FOREIGN MARKET ENTRY STRATEGIES UNDER ASYMMETRIC INFORMATION[§]

ABSTRACT

A home firm signals her private cost information by expanding in a foreign firm's country. Credible signalling to deter counter-entry may occur through a direct investment (but not through exports), and may even entail entering an unprofitable market. While this produces social benefits, uninformative signalling may be welfare-reducing. Hence, we argue that moderate to high location costs may be socially desirable. We also show that there are not simple monotonic relationships between technology/demand conditions and firms' entry modes. Thus, the signalling interpretation of international expansion makes it possible to explain some controversial empirical findings on a theoretical ground.

Keywords. Foreign direct investments; exports; oligopolistic rivalry; signalling games.

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1. Introduction

It is widely recognized that tackling informational asymmetries is inevitable to a firm which is about to enter a foreign market. In the theoretical literature on multinationals, Markusen (1995) notes that an incumbent firm in the foreign market holds superior information on local market characteristics. On the empirical side, a vast sample of multinationals indicated in survey questionnaires that the lack of information on foreign market demand and local costs has often curbed firms' international operations (United Nations, 1997). While these informational failures mainly relate to country-specific variables, firm-specific informational asymmetries (e.g., about the local firms' costs) are also frequently cited as a significant barrier to foreign entry. According to Porter (1980), local firms often hold proprietary production technology that is difficult to evaluate for a potential foreign competitor. This may be due to favorable access to local distribution channels, as well as established relations with the local government. In hi-tech industries, the local firm could be engaged in innovative activities that cannot be perfectly monitored by a foreign firm. Thus, by the foreign firm's viewpoint, the local firm may have either gained or not the sole access to a technology allowing her to produce at a low cost.

Although any industry performance depends on the amount and nature of information available to competing firms, quite surprisingly, the effects of asymmetric information in international markets have been assessed to a limited extent, which is confined to strategic trade policy (see e.g. Collie and Hviid, 1994; Qiu, 1994; Wright, 1998). The framework of these models is one of single-plant national firms that compete internationally supported by local governments. Thus, firms' location is exogenous. Moreover, national firms usually compete in third markets, so that their own countries are not directly affected by foreign rivals. Finally, these models emphasize normative concerns over positive ones.

A number of game-theoretic models endogenously find the pattern of firm location, production and trade as the outcome of strategic interaction in oligopolistic industries (see e.g. Horstmann and Markusen, 1992; Motta and Norman, 1996), but they assume firms competing under complete information. Even when a foreign firm is at an information disadvantage *vis-a-vis* a domestic one, the former is able to gather the whole information needed to start up local production by incurring an exogenous fixed cost.

The purpose of this paper is to make further steps in explaining firms' international expansion modes, based on strategic interaction under asymmetric information, which is still a rather unexplored issue. Firms' rivalry is modelled as a signalling game where a home firm that is privately informed about her production cost chooses her action (direct investment or export) to enter the market of a foreign firm, which in turn may opt for a counter-entry[1]. Since the source of this informational asymmetry is firm-specific[2], then we allow for information strategic manipulation by the privately-informed firm trying to gain advantage on her rival. The basic idea is that the home firm's commitment in her entry strategy is a signal of productive efficiency that may dissuade the rival from going abroad, while a failure to enter her rival's market may indicate that she is a high-cost producer[3].

As most studies in strategic trade policy, the proposed model borrows from signalling models used in industrial organization to explain a variety of oligopolists' strategies (for a

[1] To prevent confusion, the home firm is hereafter referred to as "she", and the foreign firm as "he".

[2] Assuming asymmetric information is standard practice in signalling models, even when these are applied to strategic trade policy, where home and foreign firms symmetrically compete in third markets. This simplifies the analysis compared to two-sided incomplete information, but is not crucial for the results.

[3] Signalling may be less costly if the home firm decides to preserve domestic monopoly by simply increasing output in her country. However, in our setting, this requires her incurring the opportunity cost of the lost profit in the rival firm's country. We will show that, even when this cost is lower than the avoided entry cost, strategic interaction may provide a rationale for signalling by investing abroad.

review on entry deterrence, see Wilson, 1992). However, the signal we analyze here is the location decision, so that the home firm signals her cost information by committing to a particular *mode* of entry. This is in contrast to strategic trade policy studies, where a firm signals its cost information by committing to an output *level*, for a given mode of entry.

The exchange of information between agents has usually played a role for a firm's internalization decision, when establishing a plant abroad is compared with arms-length transactions with local partners. Following Vernon (1966), Bagwell and Staiger (2003) have shown that information transmission is also crucial for understanding the location decision. In fact, a firm may invest abroad to signal cost information to foreign rivals[4]. In their model, an incumbent in a given country competes with a number of entrants in a foreign market. However, competition occurs only in the new market (where entry accommodation is the sole alternative), while entry in the incumbent's country is banned.

Conversely, our paper defines a "reciprocal-markets model" (see Brander, 1995). This closely reflects the real pattern of global competition, particularly in developed countries. Ito and Rose (2002) provide empirical evidence of international oligopolistic reaction. Their results show that global firms observe, and possibly match, the worldwide movements of competition. In this framework, our model investigates the role of the home firm's location choice as a signalling device for entry deterrence. Our model also includes the possibility that the firm decides not to sell abroad.

The signalling interpretation of international expansion sheds new light on the dichotomy between the technology exploitation and the technology sourcing hypotheses for foreign direct investments[5]. In fact, by placing emphasis on *uncertainty* about

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[4] Haucap, Wey and Barmbold (2000) explore how the location of production signals a firm's product quality, but they focus on informational asymmetries between firms and consumers, rather than between firms.

[5] Contrary to the traditional paradigm (Dunning, 1993), recent work (Fosfuri and Motta, 1999) suggests that: a) firms may invest abroad not to exploit some technology-related advantage, but to acquire knowledge from

technology, rather than on technology *per se* (as in the dominant paradigm), we are able to interpret both the low-cost and the high-cost producer's investment abroad as an attempt to exploit her private information, that is, her ownership advantage. Consistent with some empirical evidence (Mutinelli and Piscitello, 1998), we also find that leading innovative firms might desist from investing abroad not so much to avoid technology dissipation as for the lack of information on their rivals' technology (that is an ownership disadvantage).

The results obtained here provide further controversial empirical findings with a theoretical underpinning. In fact, plant-specific fixed costs and transport costs are widely recognized as key determinants of firms' expansion modes. However, empirical studies, in contrast to the established theoretical literature, do not support a simple relationship. While in some cases distance (a *proxy* for transport costs) is found to encourage foreign direct investments to the detriment of exports (for US firms, see Brainard, 1997), in other cases the opposite result prevails (for Italian firms, see Mutinelli and Piscitello, 1998), or there is not a clear-cut relationship (for foreign investments in the US, see Blonigen, 2002).

This paper consistently shows that firms' entry modes cannot be simply derived from technology and market conditions[6]. In keeping with the framework of signalling models, our paper also investigates: (a) whether and how either credible signalling or uninformative signalling affect firms' choices of which markets to serve; (b) what is the signalling value of each entry mode; (c) what are the related welfare effects and policy implications.

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localised spillovers (*technology sourcing*); b) technological leaders might not invest abroad to avoid knowledge diffusion (*technology dissipation*). The technology sourcing hypothesis has received weak support from econometric evidence (Neven and Siotis, 1996), and technology exploitation (in contrast to fear of technology dissipation) still emerges as a major determinant of foreign direct investments (Love, 2003).

[6] Herander and Kamp (2003) find a similar result in a setting where a domestic firm may alter the entry mode of an uninformed foreign firm, but they model the standard quantity-setting signal and prevent the domestic firm from going abroad. This further implies that their welfare analysis is confined to the domestic country.

The strategic literature on multinationals assumes that foreign direct investments act to increase competition in host countries. This paper argues that informational aspects do matter to evaluate the welfare effects of a location decision. While an inward investment reduces industry concentration in the host country, a firm may well undertake an outward investment to preserve her domestic monopoly rents. Thus, the home firm may enter the foreign market even if such an entry is not profitable *per se*, since it deters her rival's counter-entry[7]. We show that the net welfare effects depend on the home firm's location decision being able to effectively transmit cost information to her rival. Hence, moderate to high location costs might be socially beneficial, if they make investing profitable to the low-cost firm, but not to the high-cost one. While this is in fair contrast to much of the recent strategic trade literature (see e.g. Fumagalli, 2003), it is in line with some relevant signalling models (Bagwell and Staiger, 2003; Haucap, Wey and Barmbold, 2000).

This paper is organized as follows. Section 2 introduces the model. Section 3 examines the direct investment option, while Section 4 analyzes exports. Section 5 deals with international expansion mode choices. Section 6 contains concluding remarks.

2. THE MODEL

Consider a world of two countries, *A* and *B*, each with one domestic firm, *firm* 1 (the *home firm*) and *firm* 2 (the *foreign firm*) respectively. Firms enjoy a monopoly in their respective own markets and produce a homogeneous good. National markets are segmented. Firm 1

[7] In the 1990s, South Korean companies, such as Samsung and Hyundai, collectively lost billions of dollars on their initial investments in the world market of memory chips. However, these investments pre-empted Japanese firms, so that South Korean makers became the main world producers of memory chips.

may enter country B by either establishing a manufacturing plant or exporting her output. Then, firm 2 is allowed counter-entry in country A by either installing a plant or exporting his output. Firms incur either a plant-specific fixed cost G (related to investing abroad) or a unit transport cost s (related to exports). Since both firms have already established a plant in their own countries, then they have already sunk the cost of the knowledge-based assets necessary to operate. Thus, for simplicity, firm-specific fixed costs are normalized to zero.

