represent the domestic firm's location strategy as a mapping z: $C \rightarrow Z$.

Consider first the firm-specific case. After observing the domestic firm's location choice, foreign firms must posit some belief about the domestic firm's type. Let $b(z) \in [0,1]$ represent the probability with which the $N-1$ foreign firms believe the domestic firm to have high unit labor requirements after observing the firm's location decision z. We then define $\pi^N(w(z)\theta^i, b(z)) - F^N(i,z)$, with $i = \mathrm{H}$ or L, $w(z=\mathrm{S}) = w$, $w(z=\mathrm{G}) = w^*$, and $F^N(i, z=\mathrm{S}) = 0$, as the total profit to the domestic firm if its technology is actually of type i but it is perceived to have high unit labor requirements with probability $b(z)$ when its location decision is z.[6] Finally, define $\pi^j(z, b(z)) - F^j$ as the expected total profit to foreign firm $j = 1,\ldots,N-1$ when the domestic firm's location choice is z and its unit labor requirements are perceived to be high with probability $b(z)$. $\pi^N(w(z)\theta^i, b(z)) - F^N(i,z)$ and $\pi^j(z, b(z)) - F^j$ thus summarize the payoffs associated with the firm-specific one-sided incomplete information Cournot game in which the high cost technology is believed to occur with probability $b(z)$.

Consider alternatively the country-specific case. If the domestic firm chooses to go, then all N firms have medium (M) costs, and the firms play a complete information Cournot game. We let π^j_{M} represent the variable profits to the jth firm in this game, with $j = 1,2,\ldots,N$. Set-up costs in the foreign country for foreign firms $j = 1,2,\ldots,N-1$ and for the domestic firm N facing domestic wages of type i will be denoted by F^j and $F^N(i)$, $i = \mathrm{H}$, L, respectively. If instead the domestic firm chooses to stay, then the foreign firms must posit some belief about the domestic firm's type. Let $b \in [0,1]$ represent the probability with which the $N-1$ foreign firms believe the domestic firm to face high wages after observing that the firm has decided to stay. We can then define $\pi^N(w^i\alpha, b)$, where $i = \mathrm{H}$ or L, to be the total profit to the domestic firm when it produces domestically, actually faces a wage of type i, and is perceived to face a high wage with probability b (the decision to stay eliminates the need for additional plant-specific set-up costs). Likewise, we can define $\pi^j(b)$ to be the expected variable profit to foreign firms $j = 1,2,\ldots,N-1$ facing a domestically-located Nth firm that is thought to pay the high wage with probability b. $\pi^N(w^i\alpha, b)$ and $\pi^j(b) - F^j$ thus summarize the payoffs associated with the country-specific one-sided incomplete information Cournot game in which high wages are believed to occur with probability b.

We look for a *sequential equilibrium* (Kreps and Wilson, 1982). In the present game, a sequential equilibrium is simply a combination of strategies and beliefs such that: (1) strategies are *sequentially rational*, in that each player's strategy maximizes his expected payoff, given his beliefs and the strategies of his opponents; and (2) beliefs are

[6] We assume that $\theta^{\mathrm{L}} < \theta^{\mathrm{H}} < \alpha$, so that the domestic firm would never choose to use the commonly known technology α.

Bayes-consistent, in that they agree with Bayes' rule along the equilibrium path (i.e. for events that occur with positive probability in the equilibrium). The application of sequential rationality to the quantity games is implicit in the definitions of the profit functions above.[7] The domestic firm's location strategy is sequentially rational, if, given the structure of beliefs, the firm with cost parameter i chooses the location corresponding to the maximum of the set $\{\pi^N(w^*\theta^i, b(z=\mathrm{G})) - F^N(i, z=\mathrm{G}), \pi^N(w\theta^i, b(z=\mathrm{S}))\}$ in the firm-specific case, and $\{\pi_{\mathrm{M}}^N - F^N(i), \pi^N(w^i\alpha, b)\}$ in the country-specific case. For example, if $\pi^N(w^{\mathrm{L}}\alpha, b)$ and $\pi^N(w^{\mathrm{H}}\alpha, b)$ exceed $\pi_{\mathrm{M}}^N - F^N(\mathrm{L})$ and $\pi_{\mathrm{M}}^N - F^N(\mathrm{H})$, respectively, then sequential rationality requires $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{S}$ in the country-specific game. Finally, Bayes-consistency is met if and only if the following conditions hold.

Firm-specific case:

(i) If $z(\mathrm{L}) = z(\mathrm{H}) = k$, then $b(z=k) = \delta_{\mathrm{H}}$ for $k = \{\mathrm{S}, \mathrm{G}\}$.
(ii) If $z(\mathrm{L}) \neq z(\mathrm{H}) = \mathrm{S}$, then $b(z=\mathrm{S}) = 1$ and $b(z=\mathrm{G}) = 0$.
(iii) If $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{S}$, then $b(z=\mathrm{S}) = 0$ and $b(z=\mathrm{G}) = 1$.

Country-specific case:

(i) If $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{S}$, then $b = \delta_{\mathrm{H}}$.
(ii) If $z(\mathrm{L}) \neq z(\mathrm{H}) = \mathrm{S}$, then $b = 1$.
(iii) If $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{S}$, then $b = 0$.

In case (i), *pooling* occurs in that the location choice provides no information about cost type. Bayesian updating then requires the posterior belief (b) to equal the prior belief (δ_{H}). By contrast, in cases (ii) and (iii), location choices *separate* firm types. Here, Bayesian updating requires foreign firms to correctly guess the domestic firm's type. Observe finally that b is unrestricted when $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$ in the country-specific case, for in this case the S choice is a zero probability event (''off the equilibrium path'') and so Bayes' rule cannot be applied. Likewise, in the firm-specific case, $b(z=\mathrm{G})$ is unrestricted when $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{S}$, and $b(z=\mathrm{S})$ is unrestricted when $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$. We discuss these possibilities in more detail below.

Having defined a sequential equilibrium for our game, we now place assumptions on the profit functions and then explore the nature of equilibrium behavior. We consider each case in turn.

2.1. Firm-specific case

Assumptions.

(i) $\pi^N(w(z)\theta^i, b)$ is strictly decreasing in b for all $i \in \{\mathrm{L}, \mathrm{H}\}$, $b \in [0,1]$, $z \in \{\mathrm{S}, \mathrm{G}\}$.
(ii) $\pi^N(w(z)\theta^{\mathrm{L}}, b) > \pi^N(w(z)\theta^{\mathrm{H}}, b)$ for all $b \in [0,1]$, $z \in \{\mathrm{S}, \mathrm{G}\}$.
(iii) $\pi^N(w\theta^i, b) > \pi^N(w^*\theta^i, b) - F^N(i, z=\mathrm{G}) > 0$ for all $b \in [0,1]$ and $i \in \{\mathrm{L}, \mathrm{H}\}$.
(iv) $\pi^j(b, z) - F^j$ is non-negative for all $b \in [0,1]$, $j \in \{1, 2, \ldots, N-1\}$, $z \in \{\mathrm{S}, \mathrm{G}\}$.

