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Entry, Location and R&D Decisions in an International Oligopoly

by

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Abstract

We examine two questions, both motivated by an empirical regularity. First, when are incumbent firms' foreign direct investment (FDI) and R&D expenditures positively associated in equilibrium in an international oligopoly? We show that a positive association can be expected to exist only if most of the variation between observations represents market size differences: large markets support the sunk costs of both FDI and R&D. Second, when will incumbent firms in an international oligopoly use FDI to pre-empt entry into the industry by outside firms and thereby maintain concentration? We find that entry-detering FDI is feasible only in intermediate-sized markets and that, due to free riding, it is underprovided in equilibrium from the viewpoint of the incumbent oligopoly.

JEL classification: F21, F23, L13, O31.

Keywords: foreign direct investment; process R&D; entry; international oligopoly; equilibrium industrial structure.

Outline

1. *Introduction*
2. *The Modelling Structure*
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Non-Technical Summary

We pose two questions. First, when are incumbent firms' FDI and R&D expenditures positively associated in equilibrium in an international oligopoly? This question was provoked by the widespread empirical evidence of a strong positive correlation between FDI and R&D intensities (at both firm and industry levels). Second, when will incumbent firms in an international oligopoly use intra-industry FDI to pre-empt entry into the industry by outside firms and thereby maintain concentration? This question was motivated by widespread evidence of positive correlations between FDI intensity and product market "concentration" at the industry level. In the empirical literature debate on the causes of the observed FDI/concentration correlations is lively with some arguing that the association disappears once other influences on concentration (e.g. scale economies) are controlled for, so a deeper theoretical understanding of the FDI/ concentration relationship is particularly valuable.

To address the first question on the FDI/ R&D relationship, a model was developed of the FDI and R&D decisions of incumbent international duopolists in a two-country world. Our key finding was that the levels of intra-industry FDI and R&D investment will be positively correlated if most of the variation between observations is due to market size differences: large markets support the sunk costs of both FDI and R&D. However, this positive association fails if the bulk of the variation stems from differences in the probability of R&D success. Although equilibrium R&D investment is increasing in the success probability, equilibrium intra-industry FDI flows are hump-shaped in the success probability. The "best" outcome for an incumbent if both undertake process R&D, under which the likelihood of its being able to cover the sunk cost of FDI is greatest, is success for its own R&D effort but failure for its rival's, and – given that R&D outcomes are independent across firms – the probability of obtaining such an "R&D advantage" approaches zero as the R&D success probability itself approaches zero or one, implying that FDI is "most likely" at intermediate probabilities of R&D success.

Turning to the second question on the FDI/ concentration relationship, we extended the previous model to include, at an intermediate stage, the entry decision at a global level of an outside firm. Entry deterrence (i.e. the maintenance of concentration) via intra-industry FDI is possible only in intermediate-sized markets: in small markets entry never occurs, whereas in large markets entry always occurs. Although the potential for strategic entry deterrence creates an additional incentive (i.e. to "tariff-jumping") for FDI in intermediate-sized markets, we show that FDI occurs there in equilibrium only if cost conditions are reasonably conducive to tariff-jumping FDI (i.e. a sufficiently small plant sunk cost relative to the trade cost). This is because an incumbent free rides on the entry-detering FDI undertaken by its rival, implying that an individual incumbent's incentive for FDI is "too weak" from the viewpoint of the incumbent duopoly.

A general conclusion of this paper is that the relationships between firms' "corporate structure" decisions (e.g. FDI, R&D and entry into new industries) in an international oligopoly are both subtle and important in the determination of equilibrium outcomes.

1 Introduction

Empirical work on foreign direct investment (FDI) has uncovered a number of robust and intriguing stylized facts.¹ This paper focuses on two. First, FDI intensity is generally found to be strongly positively correlated with R&D intensity at both firm and industry levels. For example, in their industry-level study of US FDI in Europe, Barrell and Pain (1999) estimate that a 1% rise in the stock of R&D accumulated at home eventually raises the stock of FDI owned by US multinational enterprises (MNEs) in Europe by 0.37%. Indeed, Caves (1996, p. 8) argues that “research and development intensity... is a thoroughly robust predictor” of firms’ horizontal FDI intensities. Second, FDI intensity is generally found to be positively correlated with measures of source- and host-country product market concentration. Davies and Lyons (1996, chapter 7), for example, report a correlation coefficient of +0.5 between indices of the “transnationalization” within the EU of large European manufacturers and production concentration across firms at the EU level.² It therefore appears that the FDI decisions of incumbent firms in international oligopolies are closely associated with their R&D decisions and with the entry decisions of “outside” firms (at a global level). This paper investigates the causes of these well-established empirical associations.

Because multinational enterprises typically operate in concentrated industries, where considerations of strategic inter-firm rivalry are likely to exert a significant influence on equilibrium outcomes, it is common in the formal literature to model firms’ FDI decisions game-theoretically.³ However, despite the empirical associations noted above, the potential connections between FDI decisions and other dimensions of corporate strategy (e.g. R&D investment and entry into new industries) remain relatively unexplored.⁴ Therefore, this paper presents a unified framework for examining the connections in an international oligopoly between (i) incumbent firms’ FDI and R&D decisions, and (ii) incumbent firms’ FDI decisions and the entry decisions (at a global level) of outside firms. We are concerned with two questions. First, when are FDI and R&D investments positively associated in equilibrium? The analysis here contributes to the literature that formalizes and extends Dunning’s famous (1977) OLI (“ownership-location-internalization”) framework for explaining how firms serve foreign markets (i.e. exporting vs. licensing vs. FDI).

¹For exhaustive surveys, see Markusen (1995) and Caves (1996).

²For additional evidence, see Caves (1996, section 4.1) and UNCTAD (1997, chapter 4).

³Canonical models of rival firms’ reciprocal FDI decisions in a two-firm, two-country world are Dei (1990), Horstmann and Markusen (1992) and Rowthorn (1992). The same basic framework for determining production locations has been extended to consider the effects of regional economic integration (Motta and Norman, 1996), non-tariff barriers (Sanna-Randaccio, 1996), and productivity spillovers (Fosfuri and Motta, 1999; Siotis, 1999).

⁴In parallel with the literature that examines FDI decisions independently of other “corporate strategy” decisions, there are closed-economy literatures on firms’ R&D decisions (e.g. Dasgupta and Stiglitz, 1980; Brander and Spencer, 1983; Leahy and Neary, 1997) and entry decisions (e.g. Dixit, 1980; Fudenberg and Tirole, 1984). A general contribution of this paper is to examine how the additional costs (e.g. trade costs) and strategies (e.g. FDI to build extra plants) associated with an open economy affect behaviour. Ongoing trade liberalization and “globalization” make this analysis increasingly relevant.

In particular, whereas Dunning and a number of formal models inspired by the OLI framework (e.g. Horstmann and Markusen, 1992; Brainard, 1993; Ethier and Markusen, 1996; Markusen and Venables, 1998) take as given a firm’s possession of the “ownership advantages” necessary to compete internationally, we endogenize the R&D investment decision. This allows consideration of “feedback” effects from FDI to R&D and of the common structural determinants of both FDI and R&D in equilibrium.⁵ Second, when will incumbent firms in an international oligopoly use FDI to pre-empt entry into the industry by outside firms and thereby maintain “concentration”?⁶ This analysis builds on the literature, stemming from Horstmann and Markusen (1987) and Smith (1987), on pre-emptive FDI in the face of an entry threat by an outside firm. We extend the analysis to consider two incumbents (and thereby considerations of potential “free riding” in the provision of entry deterrence) and equilibrium corporate structures across two countries.⁷ These two extensions are intimately interconnected: with two incumbents, initially owning “home” plants in different countries and able to undertake both FDI and R&D, the firms’ sunk investment (“corporate structure”) decisions are, in general, interdependent. For example, if one firm undertakes process R&D, the profitability of undertaking FDI for its rival is affected (probably adversely, as product market competition toughens).⁸ Therefore, when determining a firm’s equilibrium corporate structure, only a partial (and somewhat distorted) picture is created by holding its foreign rival’s corporate structure fixed.

To address the first question on the FDI/ R&D relationship, we solve a two-stage game for the equilibrium FDI and R&D choices of international duopolists, assuming *blockaded entry* into the industry at a global level.⁹ At stage one, the firms choose whether to undertake FDI, which allows them to “jump” the specific trade cost, or risky process R&D, or both. Both discrete decisions entail a sunk cost. At stage two, Bertrand competition determines market equilibria in both countries.¹⁰ Our comparative-statics analysis of equilibrium behaviour shows that FDI

⁵Dunning argued that R&D *causes* FDI by granting the firm a proprietary cost (“ownership”) advantage sufficient to offset the extra costs of co-ordinating business across national borders (e.g. costs of learning foreign languages, legal systems, and business customs), which are not faced by host-country firms. Building on Dunning, the four formal analyses cited all assume that firms spend given amounts on R&D, represented by exogenous firm-specific fixed costs. A generic conclusion is that MNEs are more likely to arise in equilibrium, the larger are firm-specific relative to plant-specific fixed costs (i.e. the “more important” are ownership advantages). However, R&D can only be a “proximate” cause of FDI because, in reality, both are choice variables for the firm.

⁶Here, “concentration” is to be thought of solely in terms of firm numbers.

⁷Both Smith and Horstmann/ Markusen constrain potential entrants to serve only the local market and therefore examine equilibria in one host country.

⁸Fixed and sunk costs are central to this “interdependence” feature. We provide a taxonomy of the “strategic” effects of sunk investments in section 3.2.

⁹The world comprises two countries, each containing the pre-existing “home” plant of one firm, and the product is homogeneous, an identical initial set-up to Brander and Krugman (1983). We are thus modelling FDI flows between “developed” countries (rather than North-South flows), which represent the majority of global FDI flows (Markusen, 1995, p. 171). The only form of FDI considered is “greenfield investment”, the building of a new plant abroad. For an analysis of the choice of FDI mode (greenfield investment vs. acquisition), see Ferrett (2004).

¹⁰Our blockaded entry game can be viewed as a simplification of Petit and Sanna-Randaccio

flows and R&D investment will be positively correlated if “most” of the variation between observations is due to market size differences: large markets support the sunk costs of both FDI and R&D. However, this positive association fails if the bulk of variation stems from differences in the probability of R&D success. Although equilibrium R&D investment is increasing in the success probability, equilibrium intra-industry FDI flows are hump-shaped in the success probability.¹¹ Our assumption of Bertrand competition in homogeneous goods implies that undertaking sunk investments is profitable *ex post* only if a firm’s own R&D succeeds and its rival’s fails, which becomes progressively less likely as the success probability approaches 0 or 1. Therefore, our analysis of equilibria under blockaded entry highlights the quite distinct effects of changes in market size and “technology” (the probability of R&D success) on equilibrium outcomes.

Turning to the second question on the relationship between incumbents’ FDI decisions and the entry of outside firms, we add an intermediate stage to the game described above to allow for the *potential entry* of an outside firm at a global level. We assume that entry occurs by diversification: an MNE, initially using plants in both countries to produce for another (“related”) industry, can turn its plants over to produce the good in question by making R&D investments.¹² A key result is that intra-industry FDI flows need no longer be monotonically increasing in national market size in equilibrium. If markets are small, then no FDI or entry occurs at the previously-derived blockaded-entry equilibria, so these equilibria endure under potential entry. If markets are large, then (rent-dissipating) entry must be accommodated by the incumbents, so FDI becomes “less likely” than at the corresponding blockaded-entry equilibrium (where two-way FDI occurs). However, for intermediate market sizes, entry can be deterred if the incumbents undertake *more* FDI than under blockaded entry.¹³ Therefore, the combination of the need to accommodate entry in large markets (which reduces the profitability of FDI) and the potential for entry deterrence in intermediate-sized markets (which increases the profitability of FDI) means that the incumbents’ equilibrium spending on FDI may *decrease* as market size rises from “intermediate” to “large”.¹⁴

Our result on the non-monotonicity of (the volume of) FDI in market size is related to the findings of Horstmann and Markusen (1987) and Motta (1992). (Both

(2000) whose “international duopoly” model of FDI and R&D assumes continuous R&D investment, localized spillovers and Cournot behaviour. Unlike Petit and Sanna-Randaccio, our model can be solved analytically, so a complete comparative-statics analysis of equilibrium behaviour is possible. In particular, Petit and Sanna-Randaccio do not discuss the effect of market size on equilibrium outcomes. Furthermore, unlike Norbäck’s (2001) analysis of a monopoly MNE’s process R&D decision, our oligopolistic modelling structure admits both “strategic” and “pure” incentives for sunk investments.

