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Intra- and Inter-Firm Technology Transfer in an International Oligopoly

by

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Abstract

Foreign-owned firms possess widely-documented 'productivity advantages' over domestic firms. To analyse their sources theoretically, we model the relationships between foreign direct investment (FDI) inflows and outflows and national 'productivity distributions' across firms (plants) in an international oligopoly. Industrial structure is determined endogenously, and both greenfield- and acquisition-FDI flows are allowed for. Two characteristics of the national 'productivity distributions' (across plants) in the industry considered are endogenously determined in our model: plant-level (labour) productivity, and the number of rival plants. There are three ways in which firms' FDI decisions interact with a national 'productivity distribution': via intra- and inter-firm (spillovers) technology transfer, and via their effects on entry incentives. Three principal conclusions emerge. First, relationships between industry greenfield- and acquisition-FDI flows, and structural parameters can be non-monotonic. Second, equilibrium greenfield-FDI flows and trade costs are positively associated. Third, rises in the technological lead of an incumbent firm make that firm 'less likely' to undertake greenfield-FDI in equilibrium, but they make foreign technological laggards 'more likely' to undertake ('technology-sourcing') greenfield-FDI in the leader's home country. We also briefly compare our model's predictions on the sources of MNEs' 'productivity advantages' to those of Dunning's popular OLI (ownership-location-internalisation) paradigm.

JEL classification: F21; F23; L13; O33.

Keywords: acquisition-FDI; greenfield-FDI; technology transfer; spillovers; foreign-owned firms' 'productivity advantages'.

Outline

Non-Technical Summary

This paper aims to provide a theoretical analysis of the sources of foreign-owned firms' widely-documented 'productivity advantages' over domestic firms. Our analysis will focus on two specific features of this strand of empirical literature. First, it appears that this 'productivity advantage' is not entirely due to a concentration of foreign-owned firms in sectors with particularly high physical and human capital intensities (i.e. ratios of physical capital to labour and of skilled to unskilled workers). Second, it appears that the 'productivity advantage' of foreign-owned firms is not a peculiar characteristic of the UK economy (i.e. that 'nationality effects' are not central to explaining foreign-owned firms' 'productivity advantages').

We model the relationships between foreign direct investment (FDI) inflows and outflows and national 'productivity distributions' across firms (plants) in an international oligopoly. Industrial structure is determined endogenously (as a subgame perfect Nash equilibrium of a four-stage game) in the manner of Horstmann and Markusen (1992) and Rowthorn (1992), and both greenfield- and acquisition-FDI flows are allowed for. Two characteristics of the national 'productivity distributions' (across plants) in the industry considered are endogenously determined in our model. First, plants can be either high- or low-productivity (there are two technologies), depending on which types of 'technology transfer' occur; and, second, the number of plants is endogenously determined at equilibrium (a single potential-entrant firm exists).

There are three ways in which firms' FDI decisions interact with a national 'productivity distribution' in the industry modelled. First, undertaking (either form of) FDI can lead to *inter-firm technology transfer* between the MNE's newly-established branch plant abroad and rival firms located in the host country. Inter-firm technology transfer is identical to what are sometimes labelled 'spillovers'. In our model spillovers can flow in both directions between a foreign branch plant and local rivals. Second, following a flow of acquisition-FDI, *intra-firm technology transfer* occurs: the high-productivity purchaser is able costlessly to install its (superior) technology in the acquired plant abroad. The concept of intra-firm technology transfer is identical to that employed by Long and Vousden (1995) in their model of cross-border mergers, who assume that every plant in a merged firm operates at the minimum marginal cost of its constituent plants before the merger. Third, FDI decisions interact with national 'productivity distributions' through the relationship between the greenfield-FDI/ acquisition-FDI choice (i.e. which form of FDI to choose) and the potential entrant's decision.

Three principal conclusions emerge. First, acquisition-FDI arises in equilibrium for two distinct sets of parameter values, medium-sized and very large sunk costs of greenfield-FDI; between them (i.e. large greenfield-FDI sunk costs) and for small greenfield-FDI sunk costs, firms optimally choose between exporting and greenfield-FDI in order to serve foreign product markets. The consequent 're-switching' between greenfield- and acquisition-FDI that occurs as the sunk cost of greenfield-FDI rises is a typical feature of our model. Second, rises in the trade cost make the occurrence of greenfield-FDI (rather than exporting) in equilibrium 'more likely' in regions where acquisition-FDI does not occur. This is analogous to the 'tariff-jumping' greenfield-FDI observed in other models. Third, rises in the technological lead of an incumbent firm make that firm 'less likely' to undertake greenfield-FDI in equilibrium, but they make foreign technological laggards 'more likely' to undertake ('technology-sourcing') greenfield-FDI in the leader's home country. The third conclusion contradicts the prediction of the popular OLI (ownership-location-internalisation) paradigm that the possession of 'ownership advantages' (highly productive, firm-specific assets) is necessary for (greenfield-)FDI.

1. Introduction.[1]

This paper aims to provide a theoretical analysis of the sources of foreign-owned firms' widely-documented 'productivity advantages' over domestic firms. For the UK this 'productivity gap' has been documented by Davies and Lyons (1991), Griffith (1999), and Oulton (2001). In particular, Oulton's study concludes that the labour productivity of foreign-owned firms, measured by value-added output per employee, has been continuously around 40 per cent higher than in UK-owned firms (a result derived from the respective shares of the two groups of firms in output and employment). Our analysis will focus on two specific features of this strand of empirical literature. First, it appears that this 'productivity advantage' is not entirely due to a concentration of foreign-owned firms in sectors with particularly high physical and human capital intensities (i.e. ratios of physical capital to labour and of skilled to unskilled workers). For example, Oulton found that US-owned plants in the UK enjoyed a significant additional advantage, over and above that due to higher (physical and human) capital intensities, which was equivalent to 40 per cent of their overall 'productivity advantage'. One of Oulton's conjectures on the cause of this additional US advantage is 'better process technology' (Oulton, 2001, p. 132), and we develop this line of enquiry. Second, it appears that the 'productivity advantage' of foreign-owned firms is not a peculiar characteristic of the UK economy. Globerman, Ries and Vertinsky (1994) found a similar 'productivity advantage' among foreign-owned firms in Canada, and in their study of US manufacturing Doms and Jensen (1998) found that the significant difference – in terms of 'productivity gaps' – is between multinational enterprises (MNEs) and non-MNEs, not between foreign- and domestically-owned firms. Both of these studies suggest that 'nationality effects' are not central to explaining foreign-owned firms' 'productivity advantages'.

We model the relationships between foreign direct investment (FDI) inflows and outflows and national 'productivity distributions' across firms (plants) in an international oligopoly. Industrial structure is determined endogenously (as a subgame perfect Nash equilibrium of a four-stage game) in the manner of Horstmann and Markusen (1992) and Rowthorn (1992). The world comprises two countries with identical (linear) demand functions for a

[1] For brevity the Appendix material has not been included in this research paper. The Appendix is available from the author on request (e-mail ben.ferrett@nottingham.ac.uk). This research paper is based on a chapter of my Warwick PhD thesis (Ferrett, 2003). The full text of the chapter is available from the author on request.

homogeneous good. There are three firms: two incumbents (M and T), who initially each own one plant in different countries; and one potential de novo entrant (E), who initially owns no plants. In the early stages of our game the firms choose how to serve the two national product markets: exporting, greenfield-FDI ('greenfield investment'), or acquisition-FDI (cross-border mergers and acquisitions, M&As). Although both greenfield-FDI and acquisition-FDI entail sunk costs (the price of a new plant, or 'field', for the former and an acquisition price for the latter), an incentive to undertake FDI is provided by the existence of a strictly positive per-unit trade cost: undertaking FDI allows the trade cost to be 'jumped'.

In our model no firm will ever optimally operate more than one plant in either country (because marginal production costs are constant and there is a strictly positive set-up cost for additional plants), so when examining a national 'productivity distribution' the mapping from plants to firms is one-to-one. Fixed (and sunk) costs are incurred only for greenfield-FDI, and 'productivity' differences across firms are associated with differences in (constant) marginal production costs (i.e. with differences in process technologies). Under reasonable (and conventional) assumptions, the marginal production cost is inversely proportional to 'labour productivity' as measured in the empirical studies. Two process technologies exist for production of the homogeneous good, and given our assumption that technology is unidimensional (i.e. affects only the marginal production cost) they can be unambiguously ranked in 'productivity' terms. One of the incumbents initially owns the 'more productive' (i.e. lower marginal production cost) technology, and the potential entrant and rival incumbent initially own the 'less productive' technology.

There are three ways in which firms' FDI decisions interact with a national 'productivity distribution' in the industry modelled. First, undertaking (either form of) FDI can lead to *inter-firm technology transfer* between the MNE's newly-established branch plant abroad and rival firms located in the host country. Inter-firm technology transfer is identical to what are sometimes labelled 'spillovers'. In our model spillovers can flow in both directions between a foreign branch plant and local rivals: for example, a technological laggard may undertake FDI in an attempt to 'source' technology via spillovers *from* (technologically superior) local firms. The relationship between FDI decisions and spillovers is two-way: if a foreign technological leader undertakes inward FDI, the productivity of local firms may be raised via spillovers (obviously, this cannot occur if the inward investor is a technological laggard); however, the technological leader will consider the potential for spillovers (and the dissipation of its advantage) when choosing between exporting and (both forms of) FDI. FDI inflows thus potentially affect national 'productivity distributions' in two ways: *directly* through the addition of a new plant (only in the case of greenfield-FDI), and *indirectly* through spillovers (both forms of FDI). It is also the case that outward FDI flows may affect the source country's national 'productivity distribution'. We assume that technology is a public good within the firm, so if the foreign branch plant of a technological laggard receives a spillover, the technological improvement can be costlessly applied to its domestic production (i.e. 'brought home') too. (Doing so risks that local firms in the home country may receive the technological improvement via 'second-hand' spillovers, but within our specific modelling structure this is a risk that a technologically-lagging MNE that receives spillovers abroad would always be willing to take.)

The second way in which firms' FDI decisions interact with national 'productivity distributions' relates specifically to acquisition-FDI. Our modelling structure allows the high-productivity incumbent to purchase the low-productivity incumbent abroad. Following this flow of acquisition-FDI, *intra-firm technology transfer* occurs: the high-productivity purchaser is able costlessly to install its (superior) technology in the acquired plant abroad. The concept of intra-firm technology transfer is identical to that employed by Van Long and Vousden (1995) in their model of cross-border mergers, who assume that every plant in a merged firm operates at the minimum marginal cost of its constituent plants before the merger. Although we did not use this terminology in the previous paragraph, intra-firm technology transfer also occurs when a firm 'brings home' a spillover received abroad by its foreign branch plant.

Third, FDI decisions interact with national 'productivity distributions' through the relationship between the greenfield-FDI/ acquisition-FDI choice (i.e. which form of FDI to choose) and the potential entrant's decision. As we show below, greenfield- and acquisition-FDI result – when the potential entrant comes to make her choice – in different industrial structures (duopoly vs. monopoly), and thus different entry 'incentives'. (In terms of *post-entry* industrial structures, greenfield- and acquisition-FDI result in triopoly and duopoly respectively.) Furthermore, a reverse relationship exists (from the likelihood of subsequent de novo entry to the greenfield-FDI/ acquisition-FDI choice): for example, if entry never occurs following greenfield-FDI, then the 'incentive' to undertake acquisition-FDI will be weaker if it is accompanied by subsequent entry than if it is not.