The interpretation of assumptions (i)–(iv) is as follows. Assumption (i) says that the domestic firm earns higher profits the more likely it is held by rival firms to have low unit

[7] This application is made explicit in the linear-demand example used in Section 3.

labor requirements (regardless of its actual technology). Assumption (ii) represents the actual savings associated with low unit labor requirements. Assumption (iii) says that, given any belief b, both firm types would rather locate at home than abroad, but that profits are positive at either location. In particular, with complete information, neither firm type would choose to multinationalize. Finally, (iv) guarantees that each of the foreign firms earn non-negative profits. As we will show, these assumptions are satisfied in the case of Cournot competition under the assumption that $w^* > w$.

According to assumption (iii), full information would have neither firm type multinationalize in the firm-specific case. We focus in the firm-specific case on multinational equilibria in which, as a result of the firm-specific informational asymmetry, one or both firm types go. The first theorem concerns the case in which the domestic firm chooses to multinationalize regardless of its type. We call such equilibria *pooling multinational equilibria*.

Theorem 1. *A pooling multinational equilibrium exists if and only if* $\pi^N(w^*\theta^i, \delta_H) - F^N(i, z = G) \geq \pi^N(w\theta^i, 1)$ *for* $i = H, L$.

Proof. Suppose first that an equilibrium exists with $z(L) = z(H) = G$. Then Bayes-consistency requires that $b(z = G) = \delta_H$. Therefore, $\pi^N(w^*\theta^i, \delta_H) - F^N(i, z = G) \geq \pi^N(w\theta^i, b(z = S)) \geq \pi^N(w\theta^i, 1)$ is necessary for $i = H$ and L, since otherwise $z(i) = S$ would be selected for $i = H$ or L instead. Going the other way, suppose $\pi^N(w^*\theta^i, \delta_H) - F^N(i, z = G) \geq \pi^N(w\theta^i, 1)$, for $i = H, L$. Put $z(L) = z(H) = G$ and $b(z = S) = 1$. Then, since $\pi^N(w^*\theta^i, \delta_H) - F^N(i, z = G) \geq \pi^N(w\theta^i, 1)$ for $i = H$ and L, the location choice is sequentially rational. □

The pooling multinational equilibrium constructed in the proof of Theorem 1 is supported by the pessimistic belief that if the domestic firm is observed to stay then it must have high unit labor requirements. Our equilibrium concept imposes no restrictions on $b(z = S)$ when equilibrium has $z(L) = z(H) = G$, i.e. in the pooling multinational equilibrium, but it is nonetheless important to ask whether $b(z = S) = 1$ is a plausible belief specification in this case. This belief specification would be plausible if the high unit labor requirement firm were thought to be more likely to deviate from the pooling multinational equilibrium than the low unit labor requirement firm. Observe, though, that given the prior belief δ_H both have an incentive to deviate and stay in the domestic country. Hence, there is a sense in which the "credible" belief may be $b(z = S) = \delta_H$. But pooling multinational equilibria will not exist if $b(z = S) = \delta_H$, since $\pi^N(w\theta^i, \delta_H) > \pi^N(w^*\theta^i, \delta_H) - F^N(i, z = G)$ for $i \in \{L, H\}$ according to assumption (iii).

With the above argument in mind, we follow Grossman and Perry (1986) and refer to pooling equilibria that are immune to such logic as *credible pooling multinational equilibria*. The next theorem is then immediate.

Theorem 2. *Credible pooling multinational equilibria do not exist.*

Theorem 2 suggests that firm-specific private knowledge about costs will not induce a firm to choose to multinationalize into a high wage country if in doing so the firm transmits

no cost information to its foreign rivals. Under this logic, if equilibria exist in which the firm multinationalizes because of private firm-specific knowledge, they must be separating equilibria. We thus turn to such equilibria. The following theorem states conditions under which *separating multinational equilibria* exist with $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{G}$.[8]

Theorem 3. *A separating multinational equilibrium exists with* $z(\mathrm{H}) \neq z(\mathrm{L}) = G$ *if and only if* $\pi^N(w\theta^{\mathrm{H}}, 1) \geq \pi^N(w^*\theta^{\mathrm{H}}, 0) - F^N(\mathrm{H}, \mathrm{G})$ *and* $\pi^N(w^*\theta^{\mathrm{L}}, 0) - F^N(\mathrm{L}, \mathrm{G}) \geq \pi^N(w\theta^{\mathrm{L}}, 1)$.

Proof. Suppose a separating equilibrium exists with $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{G}$. Then $\pi^N(w\theta^{\mathrm{H}}, 1) \geq \pi^N(w^*\theta^{\mathrm{H}}, 0) - F^N(\mathrm{H}, \mathrm{G})$ since otherwise H would deviate and go, while $\pi^N(w^*\theta^{\mathrm{L}}, 0) - F^N(\mathrm{L}, \mathrm{G}) \geq \pi^N(w\theta^{\mathrm{L}}, 1)$ since otherwise L would deviate and stay. Going the other way, suppose that $\pi^N(w\theta^{\mathrm{H}}, 1) \geq \pi^N(w^*\theta^{\mathrm{H}}, 0) - F^N(\mathrm{H}, \mathrm{G})$ and $\pi^N(w^*\theta^{\mathrm{L}}, 0) - F^N(\mathrm{L}, \mathrm{G}) \geq \pi^N(w\theta^{\mathrm{L}}, 1)$ Then the location choice $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{G}$ is sequentially rational, given the Bayesian beliefs that must follow. □

When the conditions of Theorem 3 are satisfied, the domestic firm's decision of whether to export to the foreign market or to multinationalize depends on whether its technology has high or low unit labor requirements. In particular, even though both firm types will have lower actual costs if the good is produced domestically and exported to the foreign market, a firm with low unit labor requirements may choose to locate production in the high wage foreign market in order to signal to its rivals that its unit labor requirements are indeed low.[9]

Finally, we define a notion of undominated equilibria and give conditions under which the separating equilibrium is unique within this class. A locational choice z is said to be *dominated* for a firm of type i if the firm makes less with the choice of z under the best of situations $(b(z) = 0)$ than it makes with the alternative choice z' under the worst of conditions $(b(z') = 1)$. Clearly, a dominated strategy will never be played. As Kohlberg and Mertens (1986) have argued, it seems therefore reasonable to require that foreign firms never believe that a dominated strategy had been played. Equilibria which satisfy this plausibility restriction on beliefs are then referred to as *undominated equilibria*. With this definition in place, we now give conditions under which "going" is dominated for the high unit labor requirement firm and profitable to the low unit requirement firm *if* $b(z = \mathrm{G}) = 0$. The unique undominated equilibrium must then be the separating multinational equilibrium.[10]

Theorem 4. *Suppose* $\pi^N(w\theta^{\mathrm{H}}, 1) \geq \pi^N(w^*\theta^{\mathrm{H}}, 0) - F^N(\mathrm{H}, \mathrm{G})$ *and* $\pi^N(w^*\theta^{\mathrm{L}}, 0) - F^N(\mathrm{L}, \mathrm{G}) > \pi^N(w\theta^{\mathrm{L}}, \delta_{\mathrm{H}})$. *Then there exists a unique undominated equilibrium, in which* $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{G}$: *that is, the unique undominated equilibrium is the separating multinational equilibrium.*

[8] Under our assumptions, it is straightforward to argue that separating equilibria cannot exist in which $z(\mathrm{L}) \neq z(\mathrm{H}) = \mathrm{G}$.

