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Foreign Direct Investment and Productivity Growth: A Survey of Theory

by

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Abstract

This paper analyses several theoretical perspectives on the relationship between foreign direct investment (FDI) flows and 'productivity growth', interpreted as growth in total factor productivity (TFP). We begin with general equilibrium models. An open economy version of Solow's famous (1956) growth model is developed, where North-to-South FDI flows both equalize the return to capital across countries and transfer technical knowledge internationally. Two recent models of general equilibrium with imperfect competition are also discussed: one allows for specialisation in intermediates production à la Ethier (1982), and the other contains endogenous R&D decisions. Three partial equilibrium models are then presented to provide 'strategic' (game theoretic) analyses of (a) how spillovers affect an MNE's choice between FDI and exporting; (b) trained worker mobility as a specific mechanism for spillovers; and (c) the relationship between FDI flows and R&D performance. Before evaluating the state of research on the FDI/ productivity relationship (in the Conclusion), the penultimate section considers whether the form of FDI ('greenfield investment' versus cross-border mergers and acquisitions) undertaken matters for its relationship with TFP growth in two game-theoretic models (first, with endogenous R&D; and, second, when firms differ in their technologies).

JEL classification: F21; F23; O31; O40.

Keywords: foreign direct investment; productivity growth; total factor productivity; spillovers; R&D; acquisition-FDI; greenfield-FDI.

Outline

Non-Technical Summary

This paper analyses several theoretical perspectives on the relationship between foreign direct investment (FDI) flows and 'productivity growth', interpreted as growth in total factor productivity (TFP), the joint productivity of a given bundle of inputs (e.g. capital and labour). Two ways in which a firm's TFP can increase can be distinguished. A firm might receive superior technical knowledge from other firms ('spillovers'), or it might develop better techniques internally, via investment in research and development (R&D). The models outlined in this paper can be viewed as formalizations of the linkage between FDI flows and these two mechanisms of TFP growth.

We begin with general equilibrium models. An open economy version of Solow's famous (1956) growth model is developed, where North-to-South FDI flows both equalize the return to capital across countries and transfer technical knowledge internationally. Two recent models of general equilibrium with imperfect competition are also discussed: one allows for specialisation in intermediates production à la Ethier (1982), and the other contains endogenous R&D decisions. Three partial equilibrium models are then presented to provide 'strategic' (game theoretic) analyses of (a) how spillovers affect an MNE's choice between FDI and exporting; (b) trained worker mobility as a specific mechanism for spillovers; and (c) the relationship between FDI flows and R&D performance.

Before evaluating the state of research on the FDI/ productivity relationship in the Conclusion, the penultimate section considers whether the form of FDI ('greenfield investment' versus cross-border mergers and acquisitions) undertaken matters for its relationship with TFP growth. By way of motivation, there are at least two general reasons for emphasizing the distinction between greenfield- and acquisition-FDI. First, the intuitive industrial-organization response that the greenfield/ acquisition distinction affects 'concentration' is confirmed by applied work; indeed, UNCTAD (2000) finds that a *persistent* 'concentration effect' is the most significant difference between greenfield- and acquisition-FDI. Second, neither type of FDI is empirically trivial; e.g. UNCTAD (2000) estimates that the ratio of acquisition- to greenfield-FDI in aggregate global FDI flows was 4:1 in the late 1990s, and since then cross-border M&A flows have collapsed.

We present two game-theoretic models of the relationship between the form of FDI and firms' TFPs. In the first, R&D is endogenous. We isolate circumstances where both consumers and firms prefer acquisition-FDI to greenfield-FDI – despite the increase in 'concentration' it implies – because R&D performance improves following acquisition. In the second model, in contrast to the first, firms are heterogeneous, differing in their (exogenous) technologies. We examine how FDI inflows and outflows of both kinds help shape the national 'productivity distribution' across plants in an industry. Technology can flow both within firms (when firms with different technologies initially merge) and between firms (via 'spillovers'). This second analysis sheds some light on how FDI flows might account for the frequently-observed 'productivity advantages' of foreign- over domestically-owned firms.

1 Introduction

This paper presents several theoretical perspectives on the relationship between foreign direct investment (FDI) flows and 'productivity growth', interpreted as growth in total factor productivity (TFP), the joint productivity of a given bundle of inputs (e.g. capital and labour). Two ways in which a firm's TFP can increase can be distinguished.[1] A firm might receive superior technical knowledge from other firms ('spillovers'), or it might develop better techniques internally, via investment in research and development (R&D). The models outlined in this paper can be viewed as formalizations of the linkage between FDI flows and these two mechanisms of TFP growth.

In the next Section we present some general equilibrium perspectives on the FDI/ productivity relationship. An open economy version of Solow's famous (1956) growth model is developed, where North-South FDI flows equalize the return to capital across countries and simultaneously transfer technical knowledge internationally. We then go on to consider the implications of some recent models of general equilibrium with imperfect competition for the FDI/ productivity relationship. These are able to account for the influence of specialisation ('variety') in production and endogenous R&D decisions, neither of which can be examined within a perfectly competitive framework. The key advantage of general equilibrium modelling is that it allows the economy-wide effects of FDI flows to be analysed. However, due to the demands of tractability, this is at the expense of detailed study of the impact of FDI at the micro level. Moreover, intuition suggests that the micro effects of FDI flows will be both subtle and important: multinational enterprises (MNEs) typically operate in 'concentrated' industries where considerations of strategic inter-firm rivalry are likely to exert a significant influence on equilibrium outcomes. Therefore, in Section 3 a variety of partial equilibrium perspectives are presented. We analyse the strategic effects of spillovers on the firm's choice between FDI and exporting (Section 3.1) and a specific mechanism – worker mobility between firms – through which spillovers occur (Section 3.2).[2] We also present a model of the interactions between FDI flows and R&D investments (Section 3.3).

To fix ideas, a comment on how 'productivity growth' is accounted for in these modelling frameworks might be useful. The general equilibrium models typically specify a production function (e.g. the aggregate production function in the Solow model), an explicit component of which is an index of TFP.[3] However, in partial equilibrium (industrial organization) models production functions are rarely explic-

[1] This classification is not meant to be exhaustive. For example, TFP growth due to increased specialisation in the production of intermediates (Adam Smith's famous pin factory) does not fit well into it.

[2] In the literature, spillovers without a well-specified mechanism are referred to as 'demonstration effects'.

[3] Note that the empirical studies often interpret 'productivity' as labour productivity, value-added output per worker. From a theoretical viewpoint, it is problematic to think of FDI as affecting labour productivity directly, because output per head is endogenously determined – given market conditions and technology – by firms' profit-maximizing choices. Unless some aspect of technology changes, there is no reason for output per head to change. Therefore, the focus in the theoretical models is on the impact of FDI on TFP.

itly specified; rather, we work with its dual, the cost function. In these models an increase in TFP is generally reflected as a reduction in (constant) marginal cost.[4]

In Section 4 we examine two modelling approaches that disaggregate FDI flows into their components, greenfield-FDI ('greenfield investment') and acquisition-FDI (cross-border mergers and acquisitions), to examine their separate relationships with productivity growth. This is an interesting exercise both because there are intuitive industrial-organization reasons for believing that market structure (at least in the short run) will be differentially affected by greenfield- versus acquisition-FDI, and because neither type of FDI is trivial in real-world flows.[5] First, we examine the relationships between the two types of FDI flow and industry R&D performance; and, second, we examine how FDI inflows and outflows (of both kinds) help shape the national 'productivity distribution' across plants in an industry. This second analysis sheds some light on how FDI flows might account for the frequently-observed 'productivity advantages' of foreign- over domestically-owned firms.

Finally, Section 5 concludes.

2 General Equilibrium Perspectives

In this Section we develop a simple model of how FDI flows can arise endogenously as an equilibrium feature of an integrated world capital market.[6] In our model FDI flows (in equilibrium) from high to low productivity countries (where 'productivity' is to be interpreted as total factor productivity, TFP), and the 'productivity advantages' of source countries are assumed to be embodied in FDI flows. Both directly (via the import of superior capital) and indirectly (via technological spillovers to local firms), FDI inflows into low-productivity 'developing' countries raise those economies' aggregate total factor productivities. Our model thus formalizes the process by which North-to-South FDI flows can enable developing countries to 'catch up' (and possibly 'converge') with industrialized countries. An appealing feature of our analysis is its general equilibrium perspective, but this comes at some cost: for example, we are unable to comment on the 'strategic' features of competition that might well be significant in the (typically concentrated) markets in which MNEs operate.

The world comprises two regions (perhaps single countries or groups of identical countries), the North and the South. Aggregate production functions take a Cobb-

[4]If the firm's production function exhibits constant returns to scale (and is therefore homothetic) and all factors of production are variable, then average cost is independent of output (and therefore equals marginal cost): factor intensities depend only on relative factor prices. TFP growth, which shifts the unit isoquant inwards in its entirety, *must* reduce average cost (the optimal, i.e. lowest, isocost line shifts inwards).

[5]If acquisition-FDI results in a more 'concentrated' market structure than greenfield-FDI, then – to the extent that firms' rents vary with 'concentration' – this poses significant problems for using value-added per worker to proxy 'technology'.

[6]Inspiration for the model presented here was drawn from Koizumi and Kopecky (1977), Findlay (1978) and Wang (1990). For simplicity, there is no 'general' economic growth in our model (i.e. the production possibilities in the 'advanced' countries are unchanging through time), but only 'catching up' by developing regions. See Wang (1990) for a model of on-going growth.

