Revisiting oligopolistic reaction: are decisions on foreign direct investment strategic complements?

Keith Head, Thierry Mayer, John Ries

Revisiting Oligopolistic Reaction: Are Decisions on Foreign Direct Investment Strategic Complements?

Keith Head

Faculty of Commerce
University of British Columbia
Vancouver, BC, V6T1Z2, Canada
keith.head@ubc.ca

Thierry Mayer

TEAM–University of Paris I and CERAS-ENPC
Paris Cedex 13, France
tmayer@univ-paris1.fr

John Ries

Faculty of Commerce
University of British Columbia
Vancouver, BC, V6T1Z2, Canada
john.ries@ubc.ca

Knickerbocker (1973) introduced the notion of oligopolistic reaction to explain why firms follow rivals into foreign markets. We develop a model that incorporates central features of Knickerbocker's story—oligopoly, uncertainty, and risk aversion—to establish the conditions required to generate follow-the-leader behavior. We find that rival foreign investment will make risk-neutral firms less inclined to move abroad once its rivals have done so. We show that Knickerbocker's prediction relies on risk aversion and derive an expression for the minimum amount of risk aversion needed to generate oligopolistic reaction.

1. Introduction

Research on foreign direct investment (FDI) has long recognized two important motives for choosing a particular country as the site for a new facility. First, firms wish to gain improved access to that

We thank two anonymous referees for their helpful comments and gratefully acknowledge support from the Commissariat Général au Plan, convention no. 4, 1998. We also thank the participants of the European Association for Research in Industrial Economics meetings held in Lausanne, September 2000.

Journal of Economics & Management Strategy, Volume 11, Number 3, Fall 2002, 453–472

country's market. A local plant can lower transportation costs or circumvent barriers to trade. Second, firms want to deploy the relatively abundant factors located in the country. That is, they seek a low-cost production platform. In his 1973 book, Frederic Knickerbocker proposed a third motivation in location choice: firms might invest in a country to match a rival's move. In particular, Knickerbocker argued that firms in industries characterized by oligopoly would tend to follow each other's location decisions.

We define oligopolistic reaction (OR) as follows: *The decision of one firm to invest overseas raises competing firms' incentives to invest in the same country.* Essentially, we want to know whether, within the structure proposed in Knickerbocker, FDI decisions are strategic complements. Following the terminology of the field of industrial organization, firms' actions are *strategic complements* when an increase in the action of one firm raises the marginal benefit of an increase in the action for another firm.

Despite the strong recognition that Knickerbocker's hypothesis has attracted in the international business and strategy literature, there is surprisingly little formal examination of the conditions that give rise to OR. This paper develops a model that incorporates important elements of Knickerbocker's framework—oligopoly, uncertainty, and risk aversion—to evaluate the conditions required for OR to hold. We show that when uncertainty exists about costs in the foreign market, a sufficiently risk-averse oligopolist is more likely to establish a manufacturing facility in a foreign country once its rivals have invested there. Hence, strong risk aversion makes FDI decisions strategic complements and Knickerbocker's proposition holds. We find that uncertainty and risk aversion are essential ingredients for obtaining OR. In the case of certainty, the incentive to move abroad falls with rival investment there. Moreover, uncertainty coupled with risk neutrality reinforces the desire not to follow a rival into a foreign market. The analysis defines the level of risk aversion necessary for Knickerbocker's hypothesis to hold in terms of the parameters of the model. This indicates how the likelihood of OR is influenced by changes in the degree of uncertainty, the number of firms in the industry, and transportation costs. Our results, therefore, can provide means for identifying the empirical relevance of Knickerbocker's hypothesis.

The persistent influence of oligopolistic reaction is underscored by the 89 citations to Knickerbocker (1973) in journals published between 1989 and 1999 according to the *Social Science and Humanities Citation Index*. A number of papers cite Knickerbocker as a motivation for adding specific covariates in regressions explaining FDI.

Kogut and Chang (1991, 1996) use the eight-firm Japanese concentration index in their analyses of Japanese FDI. They interpret the positive and significant coefficient of this variable in their 1991 study as evidence of follow-the-leader behavior. Hennart and Park (1994) and Yu and Ito (1988) add a measure of previous rival investment in their analyses of Japanese FDI in the United States. It has a significant positive effect in latter paper but an insignificant effect in the former.

The relevance of the OR hypothesis extends beyond the international business literature to the economic literature identifying sources of strategic complementarity in investment decisions. Firms obtain greater profits from clustering than from dispersing when there exist positive spillovers (agglomeration economies) between firms locating in geographic proximity. Fujita and Thisse (1996) provide a thorough overview the sources of agglomeration economies. Caves (1991) introduces the idea of mergers as strategic complements, an idea formalized in Fauli-Oller (2000). Fauli-Oller shows that in a Cournot oligopoly, a firm's incentive to merge is decreasing in the number of outside firms. Thus, mergers between two firms will increase the likelihood of subsequent mergers. Flaherty and Raubitschek (1990) show that follow-the-leader behavior will occur when the leader's investment lowers the fixed costs of subsequent investment of rivals.

Other papers focus on the role of uncertainty in generating imitative behavior in investment decisions. Banerjee (1992) models herd behavior occurring when the action of an agent conveys positive information about an uncertain investment. Bikhchandani et al. (1998) refer to the situation in which agents use observable actions of others to infer unobservable signals about the desirability of a choice as an *informational cascade*. They argue that such cascades may help us to understand imitation in a large number of contexts. Aron and Lazear (1990) and Cabral (1999) develop models where payoffs depend on rank-order position. "First to the post" competition compels the trailing firm to undertake risky actions that are matched by the leading firm. In their models, like ours, the convexity of the payoff function is an important determinant of firm behavior. In our model, however, payoffs are determined by Cournot competition and firms value individual profits rather than rank order.