[9] Of course, it could be the home country that has the high wage, in which case it would be the inefficient (θ^{H}) firm that would multinationalize in the separating equilibrium and the efficient (θ^{L}) firm that does not, i.e. locates production in the high wage domestic county.

[10] The restriction to undominated equilibria seems more justified than the restriction to credible equilibria. Readers uncomfortable with the latter restriction will note that pooling multinational equilibria also fail to be undominated under the condition of Theorem 4.

Proof. We show first that $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{G}$ in any undominated equilibrium. Observe that $z(\mathrm{H}) = \mathrm{G}$ is dominated for H, since $\pi^N(w\theta^{\mathrm{H}}, 1) > \pi^N(w^*\theta^{\mathrm{H}}, 0) - F^N(\mathrm{H}, \mathrm{G})$. Thus, $z(\mathrm{H}) = \mathrm{S}$ and $b(z = \mathrm{G}) = 0$ must be true in an undominated equilibrium. Now, $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{S}$ is then impossible, since $\pi^N(w^*\theta^{\mathrm{L}}, 0) - F^N(\mathrm{L}, \mathrm{G}) > \pi^N(w\theta^{\mathrm{L}}, \delta_{\mathrm{H}})$. It must therefore be that $z(\mathrm{L}) \neq z(\mathrm{H}) = \mathrm{S}$. Next, we complete the proof by noting that the separating multinational equilibria is in fact undominated and (by Theorem 3) does exist under the conditions of Theorem 4. □

The first condition of Theorem 4 is more likely to be met, the greater is the foreign–domestic wage differential and the greater is θ^{H}. The second condition is more likely to hold the smaller the wage differential, the smaller is θ^{L}, and the more pessimistic (higher) is the prior δ_{H}. Hence, Theorem 4 suggests that, in the presence of firm-specific private knowledge about cost, multinationalization from the lower-wage to the higher-wage country is most likely to occur: (i) in "high tech" industries where the probability of successful process innovation is deemed low (δ_{H} is high) but where process innovation, if successful, carries with it a large payoff ($\theta^{\mathrm{L}} \ll \theta^{\mathrm{H}}$); and (ii) between "not too dissimilar" countries whose wage differentials are not extreme.[11] This suggestion is confirmed in Section 3, where we illustrate our findings with a linear-demand model of Cournot competition.

2.2. *Country-specific case*

Assumptions.

(i) $\pi^N(w^i\alpha, b)$ is strictly decreasing in b, for all $i \in \{\mathrm{L}, \mathrm{H}\}$, $b \in [0, 1]$.
(ii) $\pi^N(w^{\mathrm{L}}\alpha, b) > \pi^N(w^{\mathrm{H}}\alpha, b)$ for all $b \in [0, 1]$.
(iii) $\pi^N(w^{\mathrm{L}}\alpha, 0) > \pi^N_{\mathrm{M}} - F^N(\mathrm{L}) \geq \pi^N_{\mathrm{M}} - F^N(\mathrm{H}) > \pi^N(w^{\mathrm{H}}\alpha, 1) > 0$.
(iv) $\pi^j_{\mathrm{M}} - F^j$ and $\pi^j(b) - F^j$ are non-negative for all $b \in [0, 1]$ and $j = 1, 2, \ldots, N-1$.

The assumptions are simple to interpret. By (i), the domestic firm earns higher profits when it locates domestically the more likely it is held by rival firms to face low domestic wages (regardless of the actual domestic wage). Assumption (ii) represents the actual savings associated with a low wage, while (iii) ensures that complete information variable profits are always greater than fixed costs for the domestic firm, and that with complete information and facing a high (low) wage at home the domestic firm would choose (not) to multinationalize. Finally, (iv) guarantees that foreign firms make non-negative profit. As we will see in Section 3, these assumptions are satisfied by Cournot competition when $w^{\mathrm{H}} > w^* > w^{\mathrm{L}}$.

Given assumption (iii), complete information would have the domestic firm export if it faces the low wage at home and multinationalize if the home wage is high. We are interested in equilibria in which the presence of country-specific cost information leads the

[11] Hence, the implication of our firm-specific case with regard to the impact of country similarity on the likelihood of multinational activity falls in between that of Ethier (1986) on the one hand and of Helpman (1984, 1985) and Markusen (1984) on the other hand; as in Ethier (1986), we find that the likelihood of multinational activity is diminished if country (factor price) differences are too large, while as in Helpman (1984, 1985) and Markusen (1984), the firm cannot be induced to multinationalize across countries that (already) share identical factor prices.

domestic firm to multinationalize when it faces a low domestic wage: that is, we focus on equilibria in which $z(\mathrm{L}) = \mathrm{G}$. We refer to such equilibria as *multinational equilibria*.

Theorem 5. *Separating multinational equilibria do not exist.*

Proof. The existence of such equilibria in which $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{G}$ would require $\pi^N(w^{\mathrm{H}}\alpha, 1) \geq \pi^N_{\mathrm{M}} - F^N(\mathrm{H})$ which is ruled out by assumption (iii). □

Theorem 5 implies that if multinational equilibria exist, they must be pooling equilibria in which $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$. Thus, Theorem 5 says that country-specific knowledge about costs can induce a domestic firm facing a low domestic wage to multinationalize only if in so doing the firm alters the information structure of the ensuing game from one of incomplete information to one of complete information about costs. We thus turn our attention to the existence of pooling multinational equilibria in which $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$.

Theorem 6. *A pooling multinational equilibrium exists if and only if* $\pi^N_{\mathrm{M}} - F^N(i) \geq \pi^N(w^i\alpha, 1)$, $i = \mathrm{H}, \mathrm{L}$.

