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**Theoretical and experimental insights on
firms' internationalization decisions under uncertainty**

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Abstract

We revisit and extend previous theoretical work on internationalization decisions by firms which are imperfectly informed on the state of the demand in the market into which they are planning to export or enter through foreign direct investment (FDI). The latter is a costly strategy mitigating the international firm's demand uncertainty, while the local firm is perfectly informed. We report results from an experimental test of the aforementioned framework which confirm dominant strategy play by local firms under both the good and bad states of the local demand. Also, the prediction that the magnitude of the FDI-specific cost determines whether foreign firms enter via FDI is confirmed in qualitative terms. However, in the case in which FDI is the dominant strategy under risk neutrality, less than full FDI adoption is obtained. We also find an unexpected interaction between the internationalization decision and the market strategy once entry has occurred, indicating the presence of relevant behavioral and strategic factors which are not anticipated by the theoretical model.

Keywords: mode of entry, risk and uncertainty, experiment.

JEL Classification: F12, D81, C92

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1 Introduction

Uncertainty and variability are leading driving forces in firms' internationalization strategies. The sharp fall in transportation and trade costs world-wide, which would presumably favor exports, contrasts with an increase in foreign direct investments (FDI), implying a puzzling pattern to the arguments based on the received literature on multinationals¹. In this paper, we propose an explanation of a firm's entry choice into a foreign market based on the interplay between two factors, an external one depending on market uncertainty and an internal one, the decision maker's attitude towards risk. A firm is more likely to prefer the FDI entry mode rather than to export, the higher the informational benefits from directly investing in and learning on the local market. Interestingly, the latter argument continues to hold even if firms are risk averse. In fact, firms with a more risk averse attitude require a higher learning advantage to undertake FDI. We also report results from an experiment accounting for subjects' risk aversion largely confirming these conjectures. Furthermore, we find some interesting behavioral patterns related to deviations from dominant play in the market arising from strategic risk-related phenomena.

The literature on the multinational enterprise is extensive. The traditional view that multinationals invest abroad due to the existence of specific advantages (ownership, location and internalization framework, Dunning, 1981) has been challenged by alternative specifications built on the idea that firms become multinational to acquire knowledge about foreign markets.² In relation to this idea, the recent contribution by Albornoz et al. (2012) provides evidence on the relevance of learning about foreign markets to explain firms' export dynamics. In Moner-Colonques et al. (2007), the foreign firm is placed at an informational disadvantage relative to the host firm regarding host demand. It is shown there that there is a strategic learning effect associated with the FDI strategy. Thus, FDI can be observed even in the absence of trade costs³. We complement this approach assuming that the foreign firm planning to enter the market of uncertain demand is risk

¹See Neary (2009), who offers two possible resolutions to the paradox; one is based on the effects of intra-bloc trade liberalisation, while another explanation suggests that cross-border mergers are encouraged by falling trade costs.

²Ethier and Markusen (1996) and Fosfuri and Motta (1999) investigate the rationale for FDI in terms of technology-based arguments. In the context of multiproduct firms, Baldwin and Ottaviano (2001) provide an explanation to intra-industry FDI.

³The decision of a potential multinational in an uncertain environment has been examined by Saggi (1998), and Rob and Vettas (2003), to mention a few. Although not in an international oligopoly context, Comino (2006) studies the effect of revealing information about market profitability on rival firms' entry decision. Horstmann and Markusen (1996) assume asymmetric information, in a game of mechanism design to minimize agency costs. Herander and Kamp (2003) among others, examine the role of asymmetric cost information in determining the foreign firm's entry mode decision.

averse.

Despite early insightful work and, more recent contributions⁴, the analysis of market competition under behavioral considerations has received more skepticism than attention. Asplund (2002) has presented a formal analysis of oligopolistic competition with risk-averse firms, showing the effect of risk preferences on firms' best-response strategies and, thus, on the intensity of competition. More related to our paper, Head et al. (2002) emphasize the relevance of risk aversion in generating follow-the-leader behavior in FDI. These authors study the incentives of a firm to relocate its production in the presence of cost uncertainty. They show that a sufficiently risk-averse firm is more likely to establish a manufacturing facility in a foreign country once its rivals have done so.

In this paper we develop a two-stage oligopoly game under demand uncertainty and asymmetric information, where first the foreign firm decides whether to serve the host market through exports or direct investment and, then, it competes in quantities against the informed host firm. Only when entry occurs through direct investment will the foreign firm see uncertainty resolved: it learns whether the demand realization is the good state or the bad state. We wish to study how the interplay between trade costs, the fixed costs of setting up a plant, market size, and in particular, the degree of risk aversion as well as variability in demand, influence the learning rationale for entry through direct investment. The theoretical model is further tested in the lab.