¹¹We show in Figure 1 that this result only holds if national product markets are sufficiently large. FDI never occurs in equilibrium in small markets.

¹²This modelling assumption is fully justified in the next section.

¹³Therefore, FDI can be used to maintain “concentration” only in intermediate-sized markets.

¹⁴This contrasts with the result of Shaked and Sutton (1987, Corollary to Proposition II) that increases in market size are associated with higher spending on sunk costs by incumbents, rather than entry (“fragmentation”). A key difference between our analysis and that of Shaked and Sutton is that the incumbents and the outside firm move sequentially.

papers analyse a monopoly incumbent’s FDI decision in a single host country under the threat of subsequent entry.) Horstmann and Markusen find that the MNE will always use FDI to pre-empt entry if the host country’s market can only support one profit-making plant (i.e. a natural monopoly). However, if up to two plants can be supported, then entry must be accommodated by the MNE and it chooses FDI only if plant-specific sunk costs are sufficiently small relative to trade costs, conditions conducive to “tariff-jumping” FDI.¹⁵ In section 4 we show that our model of potential entry resembles Horstmann and Markusen’s in that the incumbents undertake FDI when entry must be accommodated (because national markets are large) only if cost conditions are favourable to tariff-jumping FDI. However, we also highlight an important difference. If, in our model, one incumbent undertakes pre-emptive FDI, the rival incumbent enjoys higher expected profits.¹⁶ Therefore, appropriation of the returns to pre-emptive FDI is incomplete, and it is not true that pre-emptive FDI always arises in equilibrium if it is feasible (i.e. if national markets are not “too large”).

The remainder of the paper is organized as follows. The next section presents our models of the incumbents’ FDI and process R&D choices under blockaded and potential entry at the global level. In section 3 equilibrium industrial structures are analysed, and in section 4 the incumbents’ choice between entry deterrence and accommodation under potential entry is examined. Finally, section 5 concludes.

2 The Modelling Structure

2.1 Sequence of Moves and Equilibrium Concepts

We consider a three-firm, two-country world, where national product markets are of identical “size” and the product is homogeneous. Product markets may be served either by local production or by international trade from a plant abroad, which incurs a specific trade cost of t . There are initially four production plants, two in each country. Firms 1 and 2, the “incumbents”, initially own one plant each, and these plants are located in different countries. (Hence the incumbents “originate” from different countries.) Firm E , the “potential entrant”, initially owns the remaining two plants, which are located in different countries.

Firms can establish additional plants in either country at a sunk cost of G . Plants have constant marginal production costs, which are determined by the firm’s stock of technical knowledge. (Technology is assumed to be a public good within the firm, which can costlessly be applied to production in every plant, but a proprietary good between firms. There are no inter-firm technological spillovers.) Therefore, there are plant-level economies of scale and no firm will optimally maintain more than

¹⁵Horstmann and Markusen’s cases of natural monopoly and duopoly correspond to our cases of intermediate-sized and large markets. Motta’s (1992) model similarly displays a weaker incentive for FDI under accommodation than pre-emption, although the assumed parametrization means that FDI always arises in equilibrium under sequential moves.

¹⁶In contrast to the Gilbert and Vives (1986) Stackelberg model of entry, an incumbent in our model *does* free ride on the rival incumbent’s investments in entry deterrence.

one plant in either country.

Initially firms 1 and 2 possess the same level of technology, which sets their marginal production costs at $c \in (0, 1)$. Firm E 's initial marginal production cost is strictly greater than the monopoly price associated with c , which we define below as $x^M(c)$. Technological progress occurs in steps, and each step incurs a sunk cost of I . The technological laggard (firm E) can purchase the industry's best-practice technology (i.e. a marginal production cost of c) in one step. For firms on the technological frontier (i.e. firms 1 and 2 initially, and firm E after sinking an investment of I to catch up) I purchases a process R&D investment with a risky outcome. With probability p R&D investment "succeeds" and the firm's marginal production cost falls to 0; however with probability $1 - p$ R&D investment "fails" and the firm's marginal production cost remains at c . The probability of R&D success is identical and independent across firms.

We analyse two games: one assumes *blockaded entry* (BE) and the other allows for *potential entry* (PE) by firm E . Firm E plays no role in the two-stage BE game, which focuses on the relationships between the incumbents' FDI and R&D investments:

Stage one of the BE game: Firms 1 and 2 simultaneously and irreversibly choose their "corporate structures". Given the assumptions on initial conditions and sunk investments outlined above, there are four possible corporate structures: $1N$, $1R$, $2N$ and $2R$. The first component of each corporate structure indicates the number of plants (1 or 2, i.e. FDI) and the second shows whether (R) or not (N) process R&D is undertaken.¹⁷

Stage two of the BE game: Bertrand competition determines market equilibria in both countries.¹⁸

We assume that firms maximize expected profits, and we concentrate on subgame perfect Nash equilibria in pure strategies, which for convenience we term "equilibrium industrial structures".

In the PE game firm E 's "entry decision" occurs at an intermediate stage between stages one and two of the BE game. When making its decision, firm E can observe the incumbents' corporate structure choices but not whether any R&D investments they undertook succeeded or failed. Because firm E initially owns one plant in each country and marginal production costs are constant, its corporate structure choice only contains a technological element. This is an extremely useful simplification.

Firm E 's "entry decision" in the PE game: Firm E chooses between three corporate structures, \emptyset , E and R . \emptyset represents a decision not to invest in technological progress and to remain outside the industry. E and R both represent "entry" by firm E , potentially with production in both countries. The E strategy represents a decision to step onto the technological frontier at a sunk cost of I .

¹⁷Because $1N$ incurs no sunk costs, an "exit" strategy (to avoid loss-making in equilibrium) may legitimately be ignored.

¹⁸In both the BE and PE games we assume that choices made at any stage are common knowledge in subsequent stages and that the outcome (success/ failure) of any R&D investments undertaken becomes common knowledge at the start of the "market stage". The latter assumption may be interpreted as a weak form of spillovers.

Under the R strategy firm E attempts to take two steps at a sunk cost of $2I$: one onto the technological frontier, and an additional step via process R&D.¹⁹

Clearly, “entry” by firm E via corporate structure choices of E or R has a rather stylized meaning in our model. Von Weizsäcker (1980) argues that entrants into an industry must pay sunk costs not incurred by incumbents: whether to pay these costs is the essence of the entry decision. By assuming that firm E possesses pre-existing but highly (productively) inefficient plants in both countries, our model incorporates a von Weizsäcker-type entry decision for firm E without introducing a location decision. This restriction on firm E ’s strategic choices, implied by the assumptions of pre-existing plants and constant marginal production costs, both simplifies our analysis and generates a significant interest (because the credibility of the entry threat is increased relative to a model where firm E must sink an investment of G to establish each plant). However, the question of how to interpret entry by firm E remains. A neat interpretation is to view firm E as a diversifying MNE entrant (rather than a de novo entrant), whose pre-existing plants produce for a “related” industry (in terms of production processes) and can be adapted to produce the good under analysis.²⁰

The result in Lemma 1 simplifies the analysis of equilibrium behaviour.

Lemma 1. (i) In the BE and PE games an incumbent will never optimally choose a corporate structure of $2N$ because it is strictly dominated by one of $1N$. (ii) In the PE game the entrant will never optimally choose a corporate structure of E because it is strictly dominated by one of \emptyset .

Proof. Both results follow directly from the assumption of Bertrand competition in homogeneous goods. Choosing $2N$ over $1N$ and E over \emptyset leaves expected variable profits unchanged (because the firm does not gain a marginal cost *advantage*) but increases sunk costs.

Lemma 1 shows that the incumbents’ strategy spaces can be restricted to $\{1N, 1R, 2R\}$ and the potential entrant’s to $\{\emptyset, R\}$. The result in part (i) captures the FDI/ R&D link in OLI models. In order to make FDI profitable, the “ownership advantages” generated by process R&D are necessary. However, as is shown in section 3.2 below, there also exist “feedback” linkages from FDI to R&D.

One way of summarizing the modelling structure is that firms’ sunk investments imply that the marginal cost of serving a given national product market can take four values: 0 with local production and R&D success; t with foreign production and R&D success; c with local production and R&D failure; and $c + t$ with foreign

¹⁹Therefore, unlike the Aghion et al. (2001) model of step-by-step innovation, the technological laggard in our model potentially can leap-frog over the leaders.

²⁰The assumption of entry by a diversifying MNE can be justified on two empirical grounds. First, Geroski (1995, p. 424) notes that “de novo entry is more common *but less successful* than entry by diversification” (italics added). Therefore, entry by diversification will exert a significant influence on industrial structure in the long run because a disproportionate number of de novo entrants later exit. Second, Davies et al. (2001) in their study of 277 leading European manufacturers reported that 104 (i.e. 37.5%) were both multinational and diversified, indicating that the two strategies are often complements.

production and R&D failure. Throughout our analysis we maintain the following intuitively-appealing assumption on t and c :

$$1 > c > t > 0 \tag{A}$$

2.2 Market Size and Variable Profits

Demand conditions are identical in both countries, and the product is homogeneous. Market demand in either country is

$$Q_k = \mu(1 - x_k).$$

Q_k and x_k are demand and price in country k respectively, $k \in \{1, 2\}$. μ measures the “size” of either national product market and can be interpreted as an index of the number of homogeneous consumers in each country, all of whom have a reservation price of 1.²¹

Variable profits equal revenue minus variable costs. If either national product market is monopolized by firm i with a constant marginal cost of c_i , the monopoly price will be

$$x^M(c_i) = \frac{1}{2}(1 + c_i).$$

The monopolist’s variable profits are $\mu R^M(c_i)$, where

$$R^M(c_i) = \frac{1}{4}(1 - c_i)^2$$

measures variable profit per consumer.

If firms i and j serve either national product market in a Bertrand duopoly, then firm i ’s variable profit function is $\mu R(c_i, c_j)$, where

$$R(c_i, c_j) = \begin{cases} 0 & \text{for all } c_j \in [0, c_i] \\ (1 - c_j)(c_j - c_i) & \text{for all } c_j \in [c_i, x^M(c_i)] \\ R^M(c_i) & \text{for all } c_j \in [x^M(c_i), 1] \end{cases}$$

again measures variable profit per consumer. If $c_i > c_j$, then firm j optimally sets a price below c_i and captures the entire market (the top line). If $c_i < c_j$, there are two possibilities. If the gap between c_i and c_j is “small” (i.e. $x^M(c_i) > c_j$), firm i sets a price of $c_j - \varepsilon$, earns variable profit per unit of $c_j - c_i$, and serves the entire market with $\mu(1 - c_j)$ units (the middle line). However, if the gap between c_i and c_j is “large” (i.e. $x^M(c_i) < c_j$), firm i optimally sets its monopoly price, which is still less than c_j (the bottom line). Variable profits at a Bertand equilibrium with more than two firms can be straightforwardly derived if c_j is defined as the minimum of firm i ’s rivals’ marginal costs (i.e. $c_j \equiv \min\{c_1, c_2, \dots, c_{i-1}, c_{i+1}, \dots, c_N\}$).

²¹The international market is “segmented” because arbitrage constraints never bind in equilibrium.

Two qualitative conclusions about equilibrium industrial structures in the two-firm BE game can now be drawn. First, market equilibria when both firms produce locally are more “competitive” than when one firm produces abroad in the sense that both the maximum and the minimum possible market prices are lower.²² This occurs because the foreign firm becomes a more aggressive competitor with the local firm when it substitutes FDI for exporting and eliminates the trade cost from its marginal cost. Second, given our assumption of Bertrand competition, cross-hauling of international trade flows will never occur in equilibrium, although FDI cross-hauling may occur.

3 Analysis

3.1 Expected Profits

Under assumption (A) on the marginal cost parameters, Tables 1, 2 and 3 show the firms’ expected variable profits per consumer at Bertrand equilibrium when one incumbent (firm 1) chooses $1N$, $1R$ and $2R$ respectively. Expected profits can be derived by multiplying by μ and subtracting the relevant sunk costs: 0 for $1N$ and \emptyset , I for $1R$, $2I$ for R , and $G + I$ for $2R$. All the expected variable profit functions have the same general form: each is a weighted sum of the firm’s global variable profits across all possible “states of the world,” where each state is associated with a distinct configuration of R&D outcomes across firms and the weight applied is the probability of that state’s occurrence.²³ For example, in $(1R, 2R; \emptyset)$ – see Table 2 – firm 1 must possess a marginal production cost advantage if it is to enjoy strictly positive variable profits because firm 2 has a local plant in country 1. This occurs with probability $p(1 - p)$ when 1’s R&D effort succeeds but 2’s fails. On the other hand, firm 2 can earn strictly positive variable profits *at home* when the firms’ marginal production costs are equal (i.e. if both R&D efforts succeed with probability p^2 or fail with probability $(1 - p)^2$) because the trade cost affords its domestic plant some protection from foreign competition.

