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Follow-my-leader FDI and collusion

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This paper presents a simple model to illustrate the following idea: domestic rivals may be motivated to setup foreign production in the same country because the replication of each other's foreign direct investment (FDI) facilitates collusive behaviour in the market in which they compete. This implies *positive* interdependence between firms' FDI decisions, i.e. foreign investment by one firm brings increased incentive for others to follow-suit. So, we highlight a mechanism that propagates FDI clusters: a flurry of investment from one country, or region, to another.

1   Introduction

Briefly put, the idea is this: domestic rivals may be motivated to setup foreign production in the same country because the replication of each other's foreign direct investment (FDI) facilitates collusive behaviour in the market in which they compete. This implies *positive* interdependence between firms' FDI decisions, i.e. foreign investment by one firm brings increased incentive for others to follow-suit. So, we will highlight a mechanism that propagates FDI clusters: a flurry of investment from one country, or region, to another.

It is (too) tempting to cite the consistently large FDI flows from the US over the last fifty or so years, as a potential empirical application. We would, of course, not want to attribute the flows entirely to clustering forces. There are, after all, many reasons why US firms have found it worthwhile to produce abroad, such as: access to a superior and/or low cost factor of production; and proximity to foreign markets[2]. However, we can cite this period as a time when many US-based rivals faced a real decision of whether to setup foreign production. Therefore, this period offers a real world environment for any interdependence between firms to flourish, and in this case swell FDI flows beyond what they otherwise would have been.

Knickerbocker (1973) put forward the idea that firms' FDI is to some extent follow-my-leader

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[2] Caves (1996) presents an excellent discussion of such standard explanations of multinational enterprises and FDI.

in character[3]. The main thrust of his argument is nicely encapsulated in the following quote (p.26):

> "[F]irms A and B...export competing products to country X. Now, suppose A established a manufacturing subsidiary in X. B uncertain of productive economies, if any, that A might gain by manufacturing locally, faces the possibility that it could be underpriced by A in the market place. By establishing its own manufacturing subsidiary, B can match the production costs of A and thereby preserve its market share should A resort to price competition."

The model to be presented here is very much in the same spirit as his story, but is nevertheless a little different from Knickerbocker's vision. He saw uncertain foreign cost economies as a threat to the status quo in all markets (at home and abroad - if the firms initially export). Risk averse firms would seek to minimise the prospect of upsetting the balance of competition by replicating an initial FDI by one of their number. However, uncertainty about the foreign production environment plays no role in our model. Instead firms engage in follow-my-leader FDI because of foreign cost advantages that would threaten oligopolistic collusion if FDI was not replicated across firms.

It is worth making two further points before moving on. These concern the scope of the model to be presented. Firstly, the foreign production permitted is purely vertical in nature: the firms' foreign production is used only to serve the domestic market[4]. Thus, it is of the sort that replaces high cost domestic production with low cost foreign production, without seeking to gain entry into the foreign market, i.e. that typically associated with north-south FDI. In the context of US firms, a prime example would be their FDI into Mexico and other Central and South American nations.

Secondly, this model can be applied to firm behaviour other than FDI. This is because of how we characterise FDI in our model: (i) FDI does not affect the number of markets served by a firm; (ii) FDI involves a fixed cost in exchange for a per-unit saving. One may wish to characterise other investment (say in capital, research and development (R&D) or in a distribution network) in the same way. If so, the follow-my-leader behaviour to be illustrated here will be applicable to a wider range of firm behaviour than simply FDI.

The next section describes the model and gives results. Some concluding remarks are provided in section 3.

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[3] Indeed, he took the empirical impetus for his work from a similar source as the one we cited in the previous paragraph. He drew upon the large investments by US firms in the 1950s.

[4] Here, firms will only ever face each other in one market, their domestic market. This means that we will not be discussing the impact that multimarket contact can have on the sustainability of collusion (for an excellent discussion of these issues, see Bernheim & Whinston (1990)).

2   The model

There are two countries, A and B, and two firms, 1 and 2. Both firms are initially based in A, where they each have a plant for the production of the same homogeneous good.[5] To fix ideas we will refer to A as the *domestic* country and to B as the foreign country and assume that all output is sold on the domestic market. Domestic demand is defined according to the following inverse demand function:

$$p = \boldsymbol{a} - \boldsymbol{b}(q_1 + q_2) \qquad (1)$$

where q_i is the output produced by Firm i. Firms must decide whether to abandon domestic production and replace it with foreign production by setting up a new plant in B. Marginal production costs are constant[6]. This takes the level of c in country A, and of $c-r$ in country B. Thus if $r>0$, foreign production is relatively low cost. However, units produced abroad must be exported back to A for domestic consumption. The accompanying transport cost is a per-unit-cost of t. So, if $r-t>0$, the foreign country offers a lower cost method of serving the domestic market, than does domestic production. There is a fixed and sunk[7] cost associated with FDI, the cost of building the plant, G. So, the cost of the various options can be summarised as follows (q=output dedicated to the domestic market):

$$\textit{non-FDI}: \ TC = cq \qquad (2)$$

$$\textit{FDI}: \ TC = (c - r + t)q + G \qquad (3)$$

For simplicity, we will normalise $(\boldsymbol{a} - c)/\boldsymbol{b}$ as unity and refer to $(r-t)/\boldsymbol{b}$ as b.

