# Technology Sourcing and Strategic Foreign Direct Investment

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Abstract

Empirical evidence suggests that there are important spillovers associated with the operations of multinational enterprises. Spillovers may occur when less advanced, local firms learn from their more advanced, foreign competitors. But less advanced firms may also actively seek knowledge by investing abroad, so-called "technology sourcing" FDI. The present paper focuses on entry strategies in the presence of technological differences and spillovers. The main result is that the technological leader may choose to invest in the foreign market in order to prevent technology sourcing FDI from its less advanced rival.

JEL: F12, F23, L13, O33

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# 1 Introduction

The literature on foreign direct investment (FDI) suggests that technological spillovers are, at least potentially, significant.[1] In addition, Audretsch and Feldman (1996), Bransetter (2001), and Keller (2001) report that such spillovers are primarily local in nature, i.e., intranational, rather than international. Typical channels for spillovers include backward and forward linkages between foreign affiliates and local firms, "demonstration effects", and labor turnover. An important question in the literature on FDI and spillovers is how these spillovers affect a firm's entry choice into a foreign market.

The existing literature offers two vehicles through which spillovers can affect a firm's entry decision.[2] First, spillovers increase the competitiveness of less advanced rivals. Thus, technological leaders have an incentive to reduce spillovers in order to maintain their competitive advantage. One way to reduce spillovers is not to invest in the foreign country, but rather to service foreign demand through exports.[3] By exporting, firms can penetrate a foreign market without locating close to their less advanced rivals, thereby minimizing local spillovers. In this case, spillovers reduce the proximity gains that high-tech firms receive when they invest in the foreign market and, thus, make FDI less attractive for technological leaders.

Second, if spillovers are local, technologically less advanced firms have an incentive to actively seek these spillovers by locating close to the headquarters and production facilities of their more advanced competitors. Such investment is called "technology acquisition" or "technology sourcing" FDI. Kogut and Chang (1991), Pugel, Kragas and Kimura (1996), Neven and Siotis (1996), and van Pottelsberghe de la Potterie and Lichtenberg (2001) provide empirical evidence for this motive.

In this paper we show that while spillovers can indeed reduce the traditional proximity gains of FDI, they can also create a strategic incentive for investment by the technological leader. Our paper is most closely re-

[1] For a survey, see Blomström and Kokko (1998).

[2] Analyses of entry choice in the presence of spillovers include Ethier (1984), Ethier and Markusen (1996), Fosfuri and Motta (1999), Siotis (1999), Fosfuri (2000), Fosfuri, Motta and Rønde (2001), and Markusen (2001).

[3] Other strategies to reduce spillovers include the use of older, and less advanced vintages of the technology, higher wages in order to reduce labor turnover, or the use of fully owned subsidiaries rather than licensing agreements.

lated to Fosfuri and Motta (1999), who consider the possibility of capturing spillovers both at home and abroad. They demonstrate that spillovers may induce a technologically less advanced firm to undertake technology sourcing FDI. While their paper focuses on the entry choice of the less advanced firm, our paper emphasizes the strategies of the high-tech firm. We demonstrate that the more advanced firm has an incentive to prevent technology sourcing FDI from its less advanced rival, and that one way of doing this is to invest in the rival's home market. Moreover, while the proximity-concentration trade-off approach (Brainard, 1993 and 1997) predicts that the profitability of FDI is increasing in the level of trade costs relative to fixed investment costs, we demonstrate that this is not necessarily the case when we allow for technology sourcing FDI and strategic FDI.

The paper is organized as follows. Section 2 presents the model and outlines the basic mechanisms that drive our results. The equilibrium analysis is conducted in section 3. We examine several scenarios in order to show in how far the results depend on the various specifications of the model. Section 4 concludes.

# 2 The model

The basic setup of the model is based on Horstmann and Markusen (1992). There are two countries, A and B. Initially, i.e., prior to international investment, there is one firm in each country, a and b, respectively. Prohibitively high fixed costs on the corporate level prevent further firms from entering the market, so that the number of firms is fixed. The firms produce a homogenous good, Q, the demand for which is identical in both countries and given by

$$p_K = 1 - (Q_{aK} + Q_{bK}), \tag{1}$$

where $p_K$ is the market price in country $K = A; B$ and $Q_{iK}$ is the supplied quantity of firm $i = a; b$ in this market. The two markets are completely separable. Competition between the two firms is of Nash-Cournot type. Equilibrium operating profits for firm $i$ on its sales in country $K$ are given by

$$\pi_{iK} = \frac{1}{9}(1 - 2s_{iK} + s_{jK})^2, \qquad i \neq j; \tag{2}$$

where $s_{iK}$ denotes firm $i$'s marginal sales costs in market $K$. Cost functions are assumed to be linear. There are two ways of serving a foreign market, exports and FDI (greenfield investment). Marginal sales costs for firm $i$ exporting to $K$ are $s_{iK} = c_{iJ} + t$, where $c_{iJ}$ is firm $i$'s marginal production costs operating from market $J \neq K$, and $t$ denotes per unit trade costs. Marginal sales costs given greenfield investment in $K$ are denoted by $c_{iK}$, but in addition, this entry mode requires a fixed cost $F$.

The sequence of moves is as follows. At stage one, firms choose whether or not to invest in the foreign market. We consider both the case of simultaneous moves and, allowing for strategic investment, sequential moves, with the high-tech firm moving first. At stage two, production and sales take place, with the two firms choosing quantity supplied simultaneously.

Firms differ with respect to technology. Assume that, initially, firm $a$ is more advanced than $b$, so that the high-tech firm $a$ has lower marginal production costs than its low-tech competitor $b$. Let the initial technology gap between the two firms, as captured by the difference in their marginal production costs, be given by $c$. We simplify by assuming that the marginal production costs of the high-tech firm are equal to zero, $c_{aA} = 0$, so that the technology gap is defined by the initial marginal production costs of the low-tech firm $b$'s plant in market $B$.

The technology gap can be reduced through spillovers. In line with the empirical literature, we assume that spillovers take place locally. If located in the same country, a low-tech plant may learn from a high-tech plant, resulting in a reduction of $c$. The degree to which the low-tech plant is able to imitate the technology of the high-tech plant is given by $\lambda \in [0; 1]$, which we assume is identical in both markets. If $\lambda = 0$, no spillovers take place, whereas $\lambda = 1$ denotes the case of full spillovers, when the low-tech plant is able to imitate the advanced technology completely. In either case, firm $b$'s marginal production costs after spillovers are given by $(1 - \lambda)c$.