As shall be seen, variability in demand favors the investment strategy absent risk aversion. However, this may change when the foreign firm is risk averse. A sufficiently high degree of risk aversion will turn variability in demand advantageous to the export strategy. The question then arises, will the risk-averse foreign firm still have an incentive to enter via investment and learn local demand characteristics? We will see that the answer is positive, under some conditions. As noted above, risk aversion shapes the intensity of competition. We argue that, when the foreign firm is sufficiently risk-averse, variability in demand increases the expected utility of exports and decreases that of investment. Entry via FDI requires that the probability of the good state of demand has to be large enough (and larger than under risk neutrality); only then will it be able to cover the fixed setup costs. The validity of the learning argument can be appropriately tested with an experiment, as suggested by Milgrom and Roberts (1987). However, to our knowledge, such experimental study has not been undertaken so far in the context of an entry model with informational asymmetries. While the relevance of behavioral factors for oligopolistic markets has been recognized by a growing literature on experimental oligopolies, there is

⁴Representative pioneering papers include Baron (1970, 1971), Sandmo (1971), Leland (1971), Rubinstein (1976), Schmalensee (1989), Bresnahan (1989), Appelbaum and Katz (1986), Hviid (1989) and Kao and Hughes (1993).

almost no experimental work applying, extending or testing the theories of international oligopoly in the lab. A couple of exceptions are the paper by Engelmann and Normann (2007), on strategic trade policy and the paper by Riedl and van Winden (2011), on taxation in an international context.

Our experimental design relates somehow to Oechssler and Schipper (2003), as it involves subjects who are uncertain about the game they are playing. Their focus is on the ability of subjects to learn the game they are playing in a repeated framework, while our design allows subjects to invest in a costly strategy letting them know the game they are playing with certainty. In this way, we implement in the lab the theoretical setup assuming that FDI is a costly but uncertainty-reducing strategy, whereas exports involve lower costs but a higher uncertainty concerning the demand conditions in the local market. In a parallel experiment, we also elicit subjects' attitudes towards risk and use them to control for the effect of individual heterogeneity on market behavior.

Our findings confirm the comparative statics prediction that firms are more likely to invest in FDI (that is, to pay the cost of becoming informed), the lower the FDI-specific cost. Dominant strategies are played by informed players in both states of the demand. However, behavior by informed players in the good state of the demand unexpectedly varies according to the cost of uninformed players to become informed. More cooperative behavior is observed by informed players when such a cost is low. On the contrary, uninformed players remaining uninformed behave less cooperatively under lower values of the cost of becoming informed. Thus, the FDI-specific fixed cost has an impact on the intensity of competition following the entry mode choice.

The paper is organized as follows. Section 2 presents the model. In section 3 we describe the experimental design and discuss the results obtained. Section 4 concludes.

2 The model

To illustrate our point, let us assume the following simple framework, based on Moner-Colonques et al. (2007). There is a homogeneous goods industry with a local firm located in host country h , that faces competition from a foreign firm. Inverse demand in the host country is linear and stochastic as captured by the following inverse demand function,

$$\tilde{p} = \tilde{A} - Q, \tag{1}$$

where $\tilde{p}$ is the stochastic price, and Q is total output. The inverse demand intercept, $\tilde{A}$, is a random variable that reflects characteristics of the local economy and is distributed

as follows:

$$\tilde{A} = \begin{cases} \bar{a} & \text{with probability } \rho \\ \underline{a} & \text{with probability } 1 - \rho \end{cases}, \quad (2)$$

where $\bar{a} > \underline{a} > 0$ and therefore $\bar{a}$ is called the good state and $\underline{a}$ is the bad state. The mean of $\tilde{A}$, denoted by $\hat{a}(\rho)$, is equal to $\rho\bar{a} + (1 - \rho)\underline{a}$, and the variance, σ_A^2 , is equal to $\rho(1 - \rho)(\bar{a} - \underline{a})^2$. This distribution is known by both firms and is common knowledge.

The sequence of events is as follows. First, the value of $\tilde{A}$ is realized and this is learned by the host firm but remains unknown to the foreign firm. Then the following two-stage game is played. In the first stage, the foreign firm decides whether to export to the host market (strategy e) or to invest and create a wholly owned subsidiary there (strategy i). In the second stage, both the host and foreign firms compete in quantities. The first-stage decision has an informational implication: (i) in the event of investing, the foreign firm will learn the realization of $\tilde{A}$, that is, it will play as an informed player in the second stage, whereas (ii) if the foreign firm becomes an exporter, then its output choice in the second stage will be made under uncertainty concerning the actual state of the demand.

For simplicity, the marginal cost of output is assumed to be zero. Under exporting, the foreign firm supplies the host market at a constant marginal cost $\tau \geq 0$, where τ is the unit tariff and/or transportation cost. Alternatively, under the investment strategy, the foreign firm bears a fixed cost $G \geq 0$, which includes any possible cost related with the acquisition of information, and supplies the host market at a zero marginal cost.

We assume that firms are risk averse. In particular, firms maximize a weakly concave function of own profits. We model risk attitudes by adopting a mean-variance framework. Thus, a firm j prefers higher expected profits but dislikes profit variance. Then, when deciding on the entry mode, its objective is to maximize the expected utility $V(\Pi_j) = E[\Pi_j] - r_j \text{var}[\Pi_j]$, where E and var are the mean and variance operators, and $r_j > 0$ is the coefficient of absolute risk aversion.