A common element of this literature predicting strategic complementarity is that firms imitate because they expect it to raise their profits. In contrast, in our interpretation of Knickerbocker's hypothesis, firms choose the same locations despite the result that this *lowers* their expected profits. This occurs when highly risk-averse firms try to avoid scenarios in which their rival has a cost advantage.

The practical relevance of OR, therefore, depends on the degree of risk aversion characterizing firms' decision making.

To our knowledge, no formal mathematical models of OR exist that incorporate the features of Knickerbocker's thesis that we focus on. However, other authors have worked on models that they relate to Knickerbocker's hypothesis. Motta (1994) examines sequential FDI location decisions of oligopolists when products are vertically differentiated. He shows that both oligopolists in a country may choose FDI over exports to serve foreign customers, a result he states is consistent with Knickerbocker's hypothesis. He acknowledges, however, that his model does not demonstrate that follower investment is *in response* to the FDI of the leader firm. Aussilloux (1998) also relates the FDI export decision in a sequential entry Stackelberg game to Knickerbocker's hypothesis. Here again, however, the incentive to invest is not positively related to the number of firms that previously chose to invest. Graham (1998) develops a model with rivalrous behavior that he refers to as "exchange-of-threat." This model gives rise to reciprocal FDI by oligopolists based in different countries, a phenomenon that differs from the follow-the-leader behavior contemplated by Knickerbocker.

The following section describes the model and positions the analysis in terms of FDI decisions as strategic substitutes or complements. It specifies the imperfect-competition model we employ and expresses the profits associated with the strategy of maintaining home production and the strategy of relocating production abroad. We establish the main results about FDI decisions as strategic complements or substitutes in Section 3. We obtain results for three scenarios: (1) perfect information, (2) cost uncertainty and risk-neutral firms, and (3) cost uncertainty and risk-averse firms. Section 4 examines the equilibrium location of firms. In the final section, we summarize our results and discuss their implications for observed patterns of FDI.

2. Framework

We construct our model to reflect key features of Knickerbocker's (1973) argument. The first important aspect is oligopoly. We model Cournot oligopolists that choose between producing at home and abroad. A second feature of Knickerbocker's framework is uncertainty about economic conditions in the foreign market. The follower is "uncertain of the production economies, if any, that it [the leading firm] might gain by manufacturing locally" (p. 26). Accordingly, we allow for uncertainty about production costs in the foreign country. Finally, Knickerbocker points to the role of risk aversion: "firms minimized their risk by matching the foreign direct investment of rivals" (p. 30). We consider a firm's objective function in which variability of profits enters negatively.

We believe Knickerbocker's basic thesis is best described in the following passage explaining how a firm lowers risk by following a rival into a foreign market:

> To illustrate, if firm B [the follower] matched, move for move, the acts of its rival, firm A [the leader], B would have roughly the same chance as A to exploit each foreign market opportunity. Thus for each new market penetrated by both A and B, B's gains, either in terms of earnings or in terms of the acquisition of new capabilities, would parallel those of A. If some of A's moves turned out to be failures, B's losses would be in the range of those of A. Neither firm would be better or worse off. From the point of view of firm B, this matching strategy guaranteed that its competitive capabilities would be roughly in balance with those of firm A. (Knickerbocker, 1973, pp. 24–25)

We model a two-country, N-firm oligopoly. Each firm operates a single plant, and there are initially n_h plants (or firms) located in the home country and n_f plants in a foreign country (thus a total of $N = n_h + n_f$ firms). We consider a representative firm that operates in the home country but contemplates relocating production to the foreign country.[1] The markets in the two countries are segmented, and firms sell to both markets. We are interested in the benefit associated with relocating production to f and how foreign investment by rival home-market firms affects this benefit.

We incorporate uncertainty into our model by assuming that firms do not know the marginal cost of producing in the foreign country. Prior to relocating, a home firm perceives foreign marginal cost as a random variable. We assume that firms learn this cost following the relocation decision but prior to setting outputs.

As mentioned earlier, oligopolistic reaction can be thought of in terms of FDI decisions being strategic complements. Bulow et al. (1985) define strategic complementarity as the case where the cross partial of the payoffs with respect to each firm's strategic

1. Alternatively, the firm might retain its domestic plant and add a foreign plant to serve local demand through local production. Whether this would be optimal depends on plant-level economies of scale, transportation costs, and demand. In the appendix, we show that the qualitative results of the analysis are robust to either specification of FDI.

variable is positive. We will specify a benefit function B expressing the difference in payoffs of a representative firm keeping its home plant vs. relocating it to the foreign country. The benefit function incorporates risk aversion to uncertain costs associated with producing in the foreign country. We will analyze how the benefit function is influenced by an increase in the share of firms that have chosen to relocate production to the foreign market. We denote this share as $x \equiv n_f/N$. Thus, we view our approach as the discrete-choice (since B is a difference rather than a derivative), N-firm analog of the condition proposed by Bulow et al. OR obtains when FDI decisions are strategic complements, i.e., when $\partial B/\partial x > 0$. *Reverse* OR occurs if $\partial B/\partial x < 0$.

Bulow et al. examine a duopoly where a shock occurs that directly affects the level of a strategic variable chosen by firm 1. They show that when the strategic variables are complements, a positive shock to one firm's choice of strategic variable will increase the equilibrium level of the other firm's strategic variable. In our framework, we also have in mind the existence of shocks that influence the strategic variable—whether to relocate production abroad—of particular firms. Suppose there are sunk costs of relocation that vary across firms and time. For example, improved information may reduce relocation costs, and some firms may be better equipped to take advantage of these lower costs. These changes will make it profitable for some firms to relocate, thereby increasing x. As x changes, the expected benefits of FDI for remaining firms will rise or fall depending on whether FDI decisions are strategic complements or substitutes.

We assume that for $i = h, f$, the inverse demand functions are given by $P_i = a_i - b_i Q_i$. If firms in the same location behave identically, we have

$$Q_i = xNq_{fi} + (1-x)Nq_{hi},$$

the first subscript denoting location of the firm and the second the country where the output is sold.