Moreover, if a firm has plants in both locations, learning in one location may be applied to a plant in the other location. We shall refer to this as the mobility of technology. Let the degree to which technology is mobile be given by $\mu \in [0; 1]$, where $\mu = 0$ represents the case when none of the acquired technology can be transferred to another plant in another location, and $\mu = 1$, when all spillovers are fully transferable. We assume instantaneous learning, so that all spillovers have materialized as the production stage of the game starts.

Tables 1 and 2 show the post-spillover marginal sales costs of the two firms in country A and B, respectively. The first entry in each cell refers to the marginal sales cost of firm a and the second to that of firm b.

Table 1. Marginal Sales Costs in Country A

| a\b | Exports | Investment |
|---|---|---|
| Exports | $0; c + t$ | $0; (1 - \lambda)c$ |
| Investment | $0; (1 - \lambda)c + t$ | $0; (1 - \lambda)c$ |

Table 2. Marginal Sales Costs in Country B

| a\b | Exports | Investment |
|---|---|---|
| Export | $t; c$ | $t; \min[\mu(1 - \lambda)c + (1 - \mu)c; (1 - \lambda)c + t]$ |
| Investment | $0; (1 - \lambda)c$ | $0; (1 - \lambda)c$ |

Firm a's sales costs are straightforward. In its home market A, $s_a$ is always zero. In the foreign market B, $s_a$ is zero if it invests and $t$ if it exports. Firm b's marginal sales costs are more complicated since they are affected by spillovers, which in turn depend on location. If both firms export, there are no spillovers and $s_b$ is simply $c$ in its home market B and $c + t$ in A. If both firms invest, firm b is exposed to the same technology in both of its plants, and hence $s_{bA} = s_{bB} = (1 - \lambda)c$. If a invests in B and b exports to A, $s_{bA} = (1 - \lambda)c + t$ and $s_{bB} = (1 - \lambda)c$.

Finally, if a exports to B and b invests in A, marginal production costs of firm b's plant in A are given by $s_{bA} = (1 - \lambda)c$. A share $\mu$ of the spillovers $\lambda c$ captured in country A can be transferred back to its plant in country B, implying that $s_{bB} = \mu(1 - \lambda)c + (1 - \mu)c = c - \mu\lambda c$. Clearly, if $\mu = 1$ both plants will operate with marginal costs equal to $(1 - \lambda)c$, whereas if $\mu = 0$ firm b's plant at home will be less advanced, operating with its initial production costs $c$. However, transferring the newly acquired technology from A to B is only one option. Another option is transporting goods from A to B. Note that for $\mu < 1$, learning implies that b's foreign plant will be more efficient than its home plant. If its marginal sales costs of supplying B from its foreign plant, given by $(1 - \lambda)c + t$, are smaller than those of local production in B, i.e., when transportation costs are sufficiently small so that $t < (1 - \mu)\lambda c$, then all production by firm b will take place in its plant in country A. This implies that b services its initial home market from abroad. We will refer to this as the relocation case. Whether firm b chooses to transfer technology or goods depends on which of the two alternatives is less costly, so that marginal sales costs in this case are given by $\min[\mu(1 - \lambda)c + (1 - \mu)c; (1 - \lambda)c + t]$.

Table 1 sheds light on three central mechanisms in our paper. First, technological spillovers strengthen the incentive of firm $b$ to invest in A. Consider the case when firm $a$ is an exporter. By investing in A, firm $b$ reduces its marginal sales costs in A by $t + \lambda c$ relative to exports. The first term, $t$, is the traditional proximity gain and the second term, $\lambda c$, is the additional gains from spillovers. Second, technology sourcing by the low-tech firm is costly for the high-tech firm. The reason is simply that technology sourcing implies the local presence of the low-tech firm in the high-tech firm's home market. And equation (2) shows that a firm's operating profits are increasing in the marginal sales costs of its rival. One implication of this is that, c.p., firms wish to have their rival at a distance from their home markets, i.e., as exporters rather than as investors. Third, the high-tech firm may be able to prevent technology sourcing by investing in the home country of the low-tech firm, which we shall refer to as strategic investment, or strategic FDI. To see this, note that if $a$ chooses FDI, firm $b$ can reduce its marginal sales costs by $t$ by also undertaking FDI. However, this is less than the marginal costs savings of $t + \lambda c$ that $b$ gets from FDI when $a$ is an exporter. Hence, by investing in B, firm $a$ reduces the incentive for $b$ to choose FDI.

# 3 Analysis

While Tables 1 and 2 reveal some mechanisms, one cannot of course derive from them the exact conditions under which strategic FDI is possible and profitable. This depends on the exogenous variables $F; t; c; \lambda$ and $\mu$.

We organize the analysis into various scenarios. In order to limit the number of possible cases, we fix $F$ at a given level $\left(F = \frac{1}{12}\right)$. The traditional proximity-concentration trade-off is well understood and is captured in our analysis by varying $t$. In addition, in Scenarios 1-3 we consider extreme cases of technological spillovers and mobility, with $\lambda$ and $\mu$ taking values of either zero or one, and we focus on the way in which the equilibrium outcome depends on the the initial technology gap $c$. Scenario 4 analyzes the role of spillovers $\lambda$. Table 3 summarizes the different assumptions on variable values in the four scenarios. An alphabetical entry indicates that we carry out comparative static analysis on this variable, so that its value varies.

Table 3. The scenarios

| | $\mu$ | $\lambda$ | $c$ |
|---|---|---|---|
| Scenario 1: | 0 | 0 | $c$ |
| Scenario 2: | 0 | 1 | $c$ |
| Scenario 3: | 1 | 1 | $c$ |
| Scenario 4: | 1 | $\lambda$ | $\frac{1}{5}$ |

The payoffs and the derivation of the various equilibrium market structures are shown in the appendix. We discuss the equilibrium outcomes by use of figures, one for each scenario. In the following, let $(S; S)$ denote equilibrium foreign entry mode of the two firms, $a$ and $b$ respectively, where $S \in \{I; X; 0\}$, where $I$ denotes FDI, $X$ denotes exports, and 0 denotes no market entry.

## 3.1 Scenario 1. The no-spillover case

Let us start with a very simple benchmark case that highlights the traditional proximity-concentration trade-off arguments in the presence of technological differences between firms. If there are no spillovers ($\lambda = 0$), firms choose FDI only if it is profitable to do so from a trade cost or tariff jumping perspective. This means that both firms are more likely to set up a foreign plant if trade costs are high. But trade costs are not the only determinant. Firms' choices also depend on the initial technology gap $c$. If $c$ is high, the high-tech firm can capture a large market share in the foreign market, which makes it more likely to choose FDI. Similarly, the low-tech firm's market share in its foreign market is inversely related to its technological disadvantage, so that a high $c$ makes the low-tech firm less likely to choose FDI. Figure 1 shows the equilibrium market outcomes for various constellations of $t$ and $c$.