Firms face each other in the domestic market over an infinite number of time periods. So, each firm must decide upon its FDI strategy in order to maximise the present value of the stream of future profits it can expect to accrue. Future profits are discounted and the discount factor is represented by $\boldsymbol{d}$.

The game played out by the firms is as follows: prior to the first of their infinite number of meetings in the market, they each simultaneously decide whether to undertake FDI, and any investment is completed; prior to every proceeding output-setting stage any firm that has thus far decided against FDI, has the chance to change it's mind and invest. Thus, the decision to undertake FDI is irreversible (owing to the sunk nature of the fixed cost), but the decision to not do FDI is reversible. Furthermore, we assume that all FDI is observable to both firms when setting output.

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[5] The assumption that the goods produced are identical is made simply to save on parameters. The models generalises straightforwardly to the case of imperfect substitutes.

[6] Constant marginal costs imply that firms will never wish to produce in both locations simultaneously. This assumption is made to keep the analysis as simple as possible.

[7] This means that the cost of setting up the foreign plant is: in no way proportional to output; and non-recoverable.

First of all we will present results given the assumption that collusive behaviour is not permitted. Then, we permit tacit collusion and show how this changes things.

2.1   Collusion excluded

In equilibrium, each firm chooses whether to undertake FDI so as to maximise the present value of their profit stream. This is followed by infinitely repeated Cournot competition[8], with the production costs of the firms having been determined by their FDI decisions. The present value of profits for each firm, for each combination of FDI strategies, are as follows:

Firm i - no FDI, Firm j - no FDI
$$p_i = p_j = \frac{1}{1-d}\frac{b}{9} \tag{4}$$

Firm i - FDI,   Firm j - no FDI
$$p_i = \frac{1}{1-d}\frac{b(1+2b)^2}{9} - G \quad ; \quad p_j = \frac{1}{1-d}\frac{b(1-b)^2}{9} \tag{5}$$

Firm i - FDI,   Firm j - FDI
$$p_i = p_j = \frac{1}{1-d}\frac{b(1+b)^2}{9} - G \tag{6}$$

We present the sub-game perfect equilibria in *b, g* space[9] (where $g = (G/b)(1-d)$) in figure 1 (Firm 1's strategy is given first, F=FDI, O=no FDI). Remember: b is a measure of the variable cost saving offered by foreign production; g is a measure of the extra fixed cost associated with a foreign plant[10].

FIGURE 1 HERE

The key feature of these results is *negative interdependence* between the firms' FDI decisions. In the central region of the diagram, one firm invests abroad while the other remains domestic. Foreign investment by a firm's rival reduces its own incentive to invest abroad.

In the next section we permit collusive behaviour. We will show that, in that case, there is no simple prediction about the interdependence between the firms' FDI: it may be positive or negative.

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[8] From this point on, the terms *Cournot* and *competitive* will be used interchangeably. Thus, when we refer to competitive outcomes, this should not be taken to mean *perfect competition*. In Cournot competition output is priced in excess of marginal cost.

[9] There is an upper-bound shown for b in figure 1 (and in figure 3; section 2.2.2). This is to ensure that: a firm producing in the foreign country faces positive variable production costs; and the higher cost firm produces a positive output. Thus, the upper-bound is at the minimum of 1 and $(c-t)/b$.

[10] This measure depends upon the discount factor, d. This is because the importance that a firm attaches to a currently incurred fixed cost will be dependent on the way in which it discounts the future. If, for example, a firm values the future equally with the present (this is d =1), the fixed cost will be infinitesimally small in the mind of the firm, compared to the profits accrued in the future.

2.2   Tacit collusion

2.2.1   The model of collusion

Now we permit firms to choose between competitive and collusive behaviour. The latter involves a lowering of industry output below the Cournot level. This raises two issues that are not easily resolved: the way in which industry output will be set; and the way in which industry output will be shared-out between firms. If the firms serve the market at the same cost, it is straightforward: industry output is set at the monopoly level given marginal cost; and each firm produces half the total. However, if there is cost asymmetry, it's not so clear. It would be optimal for the low cost firm to produce all of the industry output, and for the other firm to produce nothing. This would maximise industry profits, which could then be shared out in a mutually acceptable way via side-payments from the low to high cost firm. However, we rule this out on the grounds that side-payments are unrealistic means for informal, tacit collusion to be carried out. Instead, we insist upon each firm's profits being derived only from the margin earned on their output. Thus, both firms must produce positive output for collusive outcomes to be sustained.