[INSERT TABLES 1, 2 AND 3 HERE]

²²Of course, these “polar” prices vary with R&D outcomes. When both firms produce locally, the maximum possible market price is c (when neither firm innovates successfully) and the minimum is 0 (when both firms innovate successfully). Likewise, when only one firm produces locally, the maximum possible market price is $\min\{x^M(c), c + t\}$ and the minimum is $\min\{x^M(0) = 0.5, t\}$.

²³If a firm earns strictly positive variable profits in both countries in a given “state of the world,” we apply the convention of writing domestic variable profits as the first term in square brackets and foreign variable profits as the second.

Three general features of the expected variable profit functions in Tables 1, 2 and 3 are noteworthy.²⁴ First,

$$\pi_1(2R, S_2; S_E) > \pi_1(1R, S_2; S_E) > \pi_1(1N, S_2; S_E) \quad (1)$$

for all $S_2 \in \{1N, 1R, 2R\}$ and $S_E \in \{\emptyset, R\}$. Property (1), which states that an incumbent's expected variable profits increase with the number of sunk investments undertaken, will help in analysing best responses. Because the rate of change of expected profits with respect to market size equals expected variable profits per consumer, an increase in μ from a level where an incumbent is indifferent between two corporate structures will always prompt it to select the more "investment intensive" corporate structure. Second,

$$\pi_1(S_1, S_2; \emptyset) \geq \pi_1(S_1, S_2; R) \quad (2)$$

for all $S_1, S_2 \in \{1N, 1R, 2R\}$. Entry by firm E (weakly) reduces the incumbents' expected profits.²⁵ Property (2) creates an incentive for the incumbents to deter entry strategically in the PE game. Third,

$$\pi_E(1N, S_2; R) > \pi_E(1R, S_2; R) > \pi_E(2R, S_2; R) \quad (3)$$

for all $S_2 \in \{1N, 1R, 2R\}$. Entry by firm E is "less likely," the greater the number of sunk investments undertaken by the incumbents.²⁶ Property (3) indicates that the incumbents have an incentive *to use sunk investments in FDI* to deter entry by E strategically.

Importantly, the second property above, (2), allows us to connect the incumbents' optimal behaviour in the PE game to that in the BE game. The result is given in Lemma 2.

Lemma 2. (i) Let S_1^{BR} be firm 1's best response to S_2 in the BE game. If firm E 's best response to a choice by the incumbents of the pair (S_1^{BR}, S_2) is \emptyset , then S_1^{BR} remains a best response to S_2 in the PE game. (ii) Corollary: Let $(S_1^*, S_2^*; \emptyset)$ be the equilibrium industrial structure of the BE game. If firm E 's best response to the pair (S_1^*, S_2^*) is \emptyset , then $(S_1^*, S_2^*; \emptyset)$ is also the equilibrium industrial structure of the PE game.

²⁴ $\pi_1(S_1, S_2; S_E)$ are incumbent 1's expected variable profits per consumer when the incumbents and the potential entrant choose corporate structures of S_1 , S_2 and S_E respectively. None of these properties are surprising. They all reflect the fact that all sunk investments in our model reduce the investor's marginal cost of serving at least one market. All three properties are easily verifiable by inspection of the expected variable profit functions in Tables 1, 2 and 3.

²⁵The inequality in property (2) holds strictly in all cases except $S_1 = 1N, S_2 = 2R$ where firm 1 earns 0 in both the BE and PE games.

²⁶The region in parameter space where entry by E occurs for a given number of sunk investments by the incumbents covers the regions where entry occurs for *more* sunk investments. The one ambiguity here is the case of *two* sunk investments by the incumbents, which may refer to choices of either $(1N, 2R)$ or $(1R, 1R)$. (Otherwise, the mapping from numbers of sunk investments to pairs of incumbents' choices is one-to-one.) If and only if $t < 0.5$ entry is "more likely" in response to $(1N, 2R)$ than to $(1R, 1R)$; otherwise, E 's expected profits under R are equal in these two cases.

Proof. Both results follow immediately from the fact that entry by E (weakly) reduces the incumbents' expected profits.

The results in Lemma 2 greatly simplify the analysis of equilibrium industrial structures in the PE game once those in the BE game are known. The general upshot is that firm E 's entry threat only "matters" when E will credibly choose R at the equilibrium of the BE game; otherwise, the BE game's equilibrium will endure into the PE game. It is not immediately obvious what happens when firm E optimally chooses R at the BE game's equilibrium. Clearly the equilibrium industrial structure of the BE game is undermined because it was premised on entry *not* occurring. Two possibilities deserve mention. The equilibrium industrial structure of the PE game may involve the incumbents investing more in FDI relative to the BE equilibrium in order *strategically to deter entry* by firm E . Alternatively, if for example E optimally chooses R *regardless* of the incumbents' choices, the incumbents may *accommodate* entry by undertaking less FDI than in the BE equilibrium. We shall see below that both of these possibilities do indeed arise.

3.2 Equilibrium Industrial Structures under Blockaded Entry

In the Appendix (section 6.1) we show that the following two assumptions on the cost parameters are necessary and sufficient uniquely to determine the equilibrium industrial structures of the BE game in (p, μ) -space:

$$R(0, c+t) + R(t, c) - R(c, c+t) - R(0, t) > 0 \quad (\text{B})$$

$$\frac{R(0, t)}{R(0, c) - R(t, c)} > \frac{I}{G} \quad (\text{C})$$

Given assumptions (B) and (C), Figure 1 plots the equilibrium industrial structures of the BE game. The inter-regional boundaries in Figure 1 are the incumbents' "indifference loci." Along (1BE), (2BE) and (3BE) an incumbent is indifferent between $1R$ and $1N$ in response to $1N$, $1R$ and $2R$ respectively. Therefore, these $R \mathcal{U} D$ *indifference conditions* are implicitly defined as

$$\mu\pi_1(1R, 1N; \emptyset) - I = \mu\pi_1(1N, 1N; \emptyset) \quad (\text{1BE})$$

$$\mu\pi_1(1R, 1R; \emptyset) - I = \mu\pi_1(1N, 1R; \emptyset) \quad (\text{2BE})$$

$$\mu\pi_1(1R, 2R; \emptyset) - I = \mu\pi_1(1N, 2R; \emptyset) \quad (\text{3BE})$$

[INSERT FIGURE 1 HERE]

Along (4BE) and (5BE) an incumbent is indifferent between $2R$ and $1R$ in response to $1N$ and either $1R$ or $2R$ respectively. Therefore, these *FDI indifference conditions* are implicitly defined as

$$\mu\pi_1(2R, 1N; \emptyset) - G = \mu\pi_1(1R, 1N; \emptyset) \quad (4BE)$$

$$\left. \begin{aligned} \mu\pi_1(2R, 1R; \emptyset) - G &= \mu\pi_1(1R, 1R; \emptyset) \\ \mu\pi_1(2R, 2R; \emptyset) - G &= \mu\pi_1(1R, 2R; \emptyset) \end{aligned} \right\} \quad (5BE)$$

Consider first an incumbent's R&D and FDI decisions when its rival chooses $1N$, (1BE) and (4BE). The critical μ -values implicitly defined by both are decreasing in p (the loci are rectangular hyperbolas). Intuitively, this is because the benefits of undertaking the sunk investments in either $1R$ or $2R$ in response to $1N$ are realized only if R&D succeeds; otherwise, variable profits for the investor equal those under $1N$ (see Table 1). Therefore, a rise in p must be counterbalanced by a fall in μ , which decreases the *incremental* payoff to successful R&D, to maintain indifference.

If its rival undertakes R&D, the “best” outcome for an incumbent choosing either $1R$ or $2R$ is success for its own R&D effort but failure for its rival's. The probability of winning this “R&D advantage” is $p(1-p)$, which is maximized at $p = 0.5$. Indeed, if its rival chooses $2R$, an incumbent can benefit from undertaking the sunk investments in either $1R$ or $2R$ *only* if such an R&D advantage occurs (see Tables 2 and 3); otherwise, the incumbent is unable to undercut its rival on either national product market. Therefore, (3BE) and (5BE) implicitly define U-shaped parabolas in (p, μ) -space, which are symmetric around $p = 0.5$ with asymptotes at $p = 0, 1$.²⁷ (2BE) likewise defines a U-shaped locus, reflecting the fact that an incumbent's “best” outcome when both choose $1R$ is an R&D advantage (as above). However, the locus is asymmetric, asymptotic to $p = 0$ only: whereas, in response to $1R$, an incumbent's expected variable profits are unchanged if it switches from $1N$ to $1R$ at $p = 0$, they rise at $p = 1$ (where a $1N$ -firm earns 0, but a $1R$ -firm earns strictly positive variable profits at home due to the protection afforded by the trade cost).

Before we summarize the comparative statics of the BE game in Proposition 1, two features of optimal behaviour are noteworthy. First, “two-way” relationships exist between an incumbent's FDI and R&D decisions: a commitment to undertake either FDI or R&D increases the return to the other sunk investment.²⁸ This was also found by Petit and Sanna-Randaccio (2000). The positive effect of R&D on the return to FDI is analogous to the FDI/ R&D linkage in OLI models, but MNEs also enjoy a larger return to process innovations than national firms because the “jumping” of trade costs means that an MNE's output base is larger. Second, the strategic effects of sunk investments are clearer-cut in the case of R&D than

²⁷An incumbent's indifference locus between $2R$ and $1R$ is identical in response to both $2R$ and $1R$, i.e. $\pi_1(2R, 1R; \emptyset) - \pi_1(1R, 1R; \emptyset) = \pi_1(2R, 2R; \emptyset) - \pi_1(1R, 2R; \emptyset)$. This is because product markets are “national,” so the choice between one plant and two depends on “competitive conditions” *abroad*, which are influenced by whether the foreign rival invests in R&D but not by its FDI decision.

²⁸This follows because $\pi_1(2R, S_2; S_E) - \pi_1(1R, S_2; S_E) > \pi_1(2N, S_2; S_E) - \pi_1(1N, S_2; S_E) = 0$, where the RHS equals 0 by Lemma 1(i).

FDI. If an incumbent undertakes R&D (i.e. chooses $1R$ over $1N$), its rival becomes “less likely” to under either R&D or FDI (i.e. choose $2R$ over $1R$).²⁹ This is simply because successful R&D makes a firm a more aggressive competitor. However, undertaking FDI has an ambiguous effect on the rival’s incentive to invest in R&D and no effect on its FDI incentive (because product markets are “national”).

Proposition 1. Comparative statics in the BE game:

- (i) Industry spending on both FDI and R&D is increasing in market size.
- (ii) Industry spending on R&D is increasing in the probability of R&D success.
- (iii) In small markets, independently of the probability of R&D success, intra-industry FDI never occurs. However, in large markets industry FDI spending is hump-shaped in the probability of R&D success.

Proposition 1 summarises the “general” features of Figure 1.³⁰ Neither part (i) nor part (ii) is surprising: sunk investments that reduce marginal cost are more worthwhile, the larger the market; and R&D investment is more attractive, the greater its success probability. However, the result in part (iii) that in large markets (i.e. $\mu > \mu(5BE)$) the volume of intra-industry FDI is hump-shaped in p is less obvious. It arises because of our assumption of Bertrand competition in homogeneous goods. Bertrand competitors in a homogeneous good will only incur sunk costs if they are likely to generate a marginal cost *advantage*. Therefore, playing $2R$ cannot be a best response to $2R$ for $p \cong 0$ or 1 because the most likely outcome is a market price in both countries of c or 0 respectively and a loss of $G + I$ for both firms. It follows from Proposition 1 that we would expect FDI and R&D investments to be positively correlated only if “most” of the variation between observations is due to market size differences.