The ii-curve indicates parameter values of $t$ and $c$ where the high-tech firm $a$ is indifferent between exporting and FDI when the low-tech firm $b$ is an exporter. Similarly, the low-tech firm $b$ is indifferent between exporting and FDI along the iii-curve, given that firm $a$ has chosen investment. To the right of the x-line, the combination of high marginal costs and high trade costs is such that it is not profitable for $b$ to service the foreign market at all. We see that if there are no technological differences ($c = 0$), both firms export if $t < 0.25$ and invest if $t > 0.25$. As $c$ increases, the low-tech firm is less inclined to set up a foreign plant because of the smaller market share

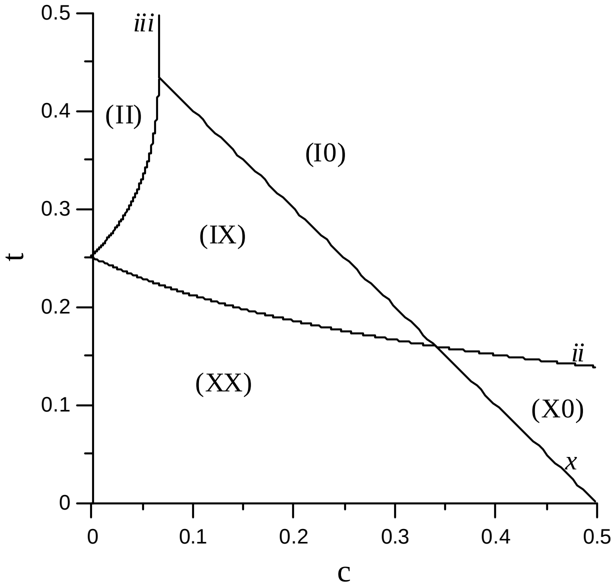


Figure 1: Scenario 1

associated with a technological disadvantage, whereas the pro...tability of FDI increases for the high-tech ...rm.

A region of parameter values appears, given by the "triangle" between the three curves, where the equilibrium market structure is $(I;X)$, i.e., FDI by the high-tech ...rm and exports by the low-tech ...rm. The asymmetry in market structure is explained by the asymmetry in the two ...rms' technology. However, the trade cost or tari¤ jumping argument prevails: For any given technological gap $c$, an increase in $t$ increases the pro...tability of FDI. We can summarize the results of Scenario 1 as:[4]

**Lemma 1** In the absence of spillovers, the high-tech ...rm is more inclined to choose FDI than the low-tech ...rm. An increase in the technology gap increases the pro...tability of FDI for the technological leader and reduces the pro...tability of FDI for the technologically weaker ...rm. An increase in trade costs increases the pro...tability of FDI for both ...rms.

[4] The proofs of the lemmas and propositions draw on the ...gures and the underlying pro...t functions. The mathematics is laid out in the appendix.

## 3.2 Scenario 2. The no-mobility case

Consider now the case of spillovers. Assume that spillovers are complete in the sense that if the low-tech …rm produces at the same location as the high-tech …rm, it closes the technological gap completely (¸ = 1). We analyze …rst the case where the mobility of technology between di¤erent plants within a …rm is prohibitively expensive (¹ = 0) and then, in Scenario 3, look at how allowing for full mobility (¹ = 1) a¤ects the market outcome. Figure 2 shows the market outcome in Scenario 2.

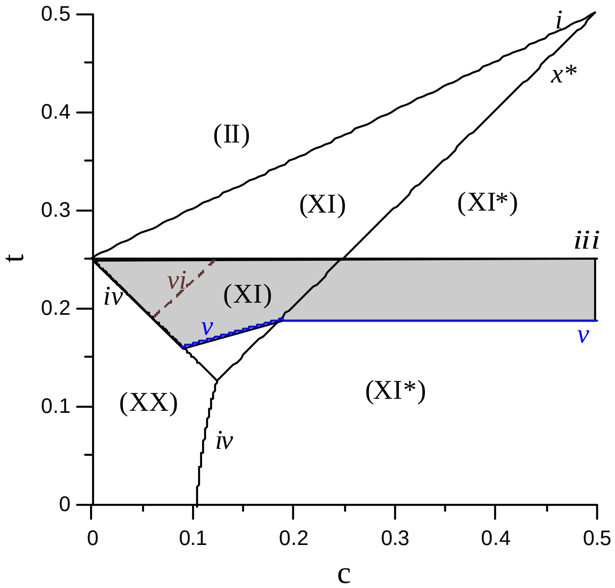


Figure 2: Scenario 2

Clearly, comparing …gures 1 and 2 we see that the presence of spillovers complicates the market structure. Again, if both …rms have identical technologies (c = 0), the switch from exporting to FDI takes place at t = 0:25 for both …rms. However, if technologies di¤er, and in the presence of spillovers, the high-tech …rm is no longer the more likely FDI candidate. Our main message is, however, that while there is a strong incentive for technology sourcing FDI by the low-tech …rm, strategic investment by the technological leader may induce the low-tech …rm not to choose FDI.

Let us …rst analyze the situation with simultaneous moves in the investment game. The i-curve shows combinations of t and c for which …rm a is indifferent between exporting and investing, given that the low-tech firm has chosen investment. Above this curve $a$ chooses investment, below it exports. Firm $a$'s choice of entry mode given that $b$ has chosen exports is trivial: It also chooses exports in order not to given away its technological advantage.

The iv-curve shows combinations of $t$ and $c$ for which the low-tech firm is indifferent between investing and exporting, given that the high-tech firm chooses exports; to the right of it the low-tech firm chooses investment and to the left of it exports. Above the iii-line, given by $t = 0.25$, the dominant strategy of the low-tech firm is investment. Clearly, since we are to the right of the iv-line, exports by $a$ induces investment by $b$. To see why an investment by $a$ also results in investment by $b$, consider Scenario 1. From that scenario we know that without a technology gap, both firms choose FDI for $t > 0.25$. But if $a$ invests in market B, technological differences between the two firms would indeed be eliminated. Hence, we know that for $t > 0.25$ firm $b$ chooses FDI, irrespective of the choice of entry mode of its rival.

The incentive for technology sourcing increases with the technology gap. An increase in $c$ makes firm $b$ more inclined to choose FDI because there is more to learn. At the same time, an increase in $c$ makes firm $a$ less inclined to choose FDI because by doing so it gives away a larger technological advantage. This finding can be summarized as:

**Lemma 2** With spillovers and technological differences, the market outcome may be one in which the low-tech firm chooses FDI and the high-tech firm chooses exports. The range of trade costs for which this market structure is an equilibrium increases with the initial technology gap.