We allow for different unit costs of production c_i between countries, and for trade to be subject to a transport cost t. We also assume fixed production cost per plant equal to G and a sunk cost F of setting up a new plant. The foreign marginal cost c_f is a country-specific random variable with mean $\bar{c}_f$ and variance σ^2. This assumption is the simplest way to capture the realistic idea that firms are able to predict costs at home without much difficulty but cannot accurately predict their costs in a foreign environment. It also makes the strong assumption that firms' costs in the foreign country are perfectly correlated with each other. The latter aspect of the model is designed to make a point with minimal algebra rather than to reflect reality. However, many types of uncertainty, such as real-exchange-rate risk or the risk of political upheaval, would in fact cause costs of all foreign firms to shift in a common way. As described earlier, firms learn c_f following the relocation decision but prior to setting outputs.

The realized profits of a representative home firm depend on whether it locates in country h or f. Denoting the profits of a firm that stays at home as π^S and the profits of a firm that relocates to the foreign country as π^R, we obtain

$$\pi^S = (P_h - c_h)q_{hh} + (P_f - c_h - t)q_{hf} - G, \tag{1}$$

$$\pi^R = (P_h - c_f - t)q_{fh} + (P_f - c_f)q_{ff} - G - F. \tag{2}$$

Firms are Cournot competitors in segmented markets, as in Brander and Krugman (1983) or Horstmann and Markusen (1992). Equilibrium quantities to each market for a firm maintaining production at home are

$$q_{hh} = \frac{a_h - c_h - Nx(c_h - c_f - t)}{b_h(N+1)}, \tag{3}$$

$$q_{hf} = \frac{a_f - c_h - t - Nx(c_h - c_f + t)}{b_f(N+1)}. \tag{4}$$

Profits earned from this strategy are

$$\pi^S = b_h q_{hh}^2 + b_f q_{hf}^2 - G. \tag{5}$$

Now consider the profitability of relocation. If a home firm were to move to the foreign country, it would increase the number of firms operating there by one. Equilibrium quantities shipped to each market by a firm producing in the foreign market are given by

$$q_{fh} = \frac{a_h - c_f - t + [N(1-x) - 1](c_h - c_f - t)}{b_h(N+1)}, \tag{6}$$

$$q_{ff} = \frac{a_f - c_f + [N(1-x) - 1](c_h - c_f + t)}{b_f(N+1)}. \tag{7}$$

Profits earned from this strategy are

$$\pi^R = b_h q_{fh}^2 + b_f q_{ff}^2 - G - F. \tag{8}$$

We assume that outputs q_{hh}, q_{hf}, q_{ff}, and q_{fh} are positive for all distributions of firms, x, across the two countries. This assumption allows us to take derivatives of profits with respect to x without running into corner conditions on outputs.[2]

We suppose that the decision makers in the firm maximize a weakly concave utility function of their income in which profits from the multinational enterprise's activities constitute a substantial portion of income. In that case, they desire higher expected profits but dislike greater variance of profits. We consider the highly tractable case of negative-exponential utility defined over a normally distributed monetary wealth, i.e., we suppose that utility over profits can be expressed as

$$U = -\exp(-\lambda\pi),$$

where λ is the coefficient of absolute risk aversion. If π were normally distributed, the expected utility [after a monotone transformation; see Varian (1992)] could be expressed as

$$\mathrm{E}[U] = \mathrm{E}[\pi] - \frac{\lambda}{2}\mathrm{V}[\pi],$$

where E and V are the mean and variance operators. Thus, we can express the benefit function, B, representing the gain in expected utility associated with relocating relative to staying, as

$$B = \mathrm{E}[U^R] - \mathrm{E}[U^S] = \mathrm{E}[\pi^R] - \mathrm{E}[\pi^S] + \frac{\lambda}{2}\big(\mathrm{V}[\pi^S] - \mathrm{V}[\pi^R]\big). \tag{9}$$

3. Best Responses to Rival FDI Decisions

We wish to determine the sign of the derivative of the FDI benefit function with respect to the share of firms in the foreign country, x. To evaluate this derivative, it is useful to express it as the sum of two differences:

$$\frac{\partial B}{\partial x} = \left(\frac{\partial \mathrm{E}[\pi^R]}{\partial x} - \frac{\partial \mathrm{E}[\pi^S]}{\partial x}\right) + \frac{\lambda}{2}\left(\frac{\partial \mathrm{V}[\pi^S]}{\partial x} - \frac{\partial \mathrm{V}[\pi^R]}{\partial x}\right). \tag{10}$$

We begin by evaluating the terms involving expected profits. This corresponds to how x influences the incentive of a risk-neutral firm ($\lambda = 0$) to relocate.

To express the expected profits associated with staying at home vs. those of moving abroad, we apply expectations to equations (5)

2. To maintain all quantities positive requires some conditions on the values of the models' parameters. These conditions are assumed to be fulfilled throughout the paper, and all numerical examples respect them.

and (8) and apply the statistics rule that $\mathrm{E}[X^2] = (\mathrm{E}[X])^2 + \mathrm{V}[X]$ to each of the $\mathrm{E}[q_{ij}^2]$ terms. This yields

$$\mathrm{E}[\pi^S] = b_h(\mathrm{E}[q_{hh}])^2 + b_f(\mathrm{E}[q_{hf}])^2 + b_h\mathrm{V}[q_{hh}] + b_f\mathrm{V}[q_{hf}] - G, \tag{11}$$

$$\mathrm{E}[\pi^R] = b_h(\mathrm{E}[q_{fh}])^2 + b_f(\mathrm{E}[q_{ff}])^2 + b_h\mathrm{V}[q_{fh}] + b_f\mathrm{V}[q_{ff}] - G - F. \tag{12}$$