Changes in the cost parameters (c, t, G, I) are relevant to the equilibrium in two ways. First, conditions (B) and (C) place restrictions on them. That (B) is only slightly more demanding than our maintained assumption (A) is clear from Figure 2, where only in region II does (A) hold but (B) fail. Furthermore, it is straightforward but tedious to show that the LHS of (C) is strictly greater than 1 for all t and c under assumption (A). Therefore, setting $G \geq I$ *certainly* satisfies (C); however, it is unnecessary.³¹ Second, given that (B) and (C) hold, altering the cost parameters shifts the inter-regional boundaries in Figure 1 (in intuitively-appealing directions). For example, rises in t and falls in G both enlarge the two regions where FDI arises in equilibrium (i.e. $\partial\mu(3BE)/\partial t > 0 > \partial\mu(4BE)/\partial t, \partial\mu(5BE)/\partial t$ and $\partial\mu(4BE)/\partial G, \partial\mu(5BE)/\partial G > 0$). A fall in I makes R&D more likely in equilibrium (i.e. $\partial\mu(1BE)/\partial I > 0$).

[INSERT FIGURE 2 HERE]

²⁹This follows because, for all p , $\mu(2BE) > \mu(1BE)$ and $\mu(5BE) > \mu(4BE)$.

³⁰In doing so, Proposition 1 abstracts from the $(1N, 2R; \emptyset)$ equilibrium. If, where both equilibria exist, $(1N, 2R; \emptyset)$ is selected over $(1R, 1R; \emptyset)$, then all three parts of Proposition 1 require minor modification.

³¹For example, if $c \gg t > 0.5$, then $R(0, t) = R(0, c) = R^M(0)$ and $R(t, c)$ is “large.” Therefore, the LHS of (C) is much greater than 1, and $I > G$ will be compatible with (C).

3.3 Equilibrium Industrial Structures under Potential Entry

In the Appendix (section 6.2) we show that the following two assumptions, counterparts of (B) and (C), are necessary and sufficient to generate Figures 3 and 4, which plot PE equilibria for “large” and “small” G respectively:

$$R(0, c+t) + R(t, c) - R(c, c+t) - R(0, c) > 0 \quad (\text{B})^*$$

$$\frac{R(0, t) [R(0, c) + R(t, c)]}{[R(0, t) + 2R(t, c)] [R(0, c) - R(t, c)]} > \frac{I}{G} \quad (\text{C})^*$$

[INSERT FIGURES 3 AND 4 HERE]

In addition to the inter-regional boundaries (incumbents’ indifference loci) from Figure 1, the construction of Figures 3 and 4 also uses E ’s *entry indifference conditions*, labelled (1PE) to (6PE). Each takes the form $\mu\pi_E(S_1, S_2; R) = 2I$, so that E is indifferent between “entering” in response to (S_1, S_2) and staying out. (1PE) and (2PE), which determine E ’s choice in response to $(1N, 1N)$ and $(1N, 1R)$ respectively, implicitly define downward-sloping loci in (p, μ) -space: increases in p must be counterbalanced by decreases in μ to keep E ’s expected profits under R equal to 0.³² (3PE) through to (6PE), which successively determine E ’s choice in response to $(1N, 2R)$, $(1R, 1R)$, $(1R, 2R)$ and $(2R, 2R)$, all implicitly define U-shaped parabolas in (p, μ) -space with asymptotes at $p = 0, 1$. The reason for this is that the “best” outcome for E when several firms undertake R&D is success for itself but failure for others, the probability of which approaches 0 as p tends to 0 or 1. Property (3) from section 3.1 shows that the series $\mu(1\text{PE}), \mu(2\text{PE}), \dots, \mu(6\text{PE})$ is increasing, so if E optimally chooses R in response to a given (S_1, S_2) , it will also optimally choose R in response to all less “investment intensive” (S_1, S_2) .³³

We next define the distinction between “large” and “small” G , which underpins Figures 3 and 4. In the PE game three regions exist where both entry-detering and entry-accommodating equilibria potentially exist: (i) between (2PE) and (4BE), where the choice is between $(1N, 2R; \emptyset)$ and $(1N, 1N; R)$; (ii) between (4PE) and the lower of (5BE) and (5PE), where the choice is between $(1R, 2R; \emptyset)$ and $(1R, 1R; R)$; and (iii) between (5PE) and the lower of (5BE) and (6PE), where $(2R, 2R; \emptyset)$ might exist in addition to $(1R, 1R; R)$. Entry deterrence requires that one incumbent or both undertake FDI, so it becomes “less likely”, the larger is G .³⁴ In the context

³²While (1PE) implicitly defines a rectangular hyperbola in (p, μ) -space, the locus from (2PE) may, strictly speaking, be U-shaped, although its value at $p = 1$ will be finite. If and only if $R(0, c) = R(0, t)$, i.e. $t \geq 0.5$, the (2PE) locus will be strictly decreasing on $p \in (0, 1)$; otherwise, it will slope upwards for “large” p for reasons analogous to (2BE).

³³Note that not all of (1PE), (2PE), ..., (6PE) appear in Figures 3 and 4, although all are used in their construction (section 6.2). Figures 3 and 4 also plot (7PE), which sets $\mu[\pi_1(2R, 1R; R) - \pi_1(1R, 1R; R)] = \mu[\pi_1(2R, 2R; R) - \pi_1(1R, 2R; R)] = G$.

³⁴This result is presented formally in Proposition 4 in the next section.

of Figures 3 and 4, “large” G means that the entry-accommodating PE equilibrium arises wherever both types of equilibrium potentially exist, and “small” G means that the entry-detering PE equilibrium arises in all three cases. In section 4 we analyse the occurrence of equilibrium entry-accommodation and -deterrence in the three regions where both types of PE equilibrium potentially exist, and we show that assumption (C)*, which restricts I/G in the PE game, is compatible with both “large” and “small” G in the sense just defined.

For our purposes, the most relevant aspect of Figures 3 and 4 is their predictions on the relationship between market size and the incumbents’ FDI spending. The comparative statics are summarized in Proposition 2.

Proposition 2. Intra-industry FDI in the PE game:

- (i) In small markets, i.e. $\mu < \mu(4PE)$, intra-industry FDI never occurs.
- (ii) In intermediate-sized markets, i.e. $\mu(4PE) < \mu < \mu(6PE)$, one- or two-way intra-industry FDI occurs only if entry is deterred in equilibrium.
- (iii) In large markets, i.e. $\mu > \mu(6PE)$, entry must be accommodated. (Two-way) intra-industry FDI occurs only if national product markets are “very large”, i.e. $\mu > \mu(7PE)$.

An interesting prediction of Proposition 2 is that the volume of intra-industry FDI does not necessarily increase monotonically in μ . To understand this result, consider the area in Figures 3 and 4 above (4PE), which is where the entry threat “matters” for equilibria.³⁵ Between (4PE) and (6PE) entry can be deterred if one or both of the incumbents undertakes FDI. However, above (6PE) choosing R is a dominant strategy for firm E , so rent-dissipating entry must be accommodated. Therefore, an incumbent’s FDI incentive is weaker just above (6PE) than just below, which is reflected in the fact that FDI never arises in equilibrium immediately above (6PE) although it frequently arises just below (6PE) if G is sufficiently small.³⁶

Figures 3 and 4 follow from assumptions (B)* and (C)* on the cost parameters. Assumption (B)* is clearly more restrictive than (B) because $R(0, c) \geq R(0, t)$. In Figure 2 the region where (B) holds but (B)* fails is III. The LHS of (C)* is strictly less than that of (C) and strictly greater than 1 for all t and c in (A).³⁷

³⁵With the relatively minor exception of the region enclosed by (3BE), (4BE) and (2PE), PE equilibria for $\mu < \mu(4PE)$ are identical to those under blockaded entry. This reflects the general incredibility of an entry threat in small markets. Furthermore, for the incumbents $(1R, 1R; \emptyset)$ Pareto dominates $(1N, 1N; R)$, so the emergence of the latter is unlikely.

³⁶An important caveat when considering the incumbents’ FDI incentives under PE is that appropriation of the returns to entry deterrence is incomplete (i.e. both incumbents benefit from a single investment in entry-detering FDI). This issue is considered in the next section.

³⁷We show in the Appendix (section 6.2) that, if (C) continues to hold, the only consequence of violating (C)* is that $(1R, 1R; \emptyset)$ becomes the *unique* equilibrium for all $\mu(2BE) < \mu < \mu(4PE)$ – with the sole exception of $\mu(4BE) < \mu < \mu(3BE)$, where $(1N, 2R; \emptyset)$ exists too (as in Figure 1).

4 The Effect of the Entry Threat

In this section we evaluate the importance of the entry threat in the PE game in two ways. First, we examine the effect of the entry threat on the incumbents' FDI incentives in large and intermediate-sized markets (Propositions 3 and 4).³⁸ Second, we compare the BE and PE equilibria for given parameter values (Proposition 5).

Proposition 3 determines intra-industry FDI flows in large markets, where E 's dominant strategy is R .

Proposition 3. Incumbents' FDI decisions in large markets, i.e. $\mu > \mu(6PE)$, where entry must be accommodated:

- (i) (Two-way) intra-industry FDI occurs if and only if national product markets are "very large", i.e. $\mu > \mu(7PE)$.
- (ii) Falls in G and rises in t make (two-way) FDI "more likely" in equilibrium.

Part (i) is observed in Figures 3 and 4. To prove part (ii), note that

$$\mu(6PE) = \frac{2I}{\pi_E(2R, 2R; R)} = \frac{I}{p(1-p)^2 R(0, c)},$$

which is independent of G and t , whereas

$$\begin{aligned} \mu(7PE) &= \frac{G}{\pi_1(2R, 2R; R) - \pi_1(1R, 2R; R)} = \frac{G}{\pi_1(2R, 1R; R) - \pi_1(1R, 1R; R)} \\ &= \frac{G}{p(1-p)^2 [R(0, c) - R(t, c)]}, \end{aligned}$$

which increases in G but decreases in t .³⁹ Part (ii) relates directly to the strength of the "tariff-jumping" motive for FDI.⁴⁰

In intermediate-sized markets the relationship between intra-industry FDI and the entry threat is more complicated because E no longer has a dominant strategy. Proposition 4 addresses this case.

Proposition 4. Incumbents' FDI decisions in intermediate-sized markets, i.e. $\mu(6PE) > \mu > \mu(4PE)$, where FDI strategically deters entry:

- (i) Falls in G and rises in t make the existence of an entry-detering equilibrium "more likely".

³⁸We do not consider small markets, where with a minor exception (see n. 35) E optimally chooses \emptyset at the BE equilibrium.

³⁹In our Propositions "more likely" refers to an expansion of the relevant region in parameter space, rather than literally to a rise in probability. For given parameters, our equilibria are in pure strategies.

⁴⁰As in Horstmann and Markusen's (1987, section 4) "incomplete preemption case", there is no "strategic" motive for FDI since E possesses a dominant strategy.

(ii) If $G = I$ and t is sufficiently large, then $(1R, 2R; \emptyset)$ is the unique equilibrium for all $\mu(4PE) < \mu < \min\{\mu(5BE), \mu(5PE)\}$. If $G = I$ and p is sufficiently large, a second equilibrium of $(2R, 2R; \emptyset)$ exists for all $\mu(5PE) < \mu < \min\{\mu(5BE), \mu(6PE)\}$. In the limit as $G \rightarrow \infty$, entry deterring equilibria never arise on $\mu(4PE) < \mu < \min\{\mu(5BE), \mu(6PE)\}$.

(iii) Free riding: If one incumbent undertakes entry-deterring FDI, its rival benefits.