It is clear from the three broad observations above that two characteristics of the national 'productivity distributions' (across plants) in the industry considered are endogenously determined in our model: first, plants can be either high- or low-productivity (there are two technologies), depending on which types of 'technology transfer' occur; and, second, the number of plants is endogenously determined at equilibrium (a single potential-entrant firm exists). In both of these respects the number of degrees of freedom afforded by our model is limited. However, our analysis makes several novel contributions to the related theoretical literature. Both Fosfuri and Motta (1999) and Siotis (1999) present two-country, two-firm models of the choice between greenfield-FDI and exporting in the context of spillovers. Our analysis extends this work by admitting an alternative (and empirically important) form of FDI, acquisition-FDI, and by allowing for potential entry. Mattoo, Olarreaga and Saggi (2001) examine how the equilibrium market structure of a single host country depends on a foreign MNE's choice between greenfield- and acquisition-FDI (exporting is excluded) in the presence of intra-firm technology transfer; spillovers, potential entry, and influences on the (global) equilibrium industrial structure through firms' actions in the MNE's home country (i.e. the *international* aspects of the equilibrium) are excluded. In terms of this (admittedly selective) literature review our model offers a 'richer' (i.e. 'more general'; additional, intuitively-important strategic effects are accommodated) framework within which to consider how firms' FDI choices interact with national 'productivity distributions'.

The remainder of the paper is organised as follows. Section 2 describes the model and our equilibrium concepts formally and derives some useful results on Cournot equilibria when firms' marginal costs differ. Section 3 derives the model's equilibrium industrial structures and examines their comparative-statics properties. Section 4 discusses the broader implications of our results for the sources of foreign-owned firms' observed 'productivity advantages'. We also contrast our findings on the sources of MNEs' 'productivity advantages' with those which (it is claimed) are implicit in Dunning's famous (1977) OLI paradigm. Finally, Section 5 concludes. Some of our more interesting results are highlighted, and a number of suggestions for future research are made.

2. The Modelling Structure.

2.1. Sequence of Moves and Corporate Structure Choices.

There are two countries in the world, H ('home') and F ('foreign'), and two incumbent firms, one in each country: at the start of the game firm M (the potential MNE via acquisition-FDI) owns a plant in H and firm T (the potential acquisition target) owns a plant in F. The firms in our model produce homogeneous goods for sale on the identical national product markets of H and F, which are perfectly segmented (i.e. consumers are immobile internationally, so well-defined 'national' demand curves exist, although international trade can occur at a per-unit trade cost of t). Market demand in either country is

$$Q_d = 1 - p \tag{1}$$

In (1) Q_d and p are the national quantity demanded and price respectively; Q_d is independent of the product price abroad because of our assumption of perfectly segmented national product markets.

There are two distinct technologies for producing the homogeneous product, both of which exhibit constant marginal (= average variable) costs. Technology is assumed to be a public good (non-rival) within the firm and intra-firm technology transfer is costless, so firms always use their 'most productive' (lowest marginal production cost) technology in all their plants. Firm M's initial technology has a marginal production cost of c_M, and firm T's initial technology has a marginal production cost of c_T. We assume that labour is the only variable productive input and that money wages are constant across both locations and firms so that any difference between c_M and c_T is due entirely to differences in labour productivity between the two technologies. In this Section and the next we maintain the following assumption on c_M, c_T:

(A) $$0 < c_M < c_T < 1$$

Assumption (A) implies that M's initial technology is 'more productive' than T's. It is quite conventional in the literature to assume that acquiring MNEs possess 'productivity advantages' over their targets (e.g. Mattoo, Olarreaga and Saggi, 2001). In Section 4 we discuss the reasons behind this conventional assumption, and we explore the implications of relaxing assumption (A) to allow for $c_M > c_T$. For the moment, however, invoking assumption (A) greatly simplifies the exposition.

Given the initial conditions of our model described above, Figure 1 illustrates the extensive form of our four-stage game. In stage one M chooses its corporate structure from a strategy space of of $\{X, G, A\}$, where each element represents a different method of serving the product market in country F. X is M's *exporting option*: M builds no additional plants (to its initial plant in H), and it serves H's product market with local production at a marginal cost of c_M and F's product market via international trade at a marginal cost of $c_M + t$. G represents *greenfield-FDI*: M builds an additional plant in F at a sunk cost of G and serves both countries' product markets from local production at a marginal cost of c_M. A represents *acquisition-FDI*: M makes T a take-it-or-leave-it offer of a take-over price. If T accepts M's offer, M transfers its superior technology to T's plant (*forward* intra-firm technology transfer) and serves both countries' product markets from local production at a marginal cost of c_M; thereafter, we skip stage two (T's corporate structure choice). If T rejects M's take-over offer, then M must choose between X and G. We show below (in Section 2.3) that these assumptions on the structure of moves uniquely determine the equilibrium take-over price, which equals T's expected profits under M's next-best strategy (X or G), and imply that M captures the entire surplus created by the take-over (i.e. the surplus of M's expected profits under A over the combined expected profits of M and T under M's next-best strategy). However, although these implications may appear restrictive, we show in Section 4 that the equilibrium industrial structures we derive are consistent with a much more general formulation of the bargaining process preceding the take-over. Our current assumptions on bargaining merely help to fix ideas.

[INSERT FIGURE 1 HERE]

In stage two, which only arises if M chooses X or G in stage one, T chooses its corporate structure from a strategy space of $\{X, G\}$, where the elements are analogous to those in A's strategy space. The key difference is that T's initial technology has a marginal production cost of $c_T > c_M$. To secure a marginal production cost of c_M T must rely on inter-firm technology transfers (spillovers), which are described below.

In stage three a single potential entrant (firm E) decides whether to enter the industry at a global level. E's stage-three strategy space is $\{\emptyset, G_H, G_F, G_2\}$, whose elements represent: stay out ($\emptyset$); greenfield-FDI in country H (G_H); greenfield-FDI in country F (G_F); and greenfield-FDI in both countries (G_2). E's initial marginal production cost is c_T, so M possesses a 'productivity advantage' over both its rivals under assumption (A), and E incurs sunk costs of G under G_H or G_F and $2 \cdot G$ under G_2. Like T, E must rely on inter-firm technology transfers to obtain a marginal production cost of c_M.

Stage four is the market stage: at the end of stage four all firms in the industry compete à la Cournot to serve both national product markets. Inter-firm technology transfers (spillovers) occur at the start of stage four before the production of outputs. With probability $\theta \in [0, 1]$ the 'most productive' (lowest marginal production cost) technology used in a country spills over to *all* the rival plants within that country (i.e. becomes common knowledge within that country). Therefore, spillovers are *localized*. We assume that the rival plants can absorb spillovers costlessly. If a technological laggard with two plants (firm T under G or firm E under G_2) benefits from a spillover in one country, it can costlessly apply its new technology to production in both countries (intra-firm technology transfer is costless). We assume that the probability of spillovers is identical and independent across countries. After spillovers have occurred, firms produce outputs. We assume that marginal production costs are common knowledge (i.e. firms know the *characteristics* of their rivals' technologies even if they fail to obtain the *blueprints* via spillovers).

There are three obvious advantages to our method of modelling spillovers. First, it implies (ceteris paribus) a simple game structure relative to that where the spillover mechanism is explicitly modelled (e.g. Fosfuri, Motta and Rønde, 2001). In turn, this allows us to extend the game structure in other directions while retaining tractability. For example, Fosfuri, Motta and Rønde (2001) restrict their attention to market equilibria in a single host country for greenfield-FDI. By contrast, our model comprises two host countries for FDI and two types of FDI. Furthermore, note that leaving the spillover mechanism as a 'black box' is quite familiar in the R&D literature (e.g. d'Aspremont and Jacquemin, 1988). Second, our modelling of spillovers abstracts from patterns of technology flows between specific pairs of rival plants, which quickly become very complex when we move beyond the conventional duopoly case. For example, if there are three rival plants in a location, then there are three distinct pairs of plants that technology can flow between; this contrasts with only one pair in the duopoly case. Third, our method of modelling spillovers, while simple, does permit the investigation of some interesting strategic effects. For example, it is possible for a laggard to receive (indirectly) a spillover from M even if its plant is not in the same country as M's. Assume that M, T and E choose strategies of X, G and G_F respectively (the same point applies to choices of X, X and G_2 respectively). T's probability of receiving a spillover from M, which it applies in both its plants, is θ. Therefore, if spillovers occur in *both* countries with probability θ^2, E (located in F) will receive a spillover from M via T. The underlying message is intuitively appealing: it is not necessary to locate near a high-productivity firm's plant to receive spillovers of its technology; locating near a third firm's plant (and relying on indirect spillovers) may be sufficient if that third firm has another plant near the high-productivity firm. A related observation concerns the impact of spillovers on firms' 'incentives' to undertake greenfield-FDI, which might strengthen or weaken the 'tariff-jumping' motive for greenfield-FDI. Assume that the model's structural parameters are such that T and E will choose X and $\varnothing$ respectively. M's choice between X and G will clearly reflect the conventional tariff-jumping motivation for greenfield-FDI (i.e. M is 'more likely' to choose G, the higher is t and the lower is the sunk cost of additional plants). However, a disincentive for M to choose G is provided by the probability that its technology may spill over to T. Conversely, if M has chosen X and (the model's structural parameters are such that) E will choose $\varnothing$, an additional (to tariff-jumping) incentive for T to choose G is provided by the probability that it will receive spillovers from M.