Firms also incur a constant marginal and average variable cost. The home firm (but not the foreign firm) has private information about her marginal cost, which identifies her type. The home firm may achieve either a *low* (c_L) or a *high* (c_H) marginal cost, while that cost is c_2 for the foreign firm. This information structure is common knowledge. The following linear inverse demand curve is considered in each country:

$$p_j = a - b\,(q_{1j} + q_{2j}) \tag{1}$$

where p_j denotes the price of the good in country j (j=A,B), q_{ij} denotes the quantity of the good sold by firm i (i=1,2) in country j, while 1/b measures the size of each market.

Let us indicate a firm's action with F if it makes a direct investment in the rival firm's country; with E if it supplies the host country via exports, and with N if it does not sell abroad at all. Let (U,V) denote the industry structure resulting from the combination of the home firm's choice U and the foreign firm's choice V, with $U,V \in M=\{F,E,N\}$.

The timing of the game is as follows. Nature draws a type for the home firm from the set of feasible types $T=\{c_L,c_H\}$, according to the prior probability distribution $\{\Pr(c_L)=\alpha, \Pr(c_H)=1-\alpha\}$, where $0<\alpha<1$, that is common knowledge. At the first stage, the home firm learns her type and chooses an action from the feasible set M. At the second stage, the foreign firm observes the home firm's action and updates his beliefs about his rival's type, which is not observable. Let (β,1-β), (γ,1-γ) and (δ,1-δ) respectively denote the (posterior) foreign firm's beliefs at the information sets following the home firm's actions F, E and N.

Then, the foreign firm chooses an action from *M*. When two firms operate in any given country (irrespective of their mode), they play *à la* Cournot. Both firms aim at maximizing their payoffs, which depend on the home firm's type and on both firms' actions.

The proper solution concept is the *perfect Bayesian equilibrium* (*PBE*). We confine our analysis to pure-strategy *PBE*. A pure-strategy *PBE* is a set of strategies and beliefs such that, at any stage of the game, strategies are optimal given the beliefs and the beliefs are obtained from equilibrium strategies and observed actions by using Bayes' rule. A *PBE* is *refined* if it satisfies a proper equilibrium refinement criterion[8]. Since the game is finite, then there exists at least a *PBE* (Fudenberg and Tirole, 1991). A *PBE* is *separating* if each type selects a different action and reveals herself to the foreign firm, which updates his prior beliefs accordingly. A *PBE* is *pooling* if both types choose the same action and send no additional information to the foreign firm, which cannot update his beliefs.

For each possible industry structure, Table 1 shows firms' profit functions, Table 2 indicates firms' optimal output levels in each country under the Cournot assumption and Table 3 reports firms' optimal profits, depending on prior beliefs (where $\bar{c} = \alpha c_L + (1-\alpha)c_H$). Under pooling strategies, posterior beliefs are the same as priors, while the corresponding tables for separating strategies (and for the benchmark case with complete information) can be obtained from Tables 1 to 3 by setting either α=1 (if firm 1 is low-cost, i.e. c_k=c_L, or is perceived as such), or α=0 (if firm 1 is high-cost, i.e. c_k=c_H, or is perceived as such).

[insert Table 1, Table 2 and Table 3 about here]

In the following sections, first we deal separately with the cases where entry is based on a direct investment or export, and then extend the analysis to the case where firms select their entry modes. While showing the existence and discussing the properties of each *PBE* of the game, we use the following procedure: (i) fix an equilibrium candidate; (ii) identify

[8] The requirements for a *PBE* and the equilibrium refinement criterion are formalized in Appendix A.

the conditions on parameter values and beliefs for it to be an equilibrium; (iii) restrict the conditions on parameter values so that a home firm's type distorts her choice compared with complete information (thus focusing on an equilibrium with a signalling value); (iv) verify (when necessary) that the equilibrium passes an equilibrium refinement test[9].

3. THE DIRECT INVESTMENT OPTION

In this section, we assume that firms may either invest abroad or stay in their countries.

3.1. BENCHMARK CASE: COMPLETE INFORMATION

By using backward induction, we derive the binding parameter constraints for any pair of firms' actions to be part of a subgame-perfect Nash equilibrium of the two-stage game with full information. By setting either α=1 (if c_k=c_L) or α=0 (if c_k=c_H) in Table 3, we have that:

$$\pi_2(U,F) \geq \pi_2(U,N) \Leftrightarrow G \leq \frac{(a+c_k-2c_2)^2}{9b} = \overline{G}_k, \qquad U=F,N; \;\; k=L,H \,, \quad (2)$$

where $\pi_i(U,V)$ denotes firm i's profit (i=1,2) when firm 1 plays U and firm 2 plays V ($U,V \in M$). The second stage game yields the optimal firm 2's choice as a function of firm 1's action in the first stage. Now, firm 1 plays F if:

$$\pi_1(F,V) \geq \pi_1(N,V) \Leftrightarrow G \leq \frac{(a+c_2-2c_k)^2}{9b} = \overline{\overline{G}}_k, \qquad V=F,N; \;\; k=L,H \,, \quad (3)$$

both if $G \leq \overline{G}_k$ (so that firm 2 also plays F) and if $G > \overline{G}_k$ (so that firm 2 plays N), where $\overline{G}_k \geq \overline{\overline{G}}_k \Leftrightarrow c_k \geq c_2$, $k=L,H$.

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[9] Steps (i) and (ii) are often used in the literature to derive a *PBE*. In our two-choice model, this procedure does not preclude characterization of all the possible *PBE* of the game for any given set of parameter values.

We will generally assume throughout the paper that $c_L \leq c_2 \leq c_H$. This is not crucial for the results, but simply focuses on the most interesting case where, depending on whether she is low-cost or high-cost, firm 1 has the strongest incentive to reveal or conceal her type while firm 2's entry decision is strictly conditioned on (uncertainty about) his rival's cost[10]. It follows that $\overline{G}_L < \overline{\overline{G}}_L$ and $\overline{G}_H > \overline{\overline{G}}_H$. Thus, when firm 1's cost is c_L (c_H), we derive that:

- if $G \leq \overline{G}_L$ ($G \leq \overline{\overline{G}}_H$), then both firms make a direct investment abroad;
- if $\overline{G}_L < G \leq \overline{\overline{G}}_L$ ($\overline{\overline{G}}_H < G \leq \overline{G}_H$), then there is the unilateral expansion of firm 1 (firm 2);
- if $G > \overline{\overline{G}}_L$ ($G > \overline{G}_H$), then both firms do not expand abroad.

3.2. *SEPARATING EQUILIBRIA*

Consider a separating equilibrium where c_L plays F and c_H plays N. Bayes-consistency then implies that the foreign firm's posterior beliefs are β=1, δ=0. Hence, the high-cost type will make her complete information optimal choice. The necessary conditions for such equilibrium can be formulated as follows:

$$\pi_L(F,N) \geq \tilde{\pi}_L(N,F) \tag{4}$$

$$\tilde{\pi}_H(F,N) \leq \pi_H(N,F) \tag{5}$$

where $\tilde{\pi}_L(N,F)$ is type c_L's profit when she plays N and thus is perceived as type c_H, while $\tilde{\pi}_H(F,N)$ is type c_H's profit when she plays F and thus is perceived as type c_L. Condition (4) states that the low-cost home firm prefers investing at stage one and be

[10] This assumption is related to the typical case in entry models that, under full information, entry profits are either positive or negative, depending on whether the incumbent is high-cost or low-cost. If $c_2 > c_H$ ($c_2 < c_L$) then, though uninformed about his rival's costs, firm 2 knows that he is certainly less (more) efficient than firm 1. Thus, his entry decision may be not so much related to the information structure as to the basic model parameters. This is turn dilutes (but does not necessarily cancel out) the signalling motive for firm 1's action.

perceived as low-cost at stage two (so that the foreign firm decides not to invest abroad), rather than staying in her own country at stage one and be perceived as high-cost at stage two (so that the rival does invest abroad). Condition (5) states that the opposite relationship holds for the high-cost type. These conditions are sufficient for the separating equilibrium, since the foreign firm's information sets are on the equilibrium path, and thus beliefs are always determined by Bayes' rule and the home firm's strategy. Given the finite feasible strategy space, when both (4) and (5) hold, the separating equilibrium where type c_L plays *F* and type c_H plays *N* is also the unique (least-cost) separating equilibrium of the game.

Let the equilibrium industry structures under complete information be: (i) (*N*,*N*) with the low-cost type; (ii) (*N*,*F*) with the high-cost type. Section 3.1 indicates that the relevant threshold values are respectively: (i) $G > \overline{\overline{G}}_L$; (ii) $\overline{\overline{G}}_H < G \leq \overline{G}_H$. Then, both (i) and (ii) hold if:

$$\overline{\overline{G}}_L < G \leq \overline{G}_H , \tag{6}$$

where $\overline{\overline{G}}_L < \overline{G}_H$ requires $c_H > 3c_2 - 2c_L$. Moreover, the feasibility constraints on quantities require $a \geq 2c_H - c_2$. It directly follows that, under asymmetric information, the low-cost type has to engage in a signalling action not to be mistaken for the high-cost one, because the low-cost type's optimal choice with complete information is also profitable to type c_H.