Douglas form:

$$\begin{array}{lcl} \text{North} & : & Y_N = A_N K_N^{\alpha} L_N^{1-\alpha} \quad \Rightarrow \quad y_N = A_N k_N^{\alpha} \\ \text{South} & : & Y_S = A_S K_S^{\alpha} L_S^{1-\alpha} \quad \Rightarrow \quad y_S = A_S k_S^{\alpha} \end{array}$$

where upper and lower case letters represent aggregate and per-capita quantities respectively (Y = net output; K = capital; and L = labour). A_N and A_S index total factor productivity (assumed to be a 'pure' public good, both nonrival and nonexcludable, within the country). $\alpha \in (0,1)$ is the share of capital in national income (assuming perfect competition in product and factor markets).

Under autarky (i.e. international immobility of both factors), the steady-state level of capital per head is determined (as in the Solow growth model) by the requirement that per-capita investment (financed by savings) compensate the capital-diluting effects of depreciation and population growth:

$$\text{Autarky:} \quad \underbrace{s_i y_i}_{\substack{\text{realized investment per head} \\ \text{(determined by savings)}}} = \underbrace{(n+\delta)\, k_i}_{\substack{\text{required investment per head} \\ \text{to maintain constant } k}} \quad , \ i \in \{N, S\}$$

The rates of population growth and depreciation (common across regions) are n and δ respectively, and s is the constant average propensity to save (different across regions). Therefore, in the steady state $y/k = (n+\delta)/s$ for both regions. Substituting this into the marginal product of capital, $\partial y/\partial k = \alpha y/k$, we derive the autarky real interest rates:

$$\text{Autarky interest rates:} \quad r_N = \frac{\alpha (n+\delta)}{s_N}, \quad r_S = \frac{\alpha (n+\delta)}{s_S}$$

The important feature of r_N, r_S is that they are *independent* of A_N, A_S: the immediate (i.e. pre-accumulation) rise in the marginal product of capital caused by an improvement in TFP is entirely offset in the steady state by an increase in capital per head ('capital deepening'). We make the following intuitively-appealing assumptions:

$$\begin{array}{rcl} \text{Technological leadership} & : & A_N > A_S \\ \text{Savings behaviour} & : & s_N > s_S \end{array}$$

The top assumption means that North is the technological leader, and the lower one is sufficient to guarantee $r_S > r_N$ in autarky.[7] Figure 1 illustrates the analysis so far.[8] Note that under autarky steady-state capital and income per head are lower in the South than in the North for two reasons: the North's higher propensity to save and accumulate ($s_N > s_S$) and its higher level of TFP ($A_N > A_S$), which increases Northern savings and income per head for any $k_N = k_S$, $s_N = s_S$.

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[7] Of course, $s_N > s_S$ is unnnecessary for $r_S > r_N$ under autarky. We could plausibly assume higher population growth in South, which would achieve the same result.

[8] Nothing in our analysis implies (or requires) $y_S > s_N y_N$ for all $k_S = k_N$. Figure 1 assumes this merely for graphical convenience.

[INSERT FIGURE 1 HERE]

So far we have assumed perfect factor immobility between the two regions. Now assume that capital becomes perfectly mobile internationally ('globalization'), which implies $r_N = r_S = r_W$, the world real interest rate, in equilibrium (otherwise capital could profitably change locations). Because $r_S > r_N$ in autarky, capital will flow from North to South upon liberalization.[9] The (steady-state) equilibrium values of k_N, k_S under perfect capital mobility are characterized by two conditions:

$$r_N = r_S \quad \Rightarrow \quad \frac{k_N}{k_S} = \left(\frac{A_N}{A_S}\right)^{\frac{1}{1-\alpha}} , \tag{1}$$

which ensures that the marginal products of capital are equalized across regions,[10] and

$$\text{Capital exports = imports:} \qquad \underbrace{s_N y_N - (n+\delta)\, k_N}_{\substack{\text{Capital exports from} \\ \text{North per head}}} = \underbrace{(n+\delta)\, k_S - s_S y_S}_{\substack{\text{Capital imports by} \\ \text{South per head}}} , \tag{2}$$

which ensures that aggregate (global) capital demand and supply balance. ((2) implicitly assumes that the two regions have the same population; the extension to size asymmetries is straightforward, requiring the LHS of (2) to be multiplied by L_N/L_S.) (1) and (2) uniquely determine a (k_N, k_S)-pair with $k_N > k_S$ where both capital-labour ratios lie inside the autarky range (see Figure 1). Two features of the steady-state equilibrium under perfect capital mobility are noteworthy. First, *production* per head falls in the North and rises in the South as capital migrates southwards.[11] Second, capital (FDI) flows from the North to the South. This creates the possibility of international technology transfer if the North's TFP advantage is to some extent embodied in its capital outflows. Assume that TFP in the South, A_S, evolves according to

$$\frac{\mathrm{d}A_S}{\mathrm{d}t} = f\left(\frac{A_N}{A_S}, \frac{k_M}{k_S}\right) > 0 \;\; \text{for all} \;\; \frac{A_N}{A_S} > 1, \; \frac{k_M}{k_S} > 0$$

[9] It is important to note that nothing in the logical structure of our model implies this *direction* of FDI flow. For example, if $A_N > A_S$ but $s_S > s_N$ (so $r_N > r_S$ under autarky), then capital would flow from South to North upon liberalization.

[10] Therefore, to the extent that national TFPs differ, national capital:output ratios will also differ in equilibrium in an integrated global capital market. Lucas (1990, section II) provides an interesting numerical calibration, which suggests that the return to capital is virtually equalized between the USA and India once TFP differences are accounted for.

[11] It is important to note that this does *not* mean that national income per head has fallen in the North. In addition to domestic production, Northern citizens also receive income from their exported capital. Because capital flows Southwards as long as its marginal product in South exceeds that in North (i.e. gain > loss at the margin), Northern national income per head *rises* with capital liberalization. (The analysis of changes in the *distribution* of income between labour and capital in North is more problematic; see Ruffin, 1979.)

with $f(1,\cdot) = f(\cdot,0) = 0$. Therefore, Southern TFP grows if there exists a technological gap between North and South (i.e. $A_N > A_S$) and the South hosts Northern FDI (i.e. $k_M = k_X > 0$). Wang (1990) places more structure on the $f(\cdot,\cdot)$ function by assuming that both of its partial derivatives are strictly positive: A_S grows more rapidly, the larger is the technological gap between North and South (A_N/A_S) and the more important is Northern FDI in the Southern capital stock (k_M/k_S). The latter hypothesis was first proposed by Findlay (1978). However, this extra structure is unnecessary for our analysis of North-to-South technology transfer via FDI. Indeed, it is conceivable that $\mathrm{d}A_S/\mathrm{d}t$ may not be monotonically increasing in A_N/A_S. For example, if the South lacks sufficient 'absorptive capacity', then $\mathrm{d}A_S/\mathrm{d}t$ may *decrease* in A_N/A_S for sufficiently large A_N/A_S ('small gaps are easier to close than big ones'), perhaps making $\mathrm{d}A_S/\mathrm{d}t$ bell-shaped in A_N/A_S.

Therefore, in the world depicted in Figure 1 perfect capital mobility implies that (in the very long run) A_S converges on A_N as the South imports Northern FDI and techniques. Note from (1) that $A_S = A_N$ implies $k_S = k_N$ for real interest rate equalization. In the limit, $y_S = y_N$ for all $k_S = k_N$; but the South will continue to host FDI from the North because its propensity to save is lower. There is one especially significant respect in which our analysis differs from convention: the effects of an increase in the Southern propensity to save (s_S). Assume that s_S rises to the level of s_N. Then the two regions' autarky real interest rates will be equal, and no North-to-South capital movement will occur upon liberalization. Therefore, South is stuck in a trap and will not 'catch up' over time with North. This is an instance where saving more can stymie capital accumulation *that would otherwise have occurred* in the long run! The reason for this result is that increased Southern savings (completely) 'crowd out' FDI inflows from North, so South loses the benefit of technology transfer.[12] Of course, this is a polar case because rises in s_S that preserve $s_N > s_S$ will be consistent with North-to-South FDI flows and technology transfer upon capital liberalization. Here, the increase in Southern savings merely retards its convergence with North. These results on the effects of higher Southern savings contrast with the 'conventional' case of fixed national TFPs where increases in the propensity to save will increase the steady-state k if the economy is closed (the Solow case) or large and open (r_W will fall); only if the economy is small (a price-taker in international markets) and open will an increase in saving have no effect on k.

In the remainder of this Section we briefly review two strands of literature that examine the FDI/ productivity relationship in general equilibrium models with *imperfect competition*. Rodriguez-Clare (1996) examines how the extra demand for locally-produced intermediate goods, created by inward FDI in the final-goods sector, enables greater specialisation (division of labour) in the intermediate-goods industry as more varieties are produced (i.e. more firms enter), an issue that cannot be addressed under perfect competition where the number of firms is indetermi-

[12]Southern savings and FDI inflows from North are perfect substitutes for maintaining the Southern capital stock. The intuition behind this argument is easiest to grasp if one considers a small open economy facing a given world real interest rate. In this case (k is tied down by r_W) there is a one-for-one inverse relationship between Southern savings and FDI inflows from North.

nately large. Following Ethier (1982) in applying the Dixit-Stiglitz (1977) model of monopolistic competition to the vertical relationship between industries producing intermediate and final goods,[13] Rodriguez-Clare showed that inward FDI into the final-goods sector generates a positive externality for other final-good producers via *backward linkages:* the investing MNE's demands cause the intermediate-goods sector to expand (more varieties), which raises the TFP of *local* producers of the final good. (Rodriguez-Clare assumes that domestic firms must buy all their intermediate inputs locally, so inward FDI that represents merely a *relocation* of production – rather than a global increase – nevertheless confers external productivity benefits. However, MNEs may source their intermediates from abroad; if this occurs to a large extent, inward FDI that displaces local final-goods producers and creates an 'enclave economy' within the host country may harm local firms by reducing the number of locally-produced intermediate varieties.) Haaland and Wooton (1999) examine the implications of a model similar to Rodriguez-Clare's for the international agglomeration of final-goods production. Since inward FDI by a single MNE raises the TFP of all firms in the final-goods sector, it increases the incentive for additional MNEs to enter, perhaps leading the production plants of mobile firms to be internationally concentrated in a relatively small number of locations.