Since quantities are a linear function of costs, the first two terms in each expression represent the variable profits obtained when the foreign marginal cost equals its expected value. We specify total profits by substituting the expected foreign marginal cost, $\bar{c}_f$, in place of c_f in each quantity equation and then substituting the result into equations (5) and (8). We denote these profits as $\bar{\pi}^S$ and $\bar{\pi}^R$. Subtracting the expected profit of staying in country h from that of relocating to country f, we obtain the difference in expected profits as

$$\mathrm{E}[\pi^R]-\mathrm{E}[\pi^S] = (\bar{\pi}^R-\bar{\pi}^S)+b_h\big(\mathrm{V}[q_{fh}]-\mathrm{V}[q_{hh}]\big)+b_f\big(\mathrm{V}[q_{ff}]-\mathrm{V}[q_{hf}]\big). \tag{13}$$

The first term of this expression portrays the change in profits when the foreign marginal cost equals its expected value. The rest of the expression depends on the variance of costs in the foreign market, σ^2.

We can now see how an increase in x affects the difference in expected profits:

$$\frac{\partial\mathrm{E}[\pi^R]}{\partial x} - \frac{\partial\mathrm{E}[\pi^S]}{\partial x} = \left(\frac{\partial\bar{\pi}^R}{\partial x} - \frac{\partial\bar{\pi}^S}{\partial x}\right) + b_h\left(\frac{\partial\mathrm{V}[q_{fh}]}{\partial x} - \frac{\partial\mathrm{V}[q_{hh}]}{\partial x}\right) + b_f\left(\frac{\partial\mathrm{V}[q_{ff}]}{\partial x} - \frac{\partial\mathrm{V}[q_{hf}]}{\partial x}\right). \tag{14}$$

We decompose these terms sequentially. The derivatives of the profit functions with respect to the locations of rivals are given by

$$\frac{\partial\bar{\pi}^S}{\partial x} = 2b_h\bar{q}_{hh}\frac{\partial\bar{q}_{hh}}{\partial x} + 2b_f\bar{q}_{hf}\frac{\partial\bar{q}_{hf}}{\partial x}, \tag{15}$$

$$\frac{\partial\bar{\pi}^R}{\partial x} = 2b_h\bar{q}_{fh}\frac{\partial\bar{q}_{fh}}{\partial x} + 2b_f\bar{q}_{ff}\frac{\partial\bar{q}_{ff}}{\partial x}. \tag{16}$$

The $\bar{q}_{ij}$ correspond to the results of substituting $\bar{c}_f$ for c_f in equations (3), (4), (6), and (7). Note that

$$\frac{\partial\bar{q}_{hh}}{\partial x} = \frac{\partial\bar{q}_{fh}}{\partial x} = \frac{N(\bar{c}_f + t - c_h)}{b_h(N+1)}, \tag{17}$$

$$\frac{\partial\bar{q}_{ff}}{\partial x} = \frac{\partial\bar{q}_{hf}}{\partial x} = \frac{-N(c_h + t - \bar{c}_f)}{b_f(N+1)}. \tag{18}$$

Subtracting (15) from (16) and substituting using (17) and (18) yields

$$\frac{\partial \bar{\pi}^R}{\partial x} - \frac{\partial \bar{\pi}^S}{\partial x} = \frac{-2N}{N+1}\big[(\bar{c}_f + t - c_h)(\bar{q}_{hh} - \bar{q}_{fh}) + (c_h + t - \bar{c}_f)(\bar{q}_{ff} - \bar{q}_{hf})\big]. \quad (19)$$

Substituting equilibrium quantities into equation (19), we have

$$\frac{\partial \bar{\pi}^R}{\partial x} - \frac{\partial \bar{\pi}^S}{\partial x} = \frac{-2N^2}{(N+1)^2}\left(\frac{(\bar{c}_f + t - c_h)^2}{b_h} + \frac{(c_h + t - \bar{c}_f)^2}{b_f}\right) < 0. \quad (20)$$

This establishes the first result of the analysis, corresponding to the case of zero variance in foreign marginal cost. An increase in the rival FDI (x) lowers the incentive of a home firm to invest abroad; i.e., decisions to move overseas are strategic substitutes. In the context of our model, certainty yields *reverse* OR.[3]

We now consider the remaining portion of equation (13) that involves the variance of costs in order to evaluate its derivative with respect to x. Applying the variance operator to the quantity equations and collecting terms yields

$$b_h(\mathrm{V}[q_{fh}] - \mathrm{V}[q_{hh}]) + b_f(\mathrm{V}[q_{ff}] - \mathrm{V}[q_{hf}]) = \frac{N^2(1-2x)\sigma^2}{(N+1)^2}\left(\frac{1}{b_h} + \frac{1}{b_f}\right).$$

Differentiating with respect to x, we obtain

$$b_h\left(\frac{\partial \mathrm{V}[q_{fh}]}{\partial x} - \frac{\partial \mathrm{V}[q_{hh}]}{\partial x}\right) + b_f\left(\frac{\partial \mathrm{V}[q_{ff}]}{\partial x} - \frac{\partial \mathrm{V}[q_{hf}]}{\partial x}\right)$$
$$= \frac{-2N^2\sigma^2}{(N+1)^2}\left(\frac{1}{b_h} + \frac{1}{b_f}\right) < 0. \quad (21)$$

Thus, the second set of terms on the right-hand side of equation (14) is negative for any $\sigma^2 > 0$. We have already shown in equation (20) that the first part of the equation is negative. This means that the overall effect of an increase in rival investment is to lower the expected profits associated with relocating a plant to the foreign country. Therefore, we have established a second result corresponding to a special case of our general formulation: When there is uncertainty about foreign costs, FDI decisions are strategic substitutes for risk-neutral firms. Moreover, since the variance terms reinforce the negative first term in equation (14), the disincentive to follow a rival into a foreign market

3. This result depends in part on our partial-equilibrium approach, which takes the distribution of consumer demand as given. Combes (1997) shows that if demand responds endogenously to firm location decisions then strategic complementarity can arise in a two-location Cournot oligopoly model.

is higher under risk neutrality and uncertainty than is the case when foreign costs are known in advance.

