Privatization as a part of a Liberalization Program in an International Oligopoly

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Abstract

This paper determines the equilibrium market structure in an international oligopoly which is opened up by a privatization. Market power is shown to be an important determinant of the equilibrium market structure, when greenfield investment costs are high. When the greenfield investment costs are low, however, the risk of monopolization decreases. It is also shown that "Investment Guarantees" can be counterproductive by helping the buyer of the state assets prevent other investors from entering greenfield by credible over-investment. We also find that the negative effects on domestic firms by National Treatments clauses are partly paid for by the foreign investor in the bidding competition over the state assets.

Keywords: Privatization, FDI, Acquisitions, National Treatment, Investment Guarantees.

JEL classification: F23, L13, L33

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1. Introduction

Privatization of state enterprises has become an important part of industrial restructuring in all parts of the world. 1865 deals in more than 100 countries worth approximately $750bn are reported in the period of 1977 to 1997.[1] Numerous privatizations take place in open economies, i.e. in situations where some of the potential buyers are foreign firms and the sold state assets will be used in a market open to foreign direct investments (FDI) and imports. In Eastern Europe, for instance, privatization played a crucial role in attracting FDI by accounting for nearly two-thirds of the inflows during 1988-1993.[2]

Acquisitions by foreign firms in privatizations are not only quantitatively important, they are also often viewed differently in policy making than those made by domestic firms. For instance, many countries restrict the right of foreign individuals and firms to acquire domestic firms, or apply special restrictions to foreign firms in certain industries. At the same time, governments in many regions, such as Eastern Europe, are actively encouraging foreign investors to buy shares of former state enterprises. Moreover, many countries are signing "National Treatments", which set out the commitments of countries to treat foreign-controlled firms operating in their territories no less favorably than domestic enterprises in similar situations.[3]

Despite their importance, privatizations in open economies have received but scarce attention in the theory literature on privatization. This literature focuses

[1] See Bortolotti et al (1999).

[2] Total FDI flows into Central and Eastern Europe reached $6.3 billion in 1993 and $12 billion in 1996 UNCTAD (1995 and 1997). According to UNCTAD (1997), the prospects for privatization-related investments in the region are still good, especially in those countries that are only now embarking on large-scale privatization schemes, such as Bulgaria (in 1997-1998) and Romania (1997).

[3] UNCTAD (1999).

on what method of privatization a government should use to achieve an efficient allocation of ownership rights and generate as large revenues as possible.[4] In an open economy, the outcome of the privatization procedure is likely to interact with the incentives for FDI and imports, and the purpose of this paper is to analyze this interaction.[5] To this end, we consider a three-country partial equilibrium model. In one of the countries, the market has previously been served by a state enterprise, but will now be open to competition. Our analysis will focus on the effects of privatization in this market. In the first stage, the former state enterprise is privatized. The privatization is depicted as a simultaneous bid auction, where two firms are potential buyers of the state assets. Firm 1 is either domestic or foreign and firm 2 is foreign. In the second period, the firms can expand by investing greenfield. In the third stage, the firms sell a homogenous product and a foreign firm faces a trade cost in addition to its normal production costs, if it has not invested in the market. If both firm 1 and firm 2 are foreign, their trading costs might differ.[6]

The model is spelled out in Section 2. In Section 3, we derive the equilibrium market structure in two specific models: (i) Trade Cost Savings (TCS) Model,

[4]For an overview see, for instance, the paper by Schmidt and Schnitzer (1997). See also the paper by Cornelli and Li (1997), which focuses on the difference between foreign and domestic buyers.

[5]The theoretical literature on foreign direct investment (FDI) and multinational enterprises (MNE) is also related to our study; this literature is surveyed in Markusen (1995). A central question here is how factor endowments and trade costs interact with scale economies at the plant- and firm level in shaping firms' decisions to undertake FDI. However, this literature does not explicitly address the question of whether entry into a foreign market is greenfield, i.e. takes place through the setting up of *new* plants, or through the acquisition of *assets already in the market*, or both.