Computation based on proper manipulation of Table 3 enables us to rearrange (4) and (5) so that $G_{(S2)} \leq G \leq G_{(S1)}$, where $G_{(S1)} = \dfrac{(3a - 4c_L)^2 + (a - 2c_2 - 3c_H)2c_L + (4(a + c_2) - c_H)c_H}{36b}$ and $G_{(S2)} = \dfrac{(3a - c_L)^2 + (a - 2c_2 + 3c_H)2c_L - (7a - 2c_2 - c_H)2c_H}{36b}$, with $G_{(S1)} > G_{(S2)}$. It follows from the imposed parameter restrictions that $\overline{G}_H < G_{(S1)}$. Thus, two caveats are necessary. If $G > \overline{G}_H$, then the foreign firm does not invest abroad even if his rival is high-cost, while, if $G \leq \overline{G}_L$, then he invests abroad even if his rival is low-cost. In both cases, type c_L has no signalling incentives left. Hence, the separating equilibrium at issue does exist when:

$$\max\left\{G_{(S2)}, \overline{G}_L\right\} \leq G \leq \min\left\{G_{(S1)}, \overline{G}_H\right\} = \overline{G}_H \, . \tag{7}$$

Since the subsets of G values deriving from (6) and (7) are not disjoint then we find a separating equilibrium where the low-cost type makes a clear signalling effort. This is illustrated in the following simple example. Let a=20, b=2, c_L=2, c_2=5, c_H=12. Calculation yields that (6) implies 24.5<G≤26.9, while (7) implies 9.9≤G≤26.9. If 9.9≤G≤24.5, then the separating equilibrium perfectly replicates the complete information environment, while, if 24.5<G≤26.9, then the separating equilibrium introduces the specified distortions.

To sum up, in a separating equilibrium type c_H can obtain her full-information profits, while type c_L possibly distorts her choice away from her full-information optimal action, so as to convince firm 2 that she is indeed low-cost, and prevent counter-entry. Hence, asymmetric information may impose a cost for credible signalling on type c_L, so that she invests in country B, whereas under complete information she would not invest abroad.

The low-cost type may reduce her signalling costs if she preserves domestic monopoly by simply increasing output in her country[11]. However, this conventional way of signalling requires her incurring the cost of output distortion, plus the opportunity cost of the lost profit in country B. If these total costs exceed the avoided entry cost, then there is the rationale for signalling by investing abroad. It follows that signalling through international activity may dominate signalling through a domestic output distortion even when the home firm's opportunity cost is lower than the entry cost.

3.3. Pooling equilibria

Consider a pooling equilibrium where both types play F. Bayes-consistency then implies that β=α. Since the foreign firm learns nothing about the home firm's type, his action depends on prior beliefs. To fix ideas and keep things interesting, assume that:

[11] If type c_L does not signal at all, then by assumption she cannot prevent the rival firm's entry in her country.

(iii) the foreign firm's beliefs are such that, if both rival's types play F, he replies by N;

(iv) the equilibrium industry structures under complete information are (F,N) with the low-cost home firm, and (N,F) with the high-cost home firm[12].

We derive from Section 3.1 that (iv) holds if the following condition is satisfied:

$$\overline{\overline{G}}_H < G \leq \overline{\overline{G}}_L . \tag{8}$$

The necessary conditions for the pooling equilibrium require that both types prefer F than their complete information optimal actions and that the foreign firm plays N, so that:

$$\pi_H(F,N) \geq \pi_H(N,F) \tag{9}$$

$$\overline{\pi}_2(F,N) \geq \overline{\pi}_2(F,F) \tag{10}$$

where $\overline{\pi}_2(\cdot)$ is firm 2's expected profit[13]. Conditions (9) and (10) are sufficient if off-the-equilibrium beliefs are chosen to deter both types from deviating (because firm 2 competes as if firm 1 is high-cost). On the basis of Table 3, we are able to rearrange (9) so that:

$$G \leq \frac{(a-c_H)^2}{4b} - \frac{(a+c_2-2c_H)^2}{9b} + \frac{(2a+2c_2-3c_H-\overline{c})^2}{36b} = G_{(P1)} . \tag{11}$$

As $\alpha \to 0$, $G_{(P1)}$ approaches $\overline{\overline{G}}_H$ from above. Condition (10) can be rewritten as:

$$G \geq \left[\frac{2a-4c_2+3c_H-\overline{c}-3\alpha\,(c_H-c_L)}{6}\right] \cdot \frac{a+\overline{c}-2c_2}{3b} = G_{(P2)} . \tag{12}$$

Clearly, G should take a sufficiently high value for the foreign firm to prefer staying in his country. Since $\frac{\partial G_{(P2)}}{\partial \alpha} = -\frac{2\,(c_H-c_L)\,(a-2c_2+\overline{c})}{9b} < 0$, such a value decreases as the prior belief on the low-cost type grows up. With complete information and the high-cost type, the foreign firm does not invest abroad if $G > \overline{G}_H = \frac{(a+c_H-2c_2)^2}{9b}$. As $\alpha \to 0$, $G_{(P2)}$

[12] Condition (iv) implies that c_H signals at the pooling equilibrium. If (iii) does not hold, and the uninformed firm 2 enters country A, then signalling is of no use and type c_H would better play her full-information action.

[13] Type c_L condition is not reported here since, whatever the information structure, she always invests abroad.

approaches $\overline{G}_H$ from below. Consequently, it emerges that the high-cost type takes advantage from asymmetric information. According to (11), she is able to invest abroad for higher values of *G* than with complete information, while (12) implies that the foreign firm gives up international expansion for lower values of *G* than with complete information.

Constraints (11) and (12) are mutually compatible if $\alpha \geq \overline{\alpha} = \dfrac{2(a-c_2)}{(c_H-c_L)} - \dfrac{\sqrt{3K}}{3(c_H-c_L)}$, where $K = 17a^2 - 4c_2(2a+c_2) - 2c_H(13a-8c_2) + 5c_H^2$, with K>0 (which in turn requires that a be sufficiently high). As expected, the pooling equilibrium exists when the foreign firm places a sufficiently high prior belief on the low-cost type, so that he will refrain from expanding abroad. As $\alpha \to 1$, $G_{(P1)}$ grows while at the same time $G_{(P2)}$ decreases, so that more favorable conditions are established to the high-cost type's mimicking strategies.

Calculation reveals that it is always $G_{(P2)} > \overline{\overline{G}}_H$ and that, as $\alpha \to 1$, $G_{(P2)} < \overline{\overline{G}}_L$ holds. Since the subsets of *G* values deriving from (8) and (12) are not disjoint, then a pooling equilibrium is found where the high-cost type finds it profitable to signal. Consider again the example where a=20, b=2, c_L=2, c_2=5, c_H=12. For any $\alpha \geq \overline{\alpha} = 0.89$, there is a pooling equilibrium where both types play *F*. Let α=0.9. Easy computation yields that (11) and (12) imply that 9.4≤*G*≤9.6, while (8) implies that 0.1<*G*≤24.5. Thus, the pooling equilibrium always introduces the specified distortions compared to complete information.

Remark 1. The pooling equilibrium generally survives the intuitive criterion.

The proof is in Appendix B, where we show that the low-cost type never deviates as long as $\overline{\overline{G}}_L \geq G_{(P1)}$. In such a case, the pooling equilibrium is a refined equilibrium, with δ=0 (the separating equilibrium trivially satisfies the intuitive criterion, since there are not off-the-equilibrium information sets). In the usual numerical example, we find that $\overline{\overline{G}}_L$ =24.5>$G_{(P1)}$=9.6. Consequently, the pooling equilibrium survives the intuitive criterion.

To sum up, in a pooling equilibrium the low-cost type gains her complete information profits, while the high-cost type possibly distorts her choice away from her optimal action with complete information to conceal her nature. In particular, the high-cost type invests abroad, whereas under complete information she would give up international expansion. Consequently, the foreign firm stays in his country even when the home firm is high-cost[14].

3.4. COMPARISON OF SEPARATING WITH POOLING EQUILIBRIA

We can obtain that $G_{(P1)} \leq G_{(S2)}$ always holds. This condition suffices to conclude that the pooling equilibrium exists for low values of *G* and the separating equilibrium exists for high values of *G*, while we cannot find any subset of *G* values for which there exist both of the discussed equilibria. We can state the following remarks.

Remark 2. Incomplete information plays an essential role in determining firms' choices.

If it is common knowledge that firm 1 is high-cost (low-cost) then we have the foreign (home) firm's unilateral expansion. With incomplete information, this is preserved only in a separating equilibrium where investing abroad is not profitable to c_H (i.e., if *G* is high). In a pooling equilibrium, there is firm 1's unilateral expansion even if she is high-cost.

Remark 3. We cannot identify a simple monotonic relationship between plant-specific fixed costs and firms' international expansion modes.