The intuition for this result comes from the convexity of the profit functions. Since profit is proportional to quantity squared, an increase in the variance in quantity (caused by increasing the variance of costs) also increases the expected level of profits. This is because firms adjust quantity after they learn costs. If costs are high, they produce less, and if costs are low, they produce more. In general, a firm increases the variance of its output by locating in the country with fewest firms. What concerns us, however, is how the rivals' relocation abroad affects a home firm's incentive to relocate. When x increases, the foreign country has more plants and the home country has fewer plants. Thus the variance of output associated with producing in the foreign market falls and, correspondingly, the variance of home output rises. Hence, the benefit of following is reduced by the increase in x.

We now return to equation (10) to evaluate the general formulation allowing for risk aversion. Recall that it comprises two differences:

$$\frac{\partial B}{\partial x} = \left(\frac{\partial \mathrm{E}[\pi^R]}{\partial x} - \frac{\partial \mathrm{E}[\pi^S]}{\partial x}\right) + \frac{\lambda}{2}\left(\frac{\partial \mathrm{V}[\pi^S]}{\partial x} - \frac{\partial \mathrm{V}[\pi^R]}{\partial x}\right).$$

Since we have now established that the first difference is negative, what remains is to calculate the difference in the variance of profits between moving and staying. To express these variances in terms of x and σ^2 is not easy, since profits are a quadratic function of foreign costs. Greene (1997, p. 67) provides a useful approximation. For $Y = f(X)$ the variance of Y equals $[f'(\mathrm{E}[X])]^2\mathrm{V}[X]$ plus a second-order term.[4]

Application of this approximation yields

$$\mathrm{V}[\pi^S] \approx \frac{4x^2N^2}{(N+1)^2}(\bar{q}_{hh} + \bar{q}_{hf})^2\sigma^2, \tag{22}$$

$$\mathrm{V}[\pi^R] \approx \frac{4(1-x)^2N^2}{(N+1)^2}(\bar{q}_{fh} + \bar{q}_{ff})^2\sigma^2. \tag{23}$$

Increases in the variance of foreign costs (σ^2) also increase the variance of profits. The difference in variances is given by

$$\mathrm{V}[\pi^S] - \mathrm{V}[\pi^R] \approx \frac{4N^2\sigma^2}{(N+1)^2}\left\{\left[x(\bar{q}_{hh} + \bar{q}_{hf})\right]^2 - \left[(1-x)(\bar{q}_{fh} + \bar{q}_{ff})\right]^2\right\}. \tag{24}$$

4. This formula is derived from a linear Taylor series expansion where the expansion point is the average value of the uncertain variable, here $\bar{c}_f$. Using simulations, we found the approximation of the variance to be accurate within 2%.

What is the effect of shifting rivals to the foreign country on this difference? If relocation of rivals lowers the variance of profits of foreign production relative to that of home production, then for a sufficiently large amount of risk aversion we would obtain strategic complementarity. However, the following expression shows that this derivative cannot be signed without further restrictions:

$$\operatorname{sign}\left[\frac{\partial \mathrm{V}[\pi^S]}{\partial x} - \frac{\partial \mathrm{V}[\pi^R]}{\partial x}\right] = \operatorname{sign}\left[x\bar{q}_h^2 + (1-x)\bar{q}_f^2 + D\left\{x^2\bar{q}_h - (1-x)^2\bar{q}_f\right\}\right],$$

where $\bar{q}_i \equiv \bar{q}_{ih} + \bar{q}_{if}$. The first two terms in this derivative may be viewed as the "direct" effect of changing x while holding outputs constant. This effect is unambiguously positive and reveals that when rivals move abroad and outputs remain constant, the variability of profits is reduced for a firm located in the foreign market and increased for a firm located in the home market. The third term considers the effect of a change in x on outputs of stayers and relocators. It depends on

$$D \equiv \frac{N}{N+1}\left[(\bar{c}_f - c_h)\left(\frac{1}{b_h} + \frac{1}{b_f}\right) + t\left(\frac{1}{b_h} - \frac{1}{b_f}\right)\right].$$

This "indirect" effect cannot be signed. Furthermore, under certain extreme parameter values, the indirect effect may be a large enough negative number so that it fully offsets the direct effect. In that case, risk aversion does not generate OR. The circumstances under which this occurs involve differences between the two countries in the slopes of the demand curves (b_h and b_f) and expected costs (c_h and $\bar{c}_f$). By eliminating such differences, we remove the indirect effect and retain only the unambiguous positive direct effect in order to identify situations where OR can actually occur. Thus we proceed to impose a restriction on the parameters:

Similarity condition: $b_h = b_f = b$ and $\bar{c}_f = c_h = c$.

We now can take the derivative of equation (24) with respect to x and substitute it into equation (10) to obtain

$$\frac{\partial B}{\partial x} = \left(\frac{\partial \mathrm{E}[\pi^R]}{\partial x} - \frac{\partial \mathrm{E}[\pi^S]}{\partial x}\right) + \frac{4\lambda\sigma^2 N^2}{(N+1)^2}\left[x\bar{q}_h^2 + (1-x)\bar{q}_f^2\right], \tag{25}$$

where the term in large parentheses is negative as shown in equation (14). OR will obtain if the positive second term is large enough to dominate the negative first term. Thus, it will occur in this framework for sufficiently large values of λ.

The relocation of rival production to the foreign market reduces the variability of profits of firms located in that market and increases the variability of profits of firms remaining in the home market. With risk aversion, firms dislike increased variation in profits. Thus, a sufficiently large degree of risk aversion will make the negative effect on utility of profit variation dominate the positive effect of profit variation on expected profits. FDI decisions can be strategic complements when there exists a sufficiently high degree of risk aversion. Thus, risk-averse firms have the incentive to follow rivals into foreign markets, the behavior Knickerbocker refers to as oligopolistic reaction.