First we will resolve the setting of industry output: it will maximise industry profits given the share-out rule adopted. Thus, industry output will be the monopoly level given marginal cost at a weighted average of the firms' marginal costs of serving the market (weighted, that is, by market shares).

Now to choose from the wide range of possible share-outs. We want to focus on a set of share-outs that we feel are intuitively appealing. At one extreme there is an equal share-out, i.e. each firm produces half of the total. This is appealing because it is: the Cournot share-out before firms face the FDI decision; in some sense equitable for ex ante symmetric firms; and simply a focal point. At the other extreme is the share-out according to post-FDI Cournot proportions. This is that each colluding firm's output is the same percentage of the industry total as if they were both instead acting competitively. Thus, the low cost firm enjoys a larger market share than the high cost firm. While this set is clearly not exhaustive, we propose that it is nevertheless worthy of special attention. So, we will present results given an equal share-out, and then describe their generality across the rest of our set. Specifically, we will focus on the potential for positive interdependence between the firms' FDI.

Before we present the formal analysis we can perhaps draw a tentative conclusion: collusion is more easily sustained when firms undertake symmetric, rather than asymmetric, FDI. The discussion just presented illustrates that when firms differ in costs, there is much greater potential for confusion (and so disagreement) about the correct manner of collusion. The absence of simple, focal and equitable rules for collusion makes it more difficult for a firm to identify collusive behaviour in a rival[11]. Similarly, it is also unclear if a rival is cheating. On an intuitive level then, one can argue that

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[11] Remember, this is tacit collusion. There is no formal, written agreement between the firms.

collusion is less easily sustained when firms differ in costs. Thus, if one firm undertakes FDI, cost symmetry is broken, and any initial collusive behaviour is threatened; instead both firms may undertake FDI in order to perpetuate collusive behaviour. Indeed, such a mechanism will be the focus of the more formal analysis of the sustainability of collusion presented next.

2.2.2 Collusion with equal market shares

If in every period the firms collude, each firm producing half of the total output, the present value of profits for each firm, for each combination of FDI strategies, are as follows:

Firm i - no FDI, Firm j - no FDI
$$p_i = p_j = \frac{1}{1-d}\frac{b}{8} \qquad (7)$$

Firm i - FDI, Firm j - no FDI
$$p_i = \frac{1}{1-d}\frac{b(1+2b+\frac{3}{4}b^2)}{9} - G \; ; p_j = \frac{1}{1-d}\frac{b(1-\frac{1}{4}b^2)}{9} \qquad (8)$$

Firm i - FDI, Firm j - FDI
$$p_i = p_j = \frac{1}{1-d}\frac{b(1+b)^2}{8} - G \qquad (9)$$

Firms play an infinitely repeated quantity setting game and we model tacit collusion in the simplest possible way by assuming that it is supported by a *grim punishment strategy*[12] (see Friedman (1971)). Each firm chooses between (i) setting the collusive output now and maintaining this until the other player chooses not to collude and (ii) selecting the non-collusive output. If a firm ever chooses not to play the collusive output then its rival moves to its Cournot output forever.

First, say the firms invest in the same way, and so face the same costs. If both firms remain domestic and Firm j colludes, Firm i receives the payoff in (7) if it colludes and:

$$p_i = \left(\frac{9}{8} + \frac{8}{9}\frac{d}{1-d}\right)\frac{b}{8} \qquad (10)$$

if it cheats on the collusive understanding. It is straightforward to show that collusion yields at least as high a level of discounted profits as cheating for $d \geq 9/17$. If both firms collude having instead carried out FDI, Firm i receives the payoff in (9). If Firm i cheats while its rival does not, they receive:

$$p_i = (1+b)^2\left(\frac{9}{8} + \frac{8}{9}\frac{d}{1-d}\right)\frac{b}{8} - G \qquad (11)$$

This comparison implies the same critical discount factor as in the no FDI case, i.e. collusion occurs for $d \geq 9/17$.

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[12] It is well known that more sophisticated punishments can be used to expand the range of discount factors over which collusion can be supported. (See Vives (1999) chapter 9 for a recent survey of oligopoly supergames.) We aim in this paper to keep the analysis as simple as possible. However, we conjecture that more sophisticated punishment strategies would not affect our qualitative results.

Suppose Firm i relocates production abroad while Firm j remains domestic. Then Firm i's discounted profits if it cheats are:

$$\boldsymbol{p}_i = \boldsymbol{b}\left[\left(\frac{3}{8}+\frac{7}{16}b\right)^2 + \frac{\boldsymbol{d}}{1-\boldsymbol{d}}\frac{(1+2b)^2}{9}\right] - G \qquad (12)$$

The payoff to Firm j if it cheats is:

$$\boldsymbol{p}_j = \boldsymbol{b}\left[\left(\frac{3}{8}-\frac{1}{16}b\right)^2 + \frac{\boldsymbol{d}}{1-\boldsymbol{d}}\frac{(1-b)^2}{9}\right] \qquad (13)$$

From these profits we again derive the critical value of $\boldsymbol{d}$, above which the firms will find it optimal to collude. In this case, the critical value differs between firms. It is the highest of these values that counts as both firms must be willing to collude for collusion to be sustained. Figure 2 presents these critical values of $\boldsymbol{d}$ in b, $\boldsymbol{d}$ space, where:

F,O [Firm j (no FDI)]: this downward sloping curve gives the critical $\boldsymbol{d}$ above which Firm j will collude.
F,O [Firm i (FDI)]: this upward sloping curve gives the critical $\boldsymbol{d}$ above which Firm i will collude.