In part (i) there are two (reinforcing) motives for FDI, tariff-jumping and strategic entry deterrence. If μ lies between (4PE) and the lower of (5BE) and (5PE), the unique PE equilibrium is $(1R, 2R; \emptyset)$ if and only if

$$\begin{aligned} & \mu\pi_1(2R, 1R; \emptyset) - G - I > \mu\pi_1(1R, 1R; R) - I \\ \Leftrightarrow \mu > & \frac{G}{p(1-p)[R(0, c+t) + R(0, c) - (1-p)\{R(0, c) + R(t, c)\}] + (1-p)^2R(c, c+t) + p^3R(0, t)}, \end{aligned} \quad (4)$$

which ensures that $2R$ is strictly preferred to $1R$ in response to $1R$ given E 's subsequent best responses.⁴¹ If μ lies between (5PE) and the lower of (5BE) and (6PE), a PE equilibrium of $(2R, 2R; \emptyset)$ exists if and only if

$$\mu\pi_1(2R, 2R; \emptyset) - G - I > \mu\pi_1(1N, 2R; R) \Leftrightarrow \mu > \frac{G + I}{2p(1-p)R(0, c)} \quad (5)$$

and

$$\begin{aligned} & \mu\pi_1(2R, 2R; \emptyset) - G - I > \mu\pi_1(1R, 2R; R) - I \\ \Leftrightarrow \mu > & \frac{G}{2p(1-p)R(0, c) - p(1-p)^2[R(0, c) + R(t, c)]}. \end{aligned} \quad (6)$$

Given E 's subsequent best responses, conditions (5) and (6) ensure that, in response to $2R$, an incumbent strictly prefers $2R$ to $1N$ and $1R$ respectively.⁴² The result in part (i) of Proposition 4 follows because the RHSs of (4), (5) and (6) are all increasing in G , and the RHSs of both (4) and (6) are decreasing in t . Turning to part (ii), (4) holds for all $\mu > \mu(4PE)$ if and only if

$$\frac{I}{G} > \frac{p(1-p)^2R(0, c) + p^2(1-p)R(0, t)}{p(1-p)[R(0, c+t) + R(0, c) - (1-p)\{R(0, c) + R(t, c)\}] + (1-p)^2R(c, c+t) + p^3R(0, t)}. \quad (7)$$

⁴¹On $\mu(5PE) > \mu > \mu(4PE)$ E optimally chooses R unless the incumbents choose $(1R, 2R)$ or $(2R, 2R)$. It is straightforward to show that, if both $(1N, 1R)$ and $(1R, 1R)$ provoke entry, an incumbent strictly prefers $1R$ to $1N$ in response to $1R$ for all $\mu > \mu(4PE)$. Therefore, the best response to $1R$ can only be $1R$ or $2R$.

⁴²On $\mu(6PE) > \mu > \mu(5PE)$ E optimally chooses R unless the incumbents choose $(2R, 2R)$. Both (5) and (6) are necessary: for sufficiently large (resp. small) p on $[0, 1]$ (5) (resp. (6)) is the tighter condition.

With $G = I$, it is straightforward but tedious to show that (7) holds for all $p \in [0, 1]$ if and only if (c, t) lies in region IV of Figure 2.⁴³ The intuition for this is as follows: when t is very small (region V of Figure 2), it is never worth shouldering the sunk cost of establishing an additional plant abroad even if this will deter entry. (Note, however, that for *all* (c, t) under (B)* (7) certainly holds on $p \in [0.5, 1]$ when $G = I$.)

(5) and (6) hold, respectively, for all $\mu > \mu$ (5PE) if and only if

$$\frac{2I}{G+I} > \frac{2R(0, c)(1-p) + R(0, t)p}{2R(0, c)} \quad (8)$$

and

$$\frac{2I}{G} > \frac{2R(0, c)(1-p) + R(0, t)p}{2R(0, c) - (1-p)[R(0, c) + R(t, c)]}. \quad (9)$$

When $G = I$, (8) holds for all $p \in (0, 1]$. However, (9) holds at $G = I$ only if p is sufficiently large.⁴⁴ As G rises, the RHSs of (4), (5) and (6) all rise, and it becomes “less likely” that (7)–(9) hold. Furthermore, (5PE) and (6PE) are both independent of G , so it is always possible to set G large enough that entry deterrence does not arise (the last sentence of part (ii)).⁴⁵

Part (iii) of Proposition 4 explains why – contrary to Horstmann and Markusen’s (1987) Proposition 1 – entry deterrence does not always occur when feasible. With two incumbents, the appropriation of the returns from entry-detering FDI is incomplete. Therefore, an individual incumbent’s incentive for FDI is “too weak” from the viewpoint of the incumbent duopoly. To see this, note that the denominators on the RHSs of (4)–(6) contain only the *investor’s* variable profit gain from FDI. However, it is clear that free riding occurs: $\pi_2(2R, 1R; \emptyset) > \pi_2(1R, 1R; R)$ and $\pi_2(2R, 2R; \emptyset) > \pi_2(1R, 2R; R)$ (see Tables 2 and 3), so the RHSs of (4) and 6) are “too small”.⁴⁶

Finally, Proposition 5 rounds off our analysis of the effects of the entry threat.

Proposition 5. Comparison of equilibria under blockaded and potential entry:

⁴³Condition (B)* holds in regions IV and V of Figure 2. Setting $G = I$, (7) takes the form $\alpha - \beta p + \gamma p^2 - \delta p^3 > 0$. It can be shown that all four coefficients are strictly positive and that the LHS is larger at $p = 1$ than 0. Therefore, the LHS has an interior minimum on $p \in [0, 1]$ at the smaller root of $-\beta + 2\gamma p - 3\delta p^2 = 0$. Setting LHS = 0 at that p -value generates the boundary between regions IV and V in Figure 2. In region IV (resp. V) LHS > (resp. <) 0 at its minimum on $p \in [0, 1]$.

⁴⁴Formally, this requires $p > 2R(t, c)/[4R(0, c) + 2R(t, c) - R(0, t)]$, which is strictly less than the p -value where (5BE) and (6PE) intersect at $G = I$, $R(t, c)/R(0, c)$.

⁴⁵Analysing how changes in t affect the *sizes* of regions where entry deterrence occurs in equilibrium (as is done in Proposition 4(ii) for changes in G) is complicated by the fact that increases in t strengthen both the incumbents’ entry deterrence incentives *and* E ’s entry incentive. (Because E never trades internationally, it benefits from the protection afforded by higher trade costs.) Therefore, although the (PE) inter-regional boundaries are independent of G , they vary with t .

⁴⁶Note, however, that $\pi_2(2R, 2R; \emptyset) = \pi_2(1N, 2R; R)$, so (5) *does* reflect the return to the duopoly.

- (i) For given parameter values, the incumbents in the PE game tend to adopt “tough” (resp. “soft”) strategies when entry is deterred (resp. accommodated) in equilibrium by undertaking more (resp. less) intra-industry FDI than at the corresponding BE equilibrium.
- (ii) Because of the entry threat, equilibria in the PE game can be qualitatively different from any observed in the BE game.

Proposition 5 highlights the importance for equilibrium outcomes, rather than merely incentives, of the entry threat and thereby justifies our modelling of entry. Part (i) can be related to Fudenberg and Tirole’s (1984) taxonomy of an incumbent’s investment strategies in the face of an entry threat. The incumbents behave as “top dogs” when deterring entry but as “puppy dogs” when accommodating it. The “top dog” invests in “strength” (by undertaking extra sunk investments) to look tough and ward off rivals, whereas the “puppy dog” conspicuously avoids looking “strong” (by reducing spending on sunk investments) to appear inoffensive and avert aggressive reactions from rivals. Moreover, as part (ii) notes, rather than merely shifting regions of given equilibria, the entry threat provokes the emergence of qualitatively new equilibria.

5 Conclusion

This paper aimed to answer two questions. First, when are incumbent firms’ FDI and R&D expenditures positively associated in equilibrium in an international oligopoly? This question was provoked by the widespread empirical evidence of a strong positive correlation between FDI and R&D intensities (at both firm and industry levels). A model was developed of the FDI and R&D decisions of incumbent international duopolists in a two-country world. Our key finding was that the levels of intra-industry FDI and R&D investment will be positively correlated if most of the variation between observations is due to market size differences: large markets support the sunk costs of both FDI and R&D. However, this positive association fails if the bulk of the variation stems from differences in the probability of R&D success. Although equilibrium R&D investment is increasing in the success probability, equilibrium intra-industry FDI flows are hump-shaped in the success probability. We showed that our assumption of Bertrand competition in homogeneous goods implies that two-way intra-industry FDI never occurs in equilibrium for sufficiently extreme levels of the R&D success probability, although it does occur for intermediate levels in large markets. However, it is expected that this phenomenon (although perhaps in less stark a form) will also be observed in models that make different assumptions about market competition (e.g. Cournot or Bertrand in differentiated goods): in all cases, the “best” outcome for an incumbent if both undertake R&D, under which the likelihood of its being able to cover the sunk cost of FDI is greatest, is success for its own R&D effort but failure for its rival’s. Given that R&D outcomes are independent across firms, the probability of obtaining such an “R&D advantage” approaches zero as the R&D success probability itself approaches zero or one, implying that FDI is “most likely” at intermediate probabilities of R&D success. The

assumption of Bertrand competition in homogeneous goods *is* necessary, however, to ensure that firms never undertake FDI without R&D: in general, we would expect FDI to occur without R&D in large markets if the R&D success probability is small.

The second question posed at the outset (“When will incumbent firms in an international oligopoly use intra-industry FDI to pre-empt entry into the industry by outside firms and thereby maintain concentration?”) was motivated by widespread evidence of positive correlations between FDI intensity and product market “concentration” at the industry level. In the empirical literature debate on the causes of the observed FDI/ concentration correlations is lively with some (e.g. Driffield, 2001, for the UK) arguing that the association disappears once other influences on concentration (e.g. scale economies) are controlled for, so a deeper *theoretical* understanding of the FDI/ concentration relationship is particularly valuable. We extended the previous model to include, at an intermediate stage, the entry decision at a global level of an outside firm. Entry deterrence (i.e. the maintenance of concentration) via FDI is possible only in intermediate-sized markets: in small markets entry never occurs, whereas in large markets entry always occurs. Although the potential for strategic entry deterrence creates an additional incentive for FDI in intermediate-sized markets, we show that FDI occurs there in equilibrium only if cost conditions are reasonably conducive to tariff-jumping FDI (i.e. a sufficiently small plant sunk cost relative to the trade cost). This is because an incumbent free rides on the entry-detering FDI undertaken by its rival, implying that an individual incumbent’s incentive for FDI is “too weak” from the viewpoint of the incumbent duopoly. A general conclusion of this paper is that the relationships between firms’ “corporate structure” decisions (e.g. FDI, R&D and entry into new industries) in an international oligopoly are both subtle and important in the determination of equilibrium outcomes.

6 Appendix

6.1 Derivation of Figure 1: Equilibrium Industrial Structures in the BE Game

We first show that assumptions (B) and (C) are *sufficient* to generate Figure 1. Let $\mu(h)$ denote the critical μ -value implicitly defined by “indifference condition” h , $h \in \{1BE, 2BE, 3BE, 4BE, 5BE\}$. $\mu(2BE) > \mu(1BE)$ for all $p \in (0, 1]$ iff

$$R(0, c+t) + R(t, c) - R(c, c+t) - R(0, t) > 0. \quad (B)$$

$\mu(4BE) > \mu(2BE)$ for all $p \in (0, 1]$ iff

$$(1-p)[R(0, c+t) + R(t, c) - R(c, c+t)] + pR(0, t) > \frac{I}{G}[R(0, c) - R(t, c)],$$

where by assumption (B) the LHS is strictly decreasing in p . Therefore, $\mu(4BE) > \mu(2BE)$ at $p = 1$ iff

$$R(0, t) > \frac{I}{G} [R(0, c) - R(t, c)],$$

which can be rearranged to give assumption (C).

$\mu(5BE) > \mu(4BE)$ for all $p > 0$, and $\mu(5BE) > \mu(3BE)$ for all $p \in (0, 1)$ iff

$$\frac{I}{G} < \frac{R(0, c) + R(t, c)}{R(0, c) - R(t, c)},$$

which holds under assumption (C) because the RHS is strictly greater than that of (C).

We clearly have $\mu(3BE) > \mu(4BE)$ at $p = 1$ because $\mu(3BE) \rightarrow \infty$ as $p \rightarrow 1$. Furthermore, the three equations $\mu(3BE) = \mu(s)$, $s \in \{4BE, 2BE, 1BE\}$, all have unique solutions in p for $p \neq 0$ (“single crossing”); and $\mu(1BE) > \mu(3BE)$ for “small” p iff $R(0, c) - R(0, c+t) + R(c, c+t) > 0$, which straightforward but tedious calculations show to hold for all t, c under assumption (A).