2.2. Market Equilibria in an Asymmetric Cournot Oligopoly[2]

We apply some familiar general results to the specific framework of this paper. Consider a Cournot triopoly, where (as above) we index firms so that the set of marginal costs $\{c_i\}_1^3 = \{c_1, c_2, c_3\}$ has $0 \le c_1 \le c_2 \le c_3$. We use (8) and (9) to derive the following results on the equilibrium M-value:

$$\left.\begin{array}{l} M = 1 \text{ iff } c_1 \le 1 \text{ and } c_2 > \dfrac{1+c_1}{2} \\ M = 2 \text{ iff } c_2 \le \dfrac{1+c_1}{2} \text{ and } c_3 > \dfrac{1+c_1+c_2}{3} \\ M = 3 \text{ iff } c_3 \le \dfrac{1+c_1+c_2}{3} \end{array}\right\} \tag{13}$$

where $\frac{1+c_1}{2}$ and $\frac{1+c_1+c_2}{3}$ are (respectively) 1's monopoly price and the equilibrium price in a Cournot duopoly comprising firms 1 and 2. Of course, the number of active firms has

[2] The material in this section is more fully developed in a longer version of this research paper, which is available from the author on request.

implications for all three firms' net revenues (i.e. revenue minus variable costs). In general, the net revenues of firm *i* at Cournot equilibrium are (from (7) and (10))

$$\left(p-c_i\right)\cdot q_i = \begin{cases} \left(\dfrac{1-M\cdot c_i + c_{-i}}{M+1}\right)^2 & \forall\ i \in \{1,2,...,M\} \\ 0 \ \ \forall\ i\in\{M+1, M+2,...,N\} \end{cases}$$

Two specific cases will be of interest in our analysis. First, if firm 3 quits the market entirely, then

$$\text{Firm 1 earns } R^D\left(c_1,c_2\right) = \begin{cases} R^M\left(c_1\right) \equiv \left(\dfrac{1-c_1}{2}\right)^2 \text{ iff } c_2 > \dfrac{1+c_1}{2} \\ \left(\dfrac{1-2\cdot c_1 + c_2}{3}\right)^2 \text{ iff } c_2 \leq \dfrac{1+c_1}{2} \end{cases}$$

and

$$\text{Firm 2 earns } R^D\left(c_2,c_1\right) = \begin{cases} 0 \text{ iff } c_2 > \dfrac{1+c_1}{2} \\ \left(\dfrac{1-2\cdot c_2 + c_1}{3}\right)^2 \text{ iff } c_2 \leq \dfrac{1+c_1}{2} \end{cases}$$

where $R^M\left(c_i\right)$ is *i*'s monopoly net revenue and $R^D\left(c_i,c_j\right)$ is *i*'s net revenue in a Cournot duopoly with firm *j*. Second, with firm 3 in the market we have

$$\text{Firm 1 earns } R^T\left(c_1,c_2,c_3\right) = \begin{cases} R^D\left(c_1,c_2\right) \text{ iff } c_3 > \dfrac{1+c_1+c_2}{3} \\ \left(\dfrac{1-3\cdot c_1 + c_2 + c_3}{4}\right)^2 \text{ iff } c_3 \leq \dfrac{1+c_1+c_2}{3} \end{cases}$$

$$\text{Firm 2 earns } R^T\left(c_2,c_1,c_3\right) = \begin{cases} R^D\left(c_2,c_1\right) \text{ iff } c_3 > \dfrac{1+c_1+c_2}{3} \\ \left(\dfrac{1-3\cdot c_2 + c_1 + c_3}{4}\right)^2 \text{ iff } c_3 \leq \dfrac{1+c_1+c_2}{3} \end{cases}$$

and

$$\text{Firm 3 earns } R^T\left(c_3,c_1,c_2\right) = \begin{cases} 0 \text{ iff } c_3 > \dfrac{1+c_1+c_2}{3} \\ \left(\dfrac{1-3\cdot c_3 + c_1 + c_2}{4}\right)^2 \text{ iff } c_3 \leq \dfrac{1+c_1+c_2}{3} \end{cases}$$

where $R^T\left(c_i,c_j,c_k\right)$ with $c_k \geq c_j$ is *i*'s net revenue in a Cournot triopoly with firms *j* and *k*. (Although only the sum $\left(c_j + c_k\right)$ is relevant for *i*'s net revenue if *i* is active in equilibrium, the distribution of marginal costs across firms determines *whether i* is active in equilibrium. Therefore, we do not adopt the tempting notation $R^T\left(c_i, c_j + c_k\right)$ when describing the general forms of the $R(\cdot)$ functions.)

2.3. Equilibrium Industrial Structures.

We solve the game in Figure 1 by backwards induction. Definitions 1 and 2 formally characterise the game's subgame perfect Nash equilibria (in pure strategies) for a given choice by M. (Definition 1 applies if M chooses A, and Definition 2 applies if M chooses from $\{X, G\}$.) Definition 3 gives the equilibrium take-over price if A chooses M, and Definition 4 uses this result to state M's decision rule between A and $\{X, G\}$.

Definition 1. If M's strategy space is restricted to A, then the *equilibrium industrial structure* is $\left\{A; S_E^*\right\}$ where

$$S_E^* \equiv \underset{S_E}{\arg\max}\, E\pi_E\left(A; S_E\right)$$

for all $S_E \in \left\{\varnothing, G_H, G_F, G_2\right\}$.

If M chooses A, then the equilibrium industrial structure is determined by the straightforward requirement that E play its best response to A.

Definition 2. If M's strategy space is restricted to $\{X, G\}$, then the *equilibrium industrial structure* is $\left\{S_A^*; S_T^*; S_E^*\right\}$ where

$$S_A^* \equiv \underset{S_A}{\arg\max}\, E\pi_A\left(S_A; S_T^{BR}\left(S_A\right); S_E^{BR}\left(S_A; S_T^{BR}\left(S_A\right)\right)\right);$$

$$S_T^* \equiv S_T^{BR}\left(S_A^*\right);\ \text{and}\ S_E^* \equiv S_E^{BR}\left(S_A^*; S_T^*\right)$$

and the $S^{BR}(\cdot)$ functions

$$S_T^{BR}\left(S_A\right) = \underset{S_T}{\arg\max}\, E\pi_T\left(S_A; S_T; S_E^{BR}\left(S_A; S_T\right)\right)$$

$$S_E^{BR}\left(S_A; S_T\right) = \underset{S_E}{\arg\max}\, E\pi_E\left(S_A; S_T; S_E\right)$$

for all $S_A \in \{X, G\}$; $S_T \in \{X, G\}$; and $S_E \in \{\varnothing, G_H, G_F, G_2\}$

give the best responses of T and E to their (upstream) rivals' choices.

E's equilibrium choice is (in the penultimate stage of the game) is determined by the requirement that E play its best response to $\overset{*}{S}_A$, $\overset{*}{S}_T$ (which E takes as given). However, firm T must consider the knock-on effects of its choice of S_T on E's optimal choice; therefore, S_E^{BR} is endogenized within S_T^{BR}. Likewise, firm M (the first-mover) must consider the implications of its choice of S_M for T and E's optimal choices; therefore, the only independent variable in A's objective function is S_A.

Definition 3. If M chooses A in the equilibrium industrial structure, then the *equilibrium take-over price* is $E\pi_T\left(\overset{*}{S}_A; \overset{*}{S}_T; \overset{*}{S}_E\right)$, where $\overset{*}{S}_A$, $\overset{*}{S}_T$, $\overset{*}{S}_E$ are determined in Definition 2.

Given that M makes T a take-it-or-leave-it offer, the minimal take-over price that T will accept is (just above) T's expected profits in equilibrium if M chooses from {X, G}. This is a standard result (see, e.g., Gilbert and Newbery, 1992).

Definition 4. M chooses A in the equilibrium industrial structure iff

$$E\pi_M\left(A; \overset{*}{S}_E\right) - E\pi_T\left(\overset{*}{S}_A; \overset{*}{S}_T; \overset{*}{S}_E\right) > E\pi_M\left(\overset{*}{S}_A; \overset{*}{S}_T; \overset{*}{S}_E\right) \qquad (14)$$

where $E\pi_M(\cdot;\cdot)$ is determined in Definition 1, and $E\pi_T(\cdot;\cdot;\cdot)$, $E\pi_M(\cdot;\cdot;\cdot)$ are determined in Definition 2.

Definition 4 ulitmately ties down the equilibrium industrial structure of the game in Figure 3.1. Condition (14) is straightforward: the LHS gives M's expected payoff if acquisition-FDI occurs in equilibrium, and the RHS gives M's expected payoff if acquisition-FDI does not occur in equilibrium. An implication of condition (14), which is clear on rearrangement, is that acquisition-FDI occurs in equilibrium iff M's expected profits following acquisition-FDI are (strictly) greater than the combined expected profits of M and T if acquisition-FDI does not occur. Therefore, the decision rule for acquisition-FDI in our model is formally equivalent to the familiar co-operative decision rule for mergers of Salant, Switzer and Reynolds (1983), and our assumptions on the bargaining process *do not* restrict equilibrium behaviour. However, the assumption that M makes T a take-it-or-leave-it offer *does* restrict equilibrium payoffs following acquisition-FDI (i.e. T receives none of the 'surplus' from acquisition-FDI; see Definition 3), which are indeterminate under the co-operative decision rule. This restriction on equilibrium payoffs would primarily be a problem if we planned to undertake welfare comparisons across industrial structures, which we do not. We shall make use of the formal equivalence between condition (14) and the co-operative decision rule in Section 4 below.

When solving the model we place restrictions on c_M, c_T, t so that the functional forms of $R^D(\cdot,\cdot)$ and $R^T(\cdot,\cdot,\cdot)$ are independent of their arguments. This enables us to avoid extensive (and unrewarding) taxonomy. Specifically, we assume that all firms in the industry will be active in both countries in product market equilibrium. This assumption is additional to our maintained assumption (A) on c_M, c_T. Therefore, for example, for given c_M and c_T, t is constrained not to be so large that M can monopoly-price in its home market when T chooses X and E chooses $\varnothing$ or G_F. The key implication of this assumption is that all firms always earn strictly positive net revenue in both countries in product market equilibrium (although, of course, low-marginal cost firms earn more than high-marginal cost ones). If E chooses $\varnothing$, then the net revenues of M and T in product market equilibrium are described by the duopoly net revenue function, $R^D(\cdot,\cdot)$. The necessary-and-sufficient condition for $R^D(\cdot,\cdot) > 0$ for every possible permutation of arguments is $R^D(c_T + t, c_M) > 0$, because $c_T + t$ is the maximum possible value of a firm's own marginal cost and c_M is the minimum possible value for its rival's marginal cost (and $\partial R^D(c_i, c_j)/\partial c_i \le 0$, $\partial R^D(c_i, c_j)/\partial c_j \ge 0$). $R^D(c_T + t, c_M) > 0$ requires $c_T < (1 - 2\cdot t + c_M)/2$ (i.e. the monopoly price associated with c_M is strictly greater than $c_T + t$). The necessary-and-sufficient condition for $R^T(\cdot,\cdot,\cdot) > 0$ for every possible permutation of arguments is $R^T(c_T + t, c_M, c_M) > 0$, because the equilibrium price in a Cournot duopoly is lowest when both firms have marginal costs of c_M. $R^T(c_T + t, c_M, c_M) > 0$ requires $c_T < (1 - 3\cdot t + 2\cdot c_M)/3$ (i.e. the equilibrium price in Cournot duopoly when both firms have marginal costs of c_M is strictly greater than $c_T + t$). Given that $c_T > c_M$ from assumption (A), $c_T < (1 - 3\cdot t + 2\cdot c_M)/3$ is more restrictive than $c_T < (1 - 2\cdot t + c_M)/2$ (which is intuitive because for a constant marginal cost across firms of c_M the monopoly price is strictly greater than the duopoly price). Therefore, our assumption that all firms are active in both countries in product market equilibrium translates into

(B) $$t \in \left(0, \frac{1}{3}\right); \;\; c_M \in \left(0, 1-3\cdot t\right); \;\; c_T \in \left(c_M, \frac{1-3\cdot t+2\cdot c_M}{3}\right)$$

Given the assumptions on marginal costs in (B), we are able to derive some of the equilibrium properties of our model analytically (specifically, we solve backwards to *stage 2* – inclusive – analytically). However, as will be shown in the next Section, deriving the model's equilibrium industrial structures analytically is complicated by the model's mathematical intractability. Therefore, we solve for *M*'s stage-one choice numerically for three sets of the marginal cost parameters; these are

(S1) $$t = 0.05; \;\; c_M = 0.2; \;\; c_T = 0.25$$

(S2) $$t = 0.05; \;\; c_M = 0.2; \;\; c_T = 0.4$$

(S3) $$t = 0.15; \;\; c_M = 0.2; \;\; c_T = 0.25$$

(S1) is the benchmark case. If wages are constant across both countries and firms, then *M*'s labour productivity is 25% higher than *T*'s in (S1). Compared to (S1), (S2) represents a widening of the (labour) productivity gap between *M* and *T*; in (S2) *M*'s labour productivity is double *T*'s. Compared to (S1), (S3) represents a trebling of trade costs. (Note that all of (S1), (S2), (S3) are consistent with assumption (B).)