[6]Note that this paper focuses on the effects of privatization on the domestic market and therefore, we abstract from issues related to foreign markets.

where there are no other savings from investment than possibly savings of trade costs. This model focuses on how differences in trade costs affect the equilibrium market structure. (ii) Variable Cost Savings (VCS) Model, where a firm obtaining the state assets may gain a competitive advantage. The focus is then on how the equilibrium market structure is affected by this "first mover advantage".

Market power is shown to be an important determinant of the equilibrium market structure, when greenfield investment costs are high. The results thus suggest the importance of taking the risk of monopolization into account when privatizing in an open economy. We show, however, that when the costs of greenfield investments are low, the risk of monopolization decreases.

Moreover, in the TCS Model, the firm facing the lower trade cost is shown to obtain the state assets when greenfield costs are high and the trade cost difference between the potential buyers is large. The intuition is that when the trade cost difference becomes sufficiently high, the low trade cost firm gains a great deal of market power and therefore obtains the state assets.[7] However, in the case with low greenfield costs, a higher trade cost makes entry more profitable. This result establishes that the extent to which the tariff jumping argument (i.e. that high trade barriers induce firms to invest abroad) is valid depends on the entry mode.[8] Thus, when entry takes place through an acquisition, i.e. when greenfield costs

[7]Our results seem to fit the evidence reported by Dyck (1998) concerning the privatization program for East-German state-owned enterprises (SOE:s). The SOE:s were sold in an open sales process, which was not open only to German investors; foreign investors had equal opportunities to make bids on these assets. Dyck (1998) finds that a majority of the East-German SOE:s (74.1 %) were bought by West-German firms. In terms of our model, the West-German firms were closer to the market and thus had a stronger incentive to limit competition by acquiring the SOE:s.

[8]In the formal MNE literature, such as e.g. Horstmann and Markusen (1992) and Motta (1992), cost synergies are also necessary for multinational firms to emerge.

are high, the firm facing the lower trade cost obtains the state assets,[9] which constitutes a contrast to the "tariff-jumping" effect shown in the FDI literature.

In Section 4, we consider some welfare aspects of privatization in an international oligopoly market. It is shown that the private and social incentives for the buyer's identity do not necessarily coincide.

Section 5 makes some observations concerning privatization and investment policies. In the debate of National Treatment, there have been different arguments why FDI might "crowd out" domestic investments.[10] We show that the potential negative effects of a National Treatment Clause through crowding out is partly mitigated if entry takes place through an acquisition in a "privatization-auction". This is due to the fact that the negative externalities on domestic firms created by the acquisition are partly paid for by the foreign investor in the bidding competition over the state assets.

The practice of requiring future investments when selling former state assets in order to ensure such investments — so called "Investment Guarantees" — has been fairly widespread.[11] It is shown that Investment Guarantees can be counterproductive in the sense of leading to more concentrated markets. The intuition is that the Investment Guarantee helps the buyer of the state assets prevent other investors from entering greenfield by "over investing".

Section 6 discusses the robustness of some of the results in the paper. Section 7 concludes. Finally, most proofs appear in the Appendix.

[9]Horn and Persson (2000) identified this mechanism in a merger formation model without greenfield investment. The authors showed that domestic firms have incentives to merge for sufficiently high trade barriers, in order to prevent international mergers.

[10]See World Investment Report 1999.

[11]For instance, in Eastern Germany, the Treuhandanstalt bargained on the terms of trade and negotiated employment and investment guarantees (Schmidt and Schnitzer (1997).