Proof. Suppose first that an equilibrium exists in which $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$. Then $\pi^N_{\mathrm{M}} - F^N(i) \geq \pi^N(w^i\alpha, b) \geq \pi^N(w^i\alpha, 1)$ is necessary for $i = \mathrm{H}$ and L, lest $z(i) = \mathrm{S}$ be selected for $i = \mathrm{H}$ or L instead. Going the other way, suppose $\pi^N_{\mathrm{M}} - F^N(i) \geq \pi^N(w^i\alpha, 1)$, $i = \mathrm{H}, \mathrm{L}$. Put $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$ and $b = 1$. Then, since $\pi^N_{\mathrm{M}} - F^N(i) \geq \pi^N(w^i\alpha, 1)$ for $i = \mathrm{H}$ and L, the location choices are sequentially rational. □

As in the pooling multinational equilibrium of Theorem 1, the pooling multinational equilibrium constructed in the proof of Theorem 6 is supported by the pessimistic belief that if the domestic firm stays then it faces high wages. Our equilibrium concept imposes no restrictions on b in multinational equilibria, and it is thus important to ask whether $b = 1$ is a plausible belief specification. In one case it certainly is not. Specifically, suppose that $\pi^N_{\mathrm{M}} - F^N(i) \geq \pi^N(w^i\alpha, 1)$ for $i = \mathrm{H}, \mathrm{L}$, and $\pi^N_{\mathrm{M}} - F^N(\mathrm{H}) > \pi^N(w^{\mathrm{H}}\alpha, 0)$; that is, suppose that a pooling multinational equilibrium exists and that facing high domestic wages, the domestic firm would rather go than stay, *even if* in staying it faced the "best" beliefs ($b = 0$). In this case, $z(\mathrm{H}) = \mathrm{S}$ is *dominated* by $z(\mathrm{H}) = \mathrm{G}$ in the presence of high domestic wages. Since $\pi^N(w^{\mathrm{L}}\alpha, 0) > \pi^N_{\mathrm{M}} - F^N(\mathrm{L})$ by assumption (iii), there are beliefs which might make $z(\mathrm{L}) = \mathrm{S}$ the optimal choice for the domestic firm when it faces low domestic wages. Thus, since staying is dominated by going for the domestic firm when domestic wages are high but not when they are low, the only reasonable belief is $b = 0$. But this belief could not support the pooling multinational equilibrium, as it would induce the domestic firm to stay if it faced low domestic wages. When $\pi^N_{\mathrm{M}} - F^N(\mathrm{H}) > \pi^N(w^{\mathrm{H}}\alpha, 0)$, pooling multinational equilibria are thus implausible equilibria. Referring again to multinational equilibria that are immune to such logic as *undominated multinational equilibria*, we now have the following theorem.

Theorem 7. *An undominated multinational equilibrium exists if and only if* $\pi^N(w^{\mathrm{H}}\alpha, 0) \geq \pi^N_{\mathrm{M}} - F^N(\mathrm{H}) \geq \pi^N(w^{\mathrm{H}}\alpha, 1)$ *and* $\pi^N_{\mathrm{M}} - F^N(\mathrm{L}) \geq \pi^N(w^{\mathrm{L}}\alpha, 1)$.

In words, multinationalization is plausible in the country-specific case if and only if the domestic firm does better when it stays, actually faces high wages, and is perceived to face a low wage than when it multinationalizes; and does better when it multinationalizes than when it stays and is thought to face high wages, regardless of its actual wage. Thus, multinationalization seems most likely in the country-specific case when perceived costs have a greater affect on profits than do actual costs. One would thus expect multinationalization to occur if foreign output is very sensitive to perceived domestic costs. We will return to this in the illustrations of Section 3.

We now give conditions under which the pooling multinational equilibrium is unique.

Theorem 8. *Suppose that* $\pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{L}) > \pi^{N}(w^{\mathrm{L}}\alpha, 1)$ *and* $\pi^{N}(w^{\mathrm{H}}\alpha, 0) > \pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H}) > \pi^{N}(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}})$. *Then, in any equilibrium,* $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$; *that is, every equilibrium is a pooling multinational equilibrium. Moreover, the pooling multinational equilibrium exists and is undominated.*

Proof. Existence and dominance arguments follow directly from Theorem 7. We prove here that every equilibrium is a pooling multinational equilibria. The proof is by contradiction. Consider first the possibility that $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{S}$. Then $b = \delta_{\mathrm{H}}$ and so the domestic firm facing domestic wages of type i earns $\pi^{N}(w^{i}\alpha, \delta_{\mathrm{H}})$. But $\pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H}) > \pi^{N}(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}})$, so $z(\mathrm{H}) = \mathrm{S}$ is not sequentially rational. Consider second $z(\mathrm{L}) \neq z(\mathrm{H}) = \mathrm{S}$. Then $b = 1$. This is contradictory, however, since $\pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H}) > \pi^{N}(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}}) > \pi^{N}(w^{\mathrm{H}}\alpha, 1)$. Finally, consider $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{S}$. Then $b = 0$. But $z(\mathrm{H}) = \mathrm{G}$ is then suboptimal, since $\pi^{N}(w^{\mathrm{H}}\alpha, 0) > \pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H})$. The only remaining case is $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$. □

Notice that $\pi^{N}(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}}) < \pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H})$ certainly holds by assumption (iii) if δ_{H} is near one and, in general, is more likely to hold the higher is δ_{H}. Thus, if the domestic wage is likely to be high (i.e. $\pi^{N}(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}}) < \pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H})$), and if perceptual cost effects are strong (i.e. $\pi^{N}(w^{\mathrm{H}}\alpha, 0) > \pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H})$ and $\pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{L}) > \pi^{N}(w^{\mathrm{L}}\alpha, 1)$, then the undominated multinational equilibrium is the unique equilibrium.

Before concluding this section, we briefly discuss the possibility of other equilibria in the country-specific case. There exist equilibria in which the domestic firm stays regardless of the domestic wage type ($z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{S}$) if and only if $\pi^{N}(w^{i}\alpha, \delta_{\mathrm{H}}) \geq \pi_{\mathrm{M}}^{N} - F^{N}(i)$ for $i = \mathrm{H}, \mathrm{L}$. (The proof is straightforward.) Thus, if δ_{H} is small, it may be that *too little* multinationalization occurs, relative to complete information choices. Finally, there may also exist efficient equilibria, that is, equilibria in which $z(\mathrm{H}) \neq z(\mathrm{L}) = \mathrm{S}$. Efficient equilibria are easily shown to exist if and only if $\pi_{\mathrm{M}}^{N} - F^{N}(\mathrm{H}) \geq \pi^{N}(w^{\mathrm{H}}\alpha, 0)$.

3. Illustrations

3.1. Firm-specific case

We consider a market in which demand is linear, and where there are no fixed costs. Let foreign demand be represented as $q = \gamma - \beta P$, where $\gamma, \beta > 0$, q is the quantity of goods

demanded in the foreign market, and P is the foreign market price. There are $N-1$ foreign firms, and a foreign firm that produces q_{f} units of output incurs a total cost of $w^*\alpha q_{\mathrm{f}}$. The single domestic firm incurs a total cost of $w(z)\theta^{\mathrm{H}}q_{\mathrm{D}}$ $(w(z)\theta^{\mathrm{L}}q_{\mathrm{D}})$ if it makes the location choice z and has technology θ^{H} (θ^{L}). Assume $w^* > w$ and $\alpha > \theta^{\mathrm{H}} > \theta^{\mathrm{L}}$.