3. Analysis.

3.1. *E*'s optimal choice (stage three).

In stage three *E* chooses a corporate structure from $\{\varnothing, G_H, G_F, G_2\}$ (see Figure 1). We deal first with the (relatively simple) case where *M*'s prior corporate structure choice was *A* (and thus *T* does not exist as an independent entity). Clearly $E\pi_E(A;\varnothing) = 0$. We also have

$$\begin{aligned} E\pi_E\left(A;G_H\right) = E\pi_E\left(A;G_F\right) = \theta\cdot\left[R^D\left(c_M,c_M\right)+R^D\left(c_M+t,c_M\right)\right] \\ +\left(1-\theta\right)\cdot\left[R^D\left(c_T,c_M\right)+R^D\left(c_T+t,c_M\right)\right]-G \end{aligned}$$

and

$$E\pi_E\left(A;G_2\right) = 2\cdot\left[\theta+\left(1-\theta\right)\cdot\theta\right]\cdot R^D\left(c_M,c_M\right)+2\cdot\left(1-\theta\right)^2\cdot R^D\left(c_T,c_M\right)-2\cdot G$$

$E\pi_E(A;G_H) = E\pi_E(A;G_F)$ (and hence E is indifferent between G_H and G_F following A) because following acquisition-FDI the two countries are identical, both containing one plant (in common ownership) with a marginal production cost of c_M. (We adopt two conventions throughout when writing down $E\pi_E(\cdot)$. First, if E has only one plant, we write *local* net revenue as the first term in square brackets and net revenue from *exports* as the second. Second, if E has two plants, we write net revenue in H before net revenue in F.) $E\pi_E(A;G_H)$ is linear and strictly increasing in θ, which makes intuitive sense because spillovers reduce E's marginal production cost. In the expression for $E\pi_E(A;G_2)$ $\theta + (1 - \theta)\cdot\theta$ measures the probability that a spillover occurs in *at least* one country (note that $(1 - \theta)\cdot\theta$ is the probability of spillovers in a country given that none occur abroad) and $(1 - \theta)^2$ measures the probability that spillovers occur in *neither* country. $E\pi_E(A;G_2)$ is increasing and strictly concave in θ on [0, 1], which is again intuitive because $\mathrm{d}^2[\theta + (1 - \theta)\cdot\theta]/\mathrm{d}\theta^2 < 0$ so increases in θ have progressively smaller impacts on the *overall* probability of receiving spillovers.

As noted above, E has $G_H \sim G_F$ in response to A. Furthermore, in response to A

$$E \text{ has } \begin{cases} G_H, G_F \succ \varnothing \quad \text{iff} \quad ER_E\left(A;G_H\right) > G \\ G_2 \succ \varnothing \quad \text{iff} \quad \dfrac{1}{2}\cdot ER_E\left(A;G_2\right) > G \\ G_2 \succ G_H, G_F \quad \text{iff} \quad ER_E\left(A;G_2\right) - ER_E\left(A;G_H\right) > G \end{cases} \tag{15}$$

where $ER_E(\cdot)$ denotes E's expected net revenues in a given industrial structure. Iff

$$2\cdot ER_E\left(A;G_H\right) > ER_E\left(A;G_2\right) \tag{16}$$

then the plot of E's best responses to A in (θ, G)-space resembles Figure 2. Condition (16) holds in all of (S1), (S2), (S3). The sufficiency of (16) for Figure 2 is obvious from inspection; its necessity is made clear by considering E's best responses to A if (16) fails. (If $ER_E(A;G_2) \geq 2\cdot ER_E(A;G_H)$, then E would never optimally choose G_H, G_F in response to A; the best response to A would be G_2 (resp. $\varnothing$) iff $ER_E(A;G_2) >$ (resp. $<$) $2\cdot G$. Therefore, an alternative interpretation of (16) is that it ensures that the region where G_H or G_F is E's best response is non-empty.) Necessary-and-sufficient conditions akin to (16), which states that twice the net revenue from exporting (from a single plant) must strictly exceed the net revenue from undertaking (additional) greenfield-FDI (and establishing a second plant), will occur repeatedly in our analysis of E's best responses. Those familiar with the literature on tariff-jumping greenfield-FDI might find it difficult to conceive of circumstances where (16) fails since, if a foreign market can be served via exporting, undertaking greenfield-FDI will typically increase *but not double* total net revenues. Consider, however, E's expected net revenues in $\{A; G_H\}$ and $\{A; G_2\}$ when t is so large that no international trade occurs in product-market equilibrium. In this case $ER_E(A; G_H) = \theta \cdot R^D(c_M, c_M) + (1 - \theta) \cdot R^D(c_T, c_M)$ because $R^D(c_M + t, c_M) = R^D(c_T + t, c_M) = 0$, and straightforward but tedious algebra shows that (16) fails for all $\theta \in [0, 1]$ (since $c_T > c_M$). The intuition for this (surprising) result (i.e. that adding a second plant *more* than doubles E's global expected net revenues) is that only local producers serve product markets in equilibrium if t is 'very large' so (i) *all* of E's variable profits abroad under greenfield-FDI represent a net increase in its global variable profits, and (ii) because E 'meets' M in two markets rather than one, adding a second plant increases E's probability of receiving spillovers.

[INSERT FIGURE 2 HERE]

The effects of changing G in Figure 2 are entirely intuitive: increases in G decrease E's optimal number of plants. The effects of changing θ are more complex, however, because it is *not* the case that increasing θ always increases E's equilibrium number of plants. Where $ER_E(A;G_2) - ER_E(A;G_H)$ is downward-sloping, an increase in θ (for given G) can reduce E's equilibrium number of plants from two to one: this occurs because increases in θ raise $ER_E(A;G_H)$ more than $ER_E(A;G_2)$ for large θ, so the gain in expected net revenue from choosing two plants over one, $ER_E(A;G_2) - ER_E(A;G_H)$, falls.

We can also examine the comparative-statics effects of changing the marginal cost parameters c_M, c_T, t in Figure 2. Increasing t reduces $ER_E(A;G_H)$ as net revenues from abroad fall, but $ER_E(A;G_2)$ is unaffected because no international trade occurs in $\{A; G_2\}$ (A and E produce locally in both countries). Therefore, the top ($\varnothing$) and bottom (G_2) regions in Figure 2 both increase in size, and the middle (G_H or G_F) region is squeezed from both directions. (This is the case in (S3) relative to (S1).) Intuitively, an increase in t strengthens both E's preference for zero plants over one (i.e. $ER_E(A;G_H)$ falls) and E's preference for two plants over one (i.e. $ER_E(A;G_2) - ER_E(A;G_H)$ rises, an enhanced 'tariff-jumping' motive); thus the regions where $\varnothing$ and G_2 are best responses grow at the expense of that where G_H or G_F is optimal.

We next consider the effects of raising c_T on Figure 2. (This is the case in (S2) relative to (S1).) Note first that both inter-regional boundaries in Figure 2 are independent of c_T at $\theta = 1$. This is because neither firm will have a marginal production cost in the product-market competition stage of c_T if spillovers are certain, so c_T becomes irrelevant. $ER_E(A;G_H)$, the upper inter-regional boundary in Figure 2, shifts downwards for all $\theta \in [0, 1)$ when c_T rises, because E's preference for zero plants over one strengthens (if spillovers do not occur, higher c_T reduces E's net revenues under G_H or G_F). $ER_E(A;G_2) - ER_E(A;G_H)$, the lower inter-regional boundary in Figure 2, shifts downwards for small θ but upwards for large (but <1) θ when c_T rises, reflecting the fact that a two-plant entrant has a higher probability of receiving spillovers than a one-plant entrant and so is less harmed by rises in c_T. Therefore, increasing c_T can strengthen E's preference for G_2 over G_H or G_F, implying that the bottom region in Figure 2 expands at the expense of the middle one.

Finally, we consider the effects on Figure 2 of varying c_M, which are more complex than the effects of varying t, c_T. Reducing c_M shifts $ER_E(A;G_H)$ downwards at $\theta = 0$ but upwards at $\theta = 1$ (in the linear Cournot duopoly considered here a common cut in both firms' marginal costs increases both firms' net revenues because the 'own' effect outweighs the 'cross' effect). Therefore, for appropriate G and small θ (e.g. just below the upper inter-regional boundary in Figure 2) a cut in c_M shifts E's best response to A from G_H or G_F to $\varnothing$: entry is discouraged because M becomes a tougher competitor. However, for appropriate G and large θ (i.e. just above the upper inter-regional boundary in Figure 2) a cut in c_M shifts E's best response to A in the opposite direction, from $\varnothing$ to G_H or G_F: despite the tougher competition from M, entry is on balance encouraged by the desire to receive spillovers of its (now more valuable) technology. Turning to the lower inter-regional boundary in Figure 2, $ER_E(A;G_2) - ER_E(A;G_H)$ shifts in the same direction as $ER_E(A;G_H)$ near and at its end-points ($\theta \approx 0, 1$); however, further analysis is excessively complex given the illustrative comparative-statics exercise at hand.

If M and E do not choose A and $\varnothing$ respectively, then both national product markets will be served by Cournot triopolies in stage four. Firm i's net revenue in a Cournot triopoly with firms j and k was described by the function $R^T(c_i, c_j, c_k)$ in Section 2.2. However, if the Cournot first-order condition (2) binds (which is guaranteed by assumption (B)), then firm i's best-response output depends only on the *sum* of its rivals' marginal costs, $c_i + c_k$. Therefore, to lighten notation we write i's net revenue function in a Cournot triopoly as $R^T(c_i, c_j + c_k)$ given assumption (B).