For b>0, the critical discount factor in order for the firm that invests abroad to collude, is above that for the firm that remains domestic. Figure 3 permits one to compare the sustainability of collusion in F,F, O,O and F,O. The configuration of FDI that requires the largest discount factor for collusion is F,O. Thus, according to figure 3, symmetric FDI facilitates collusive behaviour.

However, we must also consider the possibility that a firm will wish to change it's FDI decision once cheating occurs. The example of this that proves most important is where collusive O,O breakd down into competitive F,O[13]. Here then, firms act collusively in O,O, but once cheating has occurred and they are faced with Cournot competition forever more, one of the firms wishes to do FDI. We assume that in this situation, the cheating firm of the previous period (say, Firm i) will use it's earlier knowledge of it's plans to cheat to act as a first-mover and undertake FDI before the firms compete next in the marketplace. In this scenario, the sustainability of collusion in QO will be somewhere between that in F,O and that in F,F. Thus, collusion is less easily sustained in O,O than in F,F. This is because F,F offers a greater commitment by the firms to symmetry in the future. Figure 4 presents the critical values of $\boldsymbol{d}$ in b, $\boldsymbol{d}$ space, where:

O,O [Firm j (no FDI)]: this downward sloping curve gives the critical $\boldsymbol{d}$ above which Firm j will collude.
O,O [Firm i (FDI)]: this upward sloping curve gives the critical $\boldsymbol{d}$ above which Firm i will collude.

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[13] The firms will, given other parameter values, switch from O,O to F,F. We do not discuss such a switch in the text in order to make the point (that collusion may not be as stable in O,O, as it is in F,F) as simply as possible. However, it is possible that collusion is not sustainable in O,O given a switch to F,O, but is sustainable given a switch upon cheating to F,F. If so, some part of the region in figure 7 devoted to F,F , will also support O,O as an equilibrium outcome. This part will be the intersection of the region in figure 1 devoted to F,F, and the region in figure 6 devoted to F,F;O,O. Thus, the case discussed here gives results that lie somewhere between those of figures 6 and 7.

FIGURES 2 to 5 HERE

First assume $d \geq 9/17$, but that b is sufficiently large to cause a breakdown of collusion when only one firm engages in FDI[14]. This leaves two possibilities: (1) collusion is sustained only in O,O and F,F (associated with region (1) in figures 3 and 5[15]); (2) collusion is sustained in F,F, and in O,O only so long as there is no switch to F,O were cheating to occur (associated with region (2) in figure 5[16]).

(1)   In this case we get collusion if there is symmetric investment but not if it is asymmetric. The gains from softening competition act to promote FDI clustering, i.e. when both firms invest or neither does. Figure 6 presents the equilibrium outcomes in b, g space.

FIGURE 6 HERE

When the fixed cost of setting up a new plant (g) is high, both firms remain domestic. If g is low, but the marginal cost reduction (b) is high, both firms engage in FDI. At high levels of b there is an intermediate range of g that exhibits the same negative interdependence in FDI shown in the competitive case (section 2.1) - labelled F,O;O,F in figure 6. Here, collusion is not sustainable. However, for lower b, equilibria in the intermediate range will be such that: if one firm does FDI, the other follows as it knows this is the only way to avoid a breakdown in collusion. Indeed given such a breakdown, it will face a relatively low cost competitor.

The key feature of these results is the potential for *positive interdependence* between the firms' FDI decisions. FDI clustering occurs due to the follow-my leader behaviour of investors. By comparing figure 1 (the competitive case) with figure 6, one can see the latter results show a greater prevalence of symmetric FDI (i.e. F,F and O,O replaces F,O and O,F).

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[14]   In figure 2, this is the region bounded from below by 9/17, from the right by the upper-bound on b, from the left by Firm i's loci of critical values, and from above by one (if one is taken to be the largest reasonable discount factor in such a model).

[15] This is true in the regions marked with a (1) in both figure 3 and figure 5. It requires that the discount factor is such that it is large enough for collusion to be sustained in O,O and F,F, but too small for collusion to be sustained in F,O.

[16] This is true in the region marked with a (2) in figure 5. It requires that the discount factor is such that it is large enough for collusion to be sustained in F,F, but too small for collusion to be sustained in O,O or F,O.

(2)   In this case, we get collusion if there is symmetric FDI that is not threatened by a breakdown of collusive behaviour. Owing to the irreversibility of investment, the gains from softening competition act to promote follow-my-leader behaviour where both firms invest. Figure 7 presents the equilibrium outcomes in b, g space.