The second group of general equilibrium models with imperfect competition examines the relationships between Northern firms' R&D decisions, undertaken to move up the 'quality ladder' and exploit a monopoly position in a niche market, and Southern firms' rate of imitation. (Imperfect competition is necessary here because it generates the rents firms need to finance sunk R&D investments.) Benchmark models (although without FDI) of product-cycle trade, where Northern firms innovate and produce 'young' goods before production eventually moves to the cheaper South, are provided by Grossman and Helpman (1991, chs. 11 and 12) and Helpman (1993). A higher rate of imitation by Southern firms of Northern goods, which shifts production Southwards due to its cost advantage, can – somewhat paradoxically – increase R&D spending in the North: although the monopoly profits from a successful innovation are shorter lived, they may be larger than previously because the general Southwards migration of production will depress factor prices in the North. Glass and Saggi (1999) introduce FDI by Northern firms into this framework. There are now two channels of 'international technology transfer' between North and South: Southern firms may imitate either Northern 'national' firms or Northern MNEs. The impact of Northern FDI in the South on the level of R&D in the North depends on how aggregate Southern imitation responds to inward FDI. If total imitation rises, then R&D spending in the North will rise via the previous mechanism; however, if imitation of Northern MNEs merely substitutes for imitation of Northern 'national' firms, then Northern R&D spending will be essentially

[13] Compared to the Dixit-Stiglitz model of monopolistically-competitive firms selling to consumers, Ethier relabels the firm sector 'intermediate-goods producers' and the consumer sector 'final-goods producers'. The love-for-variety utility function of consumers in Dixit-Stiglitz becomes the production function for final goods: ceteris paribus, the output of final goods rises if the number of intermediate varieties rises, which is interpreted as a rise in TFP caused by greater specialisation in intermediates production.

unaffected.[14]

3 Partial Equilibrium Perspectives

3.1 Demonstration Effects

In this Section we simplify from general to partial equilibrium. This has the advantage that we are able to deepen our analysis in certain respects (notably, the inclusion of strategic behaviour) while retaining analytic tractability. We begin with a simple example to highlight some of the issues involved. Assume that a foreign MNE is considering whether to serve a host-country product market by exporting from its domestic production base or by establishing local production facilities (greenfield-FDI). The MNE's (constant) marginal production cost is c_M and exporting incurs a per-unit trade cost of t. The sunk cost of establishing a new plant in the host country is G. The host-country product market contains a single local firm with marginal production cost c_L. For the moment we do not need to place restrictions on c_L, c_M relative to each other. Assume that if both firms produce in the host country there is a probability $\theta \in (0,1)$ that the more productive firm's technology spills over (via unspecified 'demonstration effects') to its rival.[15] Denoting the variable profits of firm i in duopolistic competition (perhaps à la Cournot) with firm j by $\mu\pi_D(c_i, c_j)$, where μ is host-country 'market size' (population), and assuming $c_L > c_M$ (which fixes – if it occurs – the direction of spillover as M-to-L), the MNE optimally chooses FDI over exporting iff

$$\{c_L > c_M\!:\} \quad \underbrace{\mu\left[\theta\pi_D(c_M, c_M) + (1-\theta)\pi_D(c_M, c_L)\right]}_{\substack{\text{Expected variable profits}\\ \text{with local production (FDI)}}} - G > \underbrace{\mu\pi_D(c_M + t, c_L)}_{\substack{\text{Variable profits}\\ \text{under exporting}}} \qquad (3)$$

A number of comparative-statics results are immediately clear from (3). First, an increase in θ makes FDI 'less likely' (FDI profits fall because $\pi_D(c_M, c_L) > \pi_D(c_M, c_M)$ if $c_M < c_L$ but exporting profits are unchanged) as the risk that the MNE will lose its technological advantage via spillovers increases. Second, an increase in G makes FDI 'less likely' (FDI profits fall but exporting profits are unchanged), but an increase in t makes FDI 'more likely' (exporting profits fall but

[14] Two further relevant references are Walz (1997), where FDI spillovers provide the only channel of North-South 'international technology transfer', and Glass and Saggi (1998), who examine in detail how the 'absorptive capacity' of the South affects its ability to imitate Northern firms.

[15] Therefore, the scope of spillovers is geographically bounded (i.e. localized). In our formulation spillovers occur when the more productive firm's (process) technology becomes common knowledge. This contrasts with the modelling of spillovers in d'Aspremont and Jacquemin (1988), where a *proportion*, λ, of marginal cost spills over. In this case, equation (3) would become

$$\pi_D(c_M, \lambda c_M + (1-\lambda)c_L) - G > \pi_D(c_M + t, c_L).$$

See Ferrett (2003c) for more discussion of this distinction.

FDI profits are unchanged).[16] This replicates the well-known result that the 'tariff-jumping' motive for FDI strengthens as tariffs rise (Motta, 1992). Third, the effect of an increase in c_L (i.e. in the MNE's 'technological lead') on the MNE's optimal decision depends on whether spillovers are 'large' or 'small'. If θ is 'large' ($\cong 1$), then exporting profits rise but FDI profits are (approximately) unchanged, so FDI becomes 'less likely'. However, if θ is 'small' ($\cong 0$), then both exporting and FDI profits increase following a rise in c_L but FDI profits will rise by more, making FDI 'more likely'.[17] Fourth, as with technological lead, the effect of a rise in market size, μ, depends on the probability of spillovers. If θ is 'small' ($\cong 0$), increasing market size makes greenfield-FDI 'more likely' (because $\pi_D(c_M, c_L) > \pi_D(c_M + t, c_L)$). However, if θ is 'large' ($\cong 1$), then an increase in market size will make greenfield-FDI 'less likely' if and only if $\pi_D(c_M + t, c_L) > \pi_D(c_M, c_M)$ (e.g. if t is small and c_L is large relative to c_M).[18]

An important assumption underlying the preceding analysis is $c_L > c_M$ (i.e. the MNE's technology at the outset is more productive). This assumption is a persistent theme in theoretical modelling of competition between MNEs and 'national' firms. We cover some of the reasons motivating it in Section 4. Note, however, that in the simple framework outlined above there is no (logical) reason not to explore the consequences of setting $c_M > c_L$, 'multinationals without advantages' (Fosfuri and Motta, 1999).[19] If $c_M > c_L$, the MNE optimally chooses greenfield-FDI over exporting iff

$$\{c_M > c_L\text{:}\} \quad \underbrace{\mu\left[\theta\pi_D(c_L, c_L) + (1-\theta)\pi_D(c_M, c_L)\right]}_{\substack{\text{Expected variable profits} \\ \text{with local production}}} - G > \underbrace{\mu\pi_D(c_M + t, c_L)}_{\substack{\text{Variable profits} \\ \text{under exporting}}} \tag{4}$$

The difference between (3) and (4) lies in the first term on the LHS: if spillovers occur, they flow from the MNE to the local firm when $c_L > c_M$ but in the opposite direction when $c_M > c_L$. Some of the comparative-statics analysis of (4) (i.e. for t, G) mirrors that of (3). However, if θ rises when $c_M > c_L$, greenfield-FDI becomes 'more likely' (because $\pi_D(c_L, c_L) > \pi_D(c_M, c_L)$): such inward FDI has been nicknamed 'technology-sourcing FDI' (Driffield and Love, xxxx), undertaken in the hope of enabling the MNE to benefit from 'reverse' spillovers from local firms. If the local firm's technological lead (i.e. c_M) rises, then greenfield-FDI becomes 'less likely' if

[16] 'Less likely' and 'more likely' here refer to the direction of change in the size of a region in parameter space. For given parameter values, there is no probabilistic element to the MNE's decision (hence the quotation marks).

[17] For example, in a 'linear' Cournot duopoly (constant marginal cost, linear inverse demand) a given increase in rival's marginal cost causes the *same* changes in industry price (upwards) and firm production (net decrease) *independently* of marginal cost *levels* (see Shy, 1995). Therefore, a lower-marginal cost firm will benefit more from a given increase in rival's marginal cost (i.e. given increase in industry price) because its scale of production is larger.

[18] Note that this result contrasts with the models of Rowthorn (1992) and Horstmann and Markusen (1992) where spillovers are not considered (i.e. $\theta = 0$ in our terminology) and increases in market size always make FDI 'more likely' in equilibrium. (Those models implicitly set $c_M = c_L$.)

[19] Both Fosfuri and Motta (1999) and Siotis (1999) analyse this case.

spillovers are 'small' but 'more likely' if they are 'large' (because the value of 'catching up' is greater, the larger the technology gap). Finally, if $c_M > c_L$ an increase in market size makes greenfield-FDI 'more likely' independently of the probability of spillovers.