We next consider E's best responses to $\{G; G\}$, $\{G; X\}$, $\{X; G\}$ and $\{X; X\}$. E's expected profit functions for each case are presented in the Appendix; some commentary on them is also provided, and the more mechanical (i.e. less economically interesting) aspects of E's best responses are derived. In each of these four cases we can state a necessary-and-sufficient condition analogous to (16) for E's best responses in (θ, G)-space to resemble Figure 2. ('Resemble' is used here loosely to mean that each plot would have three distinct regions, which are ordered identically to those in Figure 2. Inter-regional boundaries may be shaped differently to those in Figure 2.) The relevant necessary-and-sufficient conditions are

For E's best responses to $\{G; G\}$:

$$2 \cdot ER_E\left(G;G;G_H\right) > ER_E(G;G;G_2) \tag{17}$$

For E's best responses to $\{G; X\}$:

$$2 \cdot ER_E\left(G;X;G_H\right) > ER_E\left(G;X;G_2\right) \tag{18}$$

For E's best responses to $\{X; G\}$:

$$2 \cdot \max\left\{ER_E\left(X;G;G_H\right), ER_E\left(X;G;G_F\right)\right\} > ER_E\left(X;G;G_2\right) \tag{19}$$

For E's best responses to $\{X; X\}$:

$$2 \cdot ER_E\left(X;X;G_H\right) > ER_E\left(X;X;G_2\right) \tag{20}$$

(17) – (20) hold in all of (S1), (S2), (S3) (and they are unconnected to assumption (B)). Note that (17) – (20) share the same structure as (16): all five conditions state that twice the expected net revenue from establishing one plant must (strictly) exceed the expected net revenue from establishing two plants. (17) – (20) have two other characteristics in common with (16): first, if (17) – (20) fail, then E will never establish a single plant as a best response; second, (17) – (18) fail if t is so large that no international trade occurs in product-market equilibrium because in that case establishing a second plant (and thus meeting M in an additional product market) *more* than doubles E's expected net revenues (E's probability of

receiving spillovers rises). Even if (16) – (20) all hold, E's best responses will differ across cases in one noteworthy aspect: namely, E's optimal choice of *where* to locate a single plant when E's best response is one plant. In response to A, E is indifferent between G_H and G_F; this is also so in response to $\{G; G\}$. In response to both $\{G; X\}$ and $\{X; X\}$ G_H strictly dominates G_F for all parameter values. E's optimal one-plant choice in response to $\{X; G\}$ is more complex: in the region where E optimally chooses a single plant G_F is certainly (strictly) preferred to G_H for extreme θ-values (i.e. $\theta \approx 0, 1$). However, E's choice between G_H and G_F at more central θ-values depends crucially on the marginal cost parameters c_M, c_T, t. For example, in (S1) and (S2) E strictly prefers G_H to G_F in response to $\{X; G\}$ for central θ-values, whereas in (S3) E strictly prefers G_F to G_H in response to $\{X; G\}$ for all $\theta \in [0, 1]$. We do not explore in any detail *how* the marginal cost parameters affect E's choice between G_H and G_F in the one-plant region because for our purposes the fact that E chooses one plant is much more significant than its location. However, we can provide some simple intuition on why E's best response to $\{X; G\}$ might be G_H for central θ-values but G_F at the extremes. In $\{X; G; G_H\}$ E's probability of receiving a spillover is θ, whereas in $\{X; G; G_F\}$ it is θ^2. Clearly these probabilities are equal at $\theta = 0, 1$; but for $\theta \in (0, 1)$ E is strictly more likely to receive a spillover if it chooses G_H. Therefore, a desire to maximize the chance of receiving spillovers could (intuitively) explain a preference by E for G_H over G_F central θ-values in response to $\{X; G\}$.

In Figures 3 and 4 we plot, respectively, E's best responses if M chooses G and X in (θ, G)-space. Both Figures cover both of T's possible choices (X and G) and so allow us to investigate, for a given choice by M, E's best response to a *change* in T's choice. In the Appendix we show that the necessary-and-sufficient condition for the construction of Figure 3 is

$$ER_E(G;G;G_H) + ER_E(G;X;G_H) > ER_E(G;X;G_2) \tag{21}$$

which holds in all of (S1), (S2), (S3). Note that (21) is more restrictive than (17) and (18) (see the Appendix for proof).

[INSERT FIGURE 3 HERE]

Key to Figure 3

E's BR to $\{G; G\}$	E's best response (BR) to $\{G; X\}$		
$\downarrow$	$\varnothing$	G_H	G_2
$\varnothing$	region A	region B	
G_H or G_F *		region C	region D
G_2			region E

Note (*)**:** In regions C and D, E is indifferent between G_H and G_F in response to $\{G; G\}$.

In Figure 3 increases in G reduce E's optimal number of plants. Note that the critical G-values where E optimally switches from two plants to one and from one plant to zero are both higher if T chooses X (horizontal movements between cells in the key to Figure 3) than if T chooses G (vertical movements). This implies that two distinct (and mutually exclusive) cases exist in Figure 3. First, E's optimal number of plants if M chooses G may be independent of T's intervening choice (the diagonal cells in the key to Figure 3). Second, E's optimal number of plants if T chooses X may be one greater than if T chooses G (the off-diagonal cells). However, it is *never* the case that E optimally chooses (strictly) more plants if T chooses G than if T chooses X. To provide some intuition for the existence of the second case above, note that (ceteris paribus) total expected net revenues ('rents') in product-market equilibrium will be lower if T chooses G over X, because (a) 'competition' in H is more intense since the trade cost does not enter T's marginal cost; and (b) T has a higher probability of receiving spillovers from M since T and M 'meet' in two countries rather than one. Therefore, it is possible to imagine situations where there is 'room' in the industry for an additional E-plant if T chooses X but not if T chooses G.

Figure 4 shows E's best responses if M chooses X for either of T's possible choices. In the Appendix we show that the necessary-and-sufficient conditions for the construction of Figure 4 are

$$c_T \text{ 'sufficiently larger' than } c_M$$

$$2 \cdot \max\left\{ER_E\left(X;G;G_H\right), ER_E\left(X;G;G_F\right)\right\} > ER_E\left(X;G;G_2\right) \quad \text{(19) repeated}$$

$$\max\left\{ER_E\left(X;G;G_H\right), ER_E\left(X;G;G_F\right)\right\} + ER_E\left(X;X;G_H\right) > ER_E\left(X;X;G_2\right) \quad (22)$$

all of which hold in (S1), (S2), (S3). It is unclear from inspection which of (19), (22) is the more restrictive: we have both LHS(22) > LHS(19) and RHS(22) > RHS(19). However, from

Figure 4 it is clear that for small θ (22) is the more restrictive, whereas (19) is more restrictive for large θ. (This follows from how the inter-regional boundaries in the lower part of Figure 4 intersect.) A final, brief technical point worth making is that, although the *form* of Figure 4 is robust to all of (S1), (S2), (S3), the B/C, C/D and E/F inter-regional boundaries need not be kinked: in (S3) they will all be smooth.

[INSERT FIGURE 4 HERE]

Key to Figure 4

E's BR to $\{X; G\}$ ↓	E's best response (BR) to $\{X; X\}$: $\varnothing$	G_H	G_2
$\varnothing$	region A	region B	
G_H or G_F *		region C	region E
G_2		region D	region F

Note (*): In regions C and E, E is *not* indifferent between G_H and G_F in response to $\{X; G\}$. Rather, *one* of $\{G_H, G_F\}$ will be chosen by E in response to $\{X; G\}$ with *strict preference.*

Figure 4 shares several comparative-statics properties with Figure 3: in both, E's optimal number of plants falls for a given choice by T as G rises. However, it is no longer true that E's optimal number of plants is always (weakly) greater if T chooses X over G; that is, the argument that there is more 'room' for entry by E (and thus E chooses more plants in equilibrium) if T chooses X, which was invoked to rationalise the structure of Figure 3, does not (universally) hold in Figure 4. The exception occurs in region D, where E chooses two plants in response to $\{X; G\}$ but only one plant in H in response to $\{X; X\}$. The explanation for this lies in the fact that region D does not exist for small θ. If the probability of spillovers is significantly greater than zero (as in D), then by choosing G_2 in response to $\{X; X\}$ E runs a significant risk (probability θ^2) of providing a channel for T to receive M's technology (which would make T a more aggressive competitor). However, this risk is not present if M has previously chosen G. Therefore, for large θ E's gain in expected net revenues from choosing two plants over one is greater following $\{X; G\}$ than $\{X; X\}$. Note that for small θ the counterpart region to D is region E where the intuitive 'room' argument *does* hold: E chooses two plants in response to $\{X; X\}$ but only one in response to $\{X; G\}$ because the risk of indirectly providing T with M's technology is considered insignificant. It can easily be shown that the existence of region D crucially depends on c_T being 'sufficiently larger' than c_M. This makes intuitive sense: if $c_T \approx c_M$, then the cost to E in {X; X; G_2} of providing T with spillovers of M's technology will be negligible (despite the fact that the associated probability, θ^2, may be large).

3.2. *M* and *T*'s optimal choices (stages one and two).

We begin by examining T's optimal choice in stage two, which itself exists only if M chooses X or G in stage one (see Figure 1). In stage two T chooses a corporate structure from {X, G}, taking account of E's subsequent best response in stage three. T's expected profit functions in every possible industrial structure are presented for reference in the Appendix. A key feature of them for our purposes is that $E\pi_T(\cdot)$ is generally strictly decreasing in the number of plants chosen by E for given choices by M, T. This makes intuitive sense because additional entry by E (i.e. adding an extra E-plant) will typically increase 'competition' in both host-country markets (i.e. E's marginal cost of supplying a market will fall if it establishes a local plant because trade costs are eliminated and E's probability of receiving spillovers typically rises). Therefore, we can describe how T's incentive to undertake greenfield-FDI changes as we move between cells in the keys to Figures 3 and 4 (i.e. how E's subsequent location choice affects T's decision ceteris paribus). First, a *rightwards* movement between cells in either key generally *strengthens* T's incentive to undertake greenfield-FDI because T's expected net revenues from exporting fall but those from greenfield-FDI are unchanged so the gain to undertaking greenfield-FDI rises. The exception to this rule occurs in the key to Figure 4 when E's best response to {X; X} changes from G_H to G_2: because we can have $ER_T(X; X; G_2) > ER_T(X; X; G_H)$, a rightwards move from the middle to the righthand column can *weaken* T's incentive to undertake greenfield-FDI. Second, a *downwards* movement between cells in either key always *weakens* T's incentive to undertake greenfield-FDI because T's expected net revenues from greenfield-FDI fall but those from exporting are unchanged. These two points can be illustrated by considering the critical G-value, G^*, that governs T's choice between greenfield-FDI and exporting for any given cell in the key to either Figure 3 or Figure 4. G^* equals T's gain in expected net revenues from choosing greenfield-FDI over exporting, and it depends on the marginal cost parameters and θ in a form determined by the corporate structure choices of M, E. Clearly, T optimally chooses greenfield-FDI iff $G < G^*$ and exporting iff $G > G^*$ (by definition T is indifferent iff $G = G^*$). The first point above implies that G^* rises if we move rightwards between cells in either key, and the second implies that G^* falls if we move downwards between cells.

Figure 5 plots the optimal corporate structure choices of T and E if M chooses G in (S1), (S2) and (S3). Because the inter-regional boundaries in Figure 5 are identical to those in Figure 3, it would be straightforward to derive the general necessary-and-sufficient conditions on θ and the marginal cost parameters underlying Figure 5; however, we do not do so here because the remainder of our analysis will be concerned with the parameter values in (S1), (S2) and (S3). One point to note is that the pattern of optimal choices by T depicted in Figure 5 is consistent with (and explanable by) our analysis above of the effects of E's subsequent choices on T's incentives. For example, G^* (the critical G-value where T switches between greenfield-FDI and exporting, which reflects T's 'incentive' to undertake greenfield-FDI) is higher for region B in Figure 3 than for region A because entry by E is strategically deterred if T chooses G in region B whereas in region A entry is blockaded. Given our parameter restrictions, we find that the A/B inter-regional boundary lies between these two values for G^*.

[INSERT FIGURE 5 HERE]

Key to Figure 5 (in the form {best response of T; best response of E})

Region A: $\{X; \varnothing\}$; region B: $\{G; \varnothing\}$; region C: $\{X; G_H\}$; region D: $\{G; G_H \text{ or } G_F\}$ – E is indifferent between G_H and G_F; region E: $\{G; G_2\}$.