We are able to define the minimum amount of risk aversion necessary to generate OR by setting equation (25) equal to zero:

$$\lambda^{\min} = \frac{b(N+1)^2(1+t^2/\sigma^2)}{(a_h + a_f - 2c - t)^2}. \tag{26}$$

Equation (26) allows us to explore how the minimum level of λ required to generate OR varies according to the exogenous model parameters. First, it is decreasing in σ^2, indicating that the level of risk aversion inducing firms to want to match rivals' moves falls when there is more uncertainty about costs in the foreign market. Second, λ is increasing in transportation costs t. High transportation costs make foreign goods relatively uncompetitive with goods produced at home. Thus, when transportation costs are high, firms are less concerned that different realizations of the random foreign cost variable will have a strong effect on profits at home. Hence, there is less incentive to match the moves of rivals. Finally, the expression shows that when the total number of firms (N) increases, the parameter measuring the degree of risk aversion must also increase to yield the same incentive to invest. If managerial risk aversion is randomly distributed in the investor populations, these comparative statics indicate that OR will be more likely in industries characterized by high levels of concentration, great variability in foreign costs, and low transportation costs.

The results of two-stage games often depend on whether the firms' choices in the second stage of product market competition are strategic substitutes or complements. We have used Cournot competition with linear demand where outputs are strategic substitutes. This raises the issue of whether our results would generalize to Bertrand competition with differentiated products in which prices are strategic complements. We applied the model of price competition due to Ottaviano et al. (2002), with linear demands for symmetric differentiated products, to our two-stage game of location choice followed by competition in segmented product markets. Our calculations—available on request—show that our results continue to hold in that model. The intuition is that proximity of rivals is bad for profits in most imperfect-competition models. As a result, even when product-market choices are strategic complements, *location* choices are strategic substitutes unless the firm is quite risk-averse. Interestingly, we found that the more differentiated the products made by each firm are, the less risk aversion is required to generate OR.

The relationship between OR and market structure was a focus of the empirical analysis of Knickerbocker. OR predicts the clustering of FDI. Consequently, he derived a measure of spatial and temporal clustering of FDI by industry. There are, of course, other sources of FDI clustering. Firms would choose the same locations if certain countries were particularly attractive due to low costs or high demand. Agglomeration economies can also generate clustering.

To distinguish OR from other sources of clustering, Knickerbocker related his measure of FDI clustering to industry Herfindahl indexes. He argued that more concentrated industries would be more likely to exhibit OR. Knickerbocker discovered a nonmonotonic relationship between FDI clustering and industry concentration. Specifically, he found that clustering increased with industry concentration except at high levels of concentration. "Tight" (highly concentrated) oligopolies were less likely to concentrate FDI than "loose" (less concentrated) oligopolies. He explains this finding as resulting from the collusive behavior of tight oligopolies.[5] Our model suggests a positive relationship between industry concentration and OR. It does not predict the nonmonotonic relationship found by Knickerbocker.

4. Equilibrium Location Choice

Thus far, we have examined how a rival's FDI affects the expected benefit of relocating production abroad. In this section, we consider the Nash equilibrium in location choice. A share x^* in country f is a Nash equilibrium if there is no incentive for a firm in either country to switch locations unilaterally. For large numbers of firms, interior equilibria occur where $B(x^*) = 0$. However, we are interested in oligopoly situations and must adapt the equilibrium condition accordingly. For no firm in country h to want to relocate to country f, it must be the case that $B(x^*) \leq 0$. For no firm in country f to regret its relocation choice (and therefore wish to return to country h), we require

5. This explanation is, however, not easy to justify theoretically. See Friedman and Thisse (1993).

$B(x^* - 1/N) \geq 0$. For a corner solution with all firms at home, i.e., $x^* = 0$, we drop the second condition and require only $B(0) \leq 0$. Correspondingly, a corner solution with all firms abroad, $x^* = 1$, requires only the second condition that $B(1 - 1/N) \geq 0$.

Allowing for uncertainty and risk aversion while imposing the similarity condition, we solve for the difference in expected utility for a firm in h between staying in the home country and relocating to f and express it as

$$B = \frac{2N}{(N+1)^2 b}\left(\left[N(\sigma^2 + t^2)(1-2x) + t(a_f - a_h - t)\right] - \frac{\lambda\sigma^2 N(1-2x)(a_h + a_f - 2c - t)^2}{(N+1)^2 b}\right) - F. \tag{27}$$

We plot equation (27) for different levels of λ, the risk aversion parameter, in Figure 1. This plot sets $N = 4, a_h = a_f = b = 1, c = 0.25, t = 0.1, F = 0$, and $\sigma = 0.025$. The values of λ chosen in the plot are those where the equilibrium pattern of firms' location changes given the parameters values stated above. In the case of risk neutrality ($\lambda = 0$), the slope is negative, indicating that FDI decisions are strategic substitutes.

Figure 1 illustrates the effects of increases in risk aversion on both the magnitude and the sign of OR. As can be seen in (27), an increase in λ from zero has the effect of rotating the $B(x)$ curve counterclockwise around the point where $x = \frac{1}{2}$. The sign of $B(\frac{1}{2})$ depends on $a_f - a_h - t$. For the identical demand curves we use in the plot,

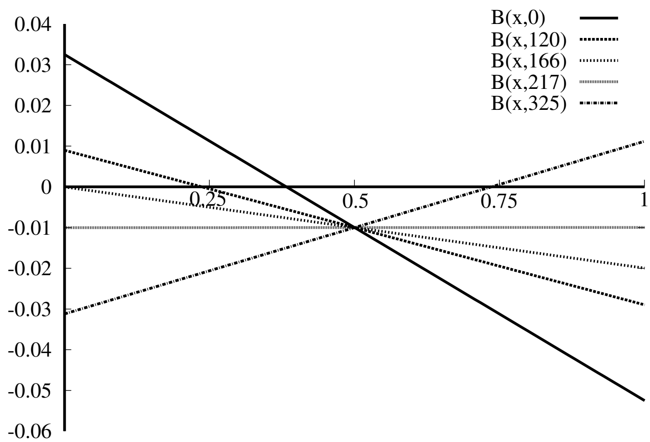

FIGURE 1. RISK AVERSION AND OLIGOPOLISTIC REACTION

the pivot point is therefore negative. With increases in λ, $B(x)$ flattens and then becomes positive. Positive slopes indicate strategic complementarity and oligopolistic reaction. For the parameters in the plot, FDI decisions become strategic complements for λ in excess of 216.84.