The two preceding models, both very simple, give some idea of how complex are the links between FDI incentives, spillover possibilities and technological gaps. In particular, I want to emphasise that if we allow MNEs to be strategic players we cannot simply take the magnitude of the FDI flow as fixed when discussing the effects of variations in the degree of spillovers (as we did in the general equilibrium model of the previous Section where FDI occurred to equalize the marginal product of capital across regions and spillovers were merely a by-product of those flows).[20]

An interesting generalization of the models presented above would allow for two-way FDI flows ('cross-hauling'), i.e. to give the local firm the option of investing in the MNE's home country. This would seriously complicate the analysis, however, because spillovers between the two firms can now occur in two countries. Therefore, a given firm's incentive to invest abroad will typically differ depending on whether or not its rival has undertaken FDI because the possible spillover flows are different. Ferrett (2003b) examines this case.[21]

The discussion thus far has focussed exclusively on 'horizontal' spillovers (i.e. between firms within a given industry). However, few of the general results appear to carry over to the case of 'vertical' spillovers. Consider a simple extension of the 'international outsourcing' model of Pack and Saggi (2001) where a monopolist has located final-goods production abroad (via FDI) and must purchase intermediate goods from a local (also monopolistic) firm. It is immediately clear that the investing MNE has a strong incentive to *encourage* 'vertical' spillovers from itself to the local supplier that reduce the latter's marginal cost, because these will reduce the MNE's input price. Furthermore, it is also the case that the MNE benefits from horizontal spillovers in the upstream (intermediate-goods) industry that reduce the marginal costs of extra potential suppliers and provoke their entry, thus stimulating 'competition' in the upstream market and reducing the MNE's input price.

In the remainder of this Section we consider two models of the relationships between FDI flows and host-country firms' productivities. The first models a spillover *mechanism* (unlike the framework examined above where spillovers were unformalized 'demonstration effects'): trained workers' mobility. The second model analyses the relationships between FDI flows and (process) R&D investment in an attempt

[20] Wang and Blomstrom (1992) and Das (1987) are both models where the degree of spillover from MNE to local rival (the parallel in the framework sketched above is the level of θ) is endogenously determined (via MNE investments in technology transfer and local-firm investments in imitation). However, both models assume that the MNE's production location (i.e. use of FDI) is given.

[21] Note that the interdependences between firms' strategies have different roots in the models of Horstmann and Markusen (1992) and Rowthorn (1992) compared to the hypothetical model described here. In Horstmann/ Markusen and Rowthorn sunk costs on production in their *home* countries (both firm- and plant-specific) create interdependences between the firms' decisions: a firm may optimally choose to exit the industry in response to inward FDI by a rival. In contrast, in the framework sketched here spillover possibilities, which vary with the two firms' locations, create interdependences.

to formalize arguments about the (positive) linkages between inward FDI, 'competition', and R&D spending.

3.2 A Spillover Mechanism: Trained Workers' Mobility

In this Section we present a model of the spillover mechanism: a foreign MNE that establishes a plant in a host country (greenfield-FDI) trains local workers, and the spillover occurs when those newly-trained workers move to local firms. The model we present is a simplified version of Fosfuri, Motta and Rønde (2001).[22] The model comprises two stages and analyses firms' equilibrium decisions within a single host country. Figure 2 shows the game tree. At stage one a foreign MNE chooses whether to serve the host country via (greenfield-)FDI or exports from a pre-existing production base abroad. The MNE's proprietary technology allows it to produce a good (serve a 'market niche') that is not currently served by host-country firms. If the MNE chooses FDI, its stage-one profit is $M - G$, where M is the monopoly profit from local production and G is the sunk cost of a plant. In this case, the MNE must train a local worker, which is assumed to be costless (labour is internationally immobile by assumption, so the MNE cannot 'import' a skilled worker from abroad). The worker's reservation wage is zero. If the MNE chooses exports, its stage-one monopoly profit is $M_X \in [0, M]$ because of trade costs. M_X is inversely related to trade costs.

[INSERT FIGURE 2 HERE]

Stage 2 is the second period of production. If the MNE chose exports in stage one, its stage-two choices are identical to those in stage one (with corresponding payoffs). I assume

$$M_X < M - G,$$

so the MNE will optimally choose FDI in stage two if it previously exported. (This amounts to assuming that the 'tariff-jumping' motive for FDI is 'sufficiently strong'.) However, if the MNE undertook FDI in stage one and trained a local worker, it must bid for the (mobile) worker in stage two with/against a single host-country entrant firm.[23] We assume that the firm with the higher valuation for the worker wins the auction, paying as a wage its rival's valuation.[24] The local firm will pay at most

$$v_L = D,$$

[22]A key simplification is that the host-country product market is constrained to be of the same size in both periods. I also ignore complications relating to the local firm's 'absorptive capacity'. Glass and Saggi (2001?) also model spillovers through workers' mobility, and they consider the host-country government's optimal policy response given a bidding instrument.

[23]Of course, it is possible to imagine the local firm already being in the product market, albeit owning a highly inefficient technology relative to the MNE.

[24]The hiring process is a first-price auction: the firms simultaneously and irreversibly make take-it-or-leave-it offers to the mobile trained worker, and we focus on the Pareto dominant equilibrium. I assume that the MNE can only write a one-period contract with the worker.

where $D \in [0, M]$ is its duopoly profit upon entry excluding wage payments. D is inversely related to the intensity of (product market) competition between the local firm and the MNE. For example, $D = 0$ if the firms compete in prices (Bertrand) and sell homogeneous goods, whereas $D = M$ if – from a demand-side view – the firms produce in independent markets.[25] The MNE will pay at most

$$v_M = M - D,$$

the difference between its second-period (variable) profits when it keeps and loses the worker.[26] Therefore, the MNE wins the auction iff

$$v_M > v_L \;\Leftrightarrow\; D < \frac{M}{2},$$

otherwise the local firm could out-bid it. Given our assumption that the MNE will undertake FDI in period two if it previously exported (i.e. $M_X < M - G$), we must now examine two cases. First, the MNE will undertake FDI in period one if it will win the subsequent auction iff

$$M_X < M - D. \tag{5}$$

Second, if it will lose the auction for the trained worker, the MNE will nevertheless undertake FDI in period one iff

$$M_X < D. \tag{6}$$

Figure 3 plots the game's subgame perfect Nash equilibria in (D, M_X)-space under the assumption that $M > 2G$.[27] Consider first 'small' M_X ($< M/2$), which relates to large trade costs. Here the MNE will always choose local production in period one ('tariff-jumping' FDI). If $v_L = D$ is small ($< M/2$), the MNE will outbid the local firm at auction, and the host country will experience a *pecuniary externality*: in period two, the MNE pays the trained worker more than her reservation wage ($= 0$). However, if $v_L = D$ is large ($> M/2$), the local firm will win the auction, and the host country experiences a *technological externality* in addition to a pecuniary one: the local firm appropriates the MNE's technology by hiring away its trained worker. Equilibria are more complicated when M_X is 'large' ($> M/2$), because first-period exporting becomes a viable option. Note that (5), (6) both embody a trade-off between export profits in period one and profits on local production after

[25] To some extent, it is natural to think of D as determined by the type of training supplied by the MNE in stage one. With training in firm-specific technology (e.g. product- and process-specific), D will be 'small'; but with 'general' training – that can readily be used in almost any firm – D will be 'large'.

[26] If the MNE loses the trained worker at auction, it must train another (costlessly) in period two. Note that even if it loses the auction, the MNE will continue local production in period two because it has already built a plant there, allowing it to 'jump' the trade cost.

[27] This guarantees that the MNE will optimally choose X in period one for some (D, M_X)-pairs with $M_X < M - G$, our maintained assumption.

the auction in period two.[28] For small D, the MNE optimally undertakes FDI in period one and wins the auction as before. However, the second-period wage of the (retained) worker increases one-for-one with D, so eventually winning the auction and producing locally in period two afterwards becomes unprofitable relative to exporting in period one (entry to the exporting region in Figure 3 from the left). If the MNE will lose the auction ($D > M/2$), then local production following the auction is more profitable than exporting in period one iff (6), i.e. for 'large' D (exit from the exporting region in Figure 3 to the right).

[INSERT FIGURE 3 HERE]

This Section has provided a formalization of the spillover mechanism that works through trained workers' mobility. An important finding is that two types of spillover are experienced by the host country: a pecuniary spillover because the trained worker commands a higher wage regardless of whether she is 'poached'; and a technological ('pure') spillover if the trained worker takes her newly-acquired skills to a local firm. The degree of competition between MNE and local rival is a key determinant of equilibrium outcomes: if they produce for 'quite different' markets ($D \cong M$), the MNE will willingly train in the knowledge that its trained worker will be poached because the business activities of the poaching firm will harm the MNE relatively little. We also discovered that the MNE's ability to export from a foreign country to the host country's market has an important influence on outcomes as a fall-back option.

3.3 FDI Flows and R&D Performance

In this Section I present a model of the greenfield-FDI and process R&D decisions of rival 'international duopolists' taken from Ferrett (2002).[29] By making both FDI and R&D decisions endogenous, I am able to analyse some of the relationships between them. Some have argued (e.g. Dunning, 1977) that R&D investments 'cause' ('precede') FDI by providing firms with the capabilities they need to compete in international markets and co-ordinate business activities across national borders, cultures, legal systems and languages. However, we shall see that the FDI/ R&D relationship is more complex than this: two-way linkages exist between these two corporate strategy decisions.