Figure 6 plots the optimal corporate structure choices of T and E if M chooses X in (S1), (S2) and (S3). Again, we could straightforwardly derive the general necessary-and-sufficient conditions on θ and the marginal cost parameters underlying Figure 6 but for brevity do not do so. Three features that Figures 5 and 6 have in common are noteworthy. First, increases in the sunk cost of greenfield-FDI are associated with reductions in the number of plants that T and E, taken together, subsequently build. (If the sunk cost of greenfield-FDI is sufficiently small, then three plants are subsequently built following choices of both X and G by M. In both Figure 5 and Figure 6 increases in the sunk cost of greenfield-FDI successively reduce the number of new-builds to two, then one, then zero.) Second, although the *total* number of subsequently-built plants is decreasing in the sunk cost of greenfield-FDI, the number built T individually is not. In region B of both Figure 5 and Figure 6 T switches, as the sunk cost of greenfield-FDI rises, from choosing X to G, before re-switching back to X in region A. The reason for this is that in region B T can strategically deter entry by E by undertaking greenfield-FDI, which is not possible in either region A or region C (in A entry is blockaded, and in C it is inevitable). Therefore, T's incentive to undertake greenfield-FDI is greater in region B than in either region A or region C. Third, where the inter-regional boundaries in Figures 5 and 6 are upward-sloping, which is generally the case, increases in θ tend to increase the total number of subsequently-built plants. This reflects the strengthening of the motive for technology-sourcing greenfield-FDI (i.e. undertaking greenfield-FDI in the hope of benefitting from 'reverse' spillovers) as the probability of receiving spillovers rises.

[INSERT FIGURE 6 HERE]

Key to Figure 6 (in the form {best response of T; best response of E})

Region A: $\{X; \varnothing\}$; region B: $\{G; \varnothing\}$; region C: $\{X; G_H\}$; region D: $\{G; G_H\}$ or $\{G; G_F\}$ – E is not indifferent between G_H and G_F; region E: $\{G; G_2\}$.

We turn finally to consider firm M's stage-one choice between $\{X, G, A\}$ and thus our game's equilibrium industrial structures. The analysis of M's optimal choice occurs in two steps. First, we consider which of $\{X, G\}$ M prefers; by identifying M's potential alternative strategy to A, this determines the acquisition price that M would have to pay for T. Second, we determine M's choice between A and its preferred candidate from $\{X, G\}$ using the decision rule in (14).

The first step involves locating the inter-regional boundaries from Figure 5 and those from Figure 6 on the same diagram, and then calculating whether M prefers X or G in each distinct region (no inter-regional boundary is the same in both Figures, so the potential number of distinct regions thus created is large). Because of the complexity of the proposed analytical task, we solve stage one numerically. As will be demonstrated below, this still yields some useful suggestive insights. We work with three distinct numerical simulations: (S1), (S2) and (S3), where variation in the marginal cost parameters is allowed for. In each simulation we consider a 55-cell grid in (θ, G)-space: we consider θ-values belonging to $\{0, 0.25, 0.5, 0.75, 1\}$ and G-values (the sunk cost of greenfield-FDI) belonging to $\{0, 1, 2,..., 8, 10, 12\}$.

In Tables A1, A2 and A3 in the Appendix we report M's preferred choice from $\{X, G\}$ in each of (S1), (S2) and (S3) respectively. Analytic representations of M's expected profit functions are also given in the Appendix for reference. (In each Figure bold lines are used to group together cells where M makes the same optimal choice from $\{X, G\}$.) Here we report only some of the key features of those Figures, which relate to the determination of the acquisition price for T. (AP stands for 'acquisition price', and each proposition holds 'other things' constant.)

AP1. If the sunk cost of greenfield-FDI rises, then the number of plants subsequently built by T and E (weakly) falls.

AP2. If θ rises, then the number of plants subsequently built by T and E (weakly) rises.

AP3. If M switches its choice from X to G, then the number of plants subsequently built by T and E (weakly) falls.

AP4. If M chooses X and c_T rises, then the number of plants subsequently built by T and E (weakly) falls for small θ but (weakly) rises for large θ. However, if M chooses G and c_T rises, then the number of plants subsequently built by T and E does not change.

AP5. If t rises, then the number of plants subsequently built by T and E (weakly) rises.

AP6. M is 'more likely' to choose G over X, the lower is the sunk cost of greenfield-FDI. If c_T rises, then M becomes 'less likely' to choose G over X. However, if t rises, then M becomes 'more likely' to choose G over X.

We now turn to the second (and final) step in the determination of the game's equilibrium industrial structures: the comparison of M's expected profits under acquisition-FDI (A) with the combined expected profits of M and T at the 'threat point' (i.e. if M chooses between X and G). From (14), acquisition-FDI occurs in equilibrium in stage one of the game if and only if M's post-acquisition profits can (more than) cover M and T's combined profits if the acquisition does not occur. In Tables 1 – 3 we report the game's equilibrium industrial structures in (S1), (S2) and (S3) respectively. In each Table bold lines are used to group together cells where M makes the same optimal choice between A and $\{X, G\}$. Some noteworthy features of the Tables are summarised in the following propositions (where EIS stands for 'equilibrium industrial structure' and – as above – 'other things' are held constant).

EIS1. As the sunk cost of greenfield-FDI rises from 0, the sequence of M's equilibrium choices is $\{X, G\}$, A, $\{X, G\}$, A. (The bold lines divide each of Table 3.1 to Table 3.3 into four regions to reflect this sequence.) Rises in the sunk cost of greenfield-FDI also reduce the number of plants built by T and E in equilibrium.

EIS2. (A weaker property than EIS1.) For intermediate sunk costs of greenfield-FDI, rises in θ shift M's equilibrium choice from A to $\{X, G\}$ if θ is initially small but from $\{X, G\}$ to A if θ is initially large.

EIS3. Where M chooses from $\{X, G\}$ in equilibrium, an increase in c_T makes M 'less likely' to choose G but T 'more likely' to choose G. An increase in c_T also shifts all four regions defined in EIS1 downwards (especially for small θ).

EIS4. Where M chooses from $\{X, G\}$ in equilibrium, an increase in t makes both M and T 'more likely' to choose G. Where M chooses A in equilibrium, an increase in t makes E 'more likely' to choose G_2 over G_H or G_F. An increase in t also shifts all four regions defined in EIS1 downwards.

Sunk cost of greenfield-FDI, G ($\times$ 100)					
12	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$
10	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$
8	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$
7	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$
6	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$
5	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$
4	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$
3	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$
2	$\{A; G_H/G_F\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_H/G_F\}$
1	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$
0	$\{G; G; G_2\}$	$\{G; G; G_2\}$	$\{G; G; G_2\}$	$\{G; G; G_2\}$	$\{G; G; G_2\}$
	0	0.25	0.5	0.75	1

Probability of spillovers, θ

Table 1: Equilibrium industrial structures in (S1) (t = 0.05; c_M = 0.2; c_T = 0.25)

Sunk cost of greenfield-FDI, G (× 100)					
12	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$
10	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$
8	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; G; \varnothing\}$	$\{X; G; \varnothing\}$
7	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$
6	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; G; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$
5	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$
4	$\{A; \varnothing\}$	$\{A; G_H/G_F\}$	$\{G; G; \varnothing\}$	$\{A; G_H/G_F\}$	$\{A; G_H/G_F\}$
3	$\{A; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_H/G_F\}$
2	$\{G; X; \varnothing\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{X; G; G_H\}$	$\{A; G_H/G_F\}$
1	$\{A; G_H/G_F\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{X; G; G_2\}$	$\{A; G_2\}$
0	$\{A; G_2\}$	$\{A; G_2\}$	$\{X; G; G_2\}$	$\{X; G; G_2\}$	$\{G; G; G_2\}$
	0	0.25	0.5	0.75	1

Probability of spillovers, θ

(Above) **Table 2: Equilibrium industrial structures in (S2)** ($t = 0.05$; $c_M = 0.2$; $c_T = 0.4$)

Sunk cost of greenfield-FDI, G (× 100)					
12	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$
10	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{A; \varnothing\}$
8	$\{A; \varnothing\}$	$\{A; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; G; \varnothing\}$
7	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{X; X; \varnothing\}$	$\{G; X; \varnothing\}$	$\{G; X; \varnothing\}$
6	$\{X; X; \varnothing\}$	$\{G; X; \varnothing\}$	$\{G; X; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$
5	$\{G; X; \varnothing\}$	$\{X; G; \varnothing\}$	$\{A; G_H/G_F\}$	$\{G; G; \varnothing\}$	$\{G; G; \varnothing\}$
4	$\{A; G_H/G_F\}$	$\{G; G; \varnothing\}$	$\{G; G; \varnothing\}$	$\{A; G_2\}$	$\{A; G_2\}$
3	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$
2	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$
1	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$	$\{A; G_2\}$
0	$\{G; G; G_2\}$	$\{G; G; G_2\}$	$\{G; G; G_2\}$	$\{G; G; G_2\}$	$\{G; G; G_2\}$
	0	0.25	0.5	0.75	1

Probability of spillovers, θ

Table 3: Equilibrium industrial structures in (S3) ($t = 0.15$; $c_M = 0.2$; $c_T = 0.25$)

4. Discussion.

In this Section we consider our model's implications for the sources of foreign-owned firms' 'productivity advantages'. Before doing so, I want briefly to set out a reference point: Dunning's (1977) OLI (ownership-location-internalisation) paradigm. The OLI paradigm implicitly assumes monopolistic competition (rather than – as here – Cournot competition with limited potential entry), so the 'representative firm' in a product market earns only normal profits in long-run equilibrium. Therefore, a necessary condition for undertaking FDI is that the potential MNE possess a (proprietary) 'ownership advantage' relative to local rivals in the host country (e.g. a highly productive technology) to offset the increased costs of co-ordinating business activities across international borders. It follows that the observed 'productivity advantages' of foreign-owned MNEs are *embodied* in their FDI inflows: either a (relatively) highly productive new plant is established via greenfield-FDI, or the technology in a pre-existing plant is upgraded (intra-firm technology transfer) following acquisition-FDI.

We now compare the relationships of equilibrium national 'productivity distributions' to FDI inflows and outflows in our model to those predicted by the OLI paradigm (as reconstructed above). In Tables 1 to 3 we see that the role played by FDI inflows in shaping the equilibrium 'productivity distribution' in country F generally conforms to the OLI predictions. For example, in the equilibrium industrial structures of $\{G; G; G_2\}$ (all three Tables), $\{G; G; \varnothing\}$ (Tables 2 and 3) and $\{G; X; \varnothing\}$ (Tables 2 and 3), firm M's inflow of greenfield-FDI into F directly adds a relatively productive new plant to F and indirectly raises the productivity of other plants in F via the probability of spillovers. Furthermore, in the equilibrium industrial structures of $\{A; \varnothing\}$, $\{A; G_H/ G_F\}$ and $\{A; G_2\}$ (all three Tables), firm M's inflow of acquisition-FDI into F directly raises the productivity of the acquired (T-) plant (intra-firm technology transfer) and – in $\{A; G_F\}$ and $\{A; G_2\}$ – indirectly raises the productivity of the E-plant in F via the probability of spillovers.