We expect that, as *G* decreases, a firm switches from staying in the domestic country to investing abroad. However, when *G* is low, strategic interaction under asymmetric information gives the counter-intuitive solution where firm 2 gives up expansion. When *G* is low, firm 1 invests abroad independent of her type and keeps firm 2 uninformed (pooling equilibrium). Hence, firm 2 does not expand abroad even when he would face a high-cost

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[14] Likewise, Herander and Kamp (2003) show that a high-cost domestic firm may expand output to mimic the low-cost one and deter entry by an uninformed foreign firm, which would occur under complete information.

rival. Conversely, if G is high enough then there is a separating equilibrium where firm 2 (but not the high-cost type) invests abroad. Thus, when the home firm is high-cost, we observe the foreign firm's unilateral expansion for high values of G, but not for low values of G (where the situation is reversed and we observe the home firm's unilateral expansion).

3.5. WELFARE ANALYSIS

In a separating equilibrium, the low-cost type may have to signal to credibly communicate her nature. When type c_L invests abroad instead of staying in her country (as in Section 3.2), she induces higher competition in the host country than under full information. Hence, the aggregate level of sales is higher and price is lower in the host country. Thus, under incomplete information consumer surplus (in country B and at the world level) gets higher at the first stage. Since firm 2's action at the second stage is always the same as the one under complete information, then consumer surplus is not subject to further changes.

In a pooling equilibrium, when type c_H invests abroad instead of staying in her country (Section 3.3), she induces higher competition in country B, so that consumer surplus at the first stage gets higher. Because firm 2 cannot infer her type, he stays in his country instead of investing abroad. Since this induces lower competition in country A, then consumer surplus decreases at the second stage. The net effect is ambiguous and depends on model parameters. If $c_2<c_H$, then consumer surplus at the world level gets worse because the less efficient firm 1 is expanding abroad at the expense of the more efficient firm 2[15].

Remark 4. In a separating equilibrium, consumer surplus is not lower than under complete information. In a pooling equilibrium, we cannot find any definite relationship.

[insert Table 4 about here]

[15] In Table 4, the notation +, - or = indicates that consumer surplus under incomplete information is higher than, lower than or equal to the one under complete information (in each country and at the world level).

4. THE EXPORTING OPTION

In this section, we assume that both firms may either export or stay in their own countries.

4.1. BENCHMARK CASE: COMPLETE INFORMATION

By setting either α=1 (if c_k=c_L) or α=0 (if c_k=c_H) in Table 3, it follows that:

$$\pi_2(U,E) \geq \pi_2(U,N) \Leftrightarrow s \leq \frac{a+c_k}{2} - c_2 = \bar{s}_k, \quad U = E,N; \;\; k = L,H \tag{13}$$

$$\pi_1(E,V) \geq \pi_1(N,V) \Leftrightarrow s \leq \frac{a+c_2}{2} - c_k = \bar{\bar{s}}_k, \quad V = E,N; \;\; k = L,H\ , \tag{14}$$

where (13) and (14) actually derive from the feasibility constraints on quantities. Thus, firm 1 plays *E* if (14) holds, both if $s \leq \bar{s}_k$ (so that firm 2 also plays *E*) and if $s > \bar{s}_k$ (so that firm 2 plays *N*), where $\bar{s}_k \geq \bar{\bar{s}}_k \Leftrightarrow c_k \geq c_2$, $k = L,H$. If $c_L \leq c_2 \leq c_H$, then $\bar{s}_L < \bar{\bar{s}}_L$ and $\bar{s}_H > \bar{\bar{s}}_H$. Hence, when firm 1's unit cost is c_L (c_H), we can obtain what follows:

- if $s \leq \bar{s}_L$ ($s \leq \bar{\bar{s}}_H$), then both firms decide to export;
- if $\bar{s}_L < s \leq \bar{\bar{s}}_L$ ($\bar{\bar{s}}_H < s \leq \bar{s}_H$), then there is the unilateral expansion of firm 1 (firm 2);
- if $s > \bar{\bar{s}}_L$ ($s > \bar{s}_H$), then both firms do not expand abroad.

4.2. SEPARATING EQUILIBRIA

Consider a separating equilibrium where c_L plays *E* and c_H plays *N*. Bayes-consistency then implies γ=1, δ=0. The necessary conditions for this equilibrium can be expressed as:

$$\pi_L(E,N) \geq \tilde{\pi}_L(N,E) \tag{15}$$

$$\tilde{\pi}_H(E,N) \leq \pi_H(N,E) \tag{16}$$

Their interpretation is quite similar to that of (4) and (5), with exports replacing direct investment. Simple manipulation of Table 3 enables us to rearrange (15) and (16), so that:

$$s_{(S4)} = (a + c_2 - 5c_H/3 - c_L/3) - \sqrt{M}/6 \leq s \leq (a + c_2 - c_H/6 - 11c_L/6) - \sqrt{N}/6 = s_{(S3)} \qquad (17)$$

(M, N>0), where $M = 9a^2 + 36c_2(2a + c_2) - 6c_H(13a + 22c_2) + 94c_H^2 - 2c_L(6(a + c_2) - 11c_H) + c_L^2$ and $N = 9a^2 + 4(3c_2 - c_H)(6a + 3c_2 - c_H) - 2c_L(33a + 60c_2 - 20c_H) + 73c_L^2$.

Extensive numerical simulations carried out in the whole feasible region of parameter values show that there is not a subset of s values that is compatible with (17).

Remark 5. The separating equilibrium with unilateral exports by type c_L does not exist[16].

It follows that exporting is a weak signal that can easily be mimicked by type c_H. Although it is perfectly conceivable that the sunk costs of investing abroad transmit private information more effectively than the variable export costs, we remark that the separating equilibria usually found in signalling models are associated with variable signalling costs.

4.3. Pooling equilibria

In a pooling equilibrium where both types play E, Bayes-consistency of beliefs implies that γ=α. To fix ideas and keep things interesting, consider the following situation:

(v) the foreign firm's beliefs are such that, if both rival's types play E, he replies by N;

(vi) the equilibrium industry structures under complete information are (E,N) with the low-cost home firm and (N,E) with the high-cost home firm (see footnote 12).

From Section 4.1, we can derive that (vi) holds if the following condition is satisfied:

$$\bar{\bar{s}}_H < s \leq \bar{\bar{s}}_L\,. \qquad (18)$$

The necessary conditions for the pooling equilibrium can be expressed as follows:

$$\pi_H(E,N) \geq \pi_H(N,E) \qquad (19)$$

$$\bar{\pi}_2(E,N) \geq \bar{\pi}_2(E,E) \qquad (20)$$

[16] Appendix C contains a formal proof of this result under the (often employed) simplifying assumption that firm 2 learns his rival's type after entry.

Their interpretation is quite similar to that of (9) and (10), provided that the export choice replaces direct investment, and similar restrictions may be imposed on out-of-equilibrium beliefs. Simple computations based on Table 3 enable us to rearrange (19) so that:

$$s \le a + c_2 - 5c_H/3 - \bar{c}/3 - \sqrt{Z}/6 = s_{(P3)}\,, \tag{21}$$

where $Z = 9a^2 + (\bar{c} - 6c_2)[\bar{c} - 6(2a + c_2)] - 2c_H(39a - 11\bar{c} + 66c_2) + 94c_H^2$ (Z>0), and (20) so that:

$$s \ge \left(a + \bar{c} - 2c_2\right)/2 = s_{(P4)}\,. \tag{22}$$

As $\alpha \to 0$, $s_{(P3)}$ approaches $\bar{\bar{s}}_H$ from above, while $s_{(P4)}$ approaches $\bar{s}_H$ from below (with $\partial s_{(P4)}/\partial\alpha = -(c_H - c_L)/2 < 0$). Both (21) and (22) imply that private information provides type c_H with a competitive advantage, since, compared to full information, she is able to export for higher values of s, while firm 2 gives up exports for lower values of s. Constraints (21) and (22) are compatible if α and a are high enough. Let a=60, c_L=2, c_2=5, c_H=12, α=0.9. Then, (21) and (22) require $26.5 \le s \le 35.2$, while (18) requires $20.5 < s \le 30.5$. If $26.5 \le s \le 30.5$, then in the pooling equilibrium firm 2 does not export even if firm 1 is high-cost, since the latter conceals her type by exporting (while with full information she would give up expanding abroad). Welfare implications are the same as those in Section 3.5.

5. INTERNATIONAL EXPANSION MODE CHOICE

Let us examine the three-choice model where firms may invest abroad, export, or stay in their countries. We intend to prove that the main unconventional results of the two-choice model are not diluted, but even strengthened in this general setting. For this purpose, rather than characterizing all the *PBE* of the game, we discuss some relevant cases where the standard full-information relationships between technology/market conditions and entry modes no longer hold. This in turn suggests that trade policy should take due account of the information structure. We relegate the benchmark full-information case to Appendix D.

5.1. SEPARATING EQUILIBRIA

Consider a separating equilibrium where c_L plays *F* and c_H plays *N*. The necessary conditions for such equilibrium can be formulated as follows:

$$\pi_L(F,N) \geq \tilde{\pi}_L(N,E) \tag{23}$$

$$\tilde{\pi}_H(F,N) \leq \pi_H(N,E) \tag{24}$$

as long as the following conditions also hold: (25) $\tilde{\pi}_L(E,E) \leq 0$; and (26) $\pi_H(E,E) \leq 0$.