FIGURE 7 HERE

Many features of the results presented in figure 6, remain here. Most notably, there is potential for interdependence between the firms' FDI decisions. Also, there is again a shift towards symmetric FDI as compared to the competitive case (see figure 1). Here though, the shift is more markedly towards F,F than is the case in figure 6. Indeed, when comparing figures 7 and 1, we have no increased prevalence of O,O. So, the shift towards symmetric FDI is due solely to an increased prevalence of F,F.

So, we have shown that there are gains from collusion; symmetry facilitates collusion; if both firms invest they thereby commit to cost symmetry forever; if neither firm invests, there is symmetry, but it can be broken by FDI were cheating to occur; this potential asymmetry hampers collusion; if collusion is sustained only if both firms invest, this promotes an FDI cluster (F,F).

2.2.3   Collusion with unequal market shares

Now let's consider unequal collusive output share-outs when there is asymmetric FDI. Across the set of share-outs described previously (from equal shares to Cournot shares), two features of the results just presented hold true: collusion is more easily sustained when the firms have symmetric FDI strategies; and there exists some range of parameter values for which there is a positive interdependence between the firms' FDI. Thus, the potential for a positive interdependence, and the resulting clustering of FDI, exists across the entire set of share-outs. Clearly, for this potential follow-my-leader behaviour to occur, there must be a suitable configuration of costs, demand conditions and discount factors. Outside the set of intuitively appealing share-outs that we have focused upon, the two main features of the results do not necessarily hold true. Where they do not[17], there exists only the negative interdependence in FDI akin to that illustrated in the competitive case (section 2.1).

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[17] Simulations show that there does exist market share combinations that actually increase the stability of collusion above the level in the symmetric investment cases. These involve the low cost firm getting an even higher market share under collusion than under competition. If firms were indeed to agree to such a split it would further strengthen the negative interdependence among firms' FDI illustrated in the competitive case (section 2.1).

3   Conclusion

We have presented a simple, rather stylised model of firms' decisions to serve their domestic market using foreign production. When the two firms are restricted to competitive behaviour, there is a negative interdependence between their FDI, i.e. one firm undertaking FDI reduces the incentive for its rival to follow suit. If the firms are instead permitted to tacitly collude, and find it possible to do so only if they execute symmetric FDI strategies, there is potential for positive interdependence in FDI. This results in follow-my-leader behaviour and FDI clusters. It is also possible that the firms will only collude if they both undertake FDI. This further promotes symmetric outcomes where both firms invest abroad. The presence of such behaviour depends on both the way in which industry output is shared-out in collusive outcomes, and the values taken by cost, demand, and discounting parameters.

The point made here is not that symmetric FDI necessarily yields collusion (it does not), or that colluding firms will undertake follow-my-leader FDI (that depends upon the output share-out; see section 2.2.3). It is simply that there is a potential for follow-my leader FDI when one permits collusion that is absent when one does not. Furthermore, we have shown that in our simple model, this potential exists given intuitively appealing collusive conduct.

In relation to an empirical application, we have proposed the north-south flows of FDI and highlighted those from the US to Mexico[18]. In the same spirit one could also highlight FDI from the UK, Germany or France to some Central and Eastern European countries. These flows may also be motivated by low cost foreign production, and produce output destined for domestic, rather than local, markets.

Finally, as stated briefly in the introduction, one can readily extend the model beyond FDI. Application to any investment decision that can be characterised as a fixed outlay in exchange for a per-unit saving, is straightforward. For example, cost-reducing research and development, and setting

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[18] In fact, alternatively one can see the model as relating to north-north FDI, say the EU operations of US firms: firms that initially export, decide whether to set up a plant in the EU. In that case, the cost savings from foreign production would arise from the proximity to the market and any advantage specific to the production environment in that region. As we have it in our model, it is domestic production that offers proximity to the market, but this is outweighed by lower production costs abroad. Whichever way it is specified, the important thing here is that foreign production offers a lower variable cost of serving the market in question. To apply our model to this case, the firms' interaction in the US market must not influence the sustainability of collusion on the EU. This is to say: cheating in the EU must not threaten collusive behaviour in the US; and cheating in the US must not threaten collusive behaviour in the EU.

up a distribution network spring to mind. So, there may be an illustration here of a potential for follow-my-leader behaviour in more than one of the ways firms interact.