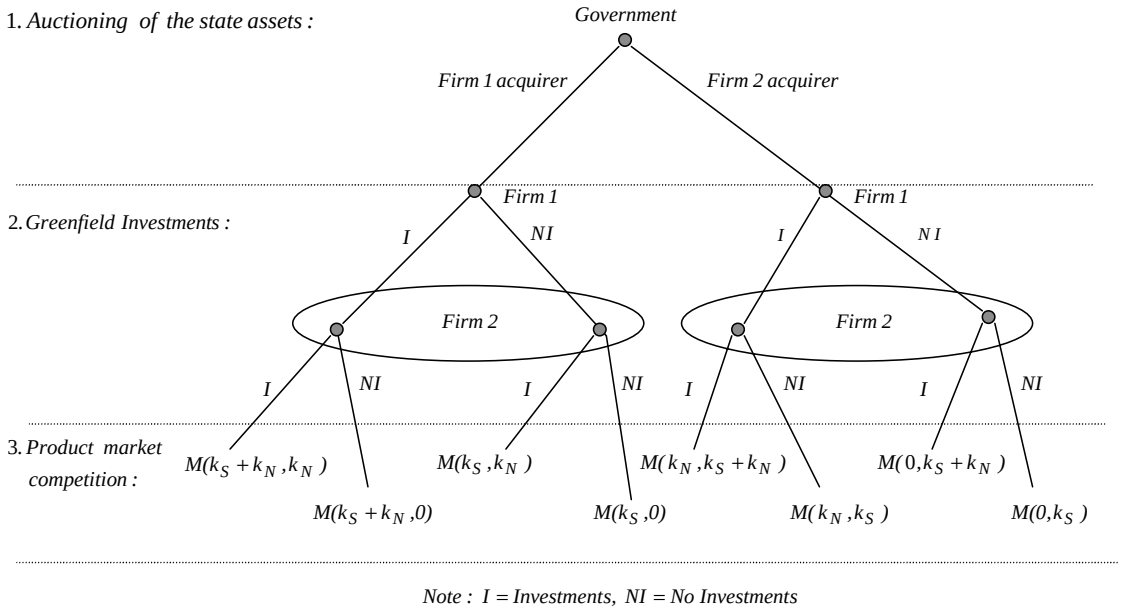

Figure 2.1: The three-stage game.

2. The Model

Consider a three-country partial equilibrium model. In one of the countries, Country S, the market has previously been served by a state enterprise, but will now be open to competition. Our analysis will focus on the effects of privatization in this market. Liberalization in country S takes place through a package of three distinct measures: (i) privatization of the state enterprise, (ii) allowing for new plants to be opened, i.e. allowing for greenfield investments and (iii) allowing for imports to the market.[12] The market will be served by two firms, firm 1 and firm 2. Firm 1 is either domestic or foreign and firm 2 is foreign.

Interaction takes place in three stages as illustrated in figure 2.1. In the first

[12]For the results derived in this paper, it is of no consequence whether the market was previously open to imports.

stage, the government sells the state assets, k_S, in one piece at an auction where firms 1 and 2 are the two potential buyers. In the second period, these firms have the option to invest in new assets, k_N, i.e. to undertake greenfield investments. Finally, in period 3, they sell a homogenous product in the market and a foreign firm faces a trade cost in addition to its normal production costs, if it has not invested in the market.[13] In Section 2.1, we describe the international oligopoly market, and in the following Section, we present the privatization model.

2.1. The International Oligopoly

In the third stage, firms compete non-cooperatively in oligopoly fashion. Let $M(k_1, k_2)$ denote the market structure where firm one possesses k_1 units of assets and firm 2 possesses k_2 units. Lemma 2 shows that the state assets will be sold in equilibrium. As illustrated in figure 2.1, this implies that there are 8 different market structures to consider.[14] For example, the duopoly where firm 1 is located in the market with state assets and firm 2 exports is denoted $M(k_S, 0)$.

Table 2.1 summarizes how production costs depend on the asset allocation. A firm which has not invested in the market ($k_i = 0$) has a constant variable cost $c_N + t_i$, $i = 1, 2,$, where t_i refers to trade costs.[15] In order to capture the notion

[13]The choice of timing between the acquisition and the greenfield investment is not obvious in a general setting. In this particular application, however, it seems natural for the acquisition decision to be made before the greenfield decision, since the assets for sale already exist in the market and entering greenfield requires the construction of a new plant, which is usually time-consuming.