Before solving the model with incomplete information and risk averse firms, we begin by looking at the *certainty case*. In so doing we will obtain some restrictions on the parameters. Suppose first that $\rho = 0$, that is $\tilde{A} = \underline{a}$. The foreign firm's decision about how to serve the host country consists of comparing the profits it would obtain as an exporter $\Pi_e(\tilde{A} = \underline{a}) = \frac{(\underline{a} - 2\tau)^2}{9}$ with those it would obtain under investing, $\Pi_i(\tilde{A} = \underline{a}) = \frac{\underline{a}^2}{9} - G$. In case the bad state realizes, we assume that internationalization occurs via exports, that is, $G > \frac{4\tau(\underline{a} - \tau)}{9}$. Suppose next that $\rho = 1$, that is $\tilde{A} = \bar{a}$ and that internationalization occurs via investment when the good state realizes which implies that $G < \frac{4\tau(\bar{a} - \tau)}{9}$. Furthermore, it must be the case that $0 < 2\tau < \underline{a} < \bar{a}$, for positive equilibrium outputs and $G < \frac{\underline{a}^2}{9}$ for positive profits under strategy i , i.e. no entry is disregarded. All these assumptions together specify an interval for the fixed set-up cost: $\frac{4\tau(\underline{a} - \tau)}{9} < G < \min\{\frac{4\tau(\bar{a} - \tau)}{9}, \frac{\underline{a}^2}{9}\}$. It

shows how the choice between exports and investment is influenced by the relative costs of these different modes of serving the host market; market size, as measured by the demand intercept, also exerts an influence on the foreign firm's choice between e and i . The model in the certainty case illustrates in a sense the traditional effects of variables whose role is well understood in the literature.

Analysis of Stage Two.

Two different scenarios can be reached depending on the first stage choice by the foreign firm.

a) If the foreign firm decides to invest in stage one, then the foreign and the host firms will play a Cournot game under certainty since both firms know the realization of demand. That is to say, if $\tilde{A} = \bar{a}$, we have that $q_i^*(\bar{a}) = q_{hi}^*(\bar{a}) = \frac{\bar{a}}{3}$, whereas if $\tilde{A} = \underline{a}$, then $q_i^*(\underline{a}) = q_{hi}^*(\underline{a}) = \frac{\underline{a}}{3}$ (star superscripts indicate equilibrium outputs and subscript h distinguishes the host firm). Then, the ex ante expected payoffs for the foreign firm are given by:

$$E\Pi_i(\rho) = \frac{\rho\bar{a}^2 + (1-\rho)\underline{a}^2}{9} - G = \frac{\hat{a}(\rho)^2 + \sigma_A^2}{9} - G; \quad (3)$$

whereas the ex ante expected variance of profits is equal to⁵

$$var[\Pi_i] = \rho(1-\rho)\frac{(\bar{a}^2 - \underline{a}^2)^2}{81} = \frac{\sigma_A^2(\bar{a} + \underline{a})^2}{81}. \quad (4)$$

Expected payoffs increase with the mean but the variance of $\tilde{A}$ affects expected payoffs and the variance of profits in a different manner. We can therefore write down the expected utility of strategy i as,

$$\begin{aligned} V(\Pi_i(\rho)) &= E\Pi_i(\rho) - r_f var[\Pi_f] \\ &= \frac{\hat{a}(\rho)^2}{9} - G + \frac{\sigma_A^2}{9} \left(1 - r_f \frac{(\bar{a} + \underline{a})^2}{9} \right), \end{aligned} \quad (5)$$

where the coefficient of absolute risk aversion enters linearly and negatively, and the overall effect of the variance is positive as long as $r_f < \frac{9}{(\bar{a} + \underline{a})^2}$. That is, a sufficiently low degree of risk aversion implies that greater variability in demand increases the expected utility of the investment strategy. However, as r_f increases the variability in demand will end up having a negative effect on the expected utility. In fact, r_f is bounded above to preclude the possibility of having a negative $V(\Pi_i(\rho))$.

b) In case the foreign firm decides to export, we have a game of incomplete information on demand (with two types). The foreign firm maximizes $V(\Pi_e)$ and the host

⁵The variance of foreign firm profits can be easily computed by using $var[\Pi_j] = E[(\Pi_j - E[\Pi_j])^2]$, for $j = i, e$.

firm maximizes expected profits, where the expectations are taken with respect to all the information available to each firm. Thus,

$$\max_{q_e} V(\Pi_e) = E[\rho(\bar{a} - q_e - q_{he}(\bar{a}) - \tau)q_e + (1 - \rho)(\underline{a} - q_e - q_{he}(\underline{a}) - \tau)q_e] \quad (6)$$

$$-r_f \rho(1 - \rho)q_e^2((\bar{a} - \underline{a}) - (q_{he}(\bar{a}) - q_{he}(\underline{a})))^2,$$

$$\max_{q_{he}} E[(\tilde{A} - q_e - q_{he}(\tilde{A}))q_{he}(\tilde{A})] \text{ for } \tilde{A} = \underline{a}, \bar{a}, \quad (7)$$