[INSERT FIGURE 5 HERE]

The foregoing results on the relative positions of the indifference loci in the BE game are brought together in Figure 5 (ignore the dashed lines in Figure 5 until section 6.2).⁴⁷ Using them and the fact (see (1) in the main text) that pushing μ upwards off an indifference locus will always prompt an incumbent to choose the more “investment intensive” corporate structure, we can isolate the subgame perfect Nash equilibria (“equilibrium industrial structures”) in each region of Figure 1 in the main text. For $\mu \in [0, \mu(1BE))$ an incumbent’s “best response set” to $1N$, $1R$ and $2R$ respectively is $\{1N, 1N, 1N \text{ or } 1R\}$, so the equilibrium industrial structure (EIS) is $(1N, 1N; \emptyset)$. For $\mu \in (\mu(1BE), \mu(2BE))$ the best response set is $\{1R, 1N, 1N \text{ or } 1R\}$, so the EIS is $(1N, 1R; \emptyset)$. For $\mu \in (\mu(2BE), \mu(4BE))$ the best response set is $\{1R, 1R, 1N \text{ or } 1R\}$, so the EIS is $(1R, 1R; \emptyset)$. For $\mu \in (\mu(4BE), \mu(3BE))$ the best response set is $\{2R, 1R, 1N\}$, so the EISs are $(1R, 1R; \emptyset)$ and $(1N, 2R; \emptyset)$. For $\mu \in (\max\{\mu(3BE), \mu(4BE)\}, \mu(5BE))$ the best response set is $\{2R, 1R, 1R\}$, so the EIS is $(1R, 1R; \emptyset)$. Finally, for $\mu > \mu(5BE)$ the best response set is $\{2R, 2R, 2R\}$, so the EIS (in dominant strategies) is $(2R, 2R; \emptyset)$.

Next, we show that assumptions (B) and (C) are *necessary* to generate Figure 1 by examining the consequences of violating them. If (B) fails, then $\mu(1BE) > \mu(2BE)$ for all $p \in (0, 1]$, and it is straightforward to show that the sequence of equilibrium industrial structures as μ rises from 0 becomes $(1N, 1N; \emptyset)$; $(1N, 1N; \emptyset)$ and $(1R, 1R; \emptyset)$; $(1R, 1R; \emptyset)$. If (C) fails, then $\mu(2BE) > \mu(4BE)$ at $p = 1$, and

⁴⁷Two aspects of Figure 1 are not constrained. First, the minimum p -value on $\mu(2BE)$ is certainly strictly greater than 0.5, the stationary point of $\mu(5BE)$, and it is strictly less than 1 iff $\text{LHS(B)} > R(0, t)$, which is more demanding than (B) and may not hold. Second, the p -value where $\mu(3BE) = \mu(4BE)$ is strictly greater than 0.5 for all G, I in (C) iff $R(0, c) + R(t, c) > 2R(0, t)$, which may hold (e.g. if $t \cong 0$) or fail (e.g. if $c \cong t > 0.5$) under (A).

it is straightforward to show that the sequence of equilibrium industrial structures for “large” p as μ rises from $\mu(1\text{BE})$ becomes $(1N, 1R; \emptyset)$; $(1N, 2R; \emptyset)$; $(1R, 1R; \emptyset)$ and $(1N, 2R; \emptyset)$. Furthermore, if (C) fails drastically, then $\mu(3\text{BE}) > \mu(5\text{BE})$ for all $p \in (0, 1)$.

6.2 Derivation of Figures 3 and 4: Equilibrium Industrial Structures in the PE Game.

We first show that assumptions (B)* and (C)* are *sufficient* to generate Figures 3 and 4. Let $S_g^*(S_j)$ denote either incumbent’s best response to the rival incumbent’s strategy, $S_j \in \{1N, 1R, 2R\}$, in the g game, $g \in \{\text{BE}, \text{PE}\}$. Furthermore, in an extension of the notation of Section 6.1, let $\mu(h)$ denote the critical μ -value implicitly defined by indifference condition h , $h \in \{1\text{PE}, 2\text{PE}, \dots, 6\text{PE}\}$.

We begin by locating $\mu(1\text{PE}), \mu(2\text{PE}), \dots, \mu(6\text{PE})$ relative to the indifference loci in the BE game. Figure 5 illustrates the results. Note first (see (3) in the main text) that on $p \in (0, 1)$

$$\mu(6\text{PE}) > \mu(5\text{PE}) > \mu(4\text{PE}) \geq \mu(3\text{PE}) > \mu(2\text{PE}) > \mu(1\text{PE}),$$

where $\mu(4\text{PE}) > \mu(3\text{PE})$ iff $R(0, c) > R(0, t)$, i.e. iff $t < 0.5$. This ranking implies that if E optimally chooses R (i.e. “entry occurs”) in response to given choices by the incumbents, then E will also optimally choose R in response to any pair of choices that is less “investment intensive.”

$\mu(1\text{PE}) > \mu(1\text{BE})$ for all $p \in (0, 1]$ iff

$$R(0, c+t) + R(t, c) - R(c, c+t) - R(0, c) > 0. \quad (\text{B})^*$$

This implies that $\mu(1\text{PE})$ ’s precise relative position in Figure 5 is irrelevant because $S_{\text{BE}}^*(1N) = 1N$ only if $\mu < \mu(1\text{BE})$ (see Lemma 2(i) in the main text). It is straightforward to show that $\mu(2\text{PE}) > \mu(2\text{BE})$ for all $p \in (0, 1]$ iff (B)* holds and that $\mu(3\text{PE}) > \mu(3\text{BE})$ for all $p \in (0, 1)$ iff $c > t$. $\mu(5\text{BE}) > \mu(4\text{PE})$ for all $p \in (0, 1)$ iff

$$(1-p)R(0, c) + pR(0, t) > \frac{I}{G} [R(0, c) - R(t, c)],$$

which requires assumption (C) – shown to be implied by (i.e. looser than) (C)* in the main text – on I/G . Assumption (C) is also sufficient (because $R(0, c) \geq R(0, t)$) to ensure (i) that $\mu(4\text{BE})$ cuts both $\mu(4\text{PE})$ and $\mu(5\text{PE})$ once on $p \in (0, 1)$; (ii) that $\mu(6\text{PE})$ cuts both $\mu(4\text{BE})$ and $\mu(5\text{BE})$ once on $p \in (0, 1)$; and (iii) that $\mu(4\text{BE}) > \mu(6\text{PE})$ for “small” p but $\mu(6\text{PE}) > \mu(5\text{BE})$ for “large” p . Two final “single crossing” properties: the two equations $\mu(4\text{BE}) = \mu(s)$, $s \in \{2\text{PE}, 3\text{PE}\}$, both have unique solutions in p for $p \neq 0$.

To complete the construction of Figure 5, we need two more restrictions on I/G . First, at the p -value where $\mu(3\text{BE}) = \mu(4\text{BE})$, $\mu(2\text{PE}) < \mu(3\text{BE}, 4\text{BE})$ iff (C)* holds. Second, $\mu(5\text{PE}) > \mu(5\text{BE})$ for “large” p and $\mu(2\text{PE}) > \mu(4\text{BE})$ at $p = 1$ iff

$$\frac{I}{G} > \frac{R(0, t)}{2[R(0, c) - R(t, c)]},$$

whose RHS is shown in the main text to be strictly less than that of (C)*. Therefore, the above condition can both hold (“small” G) and fail (“large” G) under assumption (C)*.

The second part of the sufficiency proof is to isolate the subgame perfect Nash equilibria (“equilibrium industrial structures”) between neighbouring indifference loci for E in Figure 5. From above, we know that the PE and BE equilibria are identical for all $\mu < \mu(2PE)$. Therefore, there are five cases to consider. Unless otherwise stated, the following results on best responses under PE are derived using Lemma 2(i) in the main text.

1. On $\mu \in (\mu(2PE), \mu(3PE))$:

$$\begin{aligned} S_{PE}^*(1N) &= \begin{cases} 1N \text{ or } 2R \forall \mu < \min\{\mu(3BE), \mu(4BE)\} & \text{(i)} \\ 1R \text{ or } 2R \forall \mu \in (\mu(3BE), \mu(4BE)) & \text{(ii)} \\ S_{BE}^*(1N) = 2R \forall \mu > \mu(4BE) \end{cases} \\ S_{PE}^*(1R) &= S_{BE}^*(1R) = 1R \\ S_{PE}^*(2R) &= S_{BE}^*(2R) = \begin{cases} 1N \forall \mu < \mu(3BE) \\ 1R \forall \mu > \mu(3BE) \end{cases} \end{aligned}$$

Results (i) and (ii): Given that E optimally chooses R in response to both $(1N, 1N)$ and $(1N, 1R)$, it is straightforward to show that either incumbent has $1R \succ 1N$ in response to $1N$ iff $\mu > \mu(3BE)$.

Therefore, for $\mu > \mu(3BE)$ the equilibrium industrial structure (EIS) is $(1R, 1R; \emptyset)$. For $\mu \in (\mu(4BE), \mu(3BE))$ the EIS’s are $(1R, 1R; \emptyset)$ and $(1N, 2R; \emptyset)$. For $\mu < \min\{\mu(3BE), \mu(4BE)\}$ the EIS is $(1R, 1R; \emptyset)$ for sure and *either* $(1N, 1N; R)$ or $(1N, 2R; \emptyset)$. The second equilibrium is $(1N, 2R; \emptyset)$ for all $\mu \in (\mu(2PE), \min\{\mu(3BE), \mu(4BE)\})$ iff

$$\frac{2I}{G+I} > \frac{2R(0, c)p(1-p) + R(0, t)p^2}{p[R(0, c+t) + R(0, c)] + (1-p)R(c, c+t)}. \quad (*)$$

Given that $(1N, 1N)$ provokes entry but $(1N, 2R)$ does not, it is straightforward to show that (*) is necessary and sufficient for either incumbent to have $2R \succ 1N$ in response to $1N$ for all $\mu > \mu(2PE)$. If $G = I$, (*) holds for all $p \in [0, 1]$.

2. On $\mu \in (\mu(3PE), \mu(4PE))$:

$$\begin{aligned} S_{PE}^*(1N) &= 1R \quad \text{(iii)} \\ S_{PE}^*(1R) &= S_{BE}^*(1R) = 1R \\ S_{PE}^*(2R) &= S_{BE}^*(2R) = 1R \end{aligned}$$

Result (iii): Given that E optimally chooses R in response to both $(1N, 1R)$ and $(1N, 2R)$, it is straightforward to show that either incumbent has $2R \succ 1R$ in response to $1N$ iff $\mu > \mu(5BE)$. Combine this with results (i) and (ii) above to derive $S_{PE}^*(1N)$.

Therefore, the EIS (in dominant strategies for the incumbents) is $(1R, 1R; \emptyset)$.

3. On $\mu \in (\mu(4PE), \mu(5PE))$:

$$\begin{aligned} S_{PE}^*(1N) &= \begin{cases} 1R \forall \mu < \mu(5BE) \\ 2R \forall \mu > \mu(5BE) \end{cases} \quad (\text{i), (ii) and (iii)} \\ S_{PE}^*(1R) &= \begin{cases} 1R \text{ or } 2R \forall \mu < \mu(5BE) \\ S_{BE}^*(1R) = 2R \forall \mu > \mu(5BE) \end{cases} \quad (\text{iv}) \\ S_{PE}^*(2R) &= S_{BE}^*(2R) = \begin{cases} 1R \forall \mu < \mu(5BE) \\ 2R \forall \mu > \mu(5BE) \end{cases} \end{aligned}$$

Result (iv): Given that E optimally chooses R in response to both $(1N, 1R)$ and $(1R, 1R)$, it is straightforward to show that either incumbent has $1R \succ 1N$ in response to $1R$ for all $\mu > \mu(4PE)$.

Therefore, for $\mu > \mu(5BE)$ the EIS (in dominant strategies for the incumbents) is $(2R, 2R; \emptyset)$. For $\mu < \mu(5BE)$ the EIS is *either* $(1R, 1R; R)$ (in dominant strategies for the incumbents) *or* $(1R, 2R; \emptyset)$. $(1R, 2R; \emptyset)$ is selected for all $\mu \in (\mu(4PE), \min\{\mu(5BE), \mu(5PE)\})$ iff (7) in the main text holds. (Given that $(1R, 1R)$ provokes entry but $(1R, 2R)$ does not, it is straightforward to show that (7) in the main text is necessary and sufficient for either incumbent to have $2R \succ 1R$ in response to $1R$ for all $\mu > \mu(4PE)$.)

4. On $\mu \in (\mu(5PE), \mu(6PE))$:

$$\begin{aligned} S_{PE}^*(1N) &= \begin{cases} 1R \forall \mu < \mu(5BE) \\ 2R \forall \mu > \mu(5BE) \end{cases} \quad (\text{i), (ii) and (iii)} \\ S_{PE}^*(1R) &= 1R \quad (\text{v}) \\ S_{PE}^*(2R) &= \begin{cases} 1N \text{ or } 1R \text{ or } 2R \forall \mu < \mu(5BE) \\ 2R \forall \mu > \mu(5BE) \end{cases} \end{aligned}$$

Result (v): Given that E optimally chooses R in response to both $(1R, 1R)$ and $(1R, 2R)$, it is straightforward to show that assumption (C) is sufficient for either incumbent to have $1R \succ 2R$ in response to $1R$ for all $\mu < \mu(6PE)$. Combine this with result (iv) above to derive $S_{PE}^*(1R)$.