Consider a two-firm, two-country world where the firms originate from different countries (i.e. own pre-existing home plants in different countries) and compete in a homogeneous good. The firms play the following two-stage **international duopoly game**:

[28]Independently of its period-one choice, the MNE will enjoy one period with profits of $M - G$. If it originally chooses FDI, this occurs in period one, whereas it occurs in period two following exporting.

[29]The results we discuss are those for the 'blockaded entry' game in Ferrett (2002). Petit and Sanna-Randaccio (2000) analyse a similar game with spillovers, but their analysis does not admit an analytical solution.

Stage 1. The duopolists simultaneously and irreversibly choose their *corporate structures*: whether to undertake greenfield-FDI abroad and whether to invest in process R&D.

Stage 2. All firms' adopted corporate structures become common knowledge, as does the success/ failure of any R&D investments undertaken. The duopolists compete à la Bertrand to serve the two national product markets.

In stage one, the duopolists face two discrete choices. By paying a sunk cost of G (greenfield-FDI), they can establish a plant abroad. The benefit of greenfield-FDI is that it reduces the firm's marginal cost of serving the foreign product market by t, the per-unit (specific?) trade cost. By paying a sunk cost of I, the firm undertakes process R&D: with probability p R&D is 'successful' and the firm's marginal production cost falls from c, its initial level, to 0; with probability $1-p$ R&D 'fails' and marginal production cost remains at c. (The probability of R&D success is identical and independent across firms.) I make the following assumption on the marginal cost parameters to limit the taxonomy:

$$1 > c > t > 0,$$

so the per-unit trade cost lies (strictly) between the marginal production costs of a successful and an unsuccessful innovator. This assumption on the ordering of marginal cost parameters is important partly because – given the stage-two Bertrand competition in homogeneous goods – only the lower-cost firm serves the market. The variables of immediate interest are the probability of R&D success, p, and national market size, μ, which determines the slope of the demand function in both (identical) countries:

$$Q_d = \mu\,(1 - \text{price}) \quad \text{in both countries.}$$

I assume that firms maximize their expected profits, and I solve the game by backwards induction to isolate its subgame perfect Nash equilibria. Given our assumptions, each duopolist's corporate structure belongs to $\{1N, 1R, 2N, 2R\}$, where the first element of each term indicates whether the firm owns 1 plant or (following greenfield-FDI) 2 and the second indicates whether the firm undertakes R&D (R) or not (N). To give a feel for the game's structure, I briefly present two pairs of specimen payoffs. First, if both firms choose $1N$ (i.e. to maintain only their home plants and not to invest in R&D), then each earns profits of $\mu R\,(c, c+t)$, where $\mu R\,(c_i, c_j)$ is the variable profit of firm i in Bertrand competition with firm j (c_i, c_j are their respective marginal costs) within a market of size μ. In the case where the industrial structure is $(1N, 1N)$, each firm serves only its home market and is afforded some protection from import competition by the trade cost, t. Second, in the industrial structure $(1R, 2R)$ – firm 1 chooses $1R$ and 2 chooses $2R$ – expected profits are

$$\begin{aligned} E\pi_1 &= p\,(1-p)\,\mu\,[R\,(0,c) + R\,(t,c)] - I \\ E\pi_2 &= p\,(1-p)\,\mu\,[R\,(0,c+t) + R\,(0,c)] + p^2 \mu R\,(0,t) \\ &\quad + (1-p)^2\,\mu R\,(c, c+t) - G - I \end{aligned}$$

Because firm 2 has a local plant (via greenfield-FDI) in country 1, firm 1 must possess a marginal production cost advantage if it is to earn strictly positive variable profits. 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, probability p^2, or fail, probability $(1-p)^2$) because the trade cost affords its domestic plant some protection from foreign competition.

The equilibrium industrial structures of the international duopoly game are plotted in (p, μ)-space in Figure 4.[30] Several general (but not infallible) conclusions on the comparative-statics effects of varying p, μ can be drawn from Figure 4. The number of R&D investments is (weakly) increasing in both market size and the probability of R&D success. The equilibrium number of plants is also (weakly) increasing in national market size.[31] The effect of increases in the probability of R&D success on the equilibrium number of plants is less clear. Note that the boundaries of the $(2R, 2R)$ equilibrium region are asymptotic to the lines $p = 0$ and $p = 1$, so for 'sufficiently large' p $(2R, 2R)$ is never an equilibrium industrial structure. This is due to our assumption of Bertand competition in homogeneous goods, which implies that firms 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 $p \cong 1$ because the most likely outcome is a market price of 0 in both countries and a loss of $G + I$ for both firms. This underlies the switch in equilibrium industrial structure from $(2R, 2R)$ to $(1R, 1R)$ as we move rightwards for large μ.

[INSERT FIGURE 4 HERE]

From casual inspection of Figure 4, it appears therefore that the numbers of FDI and R&D investments are (generally) positively *associated* in equilibrium. (We must be careful not to speak of causation within this framework because both FDI and R&D are endogenous variables!) However, we can go further than this conclusion and investigate how a commitment to undertake either FDI or R&D affects a duopolist's 'incentive' to undertake the other sunk investment.[32] (While this does not relate to causality, it does give a flavour of the relationships between FDI and R&D investment decisions.[33]) It is immediately clear that a firm committed to in-

[30] I show in Ferrett (2002) that sufficient conditions for Figure 4 are $G \geq I > 0$ and $c - t$ 'sufficiently large'. See Ferrett (2003c) for a complete characterization of permissible parameter values.

[31] In addition to p, μ, there are four other structural parameters: G, I, t, c. Changing their values will shift the inter-regional boundaries in Figure 4. For example, increasing G will move the $(2R, 2R)$ region upwards and will squeeze the $(1R, 1R)/\ (1N, 2R)$ region from below, making greenfield-FDI 'less likely'. However, increasing t will have the opposite effects (as well as shifting the upper boundary of the $(1R, 1R)/\ (1N, 2R)$ region upwards), as 'tariff-jumping' FDI becomes more attractive.

[32] This amounts to analysing how a hypothetical prior commitment to undertake R&D (resp. greenfield-FDI) affects the *incremental profitability* of also undertaking greenfield-FDI (resp. R&D). It is important to note that this does *not* relate directly to the determination of equilibrium industrial structures, which are determined as Nash equilibria (i.e. mutual best responses) rather than via comparisons of (joint) profit levels. Indeed, the international duopoly game in Figure 4 can exhibit Prisoner's Dilemma characteristics.

[33] Petit and Sanna-Randaccio (1998, 2000) undertake a similar analysis with similar results.

vesting in R&D is 'more likely' to undertake greenfield-FDI than one that is not. In this international duopoly model playing $2N$ is strictly dominated by $1N$ (because Bertrand competition with the foreign incumbent ensures that rents to cover G can only be earned if R&D is undetaken), so a non-R&D firm will *never* optimally undertake greenfield-FDI.[34] This result captures the FDI/ R&D link in OLI ('ownership-location-internalisation') models (Dunning, 1977; Markusen, 1995). In order to make greenfield-FDI profitable, the 'ownership advantages' generated by (successful) process R&D are *necessary.*

It can also be shown that a firm committed to undertaking greenfield-FDI is 'more likely' to invest in R&D than one that is not.[35] The reason for this is that, following greenfield-FDI and the elimination of trade costs on foreign sales, a firm has a larger output base over which to spread a successful process innovation; therefore, the value of a successful process innovation is larger to a 2-plant than to a 1-plant firm.

Therefore, two-way (positive) relationships exist between FDI flows and R&D levels. It is also possible to examine how spending on FDI or R&D by one duopolists affects its rival's incentives to undertake FDI or R&D (see Ferrett, 2003c).

4 Does the Form of FDI Matter?

The partial equilibrium models of the previous Section all identified FDI in general with greenfield-FDI ('greenfield investment') in particular, while the general equilibrium models covered in Section 2 were rather ambiguous about the precise *form* of FDI ('greenfield investment' versus cross-border mergers and acquisitions, M&As) considered.[36] In this Section we examine two modelling approaches that explicitly disaggregate FDI flows into greenfield- and acquisition-FDI.[37] The first (Ferrett, 2003a) examines how the greenfield/ acquisition choice interacts with firms' R&D decisions. Inter alia, this allows a test of the 'failing firm' defence of acquisition-FDI inflows (Ferrett, 2003c): that acquisition-FDI is associated with sufficiently enhanced technological performance to offset the adverse welfare effects of increased 'concentration'. Formally, the modelling framework builds on the 'international duopoly game' described in Section 3.3 by adding two features: first, a stage 0

[34] However, $2R$ *is* occasionally chosen over $1R$ (e.g. whenever $2R$ arises in equilibrium).

[35] See Ferrett (2003c) for a proof.

[36] This ambiguity on the form of FDI in the general equilibrium models surveyed is not surprising because both of the market structures they employ (i.e. perfect and monopolistic competition) assume long-run free entry. Therefore, in the long run the number of plants is tied down by a zero-profit condition, and the greenfield/ acquisition choice will be irrelevant for equilibrium market structure.