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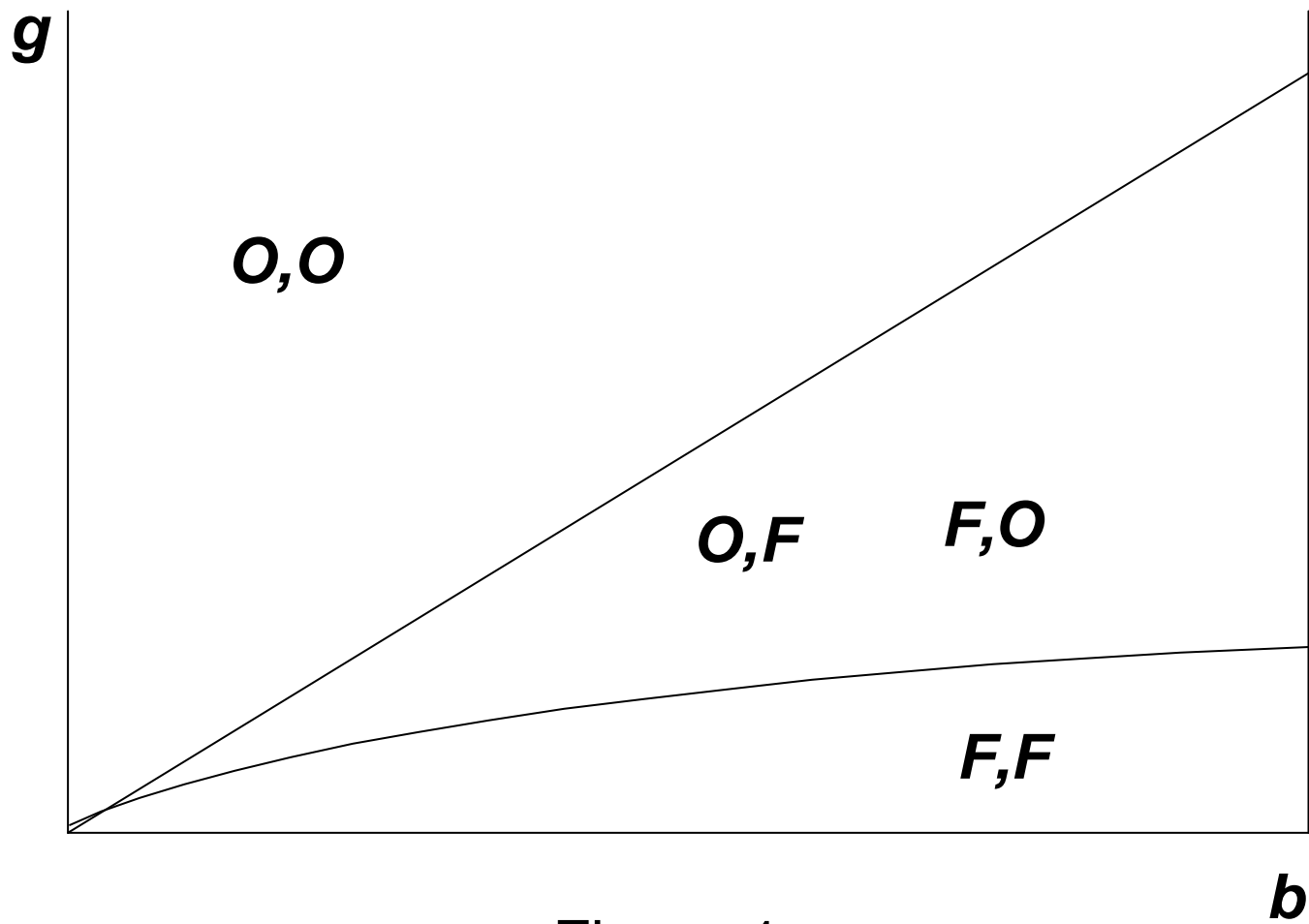
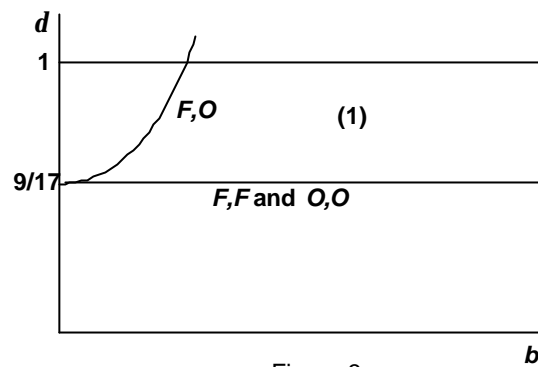Figure 1
Collusion excluded
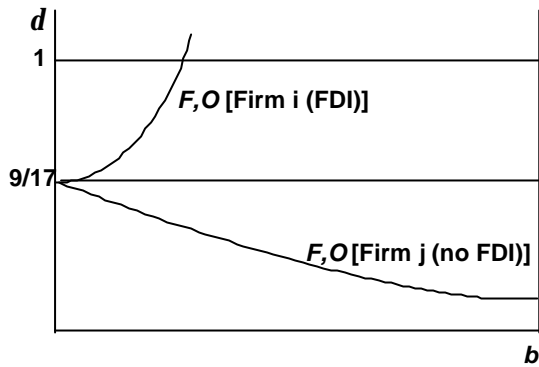
Figure 2