On the $x^*$-line firm $b$ is indifferent between keeping its home-plant active and closing it down, given that it has made an investment abroad. Marginal sales costs from sales from its foreign plant to its home-market B are simply $t$, which should be compared to marginal production costs of $c$ in the home-plant. Hence, as long as $t > c$, demand in B is supplied by its local plant, and if $t < c$, i.e., to the right of the $x^*$-line, all production by $b$ takes place in its foreign plant, with market B supplied by exports. The relocation case, that is, FDI accompanied by a closing down of the home-plant, is indicated by $I^*$.

**Lemma 3** When trade costs are lower than the difference in marginal production costs between the low-tech firm's home and foreign plant, the firm will close down its home plant and service the home market by exports from its foreign plant.

Let us now turn to the case with sequential moves at the investment stage, with the high-tech …rm acting as …rst mover.[5] From the discussion above we know that the relevant area in which strategic investment may take place is between the curves iii and iv. Above iii, the dominant strategy of …rm b is investment, and hence …rm a cannot a¤ect the entry choice of its rival. To the left of iv, the dominant strategy of …rm a is exports, so investment by b would never take place in that area.

The shaded area in Figure 2 constitutes a region of parameter values where the high-tech …rm engages in strategic FDI. The strategic investment choice is the result of a trade-o¤ between certain costs and bene…ts. Firm a faces two types of costs associated with strategic investment. First, an investment in B involves a …xed cost F. Second, by investing in country B the high-tech …rm also sacri…ces its technological superiority. Note that in the absence of technological mobility, an investment by the low-tech …rm only improves its technology in the foreign plant. By investing in B, the high-tech …rm allows its rival to upgrade the technology on all its sales. Recall, however, that to the right of the x¤-line …rm b can upgrade the technology on all its sales by investing in A and closing down its plant in B.

These costs must be weighed against a's gains from strategic FDI. By investing in country B, …rm a induces the low-tech …rm not to invest in A. Thus, the low-tech …rm continues to export to A and, by doing so, has to carry the trade costs associated with exporting. This makes it a weaker competitor in A and increases the pro…ts of the high-tech …rm in a's home market. This trade-o¤ is visualized by the v-curve. Above the v-curve, the high-tech …rm favors strategic FDI in order to induce the low-tech …rm not to invest in A. Below it, the high-tech …rm chooses exports, knowing that the response of the low-tech …rm is FDI. The v-curve is upward sloping until it meets the x¤-curve because an increase in the initial technology gap c makes it less attractive for the high-tech …rm to allow its rival to upgrade the technology on all its sales, and therefore makes investing in B less pro…table for a. Beyond the x¤-curve, this trade-o¤ no longer applies, and the v-curve is a straight line. The reason is that the alternative to strategic investment,

[5] It can be shown that if the low-tech …rm were the …rst mover, the subgame perfect equilibrium would be identical to the Nash-equilibrium in the simultaneous investment game described above.

namely that b invests in A, would also allow b to upgrade its technology on all its sales, since here, b would only operate from its foreign plant. This discussion can be summarized as:

**Proposition 1** The high-tech …rm can choose strategic FDI to prevent technology sourcing FDI by its rival …rm. Strategic investment is a subgame perfect equilibrium for "medium" levels of trade costs.

What are the implications of strategic investment for the low-tech …rm? On the one hand, the low-tech …rm dislikes to have its competitor located in its home market B. The bene…ts to b are of two kinds. First, compared to technology sourcing, the low-tech …rm saves …xed costs F. Second, with the local presence of the high-tech …rm, …rm b can employ the better technology on all its sales. The dotted vi-curve in Figure 2 illustrates the critical combination of trade costs and technology gap for which the low-tech …rm is indi¤erent between the high-tech …rm choosing strategic FDI or not; to the right of the vi-curve …rm b prefers investment by the high-tech …rm and to the left of it exports. This curve has a positive slope because a larger technology gap increases the e¤ective spillovers from an investment by the high-tech …rm, which bene…ts …rm b, whereas higher trade costs makes it relatively more pro…table for the low-tech …rm to keep its rival at a distance.

Hence, in the shaded area and to the right of the vi-curve, both …rms prefer $(I; X)$ to $(X; I)$ implying that both …rms would like the high-tech …rm to be the …rst mover at the investment stage of the game. To the left of the dotted curve, however, there is a con‡ict of interest between the …rms, with both …rms wanting to be the …rst mover. This discussion can be summarized as follows:

**Proposition 2** Strategic investment by the high-tech …rm is not necessarily bad for the low-tech …rm. The bene…t for the low-tech …rm increases with the technology gap and falls with trade costs.

## 3.3 Scenario 3. The full mobility case

Let us now assume that technologies can be transferred costlessly from the more advanced to the less advanced plant within a …rm, i.e., ¹ = 1. Figure 3 shows the market outcomes in scenario 3.

Figure 3 shows that the market outcomes are less complex in this scenario compared to the previous one. The reason is basically that with perfect

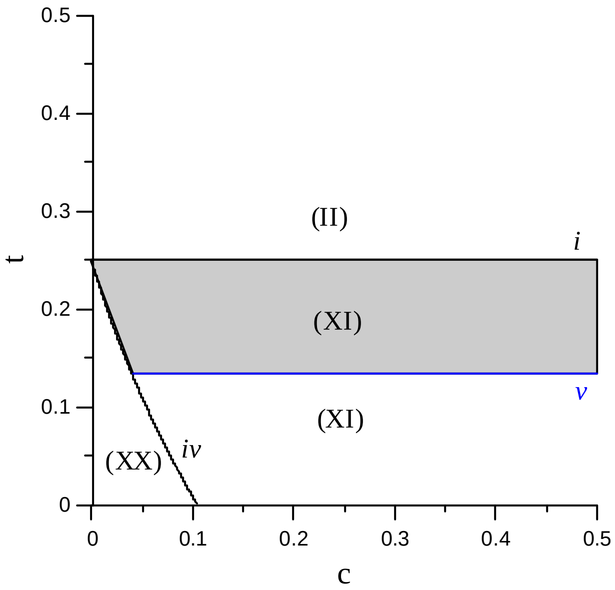


Figure 3: Scenario 3

technological mobility, if one …rm invests, the two …rms will operate with identical technology everywhere. Contrast this with Scenario 2, where an investment by b in A has no impact on the technology of its country B plant. In the full mobility case, if b sets up a plant in A, it can transfer the spillovers back to its home plant and thus become a technologically equal competitor in both markets.