[14]Note that we rule out a merger between firm 1 and firm 2. There are two basic ways in which a monopoly can be ruled out. One is to assume that the monopoly makes a smaller profit than the combined profits of less concentrated structures. The second reason why a monopoly may not be formed is that such a merger would not be permitted by the competition authorities. For simplicity, we stick to the latter interpretation.

[15]Note that if the firm is domestic, $t_i = 0$.

Table 2.1: Description of marginal costs.

Number of assets, k_i :	0	k_S	$k_S + k_N$	k_N
Marginal cost, $MC_i(k_i)$:	$c_N + t_i$	c_S	c_{SN}	c_N

that firms may reduce their trade costs by acquiring the state assets or by entering greenfield, we assume that a firm avoids trade costs when owning assets in the market.[16] A firm owning the state assets only faces a constant variable cost c_S, a firm owning new assets only faces a constant variable cost c_N, and a firm owning the state assets and new assets faces a constant variable cost c_{SN}.

The profit for firm $i = 1, 2$, where $i \neq j$, in ownership structure $M(k_i, k_j)$ is denoted $\pi_i^{k_i,k_j}(t_i, t_j)$, where firm i possesses k_i units of assets and faces a trade cost t_i and firm j possesses k_j units of assets and a trade cost t_j.

2.2. The greenfield investments

At this stage, firms may undertake a greenfield investment at a fixed cost G. Two cases should be considered: (i) when firm i did not obtain the state assets, and firm i lowers its costs from $c_N + t_i$ to c_N, by investing, and (ii) when firm i obtained the state assets. Firm i then lowers its costs from c_S to c_{SN}, by investing.

2.3. The privatization process

In practise, different types of measures have been used to privatize former state-owned enterprises. Many western countries employed various kinds of auctions to

[16] We deliberately avoid making any specific interpretation of t_i. There are several possible interpretations, however. The most immediate would be to let it refer to physical trade costs. Such costs can be avoided in a multi-national firm, since it can sell to a market using its local production facility (asset).

sell state-owned enterprises to the highest bidder. Some transition countries gave away a substantial fraction of the shares of all firms to the general population for free. In Eastern Germany, the Treuhandanstalt bargained on the terms of trade and negotiated employment and investment guarantees. Most privatization programs combined several elements of these basic methods.[17] In order to focus on the market forces as the determinate of the equilibrium buyer and the equilibrium market structure, we assume that the government sells the state assets to the highest bidder at an auction. More specifically, the privatization process is depicted as an auction where the two firms post bids and the bidder with the highest bid obtains the state assets. The winning buyer pays an amount equal to his bid. The bids are assumed to be made simultaneously.[18]

Let us now turn to the firms' valuations of an arbitrary distribution of the state assets. Generally, these valuations do not only depend on the identity of firm i, but also on the identity of the firm that will obtain the assets if firm i does not. Some notation is required in order to define a firm's valuation. Let $\mathbf{K} \equiv (k_i, k_j, k_h)$. The vector in the case where the state assets are liquidated is used as a reference point for interpretational convenience, and is denoted $\mathbf{K}^0 \equiv (k_1^0, k_2^0, 0)$. Let $\mathbf{K}^j$ denote the vector of capital stocks after firm j has obtained the state assets and $\pi_i(\mathbf{K}^j)$ denote the profit made by firm i when firm j has acquired the state assets. Then, the valuation for firm i, v_{ij}, is defined:

Definition 1. $v_{ij} \equiv \pi_i(\mathbf{K}^i) - \pi_i(\mathbf{K}^j)$

[17] See Schmidt and Schnitzer (1997).

[18] Note that in our model, all firms are completely informed about their own and other firms' characteristics. This allows us to clearly attribute the market force effects, as opposed to, say, problems of incomplete information.

Moreover, note that almost no literature derives optimal mechanisms for the selling of objects which cause externalities on other potential buyers. As far as we know, Jehiel, Moldovanu and Stacchetti (1996a) and (1996b) are the only papers on this subject.