However, there are three noticeable features of our model's equilibrium industrial structures that do not conform to the OLI predictions. First, in several equilibrium industrial structures (e.g. $\{G; G; G_2\}$, $\{X; G; \varnothing\}$, $\{G; G; \varnothing\}$ and $\{X; G; G_2\}$) firm T undertakes greenfield-FDI in country H. This occurs *despite* T's 'ownership *dis*advantage' (i.e. technology c_T is 'less productive' than technology c_M). The reason why 'ownership advantages' are unnecessary for greenfield-FDI in our model is that the scale of potential entry is limited, so the 'representative firm' can earn supernormal profits in equilibrium (there is also the important integer constraint on the number of firms). This is a replication of Fosfuri and Motta's (1999) 'multinationals without advantages' result. Indeed, stronger anti-OLI evidence in the same vein is provided in proposition EIS3 in the previous Section: if c_T rises relative to c_M (i.e. *M*'s 'ownership advantage' becomes greater), then *M* becomes 'less likely' to undertake greenfield-FDI but *T* 'more likely'. This result runs directly counter to the OLI predictions, and (as discussed in the previous Section) it is explained by *M*'s greater reluctance to risk losing its technological lead through spillovers when that lead lengthens.

The second equilibrium feature of our model that fails to conform to OLI predictions concerns acquisition-FDI. Although we set the model up by *assuming* that firm *M* is the potential acquirer, the decision rule for acquisition-FDI in (14) carries directly over to cases where the sequence of moves is modified so that (a) firm *T* is labelled the potential acquirer or (b) firms *M* and *T* are considered to merge. This is so because the decision rule is co-operative (i.e. the decision depends only on the *sum* of 'disagreement profits') and because the characteristics of the integrated firm are independent of the identity of the purchaser. Therefore, unless we assume a purchaser (as in our model), the *direction* (internationally) of acquisition-FDI flow in equilibrium in our modelling structure is indeterminate. It follows that whenever incentives for 'technology-injecting' acquisition-FDI exist in our model (i.e. the purchase of *T* by *M*), identical incentives for 'cherry-picking' acquisition-FDI (i.e. the purchase of *M* by *T*) will also exist. Therefore, our model gives no support to the OLI prediction that the purchaser in an acquisition-FDI transaction will be the technological leader: indeed, there is no reason to suppose anything a priori about the relative technological strengths of acquirer and target.

The third aspect of our model that fails to conform to OLI predictions concerns its distinction between greenfield- and acquisition-FDI (the two forms of FDI are conflated in the OLI paradigm). Because of the limited scope for potential entry in our model, we found that *M*'s choice between *A* (acquisition-FDI) and {*X*, *G*} (exporting or greenfield-FDI) frequently (i.e. for 'large' sets of parameter values) mattered for the equilibrium number of firms. Indeed, we used this feature of our model in explaining its 'pattern' of equilibrium industrial structures (see proposition EIS1 and the commentary on it in the previous Section). This suggests that more attention should perhaps be given to the distinction between greenfield- and acquisition-

FDI (in shaping equilibrium industrial structures in industries without perfectly free entry or where integer constraints are important) than is afforded it in the OLI paradigm.

5. Concluding Comments.

In this paper we have developed an equilibrium model of the relationship of FDI inflows and outflows to the national 'productivity distribution' across rival plants within an industry. We allowed for 'technology transfer' between plants in two forms: *inter-firm*, which represents 'spillovers'; and *intra-firm*, which reflects the 'public good' characteristic of technology within the firm. One of our key aims was to shed fresh (theoretical) light on the sources of foreign-owned firms' widely-documented 'productivity advantages'. Some of our principal findings in the comparative-statics analysis of equilibrium industrial structures in Section 3 were

- Acquisition-FDI arises in equilibrium for two distinct sets of parameter values, medium-sized and very large sunk costs of greenfield-FDI; between them (i.e. large greenfield-FDI sunk costs) and for small greenfield-FDI sunk costs, firms optimally choose between exporting and greenfield-FDI in order to serve foreign product markets. The consequent 're-switching' between greenfield- and acquisition-FDI that occurs as the sunk cost of greenfield-FDI rises is a typical feature of our model.
- Rises in the trade cost make the occurrence of greenfield-FDI (rather than exporting) in equilibrium 'more likely' in regions where acquisition-FDI does not occur. This is analogous to the 'tariff-jumping' greenfield-FDI observed in other models.
- Rises in the technological lead of an incumbent firm make that firm 'less likely' to undertake greenfield-FDI in equilibrium (because its technological lead could consequently be dissipated via localized spillovers in the host country), but they make foreign technological laggards 'more likely' to undertake ('technology-sourcing') greenfield-FDI in the leader's home country.

The third property above contradicts the prediction of the popular OLI (ownership-location-internalisation) paradigm that the possession of 'ownership advantages' (highly productive, firm-specific assets) is necessary for (greenfield-)FDI. In addition, we found that the incentives for 'technology-injecting' acquisition-FDI (leader purchases laggard) are identical to those for 'cherry-picking' acquisition-FDI (laggard purchases leader), so the view that foreign MNEs' 'productivity advantages' are *necessarily* embodied in acquisition-FDI inflows is without theoretical support. There is some empirical support for this view. For example, Conyon, Girma, Thompson and Wright (2002) found that, over the period 1989 – 1994, UK firms acquired by foreign MNEs exhibited an increase in labour productivity of 13% (ceteris paribus). This contrasts with a (labour) 'productivity advantage' for foreign-owned firms in their dataset of nearly 30% over domestic firms (at the industry level), which suggests that, as well as raising the labour productivity of the plants they acquire, foreign MNEs choose to purchase plants with above-average productivity.

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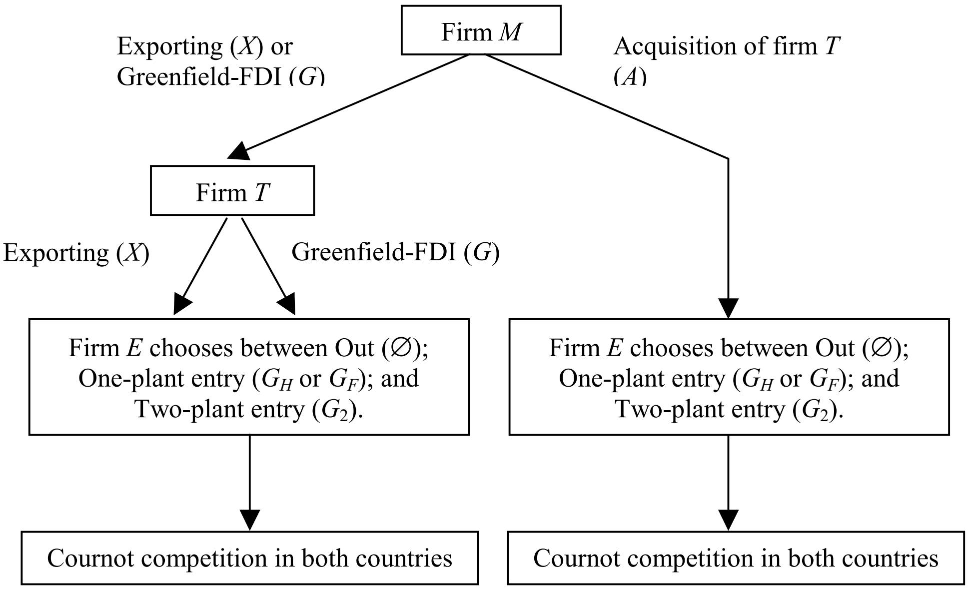
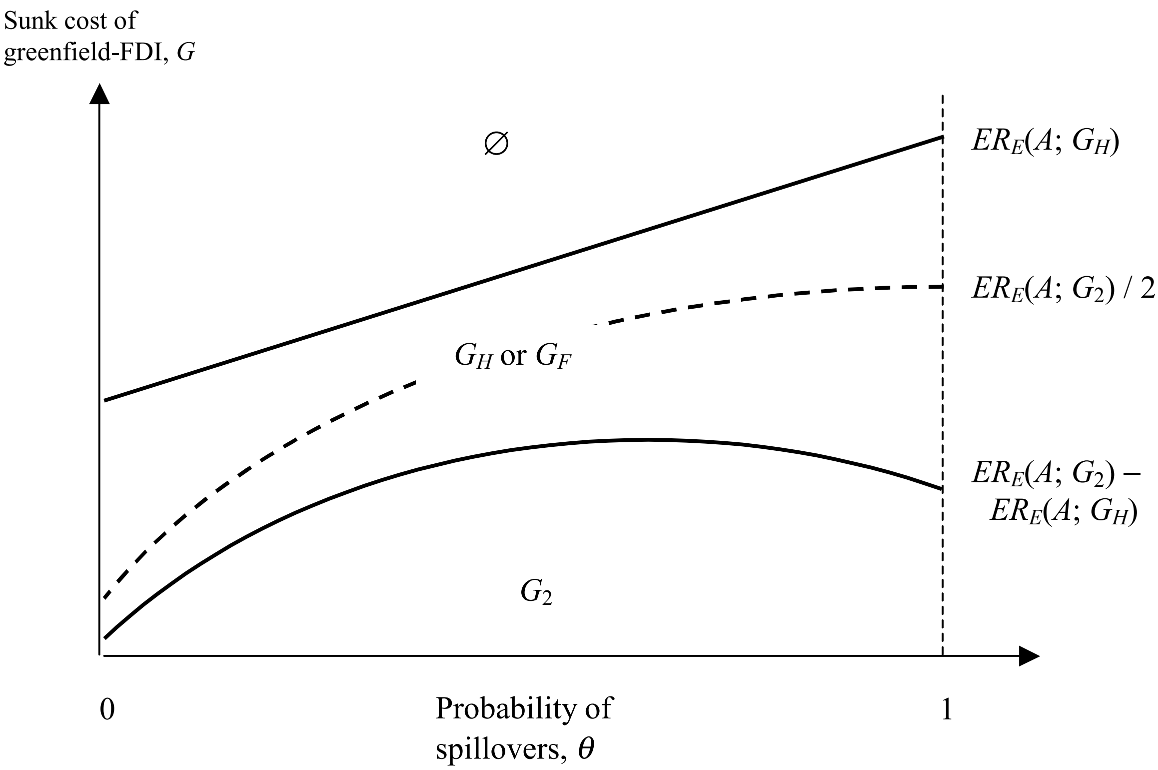
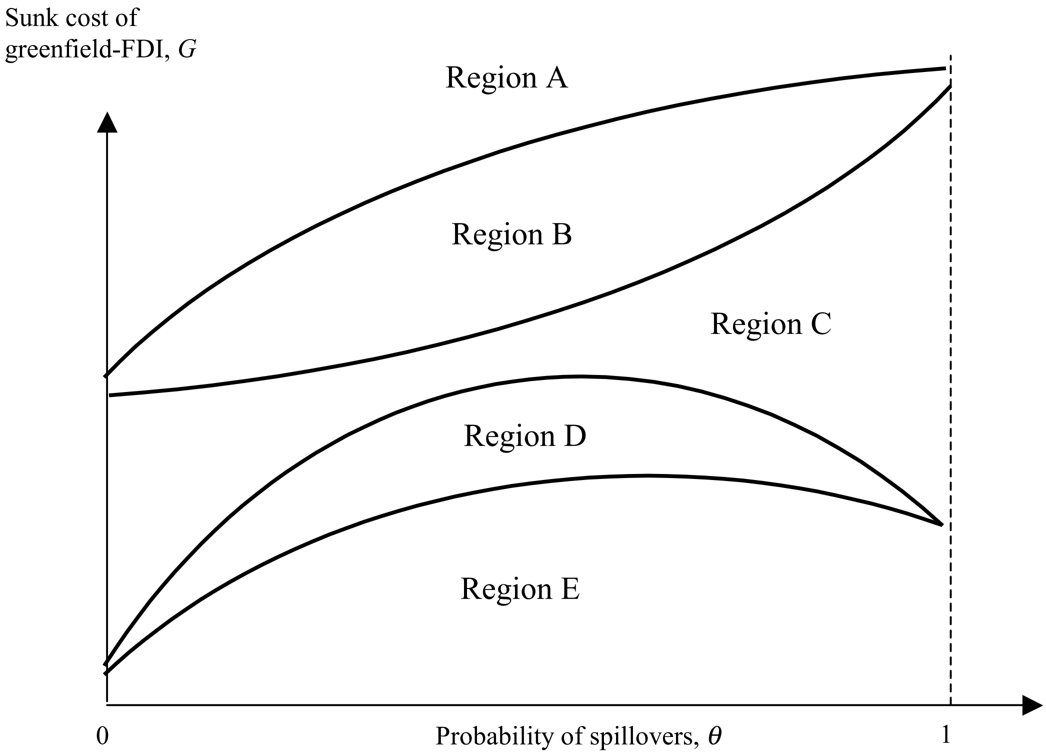