Naturally, with full mobility the incentive for the low-tech …rm to actively source the technology is larger than in the no mobility case. We can see this in Figure 3 in that the iv-curve, i.e., the curve along which b is indi¤erent between exporting and investing given exports by a, has moved to the left. However, as will become evident, the incentive for the high-tech …rm to engage in strategic investment is also larger. In the no mobility case, one disadvantage of FDI for the high-tech …rm was that it had to give up its technological superiority completely. In the full mobility case, this motive for not investing in B is no longer there. The i-curve is therefore a straight line. Above it, the dominant strategy of both …rms is investment.

Note also that decommissioning of b's home-plant is not an issue here. The reason is simply that once b has invested in A, in a world of perfect mobility of technology it can costlessly apply this technology to all its plants.

With simultaneous moves at the investment stage, the Nash equilibrium is characterized by (X; X) to the left of the iv-curve, (I; I) above the i-line, and (X; I) below i and to the right of iv. There is room for strategic investment only in the area characterized by (X; I) in Nash equilibrium. In this area, given that the high-tech ...rm makes the ...rst move at the investment stage, it chooses investment above the v-curve, illustrated by the shaded area of Fiure 3, and exports below it.

**Proposition 3** Technological mobility increases the pro...tability of technology sourcing FDI for the low-tech ...rm, but also strengthens the motive for the high-tech ...rm to undertake strategic FDI.

In contrast to Scenario 2, strategic investment by a always results in lower pro...ts for b compared to what b could get by itself investing in B. The reason is basically that when one ...rm invests, both ...rms will be entirely similar. Hence, if a is better o¤ by investing relative to choosing exports, the same must be true for ...rm b. There are therefore con‡icting interests in the entire shaded area. We can state this as:

**Proposition 4** Technological mobility makes strategic investment by the high-tech ...rm less attractive for the low-tech ...rm.

## 3.4 Scenario 4. Di¤erent levels of spillovers

We have seen that the incentive for foreign direct investment by the low-tech ...rm is weak in the absence of spillovers (Scenario 1) and strong with full spillovers (Scenarios 2 and 3). Similarly, strategic investment by a is not an issue in the absence of spillovers, but may be strong in the presence of spillovers. In the present scenario we investigate more closely how the degree of spillovers a¤ects the market outcome. For this purpose, we ...x the technology gap, and consider the interplay between trade costs and spillovers. More precisely, let c = 0:2 and assume full technological mobility (¹ = 1). We limit the graph to levels of trade costs below t · 0:3 so that exporting is always a pro...table strategy for the low-tech ...rm even if it does not get any spillovers. Figure 4 illustrates the market outcome.

The iv-curve divides the ...gure into two quite di¤erent regions. As before, this curve denotes parameter constellations where the low-tech ...rm is indifferent between exporting and investing given that the high-tech ...rm exports.

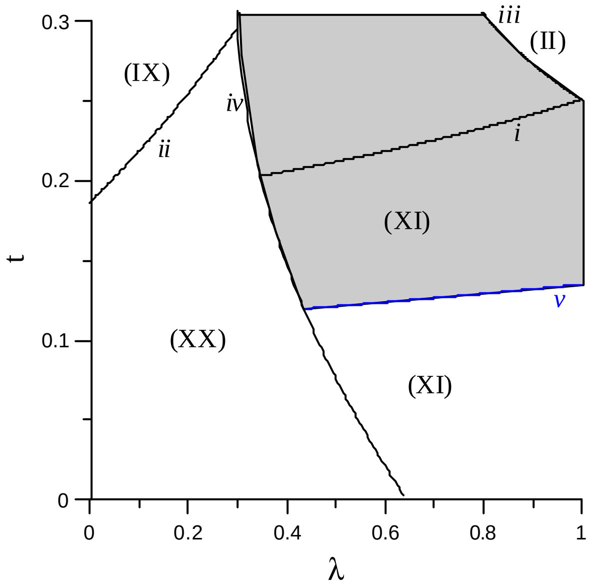


Figure 4: Scenario 4

Note that with a technology gap of $c = 0.2$ firm $b$ would never invest from a trade cost or tariff jumping perspective (see Figure 1). Thus, the motive for an investment by $b$ would be technology sourcing. To the left of the iv-curve, the spillovers are too small to trigger technology sourcing investment. In this area, the figure resembles scenario 1. Indeed, for $\lambda = 0$, the situation is exactly as in scenario 1, with $c = 0.2$. With low spillovers and low trade costs, the equilibrium market structure is $(X; X)$. Along the ii-curve, $a$ is indifferent between investment and exports given that $b$ has chosen exports, the choice of $a$ being $I$ above the ii-curve and $X$ below it. The ii-curve increases with $\lambda$ because larger spillovers make it less attractive for $a$ to invest, thereby giving away part of its technological advantage.

To the right of the iv-curve, spillovers are large enough for technology sourcing to be profitable. Here, firm $b$ chooses investment given that $a$ chooses exports. This curve falls as $\lambda$ goes up, simply because an increase in spillovers makes it more profitable for $b$ to invest in order to acquire the more advanced, foreign technology. The i-curve denotes combinations of $t$ and $\lambda$ where the high-tech firm $a$ is indifferent between the two entry modes, given that $b$ has chosen investment. It is upward sloping because $a$'s market share in the foreign market, and thus the relative attractiveness of FDI, is decreasing in the level of spillovers. Below the i-curve the Nash equilibrium is (X; I).

Along the iii-curve …rm b is indi¤erent between exporting and investing, given that a has chosen investment. The iii-curve rises as ¸ falls, since a reduction in spillovers reduces the e¢ciency of …rm b, thus reducing its equilibrium market shares and thereby b's incentive to invest. Above the iii-curve, the Nash equilibrium is given by (I; I).

Consider now the area above the i-curve, to the right of the iv-curve and to the left of the iii-curve. Here, …rm a chooses I given that b also chooses I. But if a chooses I, b's best response is X. And if b chooses X, a's best response is also X, which triggers I from b, to which a responds with I, and so on. Hence, in this area there exists no Nash equilibrium in pure strategies.

Turning to the case of sequential moves and, therefore, allowing for the possibility of strategic investment, the v-curve denotes combinations of ¸ and t along which …rm a is indi¤erent between choosing investment, the response of b being exports, and choosing exports followed by investment by b. Above the v-curve, …rm a …nds it pro…table to engage in strategic investment in order to deter market entry by its low-tech competitor. The shaded area of Figure 4 illustrates parameter values for which the subgame perfect equilibrium is characterized by strategic investment.