The figure also indicates the types of equilibria that are possible in this four-firm example. For $\lambda = 0$, the unique equilibrium occurs at $x^* = \frac{1}{2}$, where it is evident that $B(x^*) < 0$ and $B(x^* - \frac{1}{4}) > 0$. Thus, there will be two firms in each country. The intuition is that, under risk neutrality, firms have an incentive to operate in the less concentrated market, resulting in an equilibrium where each market is equally concentrated. This is consistent with the result in the location-theory literature showing that spatial proximity of competitors reduces prices and profits.[6]

As risk aversion increases, it will eventually be the case that $B(\frac{1}{4}) < 0$, resulting in a unique equilibrium of three firms at home and one abroad. Further increases in λ will generate $x^* = 0$ as the unique equilibrium and then cause the slope to switch from negative to positive. Eventually, higher λ's will make the slope steep enough to yield $B(\frac{3}{4}) \geq 0$, resulting in an equilibrium at $x = 1$. In this case, if a firm believed that its three rivals would choose country f, then it would want to do so as well. Thus, two different equilibria are possible. In the first, all firms remain at home; in the second, all firms migrate to the foreign country. This is the most interesting parameter range, since it predicts either a large cluster of FDI in the foreign country or none at all. Two otherwise equal countries might have very different levels of success in attracting investment. This is despite the fact that there are no agglomeration economies—the direct effect of clustering is still to *lower* expected profits.

How realistic are the values of λ required to generate OR? Kocherlakota's (1996) survey article on the equity-premium puzzle discusses the plausible range for the coefficient of relative risk aversion (CRRA). He argues that there is a consensus that the CRRA should be less than 10 but that only values of 18 or more can explain why equities have historically earned a 6% premium over risk-free Treasury bills. In the mean-variance expected-utility function we have used, λ is the coefficient of *absolute* risk aversion. We can obtain the implied CRRA by multiplying λ by profits. For the numerical example in the figure, OR obtains for a CRRA of about 10, and two equilibria ($x = 0$ and $x^* = 1$) exist for a CRRA above 15. We also simulated the model using the utility function $(1 - \gamma)^{-1}\pi^{1-\gamma}$, where γ is the CRRA. We calculate expected utility based on 10,000 draws

6. For a model with Cournot competition, see Anderson and Neven (1990, 1991).

of c_f. For 20 simulations, we find on average that $\gamma \geq 17$ yields OR for all x and that $\gamma = 22$ is the minimum value of the CRRA required for two equilibria. These values, while large, are in line with values required to explain the equity-premium puzzle.

5. Conclusion

Knickerbocker's OR hypothesis can be formalized in terms of FDI decisions being strategic complements, a concept that is clearly defined in the industrial-organization literature. The idea that the principal elements of the Knickerbocker story—oligopoly, uncertainty, and risk aversion—can combine to generate follow-the-leader investment behavior has intuitive appeal. The Cournot segmented-market model we develop shows that the requirements for OR are rather strict. The cases of certainty and uncertainty with risk neutrality generate the opposite result—the benefits of relocating a plant abroad are reduced when rivals invest there first. Only when a large amount of risk aversion is introduced does OR occur. Even with risk aversion, we show that parameter values in the model must be restricted to guarantee the result.

Our investigation of equilibrium patterns of location reveals that under reverse OR, there will be a tendency for investments of rival firms to be dispersed across the two locations. OR, on the other hand, can cause all firms to cluster in one location or the other. On the surface, this suggests that observations of spatially concentrated FDI lend empirical support to Knickerbocker's hypothesis. However, to verify such a claim would require distinguishing clustering due to OR from other types of clustering such as those due to agglomeration economies. Our analysis provides a potential means for identifying clustering due to OR by demonstrating that risk-reducing imitation is more likely in concentrated industries with low transportation costs and high variability in foreign costs.

Appendix

The analysis in the body of the paper focuses on the potential relocation of a single plant, thereby abstracting from the option of establishing a new plant while retaining production at the old plant. Firms would choose a two-plant structure over single-plant operation when transportation costs are high and the fixed cost per plant, G, is low relative to demand. In this appendix, we show that the results in the paper are robust to a situation where firms choose between maintaining a single plant at home and establishing a foreign plant to displace exports and serve the foreign market.