where q_e denotes the output of the foreign firm when it exports, and q_{he} denotes the output of the host firm when it faces an exporter and is a function of the realization of the demand intercept. The equilibrium output for the foreign firm is $q_e^* = \frac{\hat{a}(\rho) - 2\tau}{3 + r_f \sigma_A^2}$; note that $\frac{\partial q_e}{\partial r_f} < 0$, $\frac{\partial q_e}{\partial \sigma_A^2} < 0$ and $\frac{\partial q_e}{\partial \hat{a}(\rho)} > 0$. That is, the equilibrium output decreases with the coefficient of absolute risk aversion and the variance, and increases with the mean. Finally, the equilibrium quantities for the host firm are: $q_{he}^*(\underline{a}) = \frac{\underline{a}(3 + r_f \sigma_A^2) - \hat{a}(\rho) + 2\tau}{2(3 + r_f \sigma_A^2)}$ and $q_{he}^*(\bar{a}) = \frac{\bar{a}(3 + r_f \sigma_A^2) - \hat{a}(\rho) + 2\tau}{2(3 + r_f \sigma_A^2)}$, where $\frac{\partial q_{he}^*(A)}{\partial r_f} > 0$, $\frac{\partial q_{he}^*(A)}{\partial \sigma_A^2} > 0$ and $\frac{\partial q_{he}^*(A)}{\partial \hat{a}(\rho)} < 0$ for $A = \bar{a}, \underline{a}$. That is, the coefficient of absolute risk aversion, the variance, and the mean have the opposite effect on the host firm's equilibrium output as compared with the foreign firm's one. Furthermore, and concerning total output it is important to note that $\frac{\partial q_e^*}{\partial r_f} + \frac{\partial q_{he}^*(A)}{\partial r_f} < 0$, $\frac{\partial q_e^*}{\partial \sigma_A^2} + \frac{\partial q_{he}^*(A)}{\partial \sigma_A^2} < 0$ and $\frac{\partial q_e}{\partial \hat{a}(\rho)} + \frac{\partial q_{he}^*(A)}{\partial \hat{a}(\rho)} > 0$, for $A = \bar{a}, \underline{a}$.

The expected profits are found to be equal to

$$E\Pi_e(\rho) = \frac{2 + r_f \sigma_A^2}{2} \left(\frac{\hat{a}(\rho) - 2\tau}{3 + r_f \sigma_A^2} \right)^2 = \frac{2 + r_f \sigma_A^2}{2} (q_e^*)^2 \quad (8)$$

and these are decreasing both with the coefficient of absolute risk aversion and the variance of the demand intercept. The variance of profits is given by

$$\text{var}[\Pi_e] = \frac{\sigma_A^2}{4} \left(\frac{\hat{a}(\rho) - 2\tau}{3 + r_f \sigma_A^2} \right)^2 = \frac{\sigma_A^2}{4} (q_e^*)^2 \quad (9)$$

with the same properties regarding changes in r_f and σ_A^2 . As before, we can compute the expected utility of strategy e , which is given by

$$V(\Pi_e(\rho)) = \left(1 + \frac{r_f \sigma_A^2}{4} \right) \left(\frac{\hat{a}(\rho) - 2\tau}{3 + r_f \sigma_A^2} \right)^2 \quad (10)$$

where it is worth noting that a positive sign of $\partial V(\Pi_e(\rho))/\partial r_f$ depends on the following condition relating the coefficient of risk aversion and the variance of the demand intercept, $r_f > \frac{7}{4 - 5\sigma_A^2}$. That is, a sufficiently high degree of risk aversion implies that greater variability in demand increases the expected utility of the export strategy. Besides, $\partial V(\Pi_e(\rho))/\partial \sigma_A^2$ is positive as long as $r_f < \frac{\hat{a}(\rho) - 2\tau}{4\sigma_A^2}$, which means that the variance of $\tilde{A}$ may favor both internationalization strategies. And if it happens that $\frac{9}{(\bar{a} + \underline{a})^2} < r_f < \frac{\hat{a}(\rho) - 2\tau}{4\sigma_A^2}$,

then variability in demand promotes entry through exports rather than through investment.

Analysis of Stage One.

The foreign firm will choose strategy i as long as $V(\Pi_i(\rho)) \geq V(\Pi_e(\rho))$. The fact that risk aversion and variability in demand may affect both the investment and the export strategies either differently or in the same way motivates the analysis below.

To see the intuition, let us first consider the risk-neutrality case $r_f = 0$. Then, the difference in expected utilities reduces to

$$E\Pi_i(\rho) - E\Pi_e(\rho) |_{r_f=0} = \frac{\hat{a}(\rho)^2}{9} - G + \frac{\sigma_A^2}{9} - \frac{[\hat{a}(\rho) - 2\tau]^2}{9}, \quad (11)$$

and the foreign firm would decide to invest if

$$\underbrace{\frac{4\tau(\hat{a}(\rho) - \tau)}{9}}_{\text{"traditional" effect}} + \underbrace{\frac{\sigma_A^2}{9}}_{\text{strategic learning effect}} \geq G \quad (12)$$

This means that a setting with demand uncertainty and informational asymmetry provides the foreign firm with an additional incentive to invest abroad: the *strategic learning effect*. This effect is independent of trade costs τ and supposes that greater variability in demand favors the investment strategy. In fact, such possibility is present even if τ were zero and investment would be observed thus questioning the tariff-jumping argument for FDI. We should note that if the host firm were also uninformed about the demand intercept, that is, in a game with uncertainty and no informational asymmetry, then the traditional effect would emerge alone and the variance of demand would play no role in the entry decision.