This valuation is determined by two components. The first is the profit made by firm i when it has acquired the state assets itself. The second is the profit made by firm i when firm j has acquired the assets. We see that $v_{ij} = (\pi_i(\mathbf{K}^i) - \pi_i(\mathbf{K}^0)) + (\pi_i(\mathbf{K}^0) - \pi_i(\mathbf{K}^j))$. Thus, the valuation of obtaining the assets for firm i is the profit increase caused by its asset expansion plus the change in profits avoided by preventing firm j from acquiring the state assets. Most auction literature does not deal with situations where the latter effect exists. But, as we shall see, it plays a central part in an auction where the potential buyers compete in an oligopoly.

A bid (strategy) by one of the potential buyers is a real number $b_i \in R$. The sales mechanism α of the government is a function from $R^{n+1}$to $\{1, ..., n\}$, defining a winner.

Definition 2. *The sales mechanism α allocates the state assets to the firm posting the highest bid for the assets. If more than one firm post such a bid, each such firm obtains the assets with equal probability.*

The auctions will be solved for Nash equilibria in undominated pure strategies. There is assumed to be a smallest monetary unit, denoted ε. We assume that ties are randomly broken, and that all equalities such as $v_{ij} = v_{ji}$ are ruled out. The smallest amount ε is chosen such that all inequalities are preserved if ε is added or subtracted.

In order to make the analysis of the equilibrium more tractable, weakly dominated strategies are first eliminated. The weakly dominated and not weakly dominated strategies, are, respectively, described in the following Lemma:

Lemma 1. *We have that (i) any bid $b_i \geq v_{ij}$ is weakly dominated by the bid $b_i' \equiv v_{ij} - \varepsilon$, (ii) any bid $b_i \leq b_i'$ is not dominated.*

Proof. See the Appendix.

In the case with two firms in the industry, the analysis is straightforward as is shown by the following lemma:[19]

Lemma 2. *The state assets are acquired by the firm with the highest valuation, firm i, at a price equal to the other firm's, firm j's, valuation of obtaining the state assets instead of firm i, v_{ji}*

Proof. See the Appendix.

3. The equilibrium market structure

We are now set to derive the equilibrium buyer and the equilibrium market structures in the international oligopoly laid out above. To this end, we employ two specifications of the "investment technology", i.e., of the way in which investments affect the costs of firms. In the first model, there are no other savings from investment than possibly savings of trade costs. This will be referred to as the Trade Cost Savings (TCS) Model. In the second model, state assets are assumed to be complementary to greenfield investment, i.e. leading to lower variable costs. This will be referred to as the Variable Cost Savings (VCS) Model.

3.1. The Trade Cost Saving Model

In the third period, firms compete in Cournot fashion in a homogenous good market. The inverse demand function is linear, i.e. $P = a - bQ$. The focus of this

[19]Note that the analysis becomes much more involved when there are three or more potential buyers, since multiple equilibria might then exist. As pointed out by Jehiel and Moldovanu (1996), this is caused by the fact that the price each buyer is willing to pay in a so-called "auction with endogenous valuations" depends on which buyer he believes will obtain the assets if he does not. These beliefs are endogenously determined in equilibrium, and several consistent beliefs can be constructed.

section is the incentive for firms facing different trade cost to invest in the host country, which is captured by assuming that $t_1 \leq t_2$. To simplify, we make the following assumption concerning the variable costs:[20]

Assumption A1 $c_S = c_N = c_{SN} = 0$.