Therefore, for $\mu > \mu(5BE)$ the EISs are $(1R, 1R; R)$ and $(2R, 2R; \emptyset)$. For $\mu < \mu(5BE)$ there may be one or two EISs: (i) $(1R, 1R; R)$ is an EIS *for sure*; and (ii) $(2R, 2R; \emptyset)$ is an additional EIS iff $S_{PE}^*(2R) = 2R$. $S_{PE}^*(2R) = 2R$ for all $\mu > \mu(5PE)$ iff (8) and (9) in the main text both hold. (Given that $(1N, 2R)$ and $(1R, 2R)$ both provoke entry but $(2R, 2R)$ does not, it is straightforward to show that (8) and (9) in the main text are necessary and sufficient for either incumbent to have, respectively, $2R \succ 1N$ and $2R \succ 1R$ in response to $2R$ for all $\mu > \mu(5PE)$.)

5. On $\mu > \mu(6PE)$:

$$\begin{aligned} S_{PE}^*(1N) &= \begin{cases} 1R \forall \mu < \mu(5BE) \\ 2R \forall \mu > \mu(5BE) \end{cases} \quad (\text{i), (ii) and (iii)} \\ S_{PE}^*(1R) &= S_{PE}^*(2R) = \begin{cases} 1R \forall \mu < \mu(7PE) \\ 2R \forall \mu > \mu(7PE) \end{cases} \quad (\text{vi}) \end{aligned}$$

$$\text{where } \mu(7PE) \equiv \frac{G}{p(1-p)^2 [R(0, c) - R(t, c)]}$$

Result (vi): Given that E 's dominant strategy is R , it is straightforward to show that either incumbent has $1R \succ 1N$ in response to $2R$ for all $\mu > \mu(6PE)$. Combine this with result (iv) above to show $S_{PE}^*(1R) = S_{PE}^*(2R) \neq 1N$.

$\mu(7PE) > \max\{\mu(5BE), \mu(6PE)\}$ on $p \in (0, 1)$. (Assumption (C) is sufficient for $\mu(7PE) > \mu(6PE)$ on $p \in (0, 1)$.) Therefore, for $\mu > \mu(7PE)$ the EIS (in dominant strategies) is $(2R, 2R; R)$. For $\mu < \mu(7PE)$ the EIS is $(1R, 1R; R)$.

Finally, we briefly show that assumptions (B)* and (C)* are *necessary* for our characterization of PE equilibria by examining the consequences of violating them. If (B)* fails marginally, then it is straightforward to show that $\mu(1BE) > \mu(1PE)$ for all $p \in (0, 1]$ and that the unique EIS for all $\mu \in (\mu(1PE), \mu(1BE))$ is $(1N, 1R; \emptyset)$. If (C)* fails marginally, then it is straightforward to show that $(1R, 1R; \emptyset)$ becomes the unique EIS for all $\mu \in (\mu(2BE), \mu(4PE))$ – with the sole exception of $\mu \in (\mu(4BE), \mu(3BE))$, where $(1N, 2R; \emptyset)$ exists too (as in Figure 1). The effects of violating (B)* and (C)* drastically (so that (B) and (C) also fail) are discussed at the end of section 6.1.

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		Potential entrant's choice	
		\emptyset	R
Firm 2's choice	1N	$\pi_1 = \pi_2 = R(c, c+t)$	$\pi_1 = \pi_2 = 0$ $\pi_E = 2pR(0, c)$
	1R	$\pi_1 = (1-p)R(c, c+t)$ $\pi_2 = p[R(0, c+t) + R(t, c)]$ $+ (1-p)R(c, c+t)$	$\pi_1 = 0$ $\pi_2 = p(1-p)[R(0, c) + R(t, c)]$ $\pi_E = 2p(1-p)R(0, c) + p^2R(0, t)$
	2R	$\pi_1 = 0$ $\pi_2 = p[R(0, c+t) + R(0, c)]$ $+ (1-p)R(c, c+t)$	$\pi_1 = 0$ $\pi_2 = 2p(1-p)R(0, c)$ $\pi_E = 2p(1-p)R(0, c)$

Table 1: Expected variable profits per consumer if firm 1 chooses 1N

		Potential entrant's choice	
		\emptyset	R
Firm 2's choice	1R	$\pi_1 = \pi_2 =$ $p(1-p)[R(0, c+t) + R(t, c)]$ $+ p^2R(0, t) + (1-p)^2R(c, c+t)$	$\pi_1 = \pi_2 = p(1-p)^2[R(0, c) + R(t, c)]$ $+ p^2(1-p)R(0, t)$ $\pi_E = 2p(1-p)^2R(0, c) + 2p^2(1-p)R(0, t)$
	2R	$\pi_1 = p(1-p)[R(0, c) + R(t, c)]$ $\pi_2 = p(1-p)[R(0, c+t) + R(0, c)]$ $+ p^2R(0, t) + (1-p)^2R(c, c+t)$	$\pi_1 = p(1-p)^2[R(0, c) + R(t, c)]$ $\pi_2 = 2p(1-p)^2R(0, c) + p^2(1-p)R(0, t)$ $\pi_E = 2p(1-p)^2R(0, c) + p^2(1-p)R(0, t)$

Table 2: Expected variable profits per consumer if firm 1 chooses 1R

		Potential entrant's choice	
		\emptyset	R
Firm 2's choice	2R	$\pi_1 = \pi_2 = 2p(1-p)R(0, c)$	$\pi_1 = \pi_2 = 2p(1-p)^2R(0, c)$ $\pi_E = 2p(1-p)^2R(0, c)$

Table 3: Expected variable profits per consumer if firm 1 chooses 2R

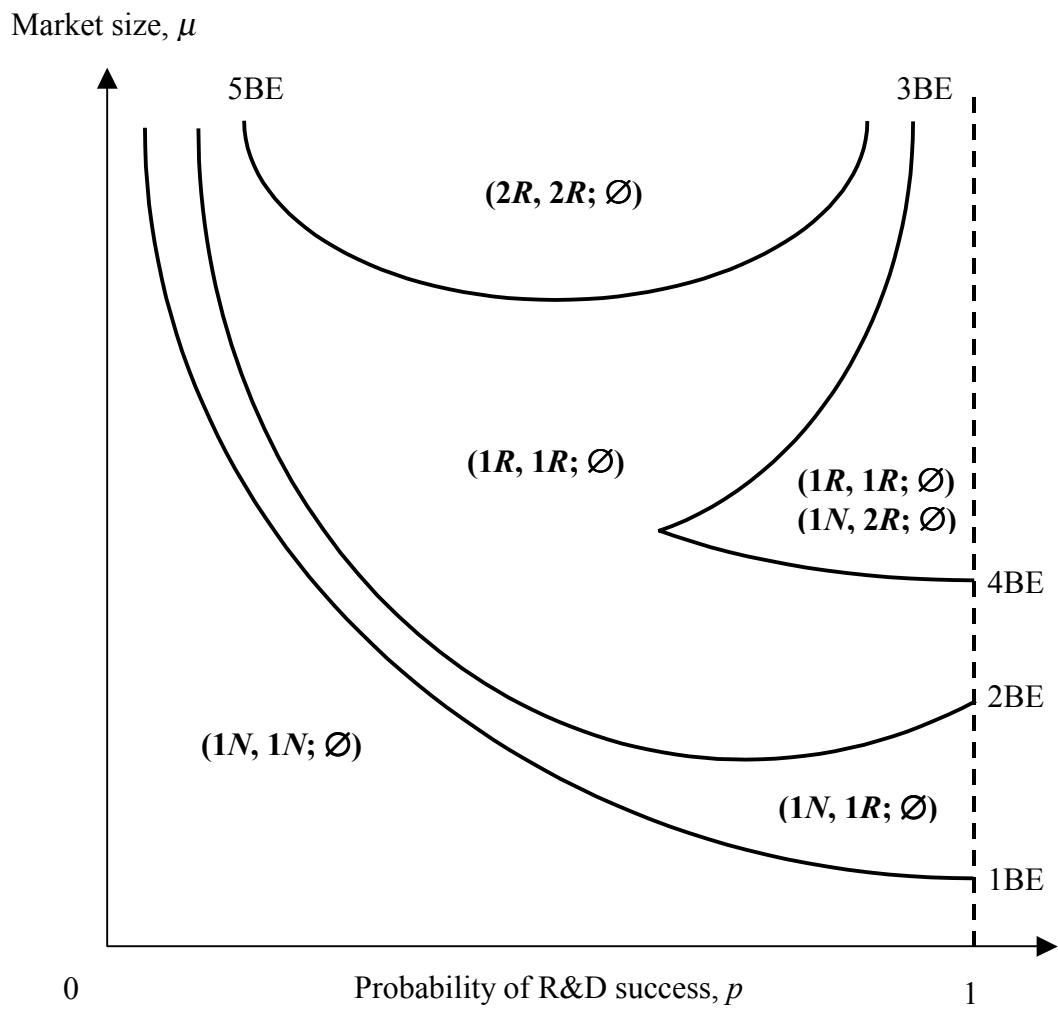


Figure 1: Equilibrium Industrial Structures in the BE Game

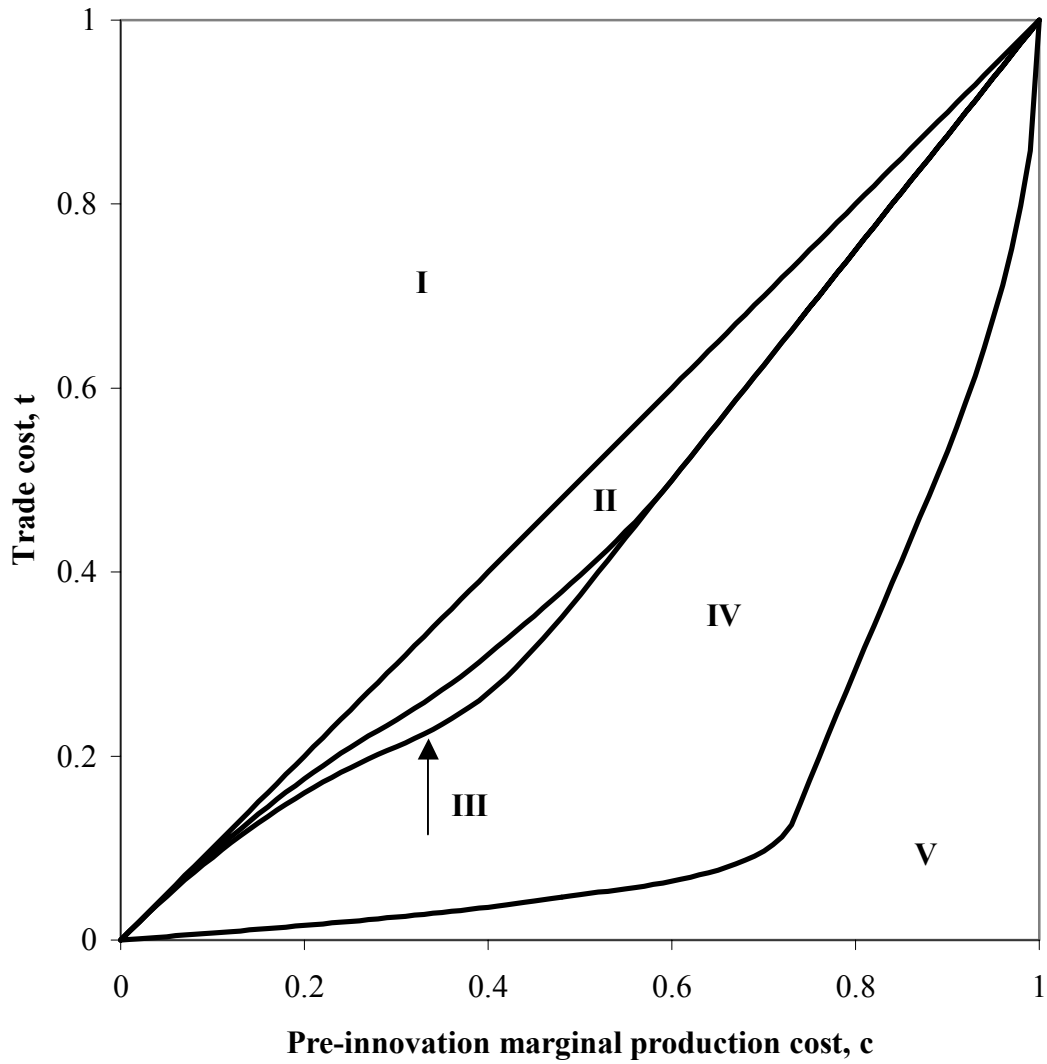


Figure 2: “Permissible” Levels of Marginal Cost Variables

		Constraint		
		(A)	(B)	(B)*
Region	I	Fails		
	II	Holds	Fails	Fails
	III	Holds	Holds	Fails
	IV	Holds	Holds	Holds
	V	Holds	Holds	Holds