The v-curve falls with a reduction in ¸, which means that a reduction in spillovers increases the incentive for strategic investment. This might sound counterintuitive, but note that when spillovers decrease, the high-tech …rm does not loose all of its technological superiority when investing in the foreign market. Thus, strategic investment is less costly, thereby making it a more attractive alternative for the high-tech …rm. However, if spillovers reach a certain threshold, given by the iv-curve, the incentive for the low-tech …rm to engage in technology sourcing FDI disappears, and with it the incentive for strategic FDI.

Proposition 5 A minimum level of spillovers is required for technology sourcing and strategic FDI.

# 4 Conclusion

Technological di¤erences between …rms may induce technology sourcing FDI. This is a well established fact in the theoretical and empirical literature. In this paper we show that a more advanced firm may have the motive and the ability to deter technology sourcing by strategically investing in the home market of the less advanced firm. The paper thus shows that the existence of spillovers not necessarily discourages technological leaders from foreign investment. Instead, spillovers can even promote FDI by the technological leader, strategically employed to deter investment by its less advanced rival firm.

To bring out the results with maximum clarity, we have chosen the simplest model possible, involving only two firms, linear costs and demand, etc. However, the results of the model are fairly intuitive, and we are confident that mechanisms that drive the results would apply also in more complex modeling frameworks.

In addition to demonstrating the possibility of strategic investment, we also investigate how the equilibrium market structure is affected by the nature of spillovers. First, we show that spillovers have to exceed a certain threshold before technology sourcing becomes profitable. Below this threshold, spillovers generally discourage FDI since the high-tech firm choose exports in order to prevent its technology from being copied by the rival firm. But once spillovers exceed this threshold, they create a complex game, characterized by technology sourcing FDI and strategic FDI. Second, we demonstrate that the incentives for both technology sourcing FDI and strategic FDI are larger if the technology acquired through spillovers is easily transferable between plants. Third, our model shows that if the mobility of spillovers is low, the low-tech firm may have an incentive to relocate its entire production to the high-tech location.

The model is sufficiently simple to allow extensions in various directions. We limit ourselves to suggesting one possibility. Throughout the paper we have assumed that the high-tech firm does not have any options to prevent spillovers. However, the literature considers varies options, depending on the nature of the spillovers. For instance, Glass and Saggi (1999) and Fosfuri, Motta and Rønde (2001) discuss the possibility of paying higher wages to prevent labor turnover. In our model, one way to reduce spillovers would be to allow the high-tech firm to optimally choose the technology with which to enter the low-tech market. Let $\tilde{c}$ be the marginal costs of the high-tech firm in the foreign market. The high-tech firm can then choose to enter the foreign market with any technology ranging from state-of-the-art technology ($\tilde{c} = 0$) to low-tech ($\tilde{c} = c$), so that $\tilde{c} \in [0; c]$. If $0 < \tilde{c} < c$, the high-tech firm accepts a lower cost advantage over the low-tech firm in order to reduce the amount of spillovers. The profit maximizing choice of $\epsilon$ would be where the low-tech firm is exactly indifferent between exporting and investing. It would thus give away enough spillovers to deter technology sourcing investment, but maintain a technological advantage over its competitor in its own home market (even in the full mobility case). This additional option makes strategic FDI even more attractive for the high-tech firm and enlarges the spectrum of parameter constellations that support strategic FDI.

# Appendix

Define $\pi^i_{KJ}$ as profits of firm $i = a, b$ when firm $a$ chooses strategy $K$ and firm $b$ chooses $J$, where $K, J \in (X, I, 0)$. For each player there are four possible payoffs involving entry.[6] For firm $b$ these are (with the first term on the right hand side denoting operating profits in market A and the second term operating profits in market B):

$$\pi^b_{XX} = \frac{1}{9}(1 - 2(c+t))^2 + \frac{1}{9}(1 - 2c + t)^2.$$

$$\pi^b_{IX} = \frac{1}{9}(1 - 2((1-\lambda)c + t))^2 + \frac{1}{9}(1 - 2(1-\lambda)c)^2.$$

$$\pi^b_{XI} = \frac{1}{9}(1 - 2(1-\lambda)c)^2 + \frac{1}{9}(1 - 2(\mu(1-\lambda)c + (1-\mu)c) + t)^2 - F.$$

$$\pi^b_{II} = \frac{1}{9}(1 - 2(1-\lambda)c)^2 + \frac{1}{9}(1 - 2(1-\lambda)c)^2 - F.$$

Note that if firm $b$ invests and decides to close down its domestic plant and service the home market from its plant abroad, the relevant profits would be given by:

$$\pi^b_{XI^*} = \frac{1}{9}(1 - 2(1-\lambda)c)^2 + \frac{1}{9}(1 - 2((1-\lambda)c + t) + t)^2 - F.$$

Similarly, payoffs for $a$ are:

$$\pi^a_{XX} = \frac{1}{9}(1 + (c+t))^2 + \frac{1}{9}(1 - 2t + c)^2.$$

[6] Profitable entry for firm $i$ requires non-negative operating profits, which from (2) implies $s_i \leq \frac{1}{2}(1 + s_j)$, $i \neq j$.

$$\Pi^a_{IX} = \frac{1}{9}(1 + ((1 - \lambda)c + t))^2 + \frac{1}{9}(1 + (1 - \lambda)c)^2 - F.$$

$$\Pi^a_{XI} = \frac{1}{9}(1 + (1 - \lambda)c)^2 + \frac{1}{9}(1 - 2t + (\mu(1 - \lambda)c + (1 - \mu)c))^2.$$

$$\Pi^a_{II} = \frac{1}{9}(1 + (1 - \lambda)c)^2 + \frac{1}{9}(1 + (1 - \lambda)c)^2 - F.$$

$$\Pi^a_{XI*} = \frac{1}{9}(1 + (1 - \lambda)c)^2 + \frac{1}{9}(1 - 2t + ((1 - \lambda)c + t))^2.$$

The curves in the Figures are given by equating the following payoffs:

$$i : \Pi^a_{XI} = \Pi^a_{II}.$$

$$ii : \Pi^a_{XX} = \Pi^a_{IX}.$$

$$iii : \Pi^b_{IX} = \Pi^b_{II}.$$

$$iv : \Pi^b_{XX} = \Pi^b_{XI}, \text{ if } (1 - \mu)\lambda c < t.$$

$$iv : \Pi^b_{XX} = \Pi^b_{XI*}, \text{ if } (1 - \mu)\lambda c > t.$$

$$v : \Pi^a_{XI} = \Pi^a_{IX}, \text{ if } (1 - \mu)\lambda c < t.$$

$$v: \Pi^a_{XI^*} = \Pi^a_{IX}, \text{ if } (1-\mu)\lambda c > t.$$

$$vi: \Pi^b_{XI} = \Pi^b_{IX}.$$

The no-entry condition in figure 1 is derived by

$$x: \pi_{bA} = 0.$$

The relocation condition in figure 2 is derived by

$$x^*: \pi^*_{bB} = \pi_{bB},$$

where $\pi^*_{bB}$ denotes firm $b$ profits from sales to market B when $b$ is located in market A.