Conditions (25) and (26) ensure that both types never find it profitable to deviate by *E*. Both of them hold as long as $s \geq \hat{\hat{s}}_{LH} = (2a - c_H + 2c_2 - 3c_L)/4$, where $\hat{\hat{s}}_{LH}$ is the transport cost value for which c_L makes zero profit when she plays *E* and is perceived as c_H. Conditions (23) and (24) imply that each type prefers playing her equilibrium action rather than deviating and being mistaken for the other type. Both of them hold as long as $G_{(S6)}(s) \leq G \leq G_{(S5)}(s)$, where $G_{(S6)}(s) = \dfrac{X - Y + c_L^2 - 2c_L(2a - 3c_H) - 2c_H(7a - c_H - 8s)}{36b}$ and $G_{(S5)}(s) = \dfrac{X - Y - c_H^2 - 2c_L(11a - 8c_L - 6s) + c_H(4(a+s) - 6c_L)}{36b}$, with $X = (9a^2 - 8as - 4s^2)$ and $Y = 4c_2(2s - c_H + c_L)$. At the equilibrium, after observing *F* (i.e., when firm 1 is low-cost) firm 2 plays *N*, so that both $s > \hat{s}_L$ and $G > \hat{G}_L(s)$ must hold; after observing *N* (firm 1 is high-cost) firm 2 plays *E*, so that both $s \leq \hat{s}_H$ and $G > \hat{G}_H(s)$ must hold. Thus, the binding constraints for firm 2's actions to be the equilibrium actions are $\hat{s}_L < s \leq \hat{s}_H$ and $G > \hat{G}_H(s)$.

To sum up, the separating equilibrium exists if and only if the following conditions are fulfilled: (27) $\max\left\{\hat{\hat{s}}_{LH}, \hat{s}_L\right\} \leq s \leq \hat{s}_H$; (28) $G_{(S6)}(s) \leq G \leq G_{(S5)}(s)$; and (29) $G > \hat{G}_H(s)$.

Finally, we may restrict the above conditions so that the separating equilibrium has a signalling value, because the low-cost type distorts her choice compared with complete information. Let the equilibrium industry structures under full information be: (vii) (*E*,*N*) with type c_L; and (viii) (*N*,*E*) with type c_H. Both (vii) and (viii) hold if $\hat{s}_L < s \leq \hat{\hat{s}}_L$ and $G > \hat{G}_H(s)$. It follows that the separating equilibrium exists and introduces the specified distortions as long as (28) and (29) hold together with condition (30): $\max\left\{\hat{\hat{s}}_{LH}, \hat{s}_L\right\} \leq s \leq \hat{\hat{s}}_L$.

In Appendix D, we find that $\partial \hat{G}_L(s) / \partial s > 0$. Thus, under full information when s rises the low-cost type is more inclined to invest abroad. Since we find that $\partial G_{(S5)}(s) / \partial s < 0$ then, quite interestingly, this relationship is reversed under asymmetric information, where an increase in s restricts the subset of G values for which type c_L invests abroad. The rationale is that, if s rises then (given that firm 2 still exports) type c_L gets a higher profit from deviating from equilibrium, so that she has a lower incentive to signal her type.

It emerges that firms' entry modes are not univocally associated with the available technology. Empirical studies either support or invalidate the claim that higher transport costs encourage foreign direct investments to the detriment of exports, depending on circumstances. We suggest that oligopolistic interaction under asymmetric information plays an important role, to the extent that these different findings have to be motivated.

We also obtain that $\partial G_{(S6)}(s) / \partial s < 0$ and $\partial\left(G_{(S5)}(s) - G_{(S6)}(s)\right) / \partial s < 0$. Hence, an increase in s reduces the scope for the separating equilibrium. Since $\partial \hat{G}_H(s) / \partial s > 0$ (see Appendix D) then we may find a value of $s \leq \hat{\hat{s}}_L$ above which $\hat{G}_H(s) > G_{(S5)}(s)$, so that the equilibrium no longer exists. Consider the example where a=20, b=2, c_L=2, c_2=5, c_H=12. Calculation yields that (30) implies 8≤s≤10.5, but, if $s \geq 10.2$ then $\hat{G}_H(s) \geq G_{(S5)}(s)$, and there is not the equilibrium. For simplicity, let $s = 9$. Hence, (28) and (29) imply 26≤G≤30.3. Conditions

(vii) and (viii) require $6 \leq s \leq 10.5$ and (if $s = 9$) $G > 26$. Hence, when the separating equilibrium exists, it introduces the specified distortions compared with full information.

5.2. *POOLING EQUILIBRIA*

Consider now a pooling equilibrium where both types play *F* and prior beliefs are such that firm 2 plays *E*. The necessary conditions for such equilibrium can be stated as follows:

$$\pi_H(F,E) \geq \pi_H(E,F) \tag{31}$$

$$\overline{\pi}_2(F,E) \geq \overline{\pi}_2(F,F) \tag{32}$$

as long as the following conditions also hold: (33) $\pi_H(E,F) \geq 0$; and (34) $\overline{\pi}_2(F,E) \geq 0$.

Conditions (33) and (34) ensure that type c_H and firm 2 never find it profitable to deviate by *N*. Both of them hold when $s \leq \hat{\hat{s}}_H$. Condition (31) implies that c_H prefers *F* than her full-information action, while (32) implies that firm 2's expected profit is higher when he plays *E*. Both of them hold if $G_{(P6)}(s) \leq G \leq G_{(P5)}(s)$, where $G_{(P6)}(s) = \dfrac{4s\left(a + \overline{c} - 2c_2 - s\right)}{9b}$ and $G_{(P5)}(s) = \dfrac{\overline{c}^2 - 2\overline{c}\left(2a + 2c_2 - 3c_H + s\right) + 4c_2\left(c_H + 3s\right) + c_H\left(4a - 7c_H - 22s\right) + 6s\left(2a - s\right)}{18b}$. Conditions (31) and (32) are mutually compatible if $\alpha \geq \breve{\alpha} = \dfrac{\sqrt{Z} - \left(2a + 2c_2 - 4c_H + 5s\right)}{(c_H - c_L)}$, where $Z = 4a^2 + 16as + 23s^2 + 4c_2(2a + c_2 - 2s) - 8c_H(2a + 2c_2 + s) + 16c_H^2$ ($Z > 0$).

To sum up, the pooling equilibrium exists when the following conditions are met[17]: (35) $s \leq \hat{\hat{s}}_H$; (36) $G_{(P6)}(s) \leq G \leq G_{(P5)}(s)$; and (37) $\alpha \geq \breve{\alpha}$.

We may restrict the above conditions so that in the pooling equilibrium the high-cost type distorts her full-information action. Let the equilibrium industry structures under

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[17] Provided that off-the-equilibrium beliefs are such that firm 2 competes as firm 1 is high-cost, these conditions are necessary and sufficient and the equilibrium survives the intuitive criterion.

complete information be: (ix) (F,E) with type c_L; and (x) (E,F) with type c_H. Both (ix) and (x) hold if $s \le \hat{\hat{s}}_H$ and $\hat{G}_L(s) < G \le \hat{\hat{G}}_L(s)$. Since $G_{(P6)}(s) > \hat{G}_L(s)$, then the pooling equilibrium exists and introduces the specified distortions when (35) and (37) hold together with condition (38): $G_{(P6)}(s) \le G \le \min\left\{G_{(P5)}(s), \hat{\hat{G}}_L\right\}$[18].

Consider again the example where a=20, b=2, c_L=2, c_2=5, c_H=12. Calculation yields that (35) implies s≤0.5, while (37) implies $\alpha \ge \breve{\alpha} = \left(\sqrt{4+23s(8+s)} - 5s - 2\right)/10$. For simplicity, let $s = 0.45$, so that $\alpha \ge \breve{\alpha} = 0.53$ must hold. If $\alpha = 0.6$, then (38) requires $1.6 \le G \le 1.9$. Conditions (ix) and (x) under complete information require s≤0.5 and (when $s = 0.45$) 1.2<G≤2.1. It follows that, when the pooling equilibrium exists, it always introduces the specified distortions compared with complete information.

It emerges that *information* can be seen as a virtual input enabling a firm to offset the superior physical production factors in the rivals' hands. Hence, privately informed high-cost firms may expand abroad better than uninformed low-cost firms. In this sense, even the high-cost firm's expansion may be rationalized as an exploitation of her ownership advantage, rather than as an effort to gain new technology. On the other hand, empirical findings highlight that the lack of information may curb innovative firms' international activities (Mutinelli and Piscitello, 1998). Actually, those firms adopt a risk-minimizing export choice even when investing would be the preferable option with full information.

5.3. *Welfare analysis and policy implications*

Compared with full information, the separating (pooling) equilibrium entails the low-cost (high-cost) type replacing exports with a direct investment, thus adopting a strategy

[18] Since $\hat{\hat{s}}_H < \hat{s}_L$, then the separating and pooling equilibria in sections 5.1 and 5.2 cannot jointly exist.

commonly known as tariff-jumping. Given the basic model parameters, tariff-jumping can thus be solely imputed to the information structure of the game. However, it is worth noting that asymmetric information also deters tariff-jumping. Actually, in the pooling equilibrium the foreign firm is prevented from unilaterally investing abroad, which would occur with full information and a high-cost type[19].

While we have not explicitly considered the role regulators might play in designing mechanisms to govern firms' entry modes, the results obtained provide useful insights to draw some policy implications. Quite interestingly, these are often not aligned with the conventional analysis of trade policy with endogenous location under full information.