[37] By way of motivation, there are at least two general reasons for emphasising this distinction. First, the intuitive industrial-organization response that the greenfield/ acquisition distinction affects 'concentration' is confirmed by applied work; indeed, UNCTAD (2000) finds that a *persistent* 'concentration effect' is the most significant difference between greenfield- and acquisition-FDI. Second, neither type of FDI is empirically trivial; e.g. UNCTAD (2000) estimates that the ratio of acquisition- to greenfield-FDI in aggregate global FDI flows was 4:1 in the late 1990s, and since then cross-border M&A flows have collapsed.

where the two incumbents are able to merge; and second, an intermediate stage between 1 and 2 where a third ('potential entrant') firm decides whether to enter the industry at a global level. If no merger occurs at stage 0, the two incumbents play the 'international duopoly game', augmented by the possibility of global entry. However, if the two incumbents merge initially, then the integrated incumbent monopolist thus created only has to decide whether to invest in R&D before facing the potential entrant's decision (the two plants initially in the industry have been integrated via acquisition-FDI).[38]

For our purposes, the welfare conclusions of this analysis are particularly relevant. Comparing the equilibrium industrial structures with and without merger, there is generally a Williamson (1968)-type welfare tradeoff between profits and consumer surplus: firms (collectively) benefit but consumers lose from the increased 'concentration' following acquisition-FDI. However, in small markets (where entry by the 'outside' firm never occurs) acquisition-FDI can be Pareto improving: the integrated monopolist created in equilibrium by acquisition-FDI invests in process R&D, whereas the incumbents acting independently would not, and this results in lower prices to consumers despite monopolization. Consumers have benefited from an increase in TFP, caused by R&D investment, that occurs only when FDI takes the form of acquisition. To understand why industry R&D spending can be higher following acquisition-FDI, consider the incumbents' R&D incentives in the no-merger 'threat point' of $(1N, 1N)$, where each incumbent maintains only her home plant and undertakes no R&D. Because they must pay trade costs on sales abroad, the return to a successful process innovation (a reduced marginal cost spread over output) is lower than that enjoyed by the integrated monopolist, who 'jumped' the trade cost using acquisition-FDI.[39]

The second approach that considers FDI/ productivity linkages in a model where FDI flows are disaggregated is Ferrett (2003b). The object is to examine the relationships between FDI inflows and outflows (of both forms) and the national 'productivity distributions' across firms (plants) in an industry. The empirical backdrop for this work is the widely-documented 'productivity gaps' between foreign- and domestically-owned firms that exist in many industries across numerous countries.[40]

[38]The merger decision is settled by applying the co-operative decision rule of Salant, Switzer and Reynolds (1983). The game is solved backwards to stage 1 to obtain subgame perfect Nash equilibria conditional on whether or not the merger occurs in stage 0; then, the payoff to the integrated incumbent is compared to the payoffs of the incumbents acting independently in the no-merger equilibrium to assess the profitability of merger.

[39]Note that the cause of Pareto improving acquisition-FDI in this model (an 'output base' effect) differs from that in Horn and Persson (2001b), where mergers are associated with savings in fixed and variable production costs ('synergies').

[40]For the UK this 'productivity gap' has been documented by Davies and Lyons (1991), Griffith (1999) and Oulton (2001). In particular, Oulton concludes that the labour productivity of foreign-owned firms has been continuously around 40 per cent higher than in UK-owned firms and that this 'productivity advantage' is not entirely due to a concentration of foreign-owned firms in industries with particularly high physical and human capital intensities. International evidence is provided by Globerman, Ries and Vertinsky's (1994) study on Canada and by Doms and Jensen's (1998) study of US manufacturing, which found that the significant difference – in terms of 'productivity gaps' – is between MNEs and non-MNEs, not between foreign- and domestically-owned firms.

In the model two characteristics of national 'productivity distributions' across plants are endogenously determined. 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* (i.e. 'spillovers') between the MNE's newly-established branch plant abroad and rival firms located in the host country. In our model spillovers can flow in both directions between a foreign branch plant and local rivals.[41] 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 and the potential entrant's decision.

The world comprises two countries and three firms, two 'incumbents' and one 'potential entrant'. The incumbents initially own one plant each, located in different countries, with different productive efficiencies (technologies). The sequence of moves is as follows. At stage 1 firm M, the high-productivity incumbent, chooses between acquisition-FDI (making a take-it-or-leave-it offer to the rival incumbent), greenfield-FDI (building a plant abroad to 'jump' the trade cost), and exporting. In stage 2 firm T, the low-productivity incumbent, chooses – if it still exists as an independent player – between greenfield-FDI and exporting. In stage 3 firm E, the low-productivity potential entrant, chooses between no-entry, 1-plant entry (and the plant's location), and 2-plant entry. Stage 4 is the 'market stage'. Spillovers (inter-firm technology transfer) occur at the start of stage 4: with probability θ, the best-practice technology installed in a country spills over to all local rivals.[42] Intra-firm technology transfer also occurs since technology is assumed to be a public good within the firm. Finally, Cournot competition determines market equilibria in both countries. (The game's equilibrium is obtained by solving backwards to stage 2 for a subgame perfect Nash equilibrium given M's choice. M's choice between acquisition-FDI and her preferred candidate of {exporting, greenfield-FDI} is determined by the Salant-Switzer-Reynolds (1983) 'profitability' criterion.)

Figure 5 gives a generic representation of the game's equilibria.[43] As the plant sunk cost rises, the equilibrium number of plants falls. However, there is also a significant non-monotonicity: acquisition-FDI arises in equilibrium on two separated intervals of plant sunk costs. The reason for this is that 'entry' (i.e. E's optimal number of plants) is 'more likely' (i.e. greater) if M chooses acquisition-FDI (and E

[41] This follows Fosfuri and Motta (1999) and Siotis (1999).

[42] Therefore, spillovers are geographically bounded in extent.

[43] Owing to the game's complexity, I am only able to solve backwards to stage 2 analytically in Ferrett (2003b). M's equilibrium choices are investigated using numerical simulations.

faces a monopolist) than if M chooses between greenfield-FDI and exporting (and E faces a duopoly). In the upper region where entry is 'inevitable', acquisition-FDI arises because it substitutes for costly greenfield-FDI. However, in the region where entry is 'conditional' – i.e. entry occurs if and only if M chooses acquisition-FDI – acquisition-FDI is rendered unprofitable by subsequent, rent-dissipating entry.

[INSERT FIGURE 5 HERE]

A number of the features of Figure 5 contrast strongly with the implications of Dunning's (1977) OLI (ownership-location-internalisation) paradigm for the sources of foreign-owned firms' observed 'productivity advantages'. The OLI paradigm argues that 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.[44] 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. In our model, in contrast, the possession of firm-specific 'ownership advantages' is evidently *un*necessary for greenfield-FDI: in the bottom three regions of Figure 5 the laggard firms, T and E, both build additional plants.[45] Moreover, an increase in M's technological lead (the difference between the marginal costs of the two technologies) *discourages* technology-dissipating greenfield-FDI by M (the technological leader) but *encourages* technology-sourcing greenfield-FDI by T (the laggard).

The OLI paradigm draws no strong distinction between greenfield- and acquisition-FDI. However, we found that – through its effect on 'concentration' and thus E's entry incentives – the greenfield/ acquisition choice exerts an important influence on equilibrium industrial structures. Furthermore, although we set the model out by *assuming* that M, the high-productivity incumbent, is the purchaser, this assumption is not necessary to support our derived equilibria (Figure 5). Because the acquisition decision rule is co-operative and the integrated firm's characteristics are independent of the purchaser's identity, we could relabel the model with firm T, the low-productivity incumbent, as the potential acquirer without altering its equilibruim predictions.[46] Therefore, whenever incentives for 'technology-embodied' acquisition-FDI exist, so do those for 'cherry-picking' acquisition-FDI, and the view that foreign MNEs' 'productivity advantages' are *necessarily* embodied in their FDI inflows is without theoretical support from our model.

[44] See Markusen (1995) for an introduction to the OLI paradigm. I have argued elsewhere (Ferrett, 2003c) that OLI's conclusions are consistent with the assumption of monopolistic competition in product markets. Helpman, Melitz and Yeaple (2004) provide a formal model of the choice between FDI and exporting along these lines.

[45] In the 'conditional entry' region T's choice between X and G depends on the level of trade costs (the 'proximity-concentration tradeoff' of Brainard, 1997), as does E's choice between one plant and two in the upper 'inevitable entry' region.

[46] This would have to preserve M's ability to move before T if no acquisition occurred.

5 Conclusion

In this paper we have surveyed a number of theoretical perspectives on the link between FDI flows and TFP growth. Sections 2 and 3 discussed, respectively, general and partial equilibrium models. In Section 2 we presented an open economy of the Solow growth model, where North-to-South FDI flows both equalize the return to capital across countries and transfer technical knowledge internationally; and in Section 3 we analysed models of (a) how spillovers affect an MNE's choice between greenfield-FDI and exporting, (b) trained worker mobility as a specific mechanism for spillovers, and (c) the relationship between greenfield-FDI flows and R&D performance. Section 4 considered how the form of FDI (greenfield-FDI vs. acquisition-FDI) undertaken affects the FDI/ productivity relationship.

The most exciting recent development in theoretical modelling of the FDI/ productivity relationship is, in my opinion, the strategic analysis of firms' international location (FDI) decisions when TFP is endogenously determined (via, e.g., spillovers or R&D investment). These game-theoretic models (discussed in Section 3) permit consideration of the effects of strategic inter-firm rivalry, which – given that MNEs typically operate in oligopolistic ('concentrated') industries – must be important in the determination of real-world outcomes. Three conclusions from this line of research are worth restating. First, the notion that the FDI decision can fruitfully be analysed as 'prior' (i.e. exogenous) to spillover possibilities – so that, for example, the greater the 'degree' of spillovers from inward FDI, the greater the TFP benefit to indigenous host-country firms – has been questioned by models showing that a technological leader's incentive to produce abroad *weakens* as spillovers become more likely. Second, the assumption that R&D investments are necessarily prior to FDI (as in Dunning's OLI paradigm) has been challenged by models where MNEs have larger output bases than national ('exporting') firms – because FDI 'jumps' trade costs – and, consequently, a stronger incentive to undertake R&D. Third, it appears that the *form* of FDI undertaken can exert a significant influence on equilibria. For example, if R&D investments are endogenously determined, then both consumers and firms might prefer acquisition-FDI to greenfield-FDI – despite the increase in 'concentration' it implies – because R&D performance improves following acquisition (see Section 4).