Figure 3
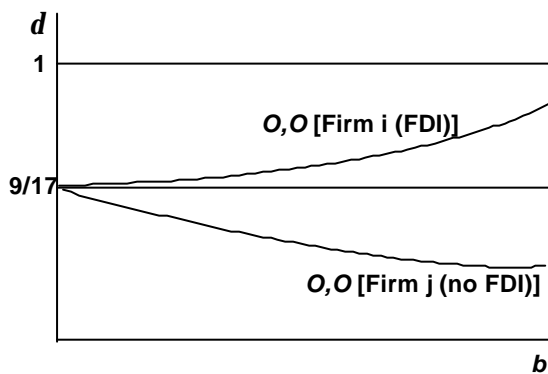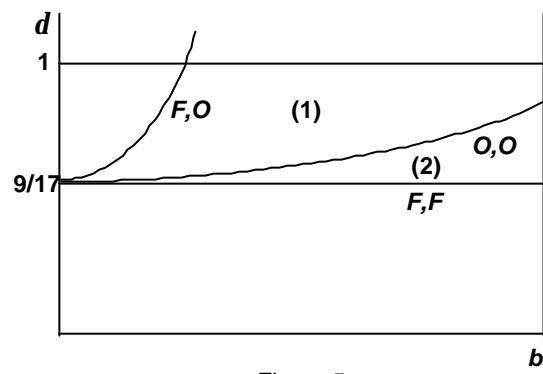Investment is constant were cheating to occur