3.1.1. Period 3

Let firm w (winner) be the firm that obtained the state asset in period 1, and firm l (loser) the firm that did not. Let $t^{\max}$ be the t_l satisfying $q_l(t_l, 0) = 0$. Let $\pi_i^D(0, t_j)$ denote the duopoly profit for firm i when it faces a variable cost of zero and firm j faces a variable cost of t_j, and let $\pi^M(0)$ denote the monopoly profit when the monopolist faces a variable cost of zero. The equilibrium profits in the different market structures are then:[21]

(i) In structures $M(k_S, 0)$, $M(k_S + k_N, 0)$, $M(0, k_S)$, and $M(0, k_S + k_N)$

$$\pi_w^{k_w,0} = \pi_i^D(0, t_l) \quad \pi_l^{0,k_w} = \pi_j^D(t_l, 0) \text{ for } t_l < t^{\max}$$
$$\pi_w^{k_w,0} = \pi^M(0) \quad \pi_l^{0,k_w} = 0 \text{ for } t_l \geq t^{\max}$$

(ii) In structures $M(k_S, k_N)$, $M(k_S + k_N, k_N)$, $M(k_N, k_S)$, and $M(k_N, k_S + k_N)$

$$\pi_w^{k_w,k_l} = \pi_l^{k_l,k_w} = \pi_i^D(0, 0)$$

[20]Note that operating a new plant and operating the formerly state owned enterprise incur the same marginal cost. It is then implicitly assumed that a firm also possesses a firm-specific asset in terms of technology. This technology can then easily be transferred to different production units within the firm (see, Markusen (1995)). Even if there were a symmetric fixed cost associated with restructuring the state assets to make them as efficient as the new assets, the results in this section would still hold.

[21]Recall that we can ignore the four market structures where the state assets are not sold, since, by Lemma 2, we know that the state assets will be sold in equilibrium.

The aggregate profits in the different duopoly structures will play an important role in the analysis below. For this purpose, note that Lemma 2 implies that the firm with the highest valuation obtains the state assets. Then, note that $v_{ij} - v_{ji} > 0$ iff $\pi_i(\mathbf{K}^i) + \pi_j(\mathbf{K}^i) - (\pi_j(\mathbf{K}^j) + \pi_i(\mathbf{K}^j)) > 0$. Thus, the aggregate profit in the industry will play an important role for determining the equilibrium buyer. In order to examine the sources of aggregate profits in a duopoly and its dependence on trade costs, consider a market where one of the two firms may or may not face a trade cost, and where the other does not. This setting encompasses all situations that may occur in any of the duopoly structures, since there is no structure where both firms will face the trade cost. Let the aggregate profit in this market be expressed as $\Pi(t_l) = P(q_w + q_l)q_w + P(q_w + q_l)q_l - t_l q_l$. Then, let us study how the aggregate profit is affected by an increase in the trade cost. As shown in the Appendix, differentiating Π with respect to Π, q_w, q_l, and t_l and using the foc's yields:

$$\frac{d\Pi}{dt_l} = \frac{dQ}{dt_l} P' q_w + \frac{dq_w}{dt_l}(t_l - t_w) - q_l \tag{3.1}$$

The first term in Equation (3.1) captures the *anti-competitive* effect which is due to the fact that an increased trade cost induces the exporting firm to be less aggressive in the market interaction, which softens competition and increases the revenues of firm w. The second term reflects the decrease in trade costs as firm w steals business from the exporting firm, firm l. This effect is referred to as the *business stealing effect*. The third term, the *direct trade cost effect*, reduces aggregate profits relative to the initial position, as the exporting firm faces higher trade costs.[22]

[22]In order to see the intuition for this result, consider the situation where firm w and firm l have the same owner. Firm l facing higher trade costs will have three effects: (i) firm l reduces its quantity and part of the reduced quantity leads to reduced aggregate quantity. Using firm

Whether $\Pi(t_2)$ is larger than $\Pi(t_1)$ depends on the balance between the incentive to form $\Pi(t_1)$ to avoid the higher trade cost, and the anti-competitive and business stealing incentive to form $\Pi(t_2)$. This balance is characterized in the following Lemma, illustrated in figure 3.1.