Let us consider a tariff policy that prevents tariff-jumping under full information. This same policy produces socially beneficial effects in the separating equilibrium, because it induces tariff-jumping by the efficient low-cost type. This in turn determines stronger competition, both in country *B* and at the world level. On the other hand, consider a tariff policy that, under full information, correctly induces tariff-jumping by the low-cost (but not the high-cost) type. This same policy is socially detrimental in the pooling equilibrium, because it produces opposite effects. Indeed, it induces tariff-jumping by the high-cost type, while preventing tariff-jumping by the foreign firm, which has lower costs. This inevitably reduces the total output sold, and thus consumer surplus at the world level.

It follows that the welfare effects of tariff-jumping under asymmetric information may be positive or negative, depending on whether the separating or the pooling equilibrium is realized. If tariff-jumping is the policy goal, then under asymmetric information this is not necessarily achieved by raising the import tariff level. Actually, this policy option does not enlarge, but even reduces the scope for tariff-jumping by the low-cost type in the

[19] Herander and Kamp (2003) also describe a pooling equilibrium where tariff-jumping no longer holds.

separating equilibrium. Hence, to reach this goal, it may be more appropriate to directly adjust the location costs of a subsidiary abroad.

Since an inward investment strengthens competition in the host country, the local government might aim at attracting new firms by lowering lump-sum taxes or granting subsidies to facilitate entry. However, this policy makes it also easier that the high-cost type invests abroad (thus mimicking the low-cost one), so that the local firm is prevented from investing abroad even though he has a competitive (technological) advantage. Consequently, the local government may either impose taxes, or grant subsidies to investing firms, depending on the set-up cost of a direct investment. If this cost is small, then the government may impose a tax aimed at preventing entry by the high-cost type (but not so large as to impede entry by the low-cost one), while, if it is large, then the government may provide a subsidy to assist entry by the low-cost type (but not such as to allow entry by the high-cost one). Note that this policy perfectly complies with the welfare goals of a supranational agency that allows (prevents) entry of efficient (inefficient) firms.

In contrast to most recent papers in strategic trade policy (see e.g. Fumagalli, 2003), but in line with some relevant signalling models (Bagwell and Staiger, 2003; Haucap, Wey and Barmbold, 2000), we find that moderate to high location costs might be socially beneficial (in the host country and at the world level), if the low-cost firm's decision of locating abroad allows her to effectively transmit cost information to her foreign rival.

6. CONCLUSIONS

We have shown that firms' international expansion modes depend on strategic interaction and the information structure, so that they cannot be simply explained by technology and market conditions, as in the traditional literature on multinationals. The results obtained justify on a theoretical ground several controversial empirical findings about the effects of plant-specific costs, transport costs and market sizes on firms' investment decisions.

Private information about technology is a firm's ownership advantage that affects equilibrium industry structures. Then, in some circumstances, high-cost firms with an information advantage, rather than uninformed low-cost firms, may successfully expand abroad. Actually, empirical evidence confirms that the lack of information may limit the international activities of innovative, efficient firms.

The signalling motivation for international expansion implies that firms may even enter unprofitable markets. Low-cost firms thus reveal their cost information and deter counter-entry, while high-cost firms strengthen their competitive position by concealing their information through uninformative signalling. In this sense, the value of a firm's expansion mode as an effective signal is higher if entry is based on a direct investment than on export. In fact, if signalling requires incurring sunk costs, then it tends to be a more effective entry-deterrence strategy than if it is only related to variable costs. Clearly, the home firm always retains the option of increasing output in her domestic country as an alternative, less costly, signalling device. However, we have shown that this option may be dominated by signalling through foreign activity, even when the home firm's opportunity cost due to the lost profit in the rival's country is lower than the avoided entry cost.

The low-cost type's expansion produces social benefits if it effectively transmits cost information to the foreign firm (i.e., in a separating equilibrium), even if counter-entry is prevented. If an inefficient firm invests abroad, thus sending an uninformative signal (i.e., in a pooling equilibrium), then social welfare may decrease, since the monopoly problem in her own country is artificially exacerbated. Hence, moderate to high location costs might be socially beneficial (in the host country and at the world level), if they allow the low-cost type pursuing a different international expansion strategy from the high-cost counterpart.

These results may help understanding of the effects of incomplete information on firms' international expansion modes and the related welfare implications. However, the proposed model is fairly stylized. Above all, it is static in nature. Otherwise, the home firm should keep on distorting her output to maintain the rival's beliefs such that counter-entry does not occur even in the long run, and this should be accounted for in the signalling cost. Thus, in a dynamic setting, the high-cost type may not be able to fool the rival by investing abroad. If the foreign firm learns her type *ex post* (after the static game has been played), then he invests in country A, independent of her strategy. However, since the high-cost type has already sunk her investment abroad, she can keep on operating profitably in country B. Under complete information, only the foreign firm would expand abroad. Therefore, the high-cost type has a dynamically sustainable benefit[20].

Future work should further investigate on the robustness of the results. First, the model assumes a structured order of actions, such that the informed party has the first-mover advantage. Provided that the information structure remains unaltered, endogenizing the timing of entry does not necessarily diminish the validity of the results obtained. On the one hand, if firm 2 decides to act as the first-mover, his entry mode may be the same as the one chosen by the uninformed firm 2 in the pooling equilibrium (where observing his rival's move does not provide firm 2 with further information about his rival's type). On the other hand, the high-cost type's signalling incentive may even be strengthened as long as failure to enter her rival's market first (and thus deter counter-entry) implies failure to enter that market at all (and the resulting loss of monopoly in her country).

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[20] The rationale for the high-cost type's expansion is also dynamically preserved if: i) symmetric multi-market contact provides firms with enough incentives to collude, or ii) she benefits from localised spillovers.

Second, there could be more realism in assuming a two-sided asymmetric information context, where each firm does not observe the rival's cost. While this complicates the quantitative analysis, the qualitative results would not be critically affected. Actually, the home firm's signalling incentive depends not so much on observing her rival's type, as on her benefits from preventing counter-entry. Thus, knowing that firm 2 is less efficient may strengthen the low-cost type's motive to invest abroad, but, concurrently, the high-cost type may expand (to conceal her type) even if she knows that firm 2 is more efficient.

Third, the intensity of competition could matter for the results. We have assumed a quantity-setting context where firms initially enjoy a monopoly in their own countries. Bertrand competition would raise a firm's cost of engaging in a sub-optimal international expansion, but, at the same time, would increase the benefits from protecting market power in the domestic country. In a price-setting regime, the low-cost type's incentive to reveal might be strengthened by the prospect of gaining monopoly in country 2. Similarly, the high-cost type might have a stronger incentive to conceal her nature, to avoid being foreclosed in her own country. Thus, we conjecture that, if firms compete *à la* Bertrand, there is still scope for either credible or uninformative signalling through international activity. Conversely, if domestic industries are oligopolies rather than monopolies, then quantity-setting firms would incur a higher signalling cost in expanding abroad, and achieve lower gains from preventing entry. Hence, firms could be less motivated to signal.

Fourth, since in our model the home firm can only choose between a direct investment and exports, then we can enrich her signalling possibilities by endogenizing the amount to be spent in investing abroad. Alternatively, this can provide uninformed local governments with a screening mechanism to lead firms' entry decisions. Since we have analyzed how some relevant *PBE* are sensitive to the exogenously given value of location costs, then we have been able to partially capture these dimensions even in our simplified model.

Clearly, the signalling motive for international expansion should only be regarded as a complement to the prevailing explanations in the literature. As such, the results obtained here seem to provide firms' strategies with a grounded rationale in those cases where existing theories are not definitely compelling with empirical findings.

APPENDIX A

A home firm's strategy is a function specifying which action $U(c_k) \in M$ is selected for each type nature draws ($k=L,H$). A foreign firm's strategy specifies which action $V[U(c_k)] \in M$ is selected for each rival's action. A pure-strategy *PBE* of the signalling game is a pair of strategies $U^*(c_k)$, $V^*[U(c_k)]$ and a belief $\Pr(c_k|U)$ satisfying the following requirements.

Requirement 1. After observing any home firm's move $U \in M$, the foreign firm updates his beliefs about the home firm's type, according to the probability distribution $\Pr(c_k|U)$, where $\Pr(c_k|U) \geq 0$ for each c_k ($k=L,H$) and $\sum_k \Pr(c_k \mid U) = 1$.

Requirement 2 (*foreign firm*). Given his beliefs $\Pr(c_k|U)$, for each $U \in M$ the foreign firm chooses his expected payoff-maximizing action. Thus, $V^*[U(c_k)]$ solves:

$$\max_{V \in M} \overline{\pi}_2(U,V) = \sum_k \Pr(c_k \mid U) \cdot \pi_2(c_k, U, V).$$

Requirement 2 (*home firm*). Given the foreign firm's optimal strategy $V^*[U(c_k)]$, for each c_k ($k=L,H$) the home firm selects her payoff-maximizing action. Thus, $U^*(c_k)$ solves:

$$\max_{U \in M} \ \pi_1(c_k, U,\ V^*[U(c_k)]) .$$

Requirement 3. For each $U \in M$, if there exists a type c_k ($k=L,H$) such that $U^*(c_k)=U$, then the foreign firm's beliefs at the information set following U are derived from Bayes' rule and the home firm's equilibrium strategy:

$$\Pr(c_k \mid U) = \frac{\Pr(c_k) \cdot \Pr(U \mid c_k)}{\sum_k \Pr(c_k) \cdot \Pr(U \mid c_k)} .$$

To trim the set of possible equilibria, we use the *intuitive criterion* (Cho and Kreps, 1987)[21]. Given a *PBE* of the game, action $U \in M$ is *equilibrium-dominated* for type c_k ($k=L,H$) if c_k's equilibrium payoff is greater than c_k's highest possible payoff from U, that is, if $\pi_1[U^*(c_k)] > \max_{V \in M} \pi_1(c_k, U, V)$. A *PBE* is *refined* if it satisfies Requirements 1 to 4.