Solving (13) as an equality with respect to ρ defines a threshold value ρ^* such that for $\rho \in (0, \rho^*)$ entry occurs via exports and for $\rho \in [\rho^*, 1)$ entry occurs via FDI. The threshold value for ρ^* is:

$$\rho^* = \frac{(\bar{a} - \underline{a} + 4\tau) - \sqrt{(\bar{a} - \underline{a})^2 + 8\tau(\bar{a} + \underline{a}) - 36G}}{2(\bar{a} - \underline{a})}.$$

Then we can characterize the payoffs for both firms:

a) For $\rho \in (0, \rho^*)$ internationalization occurs via exports. The foreign firm's expected payoffs are $E\Pi_e(\rho) = \frac{(\hat{a}(\rho) - 2\tau)^2}{9}$. The host firm's expected payoffs are $E\Pi_{he}(\rho) = \frac{(2(\underline{a} + \tau) + (\underline{a} - \hat{a}(\rho))^2)}{36}$.

b) For $\rho \in [\rho^*, 1)$ internationalization occurs via investment. The foreign firm's expected payoffs are $E\Pi_i(\rho) = \frac{\rho\bar{a}^2 + (1-\rho)\underline{a}^2}{9} - G$. The host firm's expected payoffs are $\Pi_{hi}(\rho) = \frac{\underline{a}^2}{9}$.

In order to intuitively understand the role of risk aversion on the aforementioned threshold value of ρ , we observe that the properties of (5) and (10) regarding the coefficient of absolute risk aversion and the variance of demand can make it such that variability in demand discourages the FDI strategy. In fact, it can be shown that the difference between the expected utilities of the two alternative internationalization strategies decreases as risk aversion does.⁶ Therefore we conclude that an increase in the foreign firm's risk aversion will require a higher premium to becoming informed in order for entry to be made via FDI. That is, the probability of the high state of demand has to be greater in order for a risk averse foreign firm to enter via FDI as compared to the case of risk neutrality.

3 Experimental Design and Results

A population of 48 subjects, recruited among undergraduate Economics students at Bocconi University (Milan, Italy) participated in 2 different sessions. The design is such that each one of the subjects generates an independent observation for each one of the scenarios in which they are asked to make decisions.

Game L			Game R		
Foreign\Local	A	B	Foreign\Local	A	B
A	(11, 11)	(9, 10)	A	(18, 18)	(15, 19)
B	(10, 9)	(8, 8)	B	(19, 15)	(16, 16)

Table 1: Payoff matrices for the two games potentially played by the subjects depending on the bad (L) or the good (R) state of the demand.

Table 1 displays the payoffs corresponding to the two games implemented in order to represent interaction between the local and the foreign firm in the local market. The game on the left (L) corresponds to the bad state of demand and the game on the right (R) to the good state. Observe that for a subject who knows the state of demand, A is the dominant strategy in L and B is the dominant strategy in R.⁷ In terms of the theoretical model, this is a simplification of the quantity-setting game in which firms choose their quantity strategy in the local market from a continuum. In fact, A corresponds to a low

⁶Simulations have shown that the threshold probability is increasing in r_f . Also, we can specify sufficient conditions under which this happens. It requires that either $\rho < \frac{1}{2}$ and $r_f \leq \frac{9}{(\bar{a}+\underline{a})^2}$ or that $\rho > \frac{1}{2}$ and $r_f \geq \frac{9}{(\bar{a}+\underline{a})^2}$. These are sufficient conditions for the difference $V(\Pi_i(\rho)) - V(\Pi_E(\rho))$ to be increasing in ρ (see the Appendix).

⁷When the probability of playing either game is 1/2 both strategies yield the same expected payoff. Also, risk averse subjects would choose A.

output and B to a high one, yielding a prisoners' dilemma in the good state of demand, while the Nash equilibrium is Pareto dominant in the bad state.

Uninformed players have to submit a single strategy, A or B, without knowing whether they are facing the good or the bad state, namely, whether they will be playing Game L or Game R. However, they have a possibility to pay a fixed amount, $G\text{€}$ in order to become informed (corresponding to the FDI-related fixed cost), thus, acquiring the right to play different strategies across the two games. Two treatments, one with a low (2.5€) and another with a high (5€) value of G , were implemented to test the hypothesis resulting from the corresponding comparative statics of the theoretical model concerning the internationalization stage of the game. It can be checked that risk neutral subjects should always choose to spend G in order to become informed in the low- G treatment and remain uninformed in the high- G treatment, but, as we will see below, risk neutrality should not be taken for granted.