(Above) **Figure 1: Game Tree**

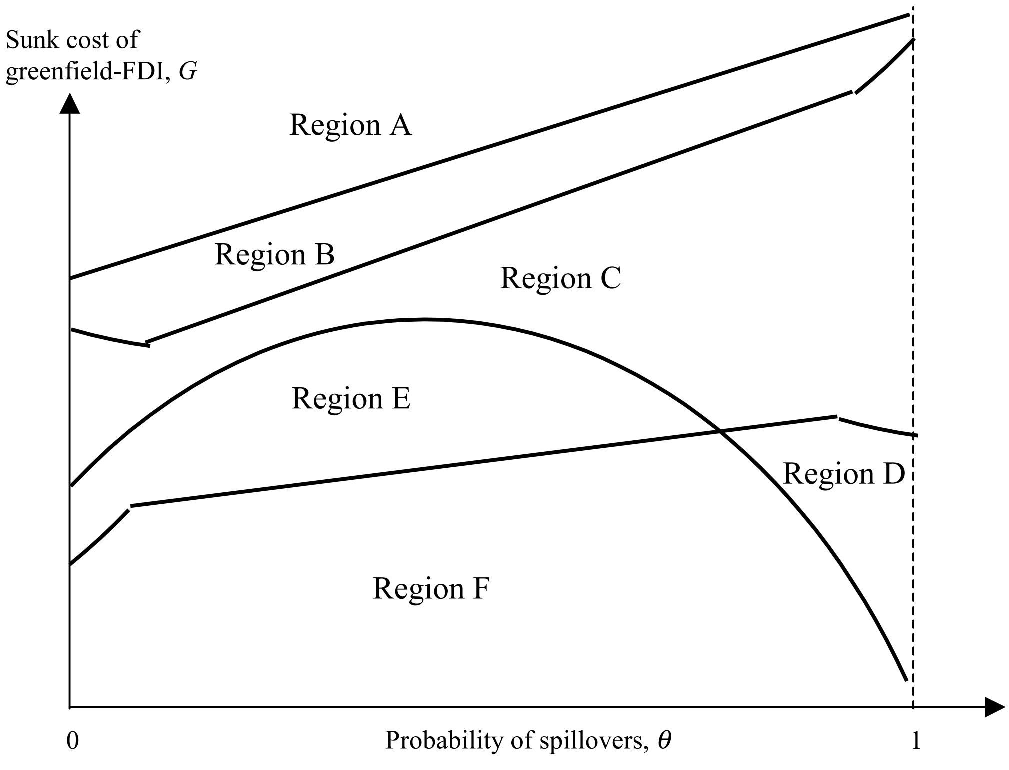


(Above) **Figure 2: *E*'s best responses if *M* chooses *A***



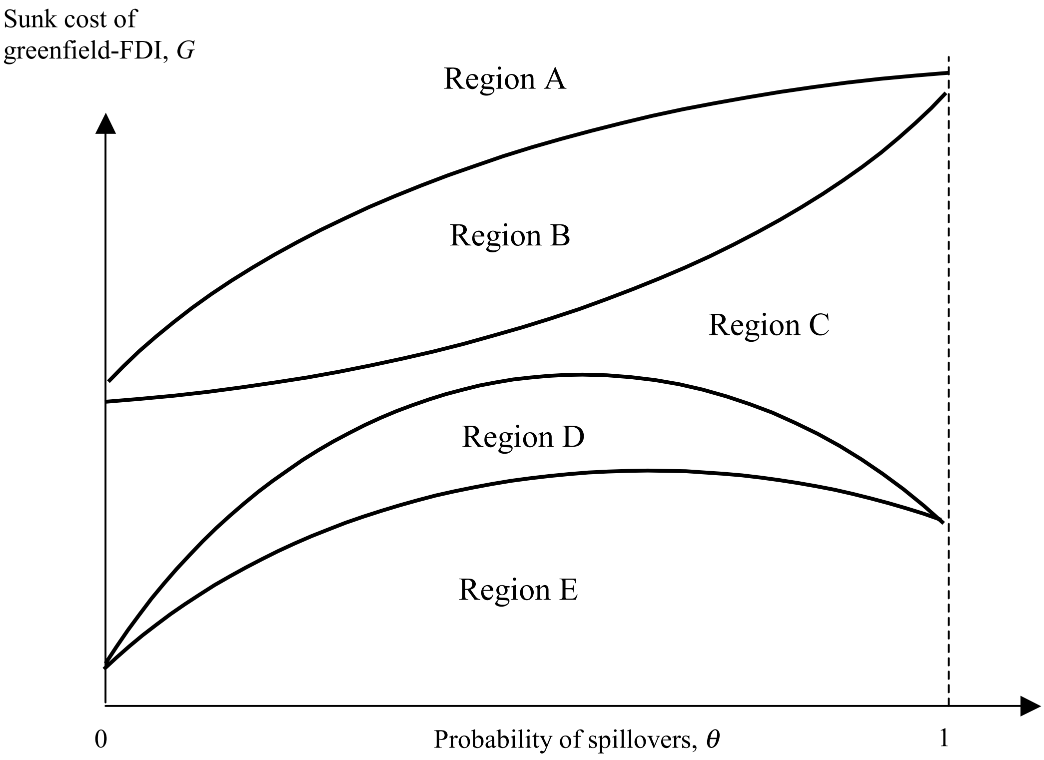
(Above) **Figure 3: *E*'s best responses if *M* chooses *G***

Inter-regional boundaries (above)**.** A/B: $ER_E(G; X; G_H)$; B/C: $ER_E(G; G; G_H$ or $G_F)$; C/D: $ER_E(G; X; G_2) - ER_E(G; X; G_H)$; D/E: $ER_E(G; G; G_2) - ER_E(G; G; G_H$ or $G_F)$.



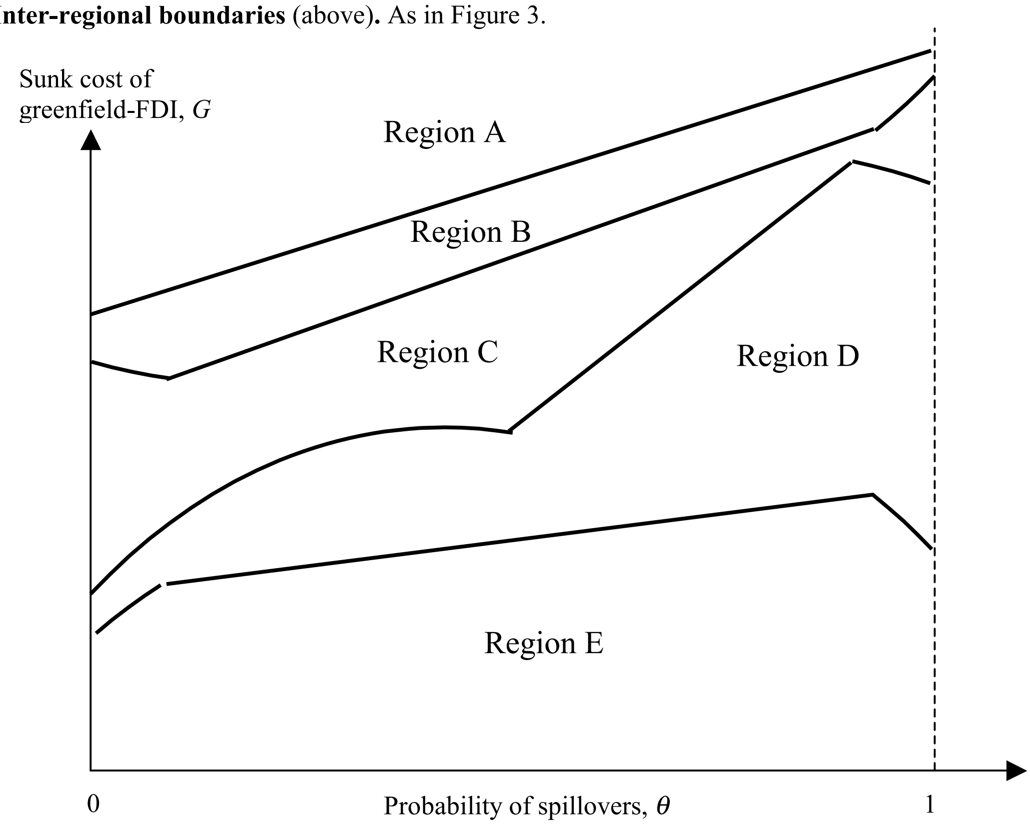
(Above) **Figure 4: *E*'s best responses if *M* chooses *X***

Inter-regional boundaries (above)**.** A/B: $ER_E(X; X; G_H)$; B/C: $\max\{ER_E(X; G; G_H), ER_E(X; G; G_F)\}$; C/D and E/F: $ER_E(X; G; G_2) - \max\{ER_E(X; G; G_H), ER_E(X; G; G_F)\}$; C/E and D/F: $ER_E(X; X; G_2) - ER_E(X; X; G_H)$.



(Above) **Figure 5: Best responses of *T* and *E* if *M* chooses *G***

Inter-regional boundaries (above)**.** As in Figure 3.



(Above) **Figure 6: Best responses of *T* and *E* if *M* chooses *X***

Inter-regional boundaries (above)**.** A/B: $ER_E(X; X; G_H)$; B/C: $\max\{ER_E(X; G; G_H), ER_E(X; G; G_F)\}$; C/D: $ER_E(X; X; G_2) - ER_E(X; X; G_H)$ for small θ, and $\min\{ER_T(X; G; G_H), ER_T(X; G; G_F)\} - ER_T(X; X; G_H)$ for large θ; and D/E: $ER_E(X; G; G_2) - \max\{ER_E(X; G; G_H), ER_E(X; G; G_F)\}$.