Figure 4

Figure 5
O,O shifts to F,O once cheating occurs

Figures 2, 3, 4 and 5
The sustainability of collusion

Figure 2 shows the critical values of for collusion to be sustained in F,O. It is the uppermost curve that counts (as both firms must be willing to collude for it to happen). Given this, figure 3 summarises the sustainability of collusion for F,O, O,O and F,F (taking the critical values for O,O and F,F as 9/17). If instead, there would be FDI were cheating to occur in a collusive O,O outcome, the critical value for O,O is no longer 9/17; figure 4 shows the critical values of for collusion to be sustained in this case; again, it is the uppermost curve that counts. Figure 5 then summarises the sustainability of collusion for F,O, O,O and F,F in this case.
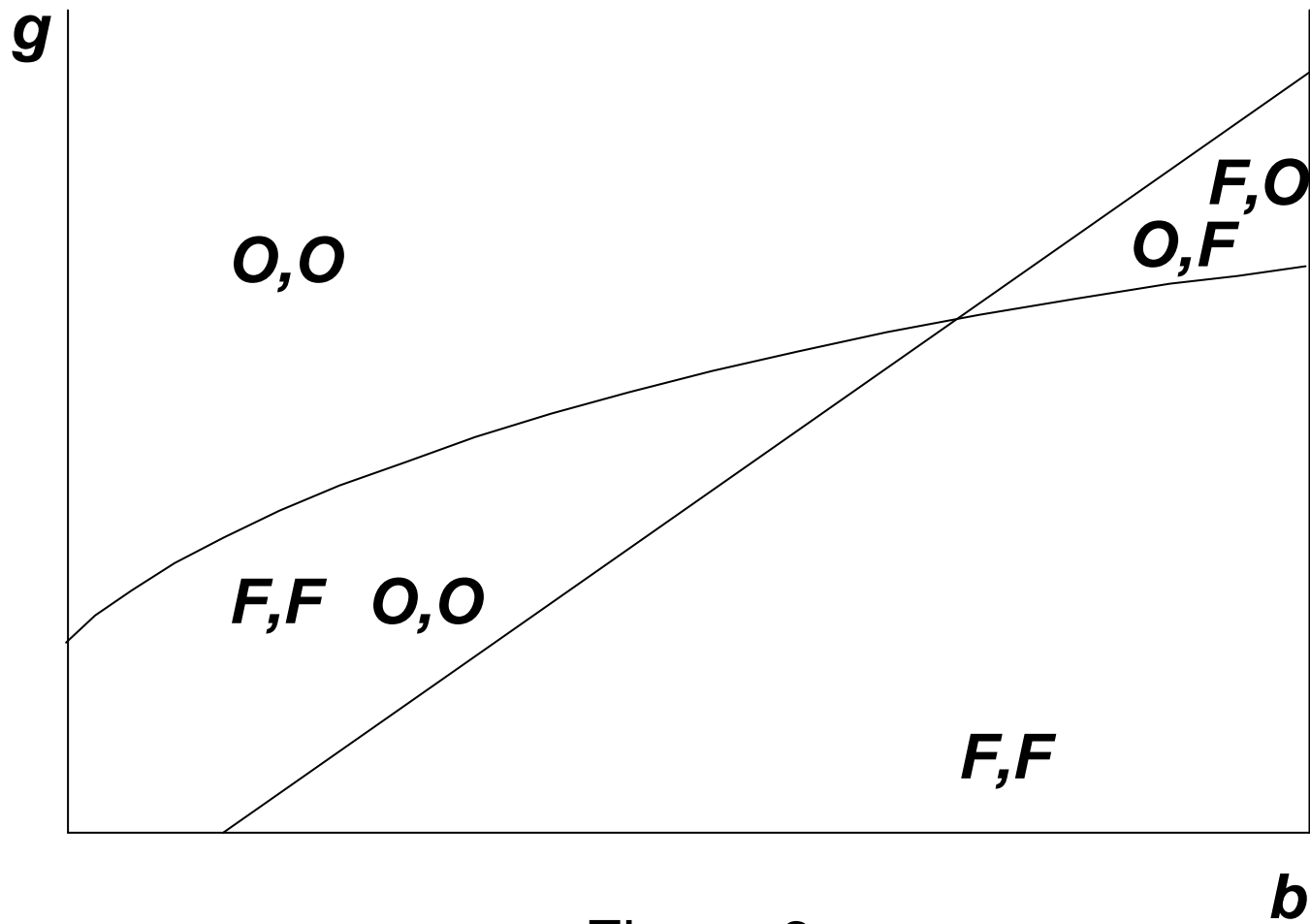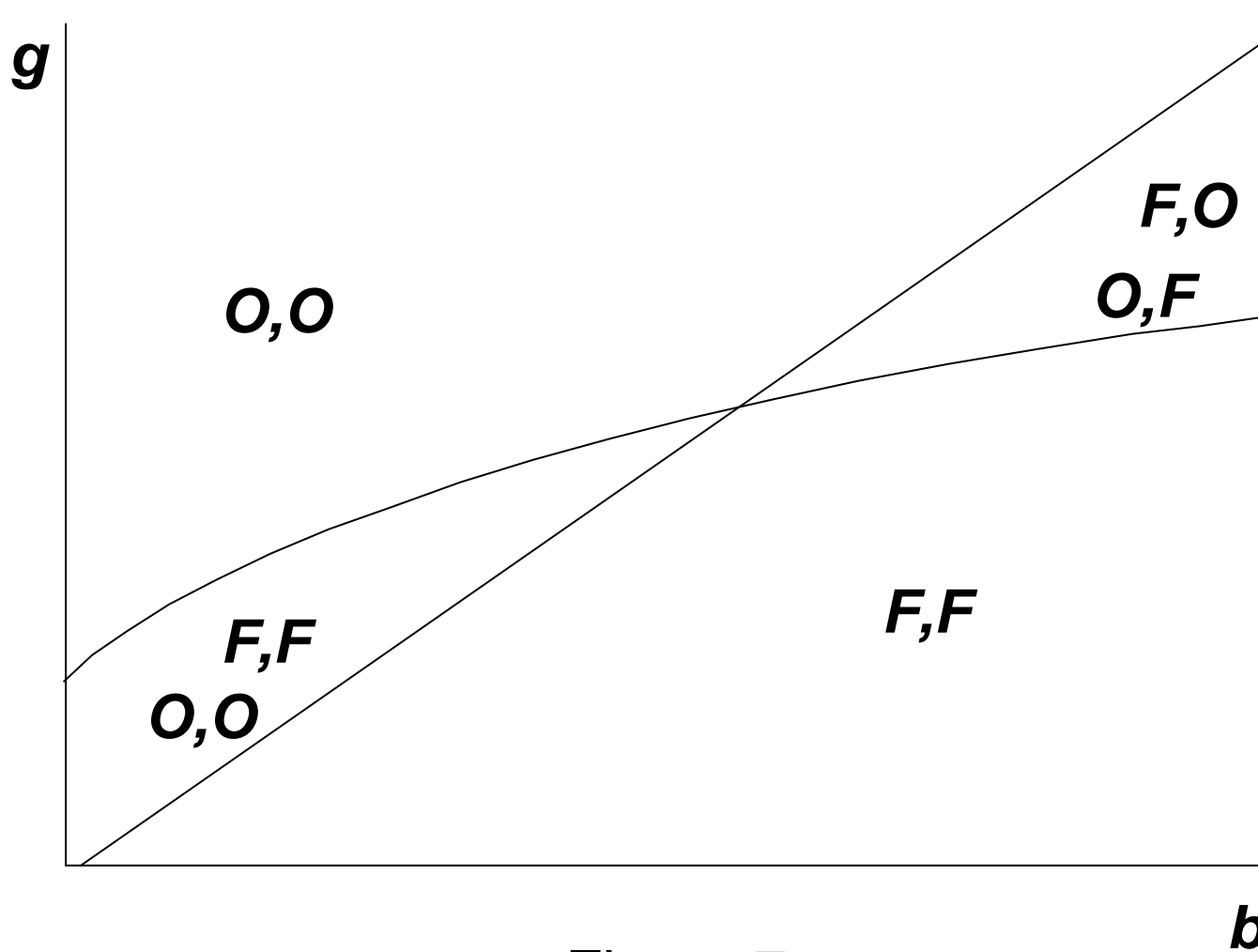
Figure 6
Collusion sustained only in O,O and F,F: (1)

Figure 7
Collusion sustained only in F,F: (2)