The experiment is implemented using the strategy method. Therefore, each subject submitted a strategy both as a local and as a foreign firm. In the former of the two cases, subjects submitted a strategy for each game under each scenario concerning their foreign rival's information (informed/uninformed). In the case in which they were playing as a foreign firm they submitted a single strategy for both games under the scenario of being uninformed and two strategies, one for each game, under the scenario of being informed. Finally, when playing as foreign firms, they decided whether to enter into the foreign market using FDI or through exports for each one of the two values of FDI-associated extra fixed cost, G . Once their strategies were submitted to the experimenter, the role of a foreign firm was randomly assigned to half of them and the role of a local firm to the other half. Then each subject's decision in the scenarios chosen was implemented for each pair of rivals to determine the final payoffs for each one of them.

In a previous stage, subjects participated in an experiment designed to elicit their preferences towards risk. Two risk-elicitation tasks were implemented, one introduced in Holt and Laury (2002) and the other in Sabater-Grande and Georgantzís (2002). The former is a broadly used test designed to classify subjects according to the intensity of their aversion or attraction to risky choices. The latter is designed to measure the degree of risk aversion, making no distinction between risk loving and risk neutral behavior. However, it captures variation of choices in response to variations in the risk premia, avoiding the usual error of deducing a subject's utility function from a single point of it⁸. There is an increasing number of experimental studies eliciting risk attitudes in an independent task

⁸ A very detailed account of the advantages and mostly the bi-dimensionality of the Sabater and Georgantzís (2002) lottery-panel task is provided in García-Gallego et al. (2012).

from the main experiment whose data are potentially explained by subjects' risk attitudes, although few of them report⁹ strongly positive results. In this paper, the data from the two aforementioned risk tests presented a low but significant correlation to each other ($r = 0.26$).

From the model in Section 2, the following hypotheses can be established and checked experimentally:

H_1 : Local firms will play the dominant strategy in the market game regardless of the foreign firms strategies.

H_2 : (1) Informed foreign firms will play the dominant strategy in the market game.

(2) Uninformed foreign firms are more likely to play A the more risk averse they are.

H_3 : For any risk attitude an increase in G implies less observed information purchase.

H_4 : For any probability of the good state of demand foreign firms are more likely to purchase information the more risk averse they are.

Percentage of A strategies under each condition	Initially Informed playing with Informed (Uninformed) rival		(if) Finally Informed		Uninformed
Treatments	Game L	Game R	Game L	Game R	Both
Low G treatment (33.3% buy info)	95.8% (95.8%)	16.6% (4%)	95.8%	20%	41%
High G treatment (0% buy info)	95.8% (100%)	8% (4%)	95.8%	12%	79%

Table 2: Percentage of subjects playing strategy A under each condition.

Table 2 reports the percentage of subjects playing strategy A . The second column corresponds to the play of an initially informed subject (equivalent to a local firm in our model) playing against an informed rival (a foreign firm adopting FDI). The percentages in parentheses refer to the play of an initially informed subject playing against an uninformed rival (a foreign exporter). Column three reports the data of a subject who purchased the information (a foreign firm adopting FDI), whereas column four reports those for an uninformed subject (a foreign exporter). Rows distinguish the two treatments

The main results coming out from the experiment can be summarized as follows:

Result 1: *The prediction of dominant play (strategy A) by initially informed players (local firms) and ex post informed ones (foreign firms adopting FDI) in Game L (bad state*

⁹For example, Sabater-Grande and Georgantzís (2002) find that when appropriately accounting for risk aversion, behavior in both a probabilistic and a deterministic version of a prisoners' dilemma depends on subjects' risk aversion.

of the demand) receives strong support (over 95%) in all cases.

Result 2: *The prediction of dominant play (strategy B) by initially informed players (local firms) in Game R (good state of the demand) playing against uninformed rivals (exporters) receives strong support (only 4% play against this prediction).*

These results provide full support to hypotheses H_1 and $H_2(1)$.

We also obtain the following results:

Result 3: *No subject has used FDI in the high-G treatment and 30% of them have done so in the low-G one.*

This result qualitatively confirms H_3 . In fact, the first part of the result fully confirms the theoretical prediction for the low value of G under risk neutrality. On the contrary, the second part of the result contradicts the prediction of global adoption of FDI. As indicated by our theoretical framework, this is compatible with risk averse behavior. Indeed, the subjects who have not purchased information in the low- G treatment have exhibited a weakly (Mann-Whitney, $p=0.1$) higher degree of risk aversion in the Sabater-Grande and Georgantzís (2002) risk elicitation task. This is in accordance to H_4 .

The experiment also delivers the following results which are related to behavioral issues not captured by the theoretical framework.

Result 4: *Unexpectedly, initially informed players (local firms) significantly vary across treatments the frequency of their cooperative play against informed entrants (foreign firms adopting FDI) in Game R (good state of the demand), depending on the value of G . Specifically, in the low- G treatment they abandon the dominant strategy B, in favor of cooperative market behavior in almost twice as many cases as they do in the high- G treatment (16.6% vs. 8%).*

This finding may be a consequence of the following result.