Requirement 4. If the information set following $U \in M$ is off the equilibrium path and U is equilibrium-dominated for type c_k, then $\Pr(c_k|U)=0$ (provided that U is not equilibrium-dominated for all types).

APPENDIX B

If the pooling equilibrium on F exists, then $\alpha \geq \overline{\alpha}$. For simplicity, let $\alpha \to 1$. A sufficient condition for type c_L to play her equilibrium strategy is $\pi_L(F,N) \geq \pi_L(N,N)$, since, if type c_L deviates, she gains $\pi_L(N,N)$ at the most. This implies $G \leq \frac{(a+c_2-2c_L)^2}{9b} = \overline{\overline{G}}_L$. Since $\overline{\overline{G}}_L \geq G_{(P2)}$, there is a subset of G values ($G_{(P2)} < G \leq \overline{\overline{G}}_L$) for which type c_L surely does not deviate. If $\overline{\overline{G}}_L \geq G_{(P1)}$, then type c_L never deviates. Type c_H plays her equilibrium strategy if $\pi_H(F,N) \geq \pi_H(N,N)$, since, if type c_H deviates, she gains $\pi_H(N,N)$ at the most. This implies $G \leq \frac{(3c_H + c_L - 2a - 2c_2)^2}{36b} = \breve{G}_H$. If $c_H > 3c_2 - 2c_L$ and $a \geq 2c_H - c_2$, then $\breve{G}_H < G_{(P2)}$. Depending on out-of-equilibrium beliefs, type c_H may deviate, so that, if N is unexpectedly observed, then it should have been played by type c_H. The intuitive criterion prescribes $\delta=0$, consistent with out-of-equilibrium beliefs supporting the equilibrium in Section 3.3.

[21] Although there may exist some stronger refinement concepts (like the Banks-Sobel divinity and universal divinity), we have used this criterion because: i) with only two types, stronger concepts are rarely more effective; and ii) the divinity criteria reduce their bite when mixed strategies are not allowed (Fudenberg and Tirole, 1991). Since it is the most popular criterion, then it also eases comparison with other relevant papers.

APPENDIX C

Let us assume that firm 2 learns his rival's type after entry, so that the post-entry Cournot duopoly game takes place under full information. It follows that condition (17) reduces to:

$$s_{(S4)}=(a+c_2-2c_H)-\frac{1}{2}\sqrt{4(a+c_2-2c_H)^2-3(a-c_H)^2}\leq s\leq(a+c_2-2c_L)-\frac{1}{2}\sqrt{4(a+c_2-2c_L)^2-3(a-c_L)^2}=s_{(S3)}.$$

Let A_L= $4(a+c_2-2c_L)^2-3(a-c_L)^2$ and A_H= $4(a+c_2-2c_H)^2-3(a-c_H)^2$, with $A_L \geq A_H$. Clearly, (17) cannot be met if $s_{(S3)}<s_{(S4)}$, that is, if $\left(\sqrt{A_L}-\sqrt{A_H}\right)>4\left(c_H-c_L\right)$. If $c_2\geq c_L$, then A_L>0. Conversely, A_H may be negative, and, if it is required that $A_H \geq 0$, then $s_{(S3)}<s_{(S4)}$. The worst case for $A_H \geq 0$ is when c_2 is minimum (i.e., $c_2=c_L$). For simplicity, let c_2=c_L=0. Then, A_L=a^2 and A_H= $a^2+13c_H^2-10ac_H$, where $A_H \geq 0$ if $a\geq(5+2\sqrt{3})c_H$[22], with $\frac{\partial A_H}{\partial a}\geq 0$ for $a\geq 5c_H$. However, $\lim_{a\to\infty}\left(\sqrt{A_L}-\sqrt{A_H}\right)=5c_H>4\left(c_H-c_L\right)$, so as if a is high enough for $\sqrt{A_H}$ to be real, then the separating equilibrium does not exist. Since $\frac{\partial A_H}{\partial c_2}\geq 0$, the best possible case for $A_H \geq 0$ is when c_2 is maximum (i.e., $c_2=c_H$), with A_L= $4(a+c_H-2c_L)^2-3(a-c_L)^2$, and $A_H=(a-c_H)^2$. By applying L'Hospital's rule, we obtain that $\lim_{c_L\to c_H}\frac{\left(\sqrt{A_L}-\sqrt{A_H}\right)}{(c_H-c_L)}=5>4$. Since $s_{(S3)}<s_{(S4)}$ is still valid, then the separating equilibrium cannot be found.

APPENDIX D

Let us solve the three-choice model in the benchmark case with complete information. By setting either α=1 (if c_k=c_L) or α=0 (if c_k=c_H) in Table 3, we obtain that:

$$\pi_2(U,F)\geq\pi_2(U,E)\Leftrightarrow G\leq\frac{4s(a+c_k-2c_2-s)}{9b}=\hat{G}_k(s),\qquad U=F,E,N;\;\; k=L,H$$

[22] Indeed, $A_H \geq 0$ also holds if $a\leq(5-2\sqrt{3})c_H$, but this is unfeasible, since, if c_2=0, then $a\geq 2c_H$ must hold.

$$\pi_2(U,E) \geq \pi_2(U,N) \Leftrightarrow \pi_2(U,E) \geq 0 \Leftrightarrow s \leq \frac{a+c_k-2c_2}{2} = \hat{s}_k, \quad U = F,E,N; \;\; k = L,H$$

$$\pi_1(F,V) \geq \pi_1(E,V) \Leftrightarrow G \leq \frac{4s(a+c_2-2c_k-s)}{9b} = \hat{\hat{G}}_k(s), \quad V = F,E,N; \;\; k = L,H$$

$$\pi_1(E,V) \geq \pi_1(N,V) \Leftrightarrow \pi_1(E,V) \geq 0 \Leftrightarrow s \leq \frac{a+c_2-2c_k}{2} = \hat{\hat{s}}_k, \quad V = F,E,N; \;\; k = L,H$$

where $\hat{G}_k(s) \geq \hat{\hat{G}}_k(s) \Leftrightarrow c_k \geq c_2$, with $\frac{\partial \hat{G}_k(s)}{\partial s} > 0$ and $\frac{\partial \hat{\hat{G}}_k(s)}{\partial s} > 0$ as long as firms get positive profits from exports, and $\hat{s}_k \geq \hat{\hat{s}}_k \Leftrightarrow c_k \geq c_2$ ($k = L,H$). Let $c_L \leq c_2 \leq c_H$. Therefore, when firm 1's unit cost is c_L (c_H), we obtain that:

- if $G \leq \hat{G}_L(s)$ ($G \leq \hat{\hat{G}}_H(s)$), then both firms make a direct investment abroad;
- if $\hat{G}_L(s) < G \leq \hat{\hat{G}}_L(s)$ ($\hat{\hat{G}}_H(s) < G \leq \hat{G}_H(s)$), then we find that:
  - if $s > \hat{s}_L$ ($s > \hat{\hat{s}}_H$), then firm 1 (firm 2) unilaterally invests abroad;
  - if $s \leq \hat{s}_L$ ($s \leq \hat{\hat{s}}_H$), then firm 1 (firm 2) invests while firm 2 (firm 1) exports;
- if $G > \hat{\hat{G}}_L(s)$ ($G > \hat{G}_H(s)$), then we find that:
  - if $s \leq \hat{s}_L$ ($s \leq \hat{\hat{s}}_H$), then both firms export;
  - if $\hat{s}_L < s \leq \hat{\hat{s}}_L$ ($\hat{\hat{s}}_H < s \leq \hat{s}_H$), then firm 1 (firm 2) unilaterally exports;
  - if $s > \hat{\hat{s}}_L$ ($s > \hat{s}_H$), then both firms do not expand abroad at all.