Despite these successes, the 'strategic' approach to analysing FDI/ productivity linkages would benefit from development. New research questions exist that are amenable to examination within (reasonably straightforward modifications of) the current 'strategic' frameworks: for example, analysis of the effect of national institutions – such as the strength of intellectual property rights (IPRs) afforded by the legal system – on firms' FDI and R&D decisions when they behave strategically vis-à-vis each other and perhaps national governments. Moreover, a key methodological drawback is its partial equilibrium character, which limits the range of issues that can be addressed (e.g. labour market and inter-industry effects are not well dealt with).[47] Examining these and other issues will ensure that theoretical analysis of

[47] Developing a tractable model of oligopoly in general equilibrium is a problem with a long and distinguished pedigree in economics. See Neary (2003) for a recent analysis.

the FDI/ productivity relationship is an active and productive area of work for the foreseeable future.

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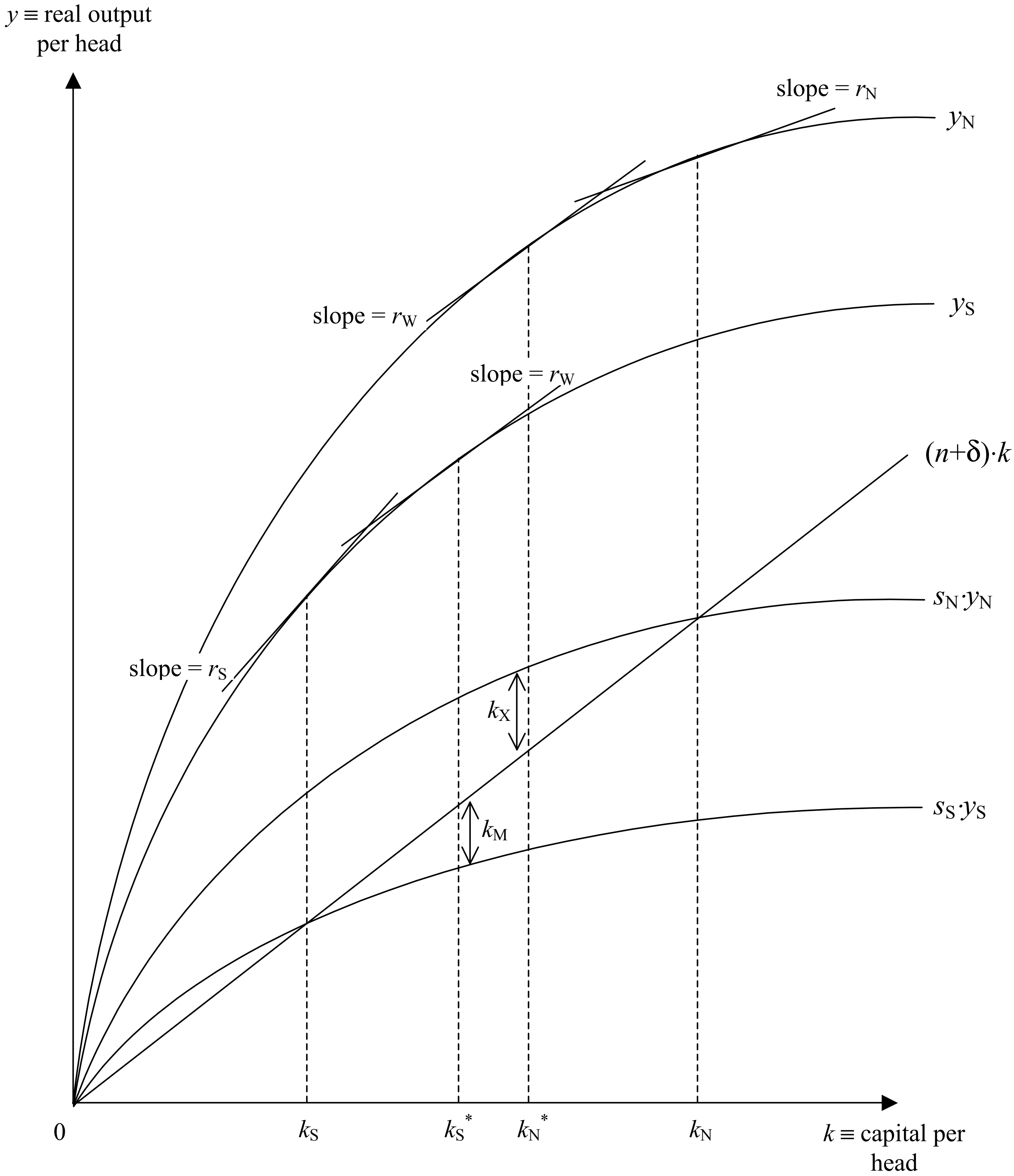

Figure 1: North-South FDI flows in General Equilibrium à la Solow

Key: k_N, k_S and r_N, r_S are autarky capital:labour ratios and real interest rates respectively. Upon integration, the common (world) real interest rate is r_W. k_N^*, k_S^* and k_X, k_M are, respectively, capital:labour ratios and capital exports and imports per head in the integrated equilibrium. $k_X = k_M$ if and only if $L_N = L_S$.

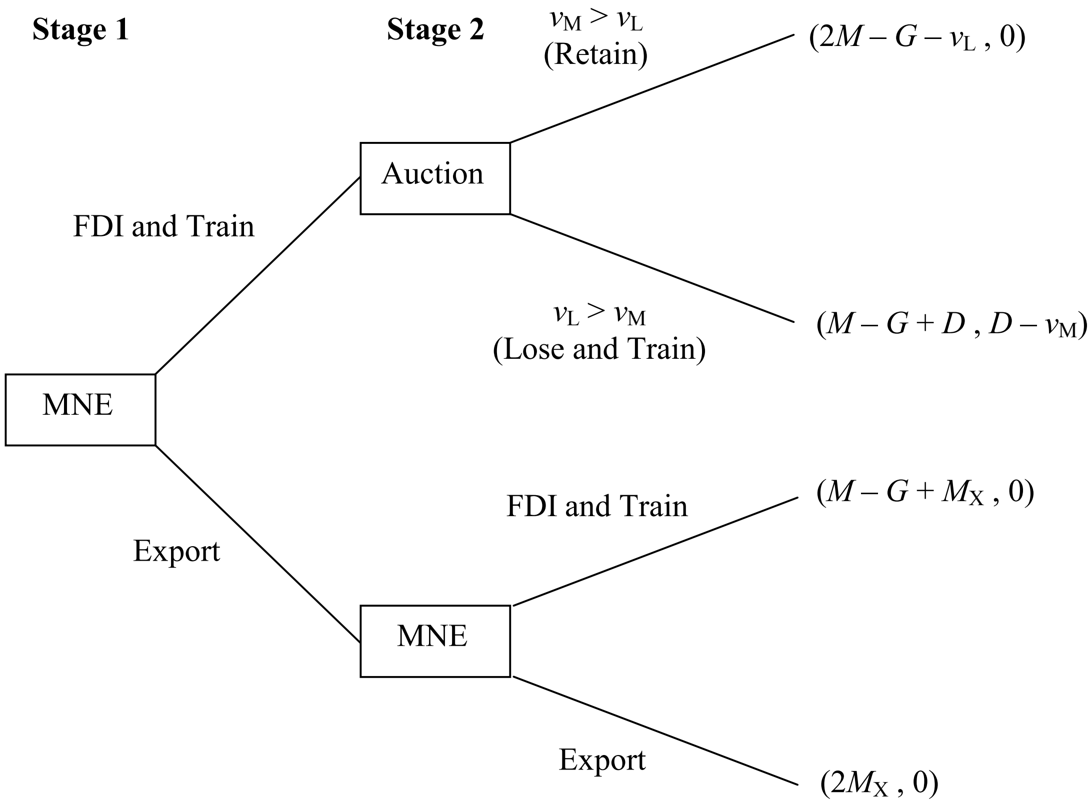

Figure 2: Game Tree for simplified Fosfuri/Motta/Rønde model
(The MNE's payoff precedes the local firm's in brackets; $v_M = M - D$ and $v_L = D$.)