Result 5: *Unexpectedly, initially uninformed players (foreign firms) who have decided to become informed (adopting FDI) behave differently in Game R (good state of the demand) under different values of G (FDI-related cost). Specifically, having to pay a lower G in order to adopt FDI makes them play cooperatively almost twice as frequently than when having to pay a high G (20% vs. 12%).*

Results 4 and 5 imply an unexpected, although intuitively plausible pattern of behavior. Foreign firms who have adopted FDI in the low- G treatment behave in a way which is straightforward to interpret. Their strategy is compatible with rational, risk neutral behavior. Following FDI adoption, they should be expected to have higher target earnings, leading them to behave more cooperatively in the foreign market than they would do otherwise. This is confirmed by their strategies and may be also the driving force behind

Result 4. On the contrary, firms who would adopt FDI in the high-G treatment¹⁰ behave in a way which is not easy to interpret without assuming some kind of extreme risk aversion. From Sabater-Grande and Georgantzís (2002), we know that highly risk averse subjects tend to behave less cooperatively in a prisoners' dilemma. This is also confirmed by our data, given that subjects whose risk aversion ranks them in the lowest quartile of our sample cooperate significantly more in all scenarios and local firms seem to anticipate this variation in their rivals' behavior depending on the value of G paid by foreign firms adopting FDI.

Finally, we need to look at the behavior of initially uninformed players who choose to remain uninformed.

Result 6: *Unexpectedly, the behavior of initially uninformed players (foreign firms) who have decided to remain uninformed (exporters) significantly varies under different values of G. Specifically, a lower G (FDI-related cost) makes an exporting firm behave significantly less cooperatively than under a higher one (41% vs. 79%).*

That is, when firms have decided to enter as exporting sellers into the foreign market, they behave less cooperatively when their decision to export has been taken in a setup which is more favorable to FDI. While the theoretical setup is agnostic to the beliefs of subjects concerning their rivals' intentions to compete or collude in the foreign market, our experimental data reveal the importance of these issues in the presence of human decision makers.

4 Concluding Remarks

This paper has developed a model where a risk-averse foreign firm decides its entry mode in a local market. Entry via FDI entails learning about local demand. It has been shown that the foreign risk-averse firm will undertake FDI rather than export when the probability of the good realization of demand is high enough.

We have tested the predictions of the learning argument under market uncertainty and risk aversion in a lab experiment. Our results confirm the main testable hypotheses, but some unpredicted interesting behavioral patterns have also been found. First, initially informed subjects play (almost with certainty, 95%) the dominant strategy A in Game L (the bad state of the demand), independently of foreign firm's informational condition. On the contrary, dominant play, strategy B, in Game R (the good state of the demand) by informed players becomes more likely in the presence of an uninformed rival. Uninformed players also play (95%) strategy A in Game L when they become informed. But *ex post*

¹⁰ Actually no subject does so, but the strategy method used makes available those data by eliciting subjects' strategies under all possible scenarios.

informed players are significantly more likely (20% vs. 12%) to play cooperatively also in Game R if the cost of becoming informed is lower. When uninformed players choose to remain so, the percentage of A play also unexpectedly varies across treatments (increasing from 41% to 79% as we move from the low-G to the high-G treatment), but in the opposite direction to that reported on finally informed subjects. Only 1/3 of the subjects in the low information cost treatment buy information (against 100% predicted) and nobody in the high information cost treatment buys information, as predicted.

Therefore, we confirm the basic comparative static prediction of the model on the role of FDI-related costs on the adoption of it as opposed to exports to the same foreign country. Furthermore, we find that the conditions determining whether FDI will or will not be adopted also affect the behavior of firms with respect to their posterior behavior in the foreign market. Depending on the extra costs associated with the FDI strategy, exporting firms will behave more or less cooperatively in the foreign market. Having chosen to export when FDI is the rational strategy for risk neutral players makes a foreign firm adopt more competitive behavior in the foreign market. The opposite happens if entry is via FDI. A possible explanation is offered when subjects' risk aversion is taken into account, with highly risk averse subjects behaving in a significantly more cooperative manner. Surprisingly, our initially informed subjects seem to have predicted this pattern by playing more cooperatively when playing against FDI-adopting firms under conditions favoring FDI adoption than when playing against FDI-adopting firms under conditions favoring exports.

This paper illustrates once more the fact that decisions made by human subjects are the result of many more features than those usually assumed by theorists. Two ongoing debates on behavioral industrial organization carry over intact to international trade settings like the one studied here: First, whether mainstream models survive as good predictors of observed market behavior, despite the uncontrolled idiosyncratic features of human nature. Here, the main comparative statics of the theoretical model and equilibrium play in various subgames are supported by our experimental results, whereas some further interesting behavioral patterns have been identified which could be used to extend the framework. Second, whether the aforementioned idiosyncratic features can be identified in real world data and whether, if relevant, we need to incorporate them into the theoretical models to significantly improve our view of the world. This second question is under investigation in many different forums and sub-disciplines of economics. International Economics should not stay out of the debate.

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A Appendix: Instructions to the subjects*

*Translation from the original in Italian.

You are going to participate in an experiment financed with public funds. Your decisions will determine your monetary reward at the end of the session. If you have questions after reading these instructions, please raise your hand.