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FIRM 2 / FIRM 1	F	E	N
F	$\Pi_1 = (a-b(q_{1A}+q_{2A}))q_{1A} + (a-b(q_{1B}+q_{2B}))q_{1B} + -c_k(q_{1A}+q_{1B}) - G$ $\bar{\pi}_2 = \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1A}^k+q_{2A}\right)\right]q_{2A} - c_2q_{2A}\right) + + \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1B}^k+q_{2B}\right)\right]q_{2B} - c_2q_{2B}\right) - G$	$\Pi_1 = (a-b(q_{1A}+q_{2A}))q_{1A} + (a-b(q_{1B}+q_{2B}))q_{1B} + -c_k(q_{1A}+q_{1B}) - G$ $\bar{\pi}_2 = \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1A}^k+q_{2A}\right)\right]q_{2A} - (c_2+s)q_{2A}\right) + + \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1B}^k+q_{2B}\right)\right]q_{2B} - c_2q_{2B}\right)$	$\Pi_1 = (a-b(q_{1A}))q_{1A} + (a-b(q_{1B}+q_{2B}))q_{1B} + -c_k(q_{1A}+q_{1B}) - G$ $\bar{\pi}_2 = \sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1B}^k+q_{2B}\right)\right]q_{2B} - c_2q_{2B}$
E	$\Pi_1 = (a-b(q_{1A}+q_{2A}))q_{1A} + (a-b(q_{1B}+q_{2B}))q_{1B} + -c_k(q_{1A}+q_{1B}) - s(q_{!B})$ $\bar{\pi}_2 = \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1A}^k+q_{2A}\right)\right]q_{2A} - c_2q_{2A}\right) + + \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1B}^k+q_{2B}\right)\right]q_{2B} - c_2q_{2B}\right) - G$	$\Pi_1 = (a-b(q_{1A}+q_{2A}))q_{1A} + (a-b(q_{1B}+q_{2B}))q_{1B} + -c_k(q_{1A}+q_{1B}) - s(q_{!B})$ $\bar{\pi}_2 = \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1A}^k+q_{2A}\right)\right]q_{2A} - (c_2+s)q_{2A}\right) + + \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1B}^k+q_{2B}\right)\right]q_{2B} - c_2q_{2B}\right)$	$\Pi_1 = (a-b(q_{1A}))q_{1A} + (a-b(q_{1B}+q_{2B}))q_{1B} + -c_k(q_{1A}+q_{1B}) - s(q_{!B})$ $\bar{\pi}_2 = \sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1B}^k+q_{2B}\right)\right]q_{2B} - c_2q_{2B}$
N	$\Pi_1 = (a-b(q_{1A}+q_{2A}))q_{1A} - c_kq_{1A}$ $\bar{\pi}_2 = \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1A}^k+q_{2A}\right)\right]q_{2A} - c_2q_{2A}\right) + + \left(\left[a-b\left(q_{2B}\right)\right]q_{2B} - c_2q_{2B}\right) - G$	$\Pi_1 = (a-b(q_{1A}+q_{2A}))q_{1A} - c_kq_{1A}$ $\bar{\pi}_2 = \left(\sum_k \Pr(c_k)\cdot\left[a-b\left(q_{1A}^k+q_{2A}\right)\right]q_{2A} - (c_2+s)q_{2A}\right) + + \left(\left[a-b\left(q_{2B}\right)\right]q_{2B} - c_2q_{2B}\right)$	$\Pi_1 = (a-b(q_{1A}))q_{1A} - c_kq_{1A}$ $\Pi_2 = (a-b(q_{2B}))q_{2B} - c_2q_{2B}$

Table 1. Firms' profit functions for each possible market structure.

FIRM 2 / FIRM 1	F	E	N
F	$q_{1A}^* = \frac{2a-\bar{c}+2c_2-3c_k}{6b}$ $q_{2A}^* = \frac{a+\bar{c}-2c_2}{3b}$ $q_{1B}^* = \frac{2a-\bar{c}+2c_2-3c_k}{6b}$ $q_{2B}^* = \frac{a+\bar{c}-2c_2}{3b}$	$q_{1A}^* = \frac{2a-\bar{c}+2c_2+2s-3c_k}{6b}$ $q_{2A}^* = \frac{a+\bar{c}-2c_2-2s}{3b}$ $q_{1B}^* = \frac{2a-\bar{c}+2c_2-3c_k}{6b}$ $q_{2B}^* = \frac{a+\bar{c}-2c_2}{3b}$	$q_{1A}^* = \frac{a-c_k}{2b}$ $q_{2A}^* = 0$ $q_{1B}^* = \frac{2a-\bar{c}+2c_2-3c_k}{6b}$ $q_{2B}^* = \frac{a+\bar{c}-2c_2}{3b}$
E	$q_{1A}^* = \frac{2a-\bar{c}+2c_2-3c_k}{6b}$ $q_{2A}^* = \frac{a+\bar{c}-2c_2}{3b}$ $q_{1B}^* = \frac{2a-\bar{c}+2c_2-4s-3c_k}{6b}$ $q_{2B}^* = \frac{a+\bar{c}-2c_2+s}{3b}$	$q_{1A}^* = \frac{2a-\bar{c}+2c_2+2s-3c_k}{6b}$ $q_{2A}^* = \frac{a+\bar{c}-2c_2-2s}{3b}$ $q_{1B}^* = \frac{2a-\bar{c}+2c_2-4s-3c_k}{6b}$ $q_{2B}^* = \frac{a+\bar{c}-2c_2+s}{3b}$	$q_{1A}^* = \frac{a-c_k}{2b}$ $q_{2A}^* = 0$ $q_{1B}^* = \frac{2a-\bar{c}+2c_2-4s-3c_k}{6b}$ $q_{2B}^* = \frac{a+\bar{c}-2c_2+s}{3b}$
N	$q_{1A}^* = \frac{2a-\bar{c}+2c_2-3c_k}{6b}$ $q_{2A}^* = \frac{a+\bar{c}-2c_2}{3b}$ $q_{1B}^* = 0$ $q_{2B}^* = \frac{a-c_2}{2b}$	$q_{1A}^* = \frac{2a-\bar{c}+2c_2+2s-3c_k}{6b}$ $q_{2A}^* = \frac{a+\bar{c}-2c_2-2s}{3b}$ $q_{1B}^* = 0$ $q_{2B}^* = \frac{a-c_2}{2b}$	$q_{1A}^* = \frac{a-c_k}{2b}$ $q_{2A}^* = 0$ $q_{1B}^* = 0$ $q_{2B}^* = \frac{a-c_2}{2b}$

Table 2. Firms' optimal output levels for each possible market structure.

FIRM 1 \ FIRM 2	***F***	***E***	***N***
F	$\pi_1^* = \frac{(2a-\bar{c}+2c_2-3c_k)^2}{18b} - G$ $\pi_2^* = 2\left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)}{6}\right)\left(\frac{a+\bar{c}-2c_2}{3b}\right) - G$	$\pi_1^* = \frac{(2a-\bar{c}+2c_2+2s)^2+(2a-\bar{c}+2c_2)^2-18c_k^2}{36b} + - c_k\left(\frac{4a-2\bar{c}+4c_2+2s-6c_k}{6b}\right) - G$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)}{6}\right)\left(\frac{2a+2\bar{c}-4c_2-2s}{3b}\right) + - 2s\frac{(a+\bar{c}-2c_2-2s)}{9b}$	$\pi_1^* = \frac{(2a-\bar{c}+2c_2-3c_k)^2+9(a-c_k)^2}{36b} - G$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)}{6}\right)\left(\frac{a+\bar{c}-2c_2}{3b}\right)$
E	$\pi_1^* = \frac{(2a-\bar{c}+2c_2)^2+(2a-\bar{c}+2c_2-4s)^2-18c_k^2}{36b} + - c_k\left(\frac{4a-2\bar{c}+4c_2-4s-6c_k}{6b}\right)$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)}{6}\right)\left(\frac{a+\bar{c}-2c_2}{3b}\right) + + \left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)+2s}{6}\right)\left(\frac{a+\bar{c}-2c_2+s}{3b}\right) - G$	$\pi_1^* = \frac{(2a-\bar{c}+2c_2+2s)^2+(2a-\bar{c}+2c_2-4s)^2-18c_k^2}{36b} + - c_k\left(\frac{4a-2\bar{c}+4c_2-2s-6c_k}{6b}\right)$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)}{6}\right)\left(\frac{2a+2\bar{c}-4c_2-s}{3b}\right) + - s\frac{(a+\bar{c}-2c_2-5s)}{9b}$	$\pi_1^* = \frac{(2a-\bar{c}+2c_2-3c_k-4s)^2+9(a-c_k)^2}{36b}$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H+2s-3\alpha(c_H-c_L)}{6}\right)\left(\frac{a+\bar{c}-2c_2+s}{3b}\right)$
N	$\pi_1^* = \frac{(2a-\bar{c}+2c_2)^2-9c_k^2}{36b} - c_k\left(\frac{2a-\bar{c}+2c_2-3c_k}{6b}\right)$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H-3\alpha(c_H-c_L)}{6}\right)\left(\frac{a+\bar{c}-2c_2}{3b}\right) + + \frac{a^2-c_2^2}{4b} - c_2\frac{(a-c_2)}{2b} - G$	$\pi_1^* = \frac{(2a-\bar{c}+2c_2+2s)^2-9c_k^2}{36b} - c_k\left(\frac{2a-\bar{c}+2c_2+2s-3c_k}{6b}\right)$ $\pi_2^* = \left(\frac{2a-\bar{c}-4c_2+3c_H-4s-3\alpha(c_H-c_L)}{6}\right)\left(\frac{a+\bar{c}-2c_2-2s}{3b}\right) + + \frac{a^2-c_2^2}{4b} - c_2\frac{(a-c_2)}{2b}$	$\pi_1^* = \frac{a^2-c_k^2}{4b} - c_k\frac{(a-c_k)}{2b}$ $\pi_2^* = \frac{a^2-c_2^2}{4b} - c_2\frac{(a-c_2)}{2b}$

Table 3. Firms' optimal profits for each possible market structure.

Consumer surplus			
Perfect Bayesian equilibria	Country *A*	Country *B*	World
SEPARATING	=	+ / =	+ / =
POOLING	– / =	+ / =	– / = / +

Table 4. The effects of asymmetric information on consumer surplus.