To find the Cournot quantities for this game of incomplete information, we perform the following maximizations:

$$\max_{q_{\mathrm{D}}^{\mathrm{L}}}\left[\frac{\gamma-(N-1)q_{\mathrm{f}}(z,b)-q_{\mathrm{D}}^{\mathrm{L}}}{\beta}-w(z)\theta^{\mathrm{L}}\right]q_{\mathrm{D}}^{\mathrm{L}} \tag{1}$$

$$\max_{q_{\mathrm{D}}^{\mathrm{H}}}\left[\frac{\gamma-(N-1)q_{\mathrm{f}}(z,b)-q_{\mathrm{D}}^{\mathrm{H}}}{\beta}-w(z)\theta^{\mathrm{H}}\right]q_{\mathrm{D}}^{\mathrm{H}} \tag{2}$$

$$\max_{q_{\mathrm{f}}}\left[\frac{\gamma-(N-2)q_{\mathrm{f}}(z,b)-q_{\mathrm{f}}-(1-b)q_{\mathrm{D}}^{\mathrm{L}}(z,b)-bq_{\mathrm{D}}^{\mathrm{H}}(z,b)}{\beta}-w^*\alpha\right]q_{\mathrm{f}} \tag{3}$$

Notice that each firm (and firm type) is on its respective reaction curve. Foreign firms act as if they are playing against an opponent whose optimal quantity is $(1-b)q_{\mathrm{D}}^{\mathrm{L}}(z,b)+bq_{\mathrm{D}}^{\mathrm{H}}(z,b)$.

Letting $\theta^b \equiv b\theta^{\mathrm{H}}+(1-b)\theta^{\mathrm{L}}$, Cournot quantities can be represented as:

$$q_{\mathrm{D}}^{\mathrm{L}}(z,b)=\frac{2\gamma+\beta[2(N-1)w^*\alpha-w(z)((N-1)\theta^b+(N+1)\theta^{\mathrm{L}})]}{2(N+1)} \tag{4}$$

$$q_{\mathrm{D}}^{\mathrm{H}}(z,b)=\frac{2\gamma+\beta[2(N-1)w^*\alpha-w(z)((N-1)\theta^b+(N+1)\theta^{\mathrm{L}})]}{2(N+1)} \tag{5}$$

$$q_{\mathrm{f}}(z,b)=\frac{\gamma-\beta[2w^*\alpha-w(z)\theta^b]}{N+1} \tag{6}$$

Profits are then given by:

$$\pi^N(w(z)\theta^{\mathrm{L}},b)=\frac{1}{\beta}(q_{\mathrm{D}}^{\mathrm{L}}(z,b))^2 \tag{7}$$

$$\pi^N(w(z)\theta^{\mathrm{H}},b)=\frac{1}{\beta}(q_{\mathrm{D}}^{\mathrm{H}}(z,b))^2 \tag{8}$$

$$\pi^j(z,b)=\frac{1}{\beta}(q_{\mathrm{f}}(z,b))^2,\quad j=1,2,\ldots,N-1 \tag{9}$$

Provided that equilibrium quantities are positive, it is straightforward to verify that the four assumptions placed on profit functions for the firm-specific case all hold. Note, moreover, that a large value of γ ensures positive quantities.

We now employ Theorem 4 to find the conditions under which every undominated equilibrium is a separating multinational equilibrium.[12] The first condition is

[12] The definition of an undominated equilibrium given in Section 2 corresponds to the elimination of dominated strategies, when the game is expressed with reduced-form payoffs parameterized by belief values. In the illustrated model, quantity choices are explicitly added to the game. Here, the requirements of an undominated equilibrium are actually stronger than the elimination of dominated strategies, since firms are required to choose quantities optimally given beliefs.

$\pi^N(w\theta^H, 1) > \pi^N(w^*\theta^H, 0)$. Calculations give:

$$\pi^N(w\theta^H, 1) = \frac{1}{\beta}\left\{\frac{2\gamma + \beta[2(N-1)w^*\alpha - 2Nw\theta^H]}{2(N+1)}\right\}^2 \tag{10}$$

$$\pi^N(w^*\theta^H, 0) = \frac{1}{\beta}\left\{\frac{2\gamma + \beta[2(N-1)w^*\alpha - (N-1)w^*\theta^L - (N+1)w^*\theta^H]}{2(N+1)}\right\}^2 \tag{11}$$

Thus, the first condition of Theorem 4 will be met if and only if:

$$\frac{w^*}{w} > \frac{2N}{(N-1)(\theta^L/\theta^H) + (N+1)} \tag{12}$$

For any $\theta^H > \theta^L \geq 0$, condition (12) will hold if the differential between w^* and w is sufficiently large. Notice that condition (12) is independent of γ.

The second condition of Theorem 4 is $\pi^N(w^*\theta^L, 0) > \pi^N(w\theta^L, \delta_H)$. Arguing as above, we find that this condition holds if and only if:

$$\frac{w^*}{w} < \frac{(N-1)\delta_H[(\theta^H/\theta^L) - 1] + 2N}{2N} \tag{13}$$

Notice that (13) is more likely to hold the *smaller* is the difference between w^* and w. Also, observe that (13) too is independent of γ, so positive quantities can be assured independent of (12) and (13).

Fig. 2 illustrates the inequalities (12) and (13). The size (and existence) of the shaded region, which gives values of the foreign and domestic wage for which both inequalities (12) and (13) hold, is determined directly by the relative magnitudes of the slopes of the

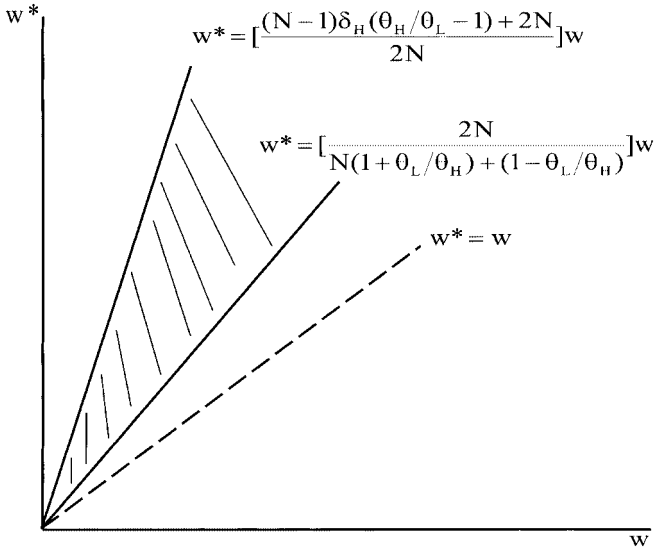

Fig. 2. Parameters for the separating multinational equilibrium.

two lines in Fig. 2, which are given by the quantities on the RHS of (12) and (13). While (12) and (13) will be satisfied under a broad range of parameter values, a sufficient condition for the existence of a range of foreign and domestic wage levels which satisfy simultaneously conditions (12) and (13) is that either δ_{H} be sufficiently close to one or that $\theta^{\mathrm{L}}/\theta^{\mathrm{H}}$ be sufficiently close to zero. Hence, the separating multinational equilibrium will be the unique undominated equilibrium of the firm-specific game for a range of foreign and domestic wages if (but not only if) either the efficiency differential between L and H is large enough or the (prior) probability that the domestic firm is inefficient is close enough to one.