You will have to submit your strategies, A or B, in the following situation: Two players, an informed (I) and an initially un-informed (U) one, play one of the two games, Left ("L") and Right ("R") whose payoffs are defined as in Table 1 (payoffs in Euros). The game is played by I-U pairs. If you are an I-type player (given that you know which game you are playing when submitting your strategy) you can submit two (potentially different) strategies, one for each game. If you are a U-type player (given that you do not know which game you will be actually playing at the moment of submitting your strategy) you are obliged to submit one strategy for both games. U players may become informed by paying an amount X , which may take two values, $X = 2.5 \text{ €}$ and $X = 5.0 \text{ €}$. This means that if you decide to become informed you can submit different strategies for different games. The initially informed player (I) will know whether you became informed or not. Before you know which type of player you are (I or U), and, if you are I, which game you play, and, if you are U-type, the actual value of X , you will have to submit your strategy for each condition and role.

Once we collect your strategies under all possible scenarios, a random process will determine your role and you will be matched with a player (whose identity will not be revealed to you) of the other type. A random process will also determine the actual game and the scenario regarding the value of X . Your decisions and those of the other player under these conditions will be used to determine your final reward.

Use the following page to submit your strategies. When you finish, wait until one of the experimenters collects the strategy-submission sheets. Soon after that, you will be

informed on the actual scenario and your reward in the experiments.

Thank you for participating!

Submit your strategy (subject ID _____):

If you are an I-type player and play against a U-type who remained uninformed under the $X = 2.5\text{€}$ scenario:

In game L, my strategy is _____ (A or B)

In game R, my strategy is _____ (A or B)

If you are an I-type player and play against a U-type who became informed under the $X = 2.5\text{€}$ scenario:

In game L, my strategy is _____ (A or B)

In game R, my strategy is _____ (A or B)

If you are an I-type player and play against a U-type who remained uninformed under the $X = 5.0\text{€}$ scenario:

In game L, my strategy is _____ (A or B)

In game R, my strategy is _____ (A or B)

If you are an I-type player and play against a U-type who became informed under the $X = 5.0\text{€}$ scenario:

In game L, my strategy is _____ (A or B)

In game R, my strategy is _____ (A or B)

If you are a U-type player and did not become informed under the $X = 2.5\text{€}$ scenario:

In both games, my strategy is _____ (A or B)

If you are a U-type player and did not become informed under the $X = 5.0\text{€}$ scenario:

In both games, my strategy is _____ (A or B)

If you are a U-type player and you chose to become informed under the $X = 2.5\text{€}$ scenario:

In game L, my strategy is _____ (A or B)

In game R, my strategy is _____ (A or B)

If you are a U-type player and you chose to become informed under the $X = 5.0\text{€}$ scenario:

In game L, my strategy is _____ (A or B)

In game R, my strategy is _____ (A or B)

If you are a U-type player, do you choose to become informed...

...if the cost X of becoming informed is 2.5€ ? _____ (“Yes” or “No”)

...if the cost X of becoming informed is 5.0€ ? _____ (“Yes” or “No”).

B Appendix: Proof of the statement in footnote 6

The next equality $V(\Pi_i(\rho^*)) - V(\Pi_e(\rho^*)) = 0$ implicitly defines the threshold ρ , denoted by ρ^* , such that for a greater probability of the good state of demand the foreign firm opts for the FDI option. Therefore an implicit function is defined that relates the threshold and the other parameters. We are interested in how ρ^* varies as r_f does. That is, we want to know the sign of the following derivative:

$$\frac{d\rho^*}{dr_f} = - \frac{\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial r_f}}{\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \rho}}$$

First, it is easy to check that $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial r_f} = -\frac{1}{81}(\bar{a} + \underline{a})^2 \sigma_A^2 + \frac{\sigma_A^2(5 + r_f \sigma_A^2)(\hat{a}(\rho) - 2\tau)^2}{4(3 + r_f \sigma_A^2)^3} < 0$ for all r_f . Note that the derivative of $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial r_f}$ with respect to r_f is negative and that $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial r_f}$ evaluated at $r_f = 0$ is negative.

Next note that $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \rho} = \frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \sigma_A^2} \frac{d\sigma_A^2}{d\rho} + \frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \hat{a}(\rho)} \frac{\partial \hat{a}(\rho)}{\partial \rho}$, where $\frac{\partial \hat{a}(\rho)}{\partial \rho} > 0$ while $\frac{d\sigma_A^2}{d\rho} > 0$ iff $\rho < \frac{1}{2}$. Also note that $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \sigma_A^2} > 0$ iff $r_f < \frac{9}{(\bar{a} - \underline{a})^2}$, while $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \hat{a}(\rho)} > 0$ for all r_f (just noting that $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \hat{a}(\rho)} = \frac{2\hat{a}(\rho)}{9} - \frac{(4 + r_f \sigma_A^2)(\hat{a}(\rho) - 2\tau)}{2(3 + r_f \sigma_A^2)^2}$, which is increasing in r_f and it is positive when it is evaluated at $r_f = 0$). Therefore the sufficient conditions are that $\frac{d\sigma_A^2}{d\rho}$ and $\frac{\partial(V(\Pi_i(\rho)) - V(\Pi_e(\rho)))}{\partial \sigma_A^2}$ be either both positive or both negative.

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