The profit from staying in the home country remains

$$\pi^S = (P_h - c_h)q_{hh} + (P_f - c_h - t)q_{hf} - G.$$

However, when the firm adds a location in the foreign country while maintaining its home plant, its profits become

$$\pi^A = (P_h - c_h)q_{hh} + (P_f - c_f)q_{ff} - 2G - F.$$

Note that the variable profits in the home market are the same under both strategies and that the two-plant firm does not export. The FDI benefit function is

$$B = \mathrm{E}[U^A] - \mathrm{E}[U^S] = \mathrm{E}[\pi^A] - \mathrm{E}[\pi^S] + \frac{\lambda}{2}(\mathrm{V}[\pi^S] - \mathrm{V}[\pi^A]),$$

where U^A is the utility associated with establishing an additional plant and, as before, U^S is the utility of maintaining a single plant at home that serves both markets. We approximate the difference in variances as

$$\mathrm{V}[\pi^S] - \mathrm{V}[\pi^A] \approx \frac{4N^2\sigma^2}{(N+1)^2}\{[x\bar{q}_{hf}]^2 - [(1-x)\bar{q}_{ff}]^2\}.$$

The derivative of the benefit function with respect to x is now

$$\frac{\partial B}{\partial x} = -\frac{4N^2}{(N+1)^2}\Bigg[\frac{\sigma^2 + (c_h + t - \bar{c}_f)^2}{2b_f} - \lambda\sigma^2\left(x\bar{q}_{hf}^2 + (1-x)\bar{q}_{ff}^2 + \frac{tN}{b_f(N+1)}x^2\bar{q}_{hf} + (1-x)^2\bar{q}_{ff}\right)\Bigg].$$

The factor in the brackets will be negative for sufficiently large values of λ, making the full expression positive and yielding oligopolistic reaction.

As with the specification maintained in the body of the text, reverse OR occurs in the restricted cases. In the case of certain costs ($\sigma^2 = 0$), the derivative of the benefit function with respect to x is negative and we have reverse OR. Moreover, as before, the negative effect of rival investment becomes larger when there is uncertainty ($\sigma^2 > 0$) and risk neutrality ($\lambda = 0$).

Thus, we have established that regardless of whether FDI implies relocating a single plant or opening a second plant in the foreign country, reverse OR obtains in the case of certainty as well as the case of uncertainty with risk neutrality. A critical level of risk aversion is necessary to result in OR.

References

Anderson, S. and D. Neven, 1990, "Spatial Competition à la Cournot: Price Discrimination by Quantity-Setting Oligopolists," *Journal of Regional Science*, 30, 1–14.

—— and ——, 1991, "Cournot Competition Yields Spatial Agglomeration," *International Economic Review*, 32, 793–809.

Aron, D.J. and E.P. Lazear, 1990, "The Introduction of New Products," *AEA Papers and Proceedings*, 80, 421–426.

Aussilloux, V., 1998, "Investissement direct à l'étranger et entrée séquentielle sur le marché," *Revue Économique*, 49, 607–615.

Banerjee, A., 1992, "A Simple Model of Herd Behavior," *Quarterly Journal of Economics*, 57, 797–817.

Bikhchandani, S., D. Hirshleifer, and I. Welch, 1998, "Learning from the Behavior of Others: Conformity, Fads, and Informational Cascades," *Journal of Economic Perspectives*, 12, 151–170.

Brander, J. and P. Krugman, 1983, "A Reciprocal Dumping Model of International Trade," *Journal of International Economics*, 23, 313–321.

Bulow J., J. Geanakoplos, and P. Klemperer, 1985, "Multimarket Oligopoly: Strategic Substitutes and Complements," *Journal of Political Economy*, 93, 488–511.

Cabral, L.B., 1999, "Football, Sailing, and R&D: Dynamic Competition with Strategic Choice of Variance and Covariance," Manuscript, New York University.

Caves, R., 1991, "Corporate Mergers in International Economic Integration," in A. Giovannini and C. Mayer, eds., *European Financial Integration*, Cambridge: Cambridge University Press, 136–160.

Combes, P.-P., 1997, "Industrial Agglomeration under Cournot Competition," *Annales d'Économie et de Statistique*, 45, 161–182.

Fauli-Oller, R., 2000, "Takeover Waves," *Journal of Economics & Management Strategy*, 9, 189–210.

Flaherty, M.T. and R. Raubitschek, 1990, "Local Presence and International Manufacturing in Technology-Intensive Industries," *Japan and the World Economy: International Journal of Theory and Policy*, 2, 301–326.

Friedman J.W. and J.-F. Thisse, 1993, "Partial Collusion Fosters Minimum Product Differentiation," *Rand Journal of Economics*, 24, 631–645.

Fujita, M. and J.-F. Thisse, 1996, "Economics of Agglomeration," *Journal of the Japanese and International Economies*, 10, 339–378.

Graham, E.M., 1998, "Market Structure and the Multinational Enterprise: A Game-Theoretic Approach," *Journal of International Business Studies*, 29, 67–83.

Greene, W.H., 1997, *Econometric Analysis*, 3rd ed., Toronto: Prentice-Hall Canada.

Hennart, J.-F. and Y.-R. Park, 1994, "Location, Governance, and Strategic Determinants of Japanese Manufacturing Investment in the United States," *Strategic Management Journal*, 15, 419–436.

Horstmann, I. and J. Markusen, 1992, "Endogenous Market Structures in International Trade (Natura Facit Saltum)," *Journal of International Economics*, 32, 109–129.

Knickerbocker, F., 1973, *Oligopolistic Reaction and Multinational Enterprise,* Cambridge, MA: Harvard University Press.

Kocherlakota, N., 1996, "The Equity Premium: It's Still a Puzzle," *Journal of Economic Literature*, 34, 42–71.

Kogut, B. and S.J. Chang, 1991, "Technological Capabilities and Japanese Direct Investment in the United States," *Review of Economics and Statistics*, 73, 401–413.

—— and ——, 1996, "Platform Investments and Volatile Exchange Rates: Direct Investment in the U.S. by Japanese Electronic Companies," *Review of Economics and Statistics*, 78, 221–231.

Motta, M., 1994, "International Trade and Investments in a Vertically Differentiated Industry," *International Journal of Industrial Organization*, 12, 179–196.

Ottaviano, G., T. Tabuchi, and J.-F. Thisse, 2002, "Agglomeration and Trade Revisited," *International Economic Review*, 43 (2), 409–436.

Varian, H., 1992, *Microeconomic Analysis*, New York: W.W. Norton.

Yu, C.-M.J. and K. Ito, 1988, "Oligopolistic Reaction and Foreign Direct Investment: The Case of the U.S. Tire and Textiles Industry," *Journal of International Business Studies*, 19, 449–460.