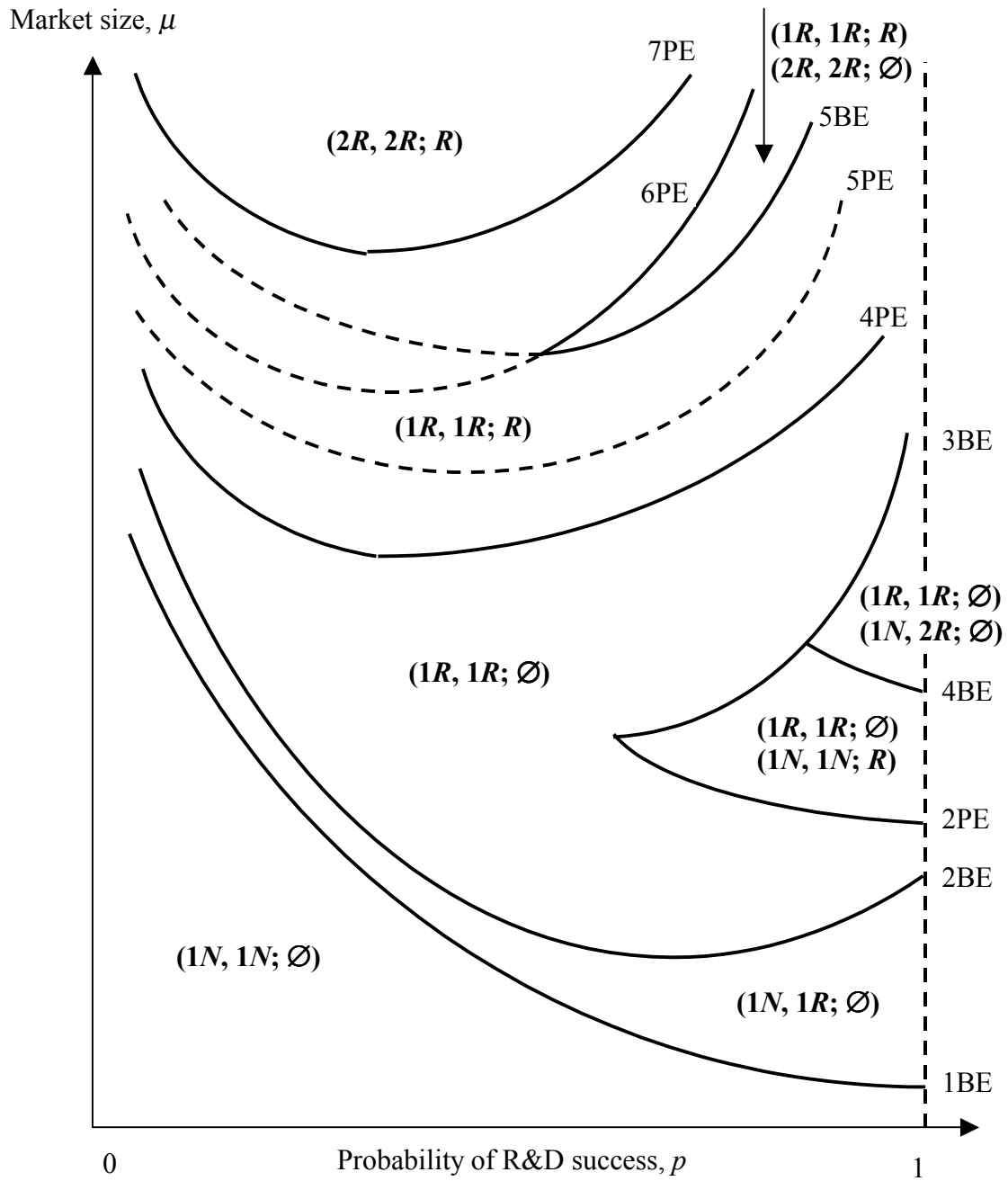


Figure 3: Equilibria in the PE Game if FDI is Costly (i.e. “large” G)

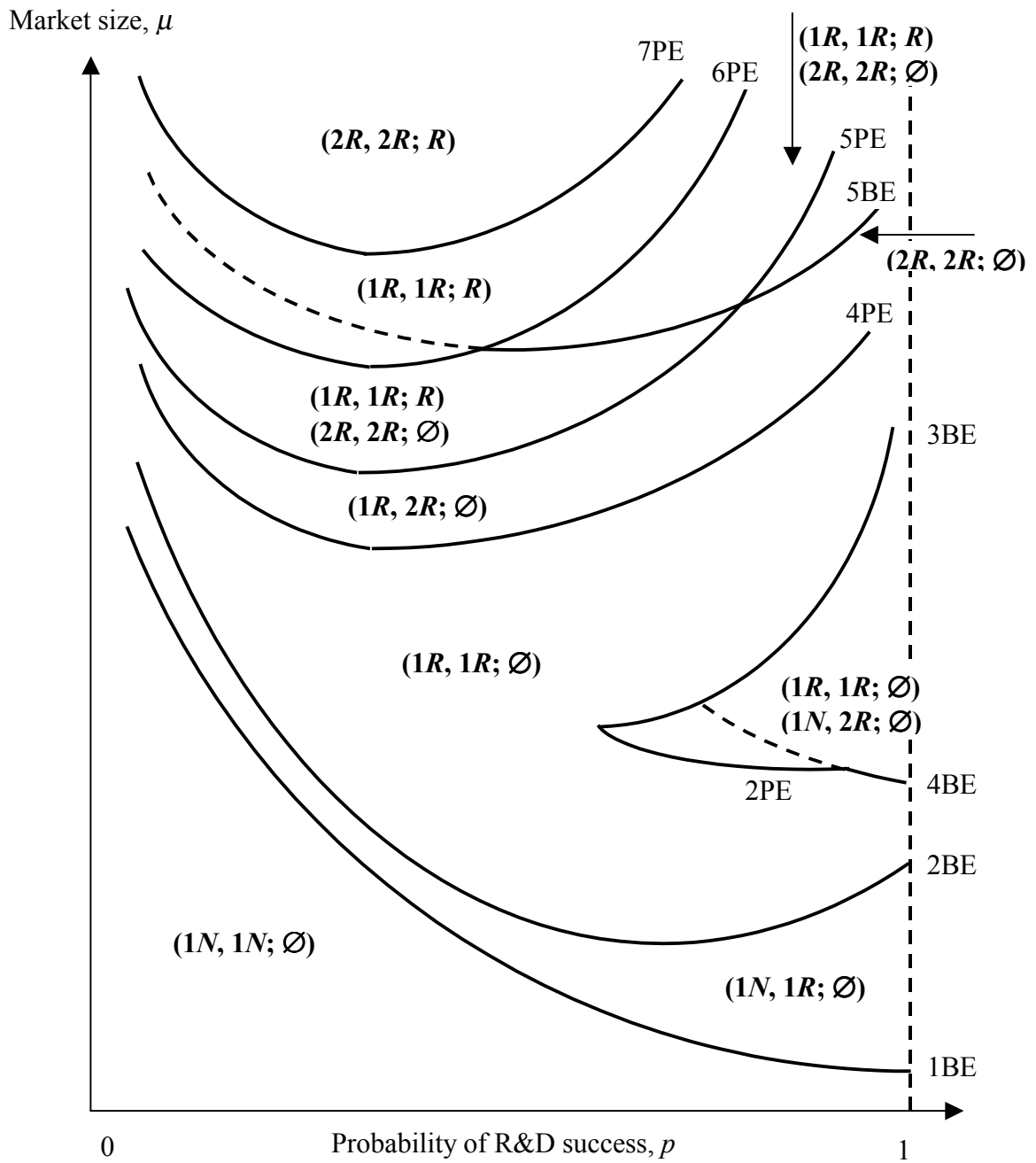


Figure 4: Equilibria in the PE Game if FDI is Cheap (i.e. “small” G)

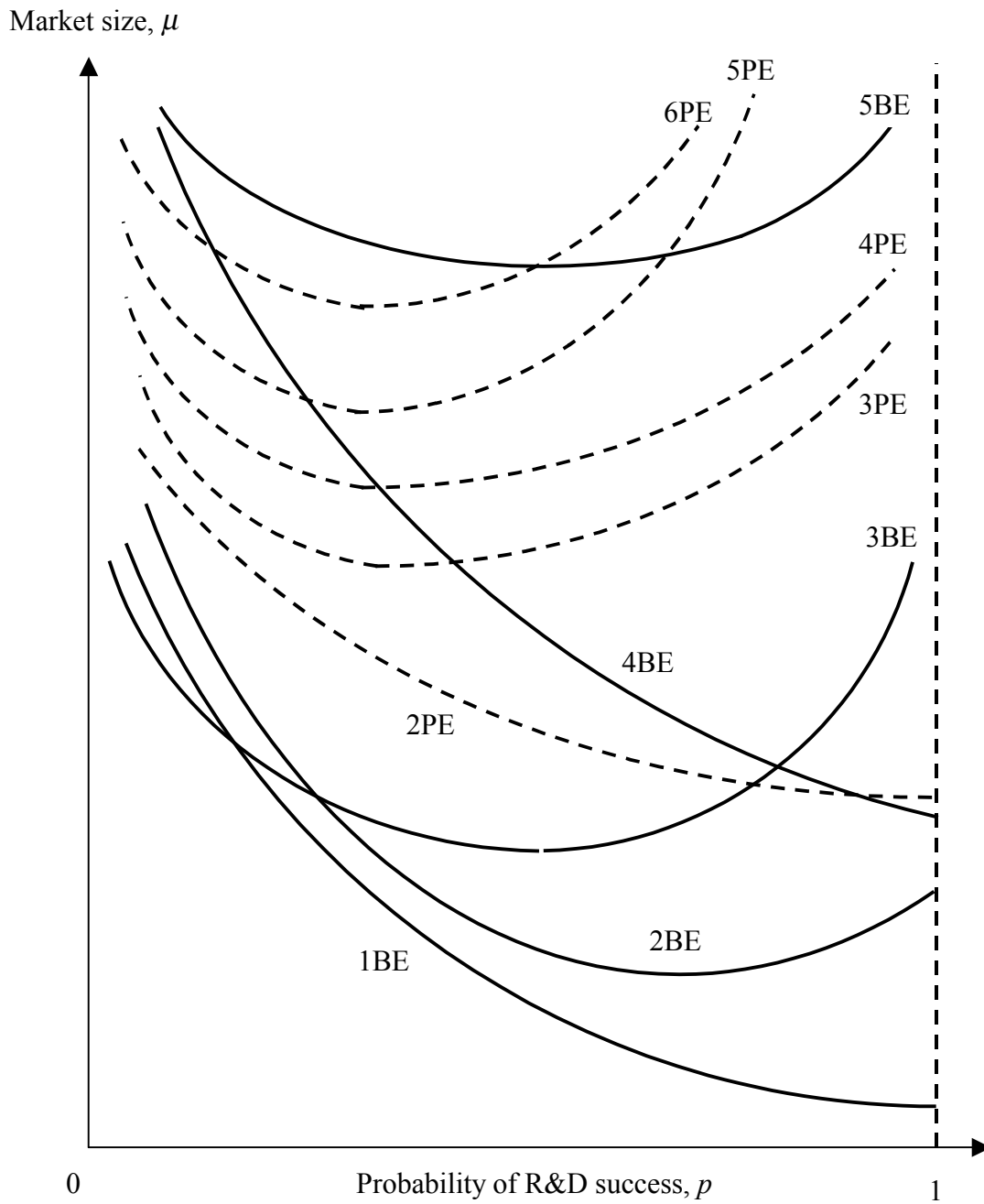


Figure 5: “Indifference Loci” in the BE and PE Games