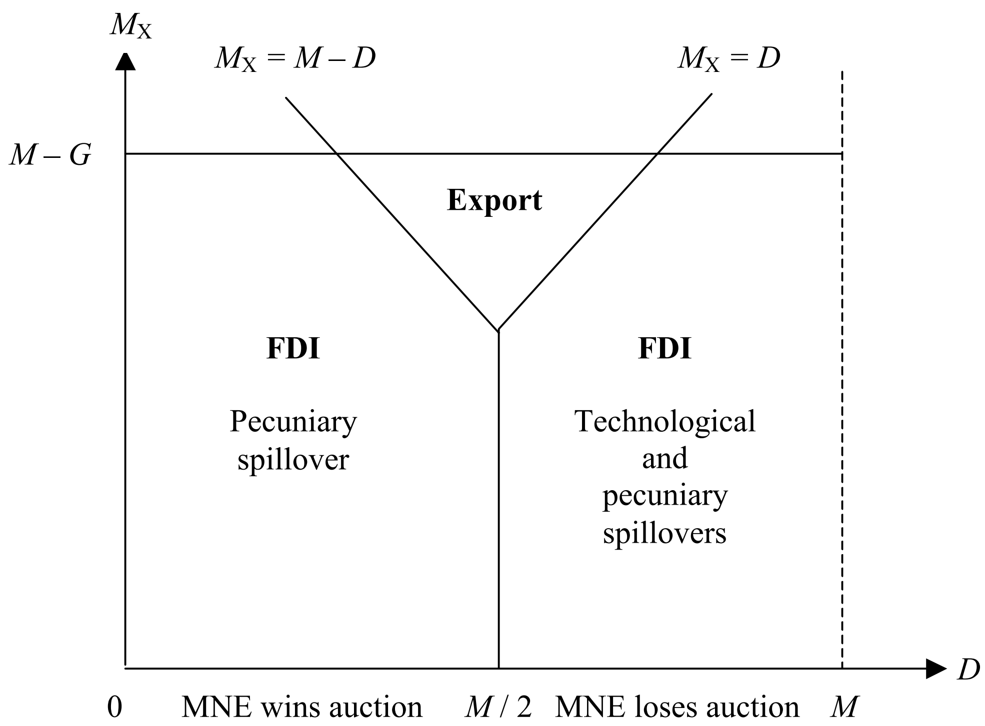

Figure 3: The MNE's equilibrium period-one choices (assuming $M > 2G$)

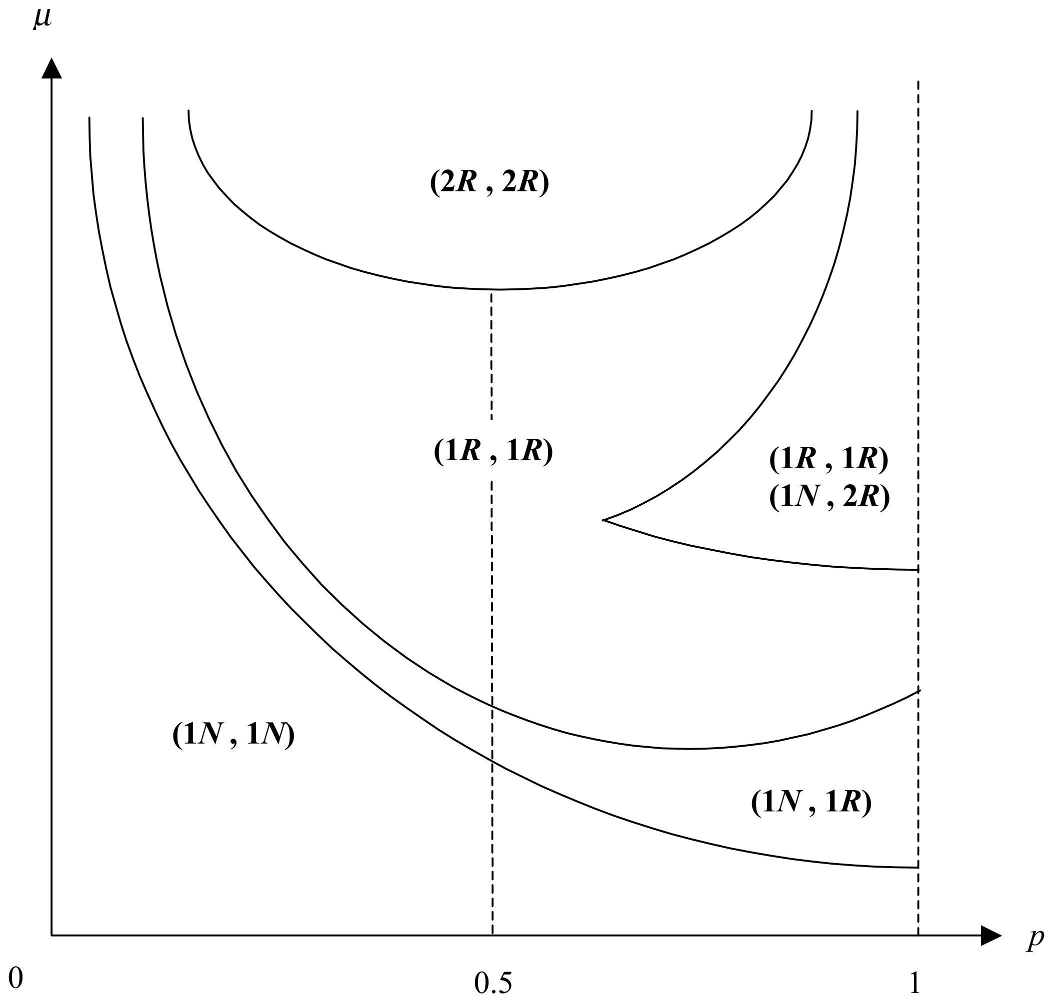

Figure 4: Equilibrium Industrial Structures in the International Duopoly Game

Key: The first element of each equilibrium choice indicates whether the firm operates **1** plant or **2**, and the second indicates whether (**R**) or not (**N**) the firm invests in R&D. See Ferrett (2002) for analytical definitions of the inter-regional boundaries.

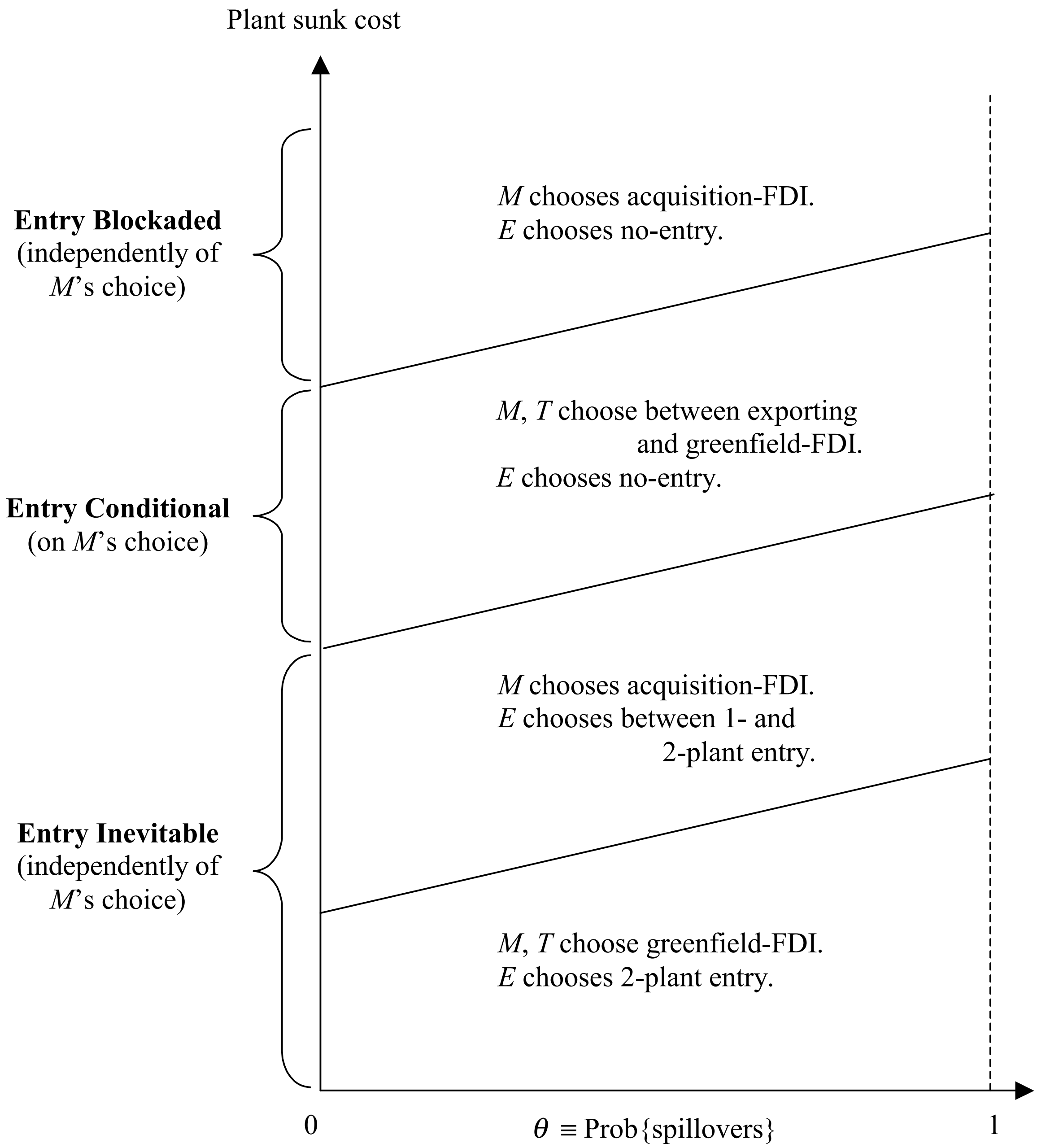

Figure 5: Equilibrium Industrial Structures

Key: Firms *M* and *T* are the high- and low-productivity incumbents respectively. Firm *E* is the (low-productivity) potential entrant.

In Bain's terminology, 'entry inevitable' means 'easy entry', which must be accommodated; 'entry conditional' means strategic entry deterrence is possible; and 'entry blockaded' means the entry threat is incredible.