In the separating multinational equilibrium, the domestic firm with low unit labor requirements tolerates a higher wage ($w^* > w$) in order to gain the perception of efficiency ($b = 0$), whereas the domestic firm with high unit labor requirements makes the opposite choice, tolerating the perception of inefficiency ($b = 1$) in order to gain a lower wage ($w < w^*$). Why is the optimal choice sensitive to the domestic firm's type? Intuitively, there are three main effects. The first effect is an amplification effect: a domestic firm with high unit labor requirements finds a higher wage more costly, since a higher wage directly amplifies the disadvantage of a high unit labor requirement. The second effect is a scale effect: a domestic firm with high unit labor requirements produces less output; therefore, it is less harmed by the greater foreign production and consequent lower price that accompanies a perception of inefficiency. Finally, there is also a scale effect that works against separation: a domestic firm with high unit labor requirements produces less output and in this respect finds a higher wage *less* costly. As our calculations confirm, the first two effects overwhelm the third, in that there exist wages such that only a domestic firm with low unit labor requirements would tolerate a higher wage in order to gain the perception of efficiency.

We now summarize with the following theorem.

Theorem 9. *When demand is linear and fixed costs are absent, there exists a set of parameter values under which the unique undominated equilibrium of the firm-specific game is the separating multinational equilibrium. A sufficient condition for a range of foreign and domestic wages to exist which yield the separating multinational equilibrium uniquely is that either the efficiency differential between* L *and* H *is large enough or the prior probability that the domestic firm is inefficient is close enough to one.*

The conclusions of Theorem 9 emerge under special assumptions about demand and costs. Nonetheless, they illustrate the more general conclusions drawn in Section 2; namely, that the kind of firm likely to exhibit multinational behavior of the sort characterized in Theorem 4 is one involved in "high tech" projects with a low probability of success (high δ_{H}) but a high payoff if successful ($\theta^{\mathrm{L}} \ll \theta^{\mathrm{H}}$), and that the countries across which such multinational activity will most likely be observed are those with wage differentials that are not "extreme".

3.2. Country-specific case

We consider first a market in which demand is linear, and where there are no fixed costs. Our initial result is negative: under these conditions, $\pi^N(w^{\mathrm{L}}\alpha, 1) > \pi^N(w^{\mathrm{H}}\alpha, 0)$ and so an undominated multinational equilibrium does not exist in the country-specific case.

Consider again the simple linear market in which foreign demand is represented as $q = \gamma - \beta P$, where $\gamma, \beta > 0$, q is the quantity of goods demanded in the foreign market, and P is the foreign market price. There are $N-1$ foreign firms, and a foreign firm that produces q_{f} units of output incurs a total cost of $w^{*}\alpha q_{\mathrm{f}} \equiv C^{\mathrm{M}} q_{\mathrm{f}}$. The single domestic firm incurs a total cost of $C^{\mathrm{M}} q_{\mathrm{D}}$ if it produces q_{D} units of output in a foreign plant. If, however, the domestic firm produces q_{D} units of output in a domestic plant, then its total cost is $w^{\mathrm{H}}\alpha q_{\mathrm{D}} \equiv C^{\mathrm{H}} q_{\mathrm{D}}$ ($w^{\mathrm{L}}\alpha q_{\mathrm{D}} \equiv C^{\mathrm{L}} q_{\mathrm{D}}$) if the domestic wage is high (low). Assume that $\alpha > 0$ and that $w^{\mathrm{H}} > w^{*} > w^{\mathrm{L}} > 0$.

To derive the various profit expressions, we consider a Cournot game of incomplete information in which the domestic firm stays and is thought to face high wages with probability b. The resulting Cournot quantities, $q_{\mathrm{D}}^{\mathrm{L}}(b)$, $q_{\mathrm{D}}^{\mathrm{H}}(b)$ and $q_{\mathrm{f}}(b)$, can then be found by performing the following maximizations:

$$\max_{q_{\mathrm{D}}^{\mathrm{L}}} \left[\frac{\gamma - (N-1) q_{\mathrm{f}}(b) - q_{\mathrm{D}}^{\mathrm{L}}}{\beta} - C^{\mathrm{L}} \right] q_{\mathrm{D}}^{\mathrm{L}} \tag{14}$$

$$\max_{q_{\mathrm{D}}^{\mathrm{H}}} \left[\frac{\gamma - (N-1) q_{\mathrm{f}}(b) - q_{\mathrm{D}}^{\mathrm{H}}}{\beta} - C^{\mathrm{H}} \right] q_{\mathrm{D}}^{\mathrm{H}} \tag{15}$$

$$\max_{q_{\mathrm{f}}} \left[\frac{\gamma - (N-2) q_{\mathrm{f}}(b) - q_{\mathrm{f}} - (1-b) q_{\mathrm{D}}^{\mathrm{L}}(b) - b q_{\mathrm{D}}^{\mathrm{H}}(b)}{\beta} - C^{\mathrm{M}} \right] q_{\mathrm{f}} \tag{16}$$

Again, each firm (and firm type) is on its respective reaction curve, and foreign firms act as if they are playing against an opponent whose optimal quantity is $q_{\mathrm{D}}^{\mathrm{L}}(b)(1-b) + q_{\mathrm{D}}^{\mathrm{H}}(b) b$.

Letting $C^{b} \equiv b C^{\mathrm{H}} + (1-b) C^{\mathrm{L}}$, it is easy to represent the Cournot quantities:

$$q_{\mathrm{D}}^{\mathrm{L}}(b) = \frac{2\gamma + \beta[2(N-1)C^{\mathrm{M}} - (N-1)C^{b} - (N+1)C^{\mathrm{L}}]}{2(N+1)} \tag{17}$$

$$q_{\mathrm{D}}^{\mathrm{H}}(b) = \frac{2\gamma + \beta[2(N-1)C^{\mathrm{M}} - (N-1)C^{b} - (N+1)C^{\mathrm{H}}]}{2(N+1)} \tag{18}$$

$$q_{\mathrm{f}}(b) = \frac{\gamma - \beta[2C^{\mathrm{M}} - C^{b}]}{N+1} \tag{19}$$

Profits are then given by:

$$\pi^{N}(w^{\mathrm{L}}\alpha, b) = \frac{1}{\beta}(q_{\mathrm{D}}^{\mathrm{L}}(b))^{2} \tag{20}$$

$$\pi^{N}(w^{\mathrm{H}}\alpha, b) = \frac{1}{\beta}(q_{\mathrm{D}}^{\mathrm{H}}(b))^{2} \tag{21}$$

$$\pi^{j}(b) = \frac{1}{\beta}(q_{\mathrm{f}}(b))^{2}, \quad j = 1, 2, \ldots, N-1 \tag{22}$$

Finally, π_{M}^{j}, $j = 1, 2, \ldots, N$ can easily be computed:

$$\pi_{\mathrm{M}}^{j} = \left[\frac{1}{\beta}\right] \left[\frac{\gamma - \beta C^{\mathrm{M}}}{N+1}\right]^{2}, \quad j = 1, 2, \ldots, N \tag{23}$$

Provided that equilibrium quantities are positive, as they will surely be for large γ, it is straightforward to verify that the four assumptions on profit functions made above all hold for this example. The country-specific theorems of Section 2 therefore apply.