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# More detailed appendix (for referee):

## Scenario 1

Parameter settings: $F = \frac{1}{12}$, $\lambda = \mu = 0$

The ii-curve:

$\Pi^{a}_{XX} = \frac{1}{9}(1 + (c + t))^2 + \frac{1}{9}(1 - 2t + c)^2$

$\Pi^{a}_{IX} = \frac{1}{9}(1 + ((1 - 0)c + t))^2 + \frac{1}{9}(1 + (1 - 0)c)^2 - \frac{1}{12}$

$\Pi^{a}_{XX} = \Pi^{a}_{IX}$ : Solution is : $t = \frac{1}{2} + \frac{1}{2}c - \frac{1}{4}\left\{\sqrt{(1 + 8c + 4c^2)}\right\}$

The iii-curve:

$\Pi^{b}_{IX} = \frac{1}{9}(1 - 2((1 - 0)c + t))^2 + \frac{1}{9}(1 - 2(1 - 0)c)^2$

$\Pi^{b}_{II} = \frac{1}{9}(1 - 2(1 - 0)c)^2 + \frac{1}{9}(1 - 2(1 - 0)c)^2 - \frac{1}{12}$

$\Pi^{b}_{IX} = \Pi^{b}_{II}$ : Solution is : $t = \frac{1}{2} - c - \frac{1}{4}\left\{\sqrt{(16c^2 - 16c + 1)}\right\}$

The x-curve:

$\pi_{bA} = \frac{1}{9}(1 - 2(c + t))^2$

$\pi_{bA} = 0$, Solution is : $t = \frac{1}{2} - c$

## Scenario 2

Parameter settings: $F = \frac{1}{12}$, $\lambda = 1$, $\mu = 0$

The i-curve:

$\Pi^{a}_{XI} = \frac{1}{9}(1 + (1 - 1)c)^2 + \frac{1}{9}(1 - 2t + (0(1 - 1)c + (1 - 0)c))^2$

$\Pi^{a}_{II} = \frac{1}{9}(1 + (1 - 1)c)^2 + \frac{1}{9}(1 + (1 - 1)c)^2 - \frac{1}{12}$

$\Pi^{a}_{XI} = \Pi^{a}_{II}$, Solution is: $t = \frac{1}{2}c + \frac{1}{4}$

The iii-curve:

$\Pi^{b}_{IX} = \frac{1}{9}(1 - 2((1 - 1)c + t))^2 + \frac{1}{9}(1 - 2(1 - 1)c)^2$

$\Pi^{b}_{II} = \frac{1}{9}(1 - 2(1 - 1)c)^2 + \frac{1}{9}(1 - 2(1 - 1)c)^2 - \frac{1}{12}$

$\Pi^{b}_{IX} = \Pi^{b}_{II}$, Solution is: $t = \frac{1}{4}$

The iv-curve:

$\Pi^{b}_{XX} = \frac{1}{9}(1 - 2(c + t))^2 + \frac{1}{9}(1 - 2c + t)^2$

$\Pi^{b}_{XI} = \frac{1}{9}(1 - 2(1 - 1)c)^2 + \frac{1}{9}(1 - 2(0(1 - 1)c + (1 - 0)c) + t)^2 - \frac{1}{12}$

$\Pi^{b}_{XI*} = \frac{1}{9}(1 - 2(1 - 1)c)^2 + \frac{1}{9}(1 - 2((1 - 1)c + t) + t)^2 - \frac{1}{12}$

$¦^{b}_{XX} = ¦^{b}_{XI}$, if $(1\ ¡\ 0)\,1c < t$, Solution is: © $t = ¡c + \frac{1}{4}$ ª

$¦^{b}_{XX} = ¦^{b}_{XI¤}$, if $(1\ ¡\ 0)\,1c > t$,

Solution is: n $t = ¡\frac{1}{2}c + \frac{1}{4}$ p$\overline{(¡28c^{2}\ ¡\ 3 + 32c)}$ o

The v-curve:

$¦^{a}_{IX} = \frac{1}{9}(1 + ((1\ ¡\ 1)\,c + t))^{2} + \frac{1}{9}(1 + (1\ ¡\ 1)\,c)^{2}\ ¡\ \frac{1}{12}$

$¦^{a}_{XI} = \frac{1}{9}(1 + (1\ ¡\ 1)\,c)^{2} + \frac{1}{9}(1\ ¡\ 2t + (0\,(1\ ¡\ 1)\,c + (1\ ¡\ 0)\,c))^{2}$

$¦^{a}_{XI¤} = \frac{1}{9}(1 + (1\ ¡\ 1)\,c)^{2} + \frac{1}{9}(1\ ¡\ 2t + ((1\ ¡\ 1)\,c + t))^{2}$

$¦^{a}_{XI} = ¦^{a}_{IX}$, if $(1\ ¡\ ¹)\,¸c < t$,

Solution is: n $t = \frac{2}{3}c + 1\ ¡\ \frac{1}{6}$ p$\overline{(4c^{2} + 24c + 27)}$ o

$¦^{a}_{XI¤} = ¦^{a}_{IX}$, if $(1\ ¡\ ¹)\,¸c > t$, Solution is: © $t = \frac{3}{16}$ ª

The vi-curve:

$¦^{b}_{IX} = \frac{1}{9}(1\ ¡\ 2((1\ ¡\ 1)\,c + t))^{2} + \frac{1}{9}(1\ ¡\ 2(1\ ¡\ 1)\,c)^{2}$

$¦^{b}_{XI} = \frac{1}{9}(1\ ¡\ 2(1\ ¡\ 1)\,c)^{2} + \frac{1}{9}(1\ ¡\ 2(0\,(1\ ¡\ 1)\,c + (1\ ¡\ 0)\,c) + t)^{2}\ ¡\ \frac{1}{12}$

$¦^{b}_{IX} = ¦^{b}_{XI}$, Solution is: n $t = 1\ ¡\ \frac{2}{3}c\ ¡\ \frac{1}{6}$ p$\overline{(27\ ¡\ 96c + 64c^{2})}$ o

The x¤-curve:

$¼_{bB} = \frac{1}{9}(1\ ¡\ 2(0\,(1\ ¡\ 1)\,c + (1\ ¡\ 0)\,c) + t)^{2}$

$¼^{¤}_{bB} = \frac{1}{9}(1\ ¡\ 2((1\ ¡\ 1)\,c + t) + t)^{2}$

$¼^{¤}_{bB} = ¼_{bB}$, Solution is: ft = cg

## Scenario 3

Parameter settings: $F = \frac{1}{12}$, $¸ = ¹ = 1$

The i-curve:

$¦^{a}_{XI} = \frac{1}{9}(1 + (1\ ¡\ 1)\,c)^{2} + \frac{1}{9}(1\ ¡\ 2t + (1\,(1\ ¡\ 1)\,c + (1\ ¡\ 1)\,c))^{2}$

$¦^{a}_{II} = \frac{1}{9}(1 + (1\ ¡\ 1)\,c)^{2} + \frac{1}{9}(1 + (1\ ¡\ 1)\,c)^{2}\ ¡\ \frac{1}{12}$

$¦^{a}_{XI} = ¦^{a}_{II}$, Solution is: © $t = \frac{1}{4}$ ª

The iv-curve:

$¦^{b}_{XX} = \frac{1}{9}(1\ ¡\ 2(c + t))^{2} + \frac{1}{9}(1\ ¡\ 2c + t)^{2}$

$¦^{b}_{XI} = \frac{1}{9}(1\ ¡\ 2(1\ ¡\ 1)\,c)^{2} + \frac{1}{9}(1\ ¡\ 2(1\,(1\ ¡\ 1)\,c + (1\ ¡\ 1)\,c) + t)^{2}\ ¡\ \frac{1}{12}$

$¦^{b}_{XX} = ¦^{b}_{XI}$, Solution is: n $t = \frac{1}{2}\ ¡\ \frac{1}{2}c\ ¡\ \frac{1}{4}$ p$\overline{(1 + 24c\ ¡\ 28c^{2})}$ o

The v-curve:

$$\pi^a_{IX} = \frac{1}{9}\left(1 + ((1-1)c + t)\right)^2 + \frac{1}{9}\left(1 + (1-1)c\right)^2 - \frac{1}{12}$$

$$\pi^a_{XI} = \frac{1}{9}\left(1 + (1-1)c\right)^2 + \frac{1}{9}\left(1 - 2t + (1(1-1)c + (1-1)c)\right)^2$$

$\pi^a_{IX} = \pi^a_{XI}$, Solution is: $t = 1 - \frac{1}{2}\sqrt{3}$

## Scenario 4

Parameter settings: $F = \frac{1}{12}$, $c = \frac{1}{5}$, $\mu = 1$

The i-curve:

$$\pi^a_{XI} = \frac{1}{9}\left(1 + (1-\lambda)\frac{1}{5}\right)^2 + \frac{1}{9}\left(1 - 2t + \left(1(1-\lambda)\frac{1}{5} + (1-1)\frac{1}{5}\right)\right)^2$$

$$\pi^a_{II} = \frac{1}{9}\left(1 + (1-\lambda)\frac{1}{5}\right)^2 + \frac{1}{9}\left(1 + (1-\lambda)\frac{1}{5}\right)^2 - \frac{1}{12}$$

$\pi^a_{XI} = \pi^a_{II}$, Solution is: $\left\{ t = \frac{3}{5} - \frac{1}{10}\lambda - \frac{1}{20}\sqrt{69 - 48\lambda + 4\lambda^2} \right\}$

The ii-curve:

$$\pi^a_{XX} = \frac{1}{9}\left(1 + \left(\frac{1}{5} + t\right)\right)^2 + \frac{1}{9}\left(1 - 2t + \frac{1}{5}\right)^2$$

$$\pi^a_{IX} = \frac{1}{9}\left(1 + \left((1-\lambda)\frac{1}{5} + t\right)\right)^2 + \frac{1}{9}\left(1 + (1-\lambda)\frac{1}{5}\right)^2 - \frac{1}{12}$$

$\pi^a_{XX} = \pi^a_{IX}$, Solution is: $\left\{ t = \frac{3}{5} - \frac{1}{20}\lambda - \frac{1}{20}\sqrt{69 - 120\lambda + 9\lambda^2} \right\}$

The iii-curve:

$$\pi^b_{IX} = \frac{1}{9}\left(1 - 2\left((1-\lambda)\left(\frac{1}{5}\right) + t\right)\right)^2 + \frac{1}{9}\left(1 - 2(1-\lambda)\left(\frac{1}{5}\right)\right)^2$$

$$\pi^b_{II} = \frac{1}{9}\left(1 - 2(1-\lambda)\left(\frac{1}{5}\right)\right)^2 + \frac{1}{9}\left(1 - 2(1-\lambda)\left(\frac{1}{5}\right)\right)^2 - \frac{1}{12}$$

$\pi^b_{IX} = \pi^b_{II}$, Solution is: $\left\{ t = \frac{3}{10} + \frac{1}{5}\lambda - \frac{1}{20}\sqrt{-39 + 48\lambda + 16\lambda^2} \right\}$

The iv-curve:

$$\pi^b_{XX} = \frac{1}{9}\left(1 - 2\left(\left(\frac{1}{5}\right) + t\right)\right)^2 + \frac{1}{9}\left(1 - 2\left(\frac{1}{5} + t\right)\right)^2$$

$$\pi^b_{XI} = \frac{1}{9}\left(1 - 2(1-\lambda)\left(\frac{1}{5}\right)\right)^2 + \frac{1}{9}\left(1 - 2\left(1(1-\lambda)\left(\frac{1}{5}\right) + (1-1)\left(\frac{1}{5}\right) + t\right)\right)^2 - \frac{1}{12}$$

$\pi^b_{XX} = \pi^b_{XI}$, Solution is: $\left\{ t = \frac{3}{10} + \frac{1}{10}\lambda - \frac{1}{20}\sqrt{-39 + 120\lambda + 36\lambda^2} \right\}$

The v-curve:

$$\pi^a_{IX} = \frac{1}{9}\left(1 + \left((1-\lambda)\left(\frac{1}{5}\right) + t\right)\right)^2 + \frac{1}{9}\left(1 + (1-\lambda)\left(\frac{1}{5}\right)\right)^2 - \frac{1}{12}$$

$$\pi^a_{XI} = \frac{1}{9}\left(1 + (1-\lambda)\left(\frac{1}{5}\right)\right)^2 + \frac{1}{9}\left(1 - 2t + \left(1(1-\lambda)\left(\frac{1}{5}\right) + (1-1)\left(\frac{1}{5}\right)\right)\right)^2$$

$\pi^a_{IX} = \pi^a_{XI}$, Solution is: $\left\{ t = \frac{6}{5} - \frac{1}{5}\lambda - \frac{1}{10}\sqrt{119 - 48\lambda + 4\lambda^2} \right\}$