We are thus left to compare $\pi^N(w^L\alpha, 1)$ and $\pi^N(w^H\alpha, 0)$. It is straightforward to show that $C^H > C^L$ is true if and only if $q_D^L(1) > q_D^H(0)$. Thus, when demand is linear and fixed costs are absent, a low wage domestic firm thought to face high wages produces more than a high wage domestic firm thought to face low wages: actual cost effects outweigh perceived cost effects. It is now immediate that $\pi^N(w^L\alpha, 1) > \pi^N(w^H\alpha, 0)$. With fixed costs set to zero by assumption, Theorem 7 then tells us that an undominated multinational equilibrium can never exist. We thus have the following negative result.

Theorem 10. *When demand is linear and fixed costs are absent, an undominated multinational equilibrium never exists in the country-specific case.*

Fig. 3 illustrates the result of Theorem 10 for the case of $N = 2$. The slopes of the (linear) foreign and domestic reaction curves are $-1/2$ and -2, respectively, reflecting the assumption of linear demand. The foreign reaction curve is labeled MM. The domestic reaction curve when the domestic firm faces high (low) wages is labeled HH (LL). If the domestic firm faces a low wage but is thought by the foreign firm to face a high wage, then the foreign firm chooses $q_f(1)$ and the best domestic response is $q_D^L(1)$. Alternatively, if the domestic firm faces a high wage but is thought by the foreign firm to face a low wage, then the foreign firm scales back its quantity choice to $q_f(0)$, and the best response of the domestic firm is $q_D^H(0)$. In the general linear-demand case, $q_D^L(1) - q_D^H(0) = [\beta(C^H - C^L)]/(N+1) > 0$. In the case illustrated in Fig. 3 with $N = 2$, $q_D^L(1) - q_D^H(0) = [\beta/3](C^H - C^L) > 0$. Thus, $\pi^N(w^L\alpha, 1) > \pi^N(w^H\alpha, 0)$.

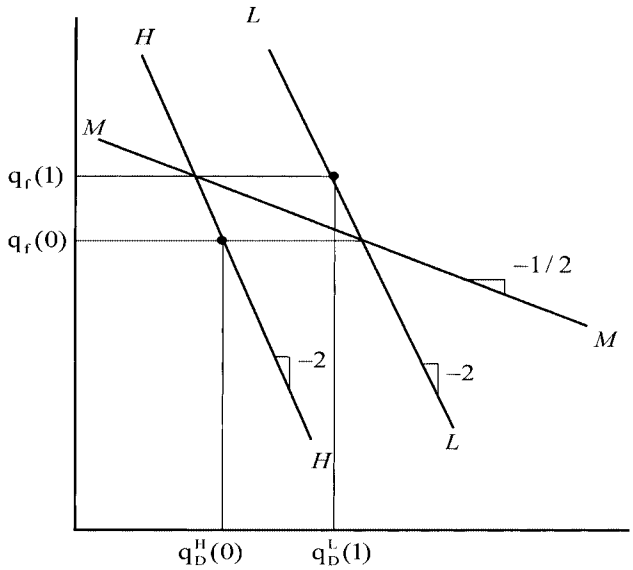

Fig. 3. Foreign and domestic reaction curves.

Evidently, when demand is linear and fixed costs are absent, foreign perceptions of domestic costs are not sufficiently important in the determination of domestic profits to overcome the direct cost effects of locating in the medium wage foreign county when actual domestic wages are low. This rules out the possibility of undominated multinational equilibria with $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$ in this case. However, the introduction of plant-specific fixed costs (incurred by the domestic firm only under multinationalization) and of transport costs (incurred by the domestic firm only if it exports) allows parameters to be found under which the multinational equilibrium exists and is the unique equilibrium. The role of transport costs is to reduce $\pi^N(w^{\mathrm{L}}\alpha, 1)$ sufficiently so that the first condition of Theorem 8 holds $(\pi^N_{\mathrm{M}} - F^N(\mathrm{L}) > \pi^N(w^{\mathrm{L}}\alpha, 1))$, while the role of plant-specific fixed costs is to reduce $\pi^N_{\mathrm{M}} - F^N(\mathrm{H})$ sufficiently so that the second condition of Theorem 8 holds $(\pi^N(w^{\mathrm{H}}\alpha, 0) > \pi^N_{\mathrm{M}} - F^N(\mathrm{H}) > \pi^N(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}}))$.

In particular, in the presence of transport costs t per unit exported from the domestic to the foreign market, the Cournot profits from exporting become:

$$\pi^N(w^{\mathrm{L}}\alpha, b) = \frac{1}{\beta}\left[\frac{2\gamma + \beta[2(N-1)C^{\mathrm{M}} - (N-1)(C^b + t) - (N+1)(C^{\mathrm{L}} + t)]}{2(N+1)}\right]^2 \tag{24}$$

$$\pi^N(w^{\mathrm{H}}\alpha, b) = \frac{1}{\beta}\left[\frac{2\gamma + \beta[2(N-1)C^{\mathrm{M}} - (N-1)(C^b + t) - (N+1)(C^{\mathrm{H}} + t)]}{2(N+1)}\right]^2 \tag{25}$$

With plant-specific fixed costs $F^N(\mathrm{H})$ $(F^N(\mathrm{L}))$ incurred by the high wage (low wage) domestic firm only if it multinationalizes, profits when multinationalization is chosen are given by:

$$\pi^N_{\mathrm{M}} - F^N(\mathrm{L}) = \frac{1}{\beta}\left[\frac{\gamma - \beta C^{\mathrm{M}}}{N+1}\right]^2 - F^N(\mathrm{L}) \tag{26}$$

$$\pi^N_{\mathrm{M}} - F^N(\mathrm{H}) = \frac{1}{\beta}\left[\frac{\gamma - \beta C^{\mathrm{M}}}{N+1}\right]^2 - F^N(\mathrm{H}) \tag{27}$$

The conditions of Theorem 8 lead us to calculate:

$$\pi^N_{\mathrm{M}}(w^{\mathrm{H}}\alpha, 0) = \frac{1}{\beta}\left[\frac{2\gamma + \beta[2(N-1)(C^{\mathrm{M}} - C^{\mathrm{L}}/2 - C^{\mathrm{H}}/2) - 2(C^{\mathrm{H}} + Nt)]}{2(N+1)}\right]^2 \tag{28}$$

$$\pi^N(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}}) = \frac{1}{\beta}\left[\frac{\begin{array}{l}2\gamma + \beta[2(N-1)(C^{\mathrm{M}} - C^{\mathrm{L}}/2 - C^{\mathrm{H}}/2) \\ \quad - 2(C^{\mathrm{H}} + Nt) - 2(N-1)\delta_{\mathrm{H}}(C^{\mathrm{H}} - C^{\mathrm{L}})]\end{array}}{2(N+1)}\right]^2 \tag{29}$$

$$\pi^N(w^{\mathrm{L}}\alpha, 1) = \frac{1}{\beta}\left[\frac{2\gamma + \beta[2(N-1)(C^{\mathrm{M}} - C^{\mathrm{L}}/2 - C^{\mathrm{H}}/2) - 2(C^{\mathrm{L}} + Nt)]}{2(N+1)}\right]^2 \tag{30}$$

Under the assumption that C^{L} and C^{H} are symmetric with respect to C^{M}, (28)–(30) can be simplified to yield:

$$\pi^N(w^{\mathrm{H}}\alpha, 0) = \frac{1}{\beta}\left[\frac{\gamma - \beta(C^{\mathrm{H}} + Nt)}{N+1}\right]^2 \tag{31}$$

$$\pi^N(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}}) = \frac{1}{\beta}\left[\frac{\gamma - \beta(C^{\mathrm{H}} + Nt) - \beta(N-1)\delta_{\mathrm{H}}(C^{\mathrm{H}} - C^{\mathrm{L}})}{N+1}\right]^2 \tag{32}$$

$$\pi^N(w^{\mathrm{L}}\alpha, 1) = \frac{1}{\beta}\left[\frac{\gamma - \beta(C^{\mathrm{L}} + Nt)}{N+1}\right]^2 \tag{33}$$

Using (26), (27) and (31)–(33), the conditions of Theorem 8 can be evaluated explicitly. It is straightforward to show that, with $F^N(\mathrm{L})$ set to zero for simplicity:

(i) $\pi^N_{\mathrm{M}} > \pi^N(w^{\mathrm{L}}\alpha, 1)$ if and only if $t > [C^{\mathrm{M}} - C^{\mathrm{L}}]/N$.
(ii) $\pi^N(w^{\mathrm{H}}\alpha, 0) > \pi^N_{\mathrm{M}} - F^N(\mathrm{H})$ if and only if $F^N(\mathrm{H}) > [\beta^2/(N+1)^2][C^{\mathrm{H}} - C^{\mathrm{L}}][\gamma - \beta(C^{\mathrm{H}} + Nt)]$.
(iii) $\pi^N_{\mathrm{M}} - F^N(\mathrm{H}) > \pi^N(w^{\mathrm{H}}\alpha, \delta_{\mathrm{H}})$ provided β is sufficiently small and δ_{H} is sufficiently close to one.

With $F^N(\mathrm{L})$ set to zero and costs symmetric, and with t, $F^N(\mathrm{H})$, β and δ_{H} chosen to satisfy (i)–(iii) above, Theorem 8 then implies that in any equilibrium, $z(\mathrm{L}) = z(\mathrm{H}) = \mathrm{G}$; that is, every equilibrium is a multinational equilibrium.[13] Note that as C^{L}, C^{M} and C^{H} are brought together, conditions (i) and (ii) will hold for any positive transport costs and plant-specific fixed costs. Thus, provided that β and δ_{H} are such that (iii) is satisfied, the pooling multinational equilibrium is more likely to be the unique equilibrium in this setting the more similar are countries, i.e. the closer are w^{H}, w^* and w^{L}. We thus have the following theorem.

Theorem 11. *In the linear-demand model with plant-specific set-up costs and transport costs, parameter values exist which make the pooling multinational equilibrium the unique equilibrium. All else the same, the pooling multinational equilibrium is more likely to be the unique equilibrium in this setting the more similar are countries.*[14]

4. Conclusions and extensions

This paper has shown that when firms behave strategically and information about costs is incomplete, multinationals can arise from the desire to transmit cost information to foreign rivals. We have explored the case of country-specific informational asymmetries where the

[13] The four assumptions on profit functions listed for the country-specific case in Section 2 also need to be satisfied. It is readily shown that a range of parameter values will simultaneously satisfy these four assumptions and the three criteria listed above.

[14] This aspect of our country-specific model conforms in spirit to the results of Ethier (1986), who finds multinationalization to be more likely between similar economies (in a factor endowment sense).

location of production facilities abroad *directly* informs rival firms of an entrant's production costs, and the case of firm-specific informational asymmetries where the decision to locate production facilities abroad *signals* the costs of the entrant. In either case, the firm may be led to multinationalize in the presence of incomplete cost information even though its actual costs of serving the foreign market are higher as a result, but only if doing so serves ultimately to inform rival firms about its costs. We also find that ''high tech'' firms are most likely to multinationalize as a result of private firm-specific knowledge about costs, while multinationalization as a result of either firm-specific or country-specific private cost information is more likely between countries that are ''not too dissimilar'' with regard to factor prices. Finally, based on our linear-demand example, it appears that the latter case—in which location signals firm-specific cost parameters—yields the more plausible multinational equilibrium.

The theory we have explored is clearly only a partial picture, and should be viewed as complementary to other theoretical work on the multinational enterprise. However, it is consistent with the empirical finding of Swedenborg (1979), that foreign direct investment by Swedish multinationals is more likely in relatively high wage countries, an observation that is inconsistent with a simple cost-minimizing view of the plant location decision. A slight modification of the firm-specific model explored above would also lead to the conclusion that foreign direct investment is likely to be positively correlated with exports to the host country market: just enough foreign direct investment would be undertaken to signal the firm's efficient technology, and the remainder of its (now expanded) foreign market share would be exported from the home plants. Most empirical work on the relationship between foreign direct investment and exports finds either no correlation or a positive correlation between the two, something which is difficult to reconcile with existing theory (see, for example, Blomstrom et al., 1987).

Our analysis suggests a number of interesting extensions. We mention here three extensions for the firm-specific model. First, this model could be modified to include dissipative advertising expenditures as a signal. We expect that location would continue to serve as a (preferred) signal in this modified model. This is because a firm with low unit labor requirements has a relative advantage when using the location signal but no such advantage when using the dissipative advertising signal.[15] Second, the model could be extended to allow for two periods of oligopoly interaction. The domestic firm could then use first-period quantity as a signal as well. The interaction of location choice and price/quantity choice as signals of cost is a potentially fruitful area for future work. Finally, the model could be modified to allow for endogenous entry by foreign firms. In such a model, the domestic firm might use its location choice to signal low costs and thereby discourage entry.

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[15] For an illustration of this point in a limit-pricing model, see Bagwell and Ramey (1988).

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