Lemma 3. *In the TCS Model under A1*

(i): $\Pi(t_2) > \Pi(t_1)$ *if* $t_1 \geq t^*$ *or if* $t_1 < t^*$ *and* $t_2 > t^{**}(t_1)$

(ii): $\Pi(t_2) < \Pi(t_1)$ *if* $t_1 < t^*$ *and* $t_2 < t^{**}(t_1)$

Proof. See Appendix ■

The U-shape of the aggregate profit can be understood as follows. When t_l is zero, the sales of firm l are large and an increase in trade costs t_l thus has a relatively strong negative impact on aggregate profits through the *direct trade cost effect*. In addition, the *business stealing effect* is zero, since the firms' costs are unchanged. Moreover, the *anti-competitive effect* is limited, for the increased market price induced by reduced industry supply then affects a smaller number of units of the winning firm. It turns out that at $t_l = 0$, the *trade cost effect* dominates the *anti-competitive effect.* At higher trade costs, however, the direct trade cost effect is weaker, since the exports of firm l are smaller. On the other hand, both the anti-competitive and the business stealing effects are stronger, since firm w has a larger market share, and each unit shifted from export production to local production implies larger costs savings. Hence, aggregate profits will start to rise, once trade costs become sufficiently high. The critical

$l's$ foc, this implies that firm $l's$ profit has not changed. However, the reduction in aggregate quantity increases firm $w's$ profit. This is the anti-competitive effect. (ii) Some of firm $l's$ reduced quantity is taken over by firm w, which has no effect on aggregate output. This is the business stealing effect. (iii) Finally firm l faces a higher production cost on its total production, which is the direct cost effect.

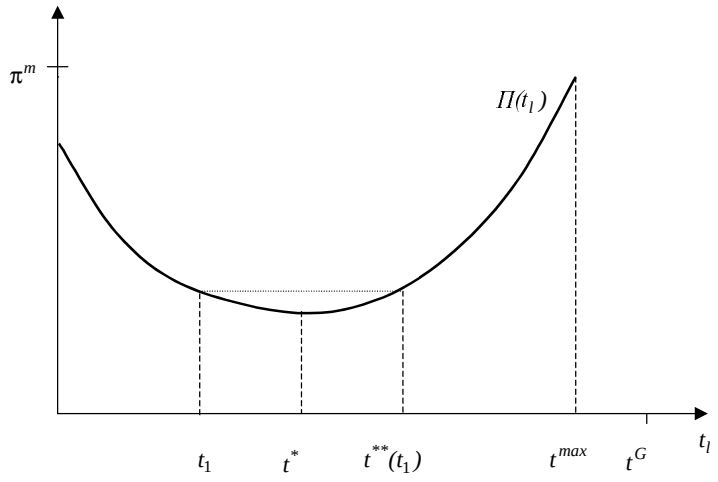

Figure 3.1: Aggregate profit in the TCS model.

trade cost when this occurs is indicated by t^* in figure 3.1. When trade costs become sufficiently high at $t_l = t^{\max}$, firm w becomes a monopolist and aggregate profit is maximized.

3.1.2. Period 2

At this stage, firms may invest greenfield. However, the firm having obtained the state assets will not have the incentive to invest greenfield, since greenfield investment neither affects the firm's own costs, nor the competitor's. Thus, we can focus on the firm that did not obtain the state assets. Firm l invests iff $\pi_l^{k_N,k_S}(0,0) - G > \pi_l^{0,k_S}(t_l,0)$. It can be shown that $\pi_j^{0,k_i}(t_j,0)$ is monotonically non-increasing in t_j in the TCS model, i.e. that $\frac{d\pi_j^{k_j,k_i}}{dt_j} \leq 0$, for $t \leq t^{\max}$, which implies that there exists a unique value of the trade cost t_j, denoted t^G, at which firm j is indifferent to making or not making the greenfield investment in period 2. To see this, note that the left-hand side of the relation is a constant which is lower than the right-hand side for $t_j = 0$ and $G > 0$. The fact that the right-hand side

decreases monotonically in t_j completes the argument. Consequently, we obtain the following result:

Lemma 4. *If firm w obtains the state assets in period 1, then the equilibrium market structure is (i) a duopoly where firm w is located in the market and firm l exports iff $t_l \leq t^G$ and (ii) a duopoly where both firm w and firm l are located in the market iff $t_l > t^G$.*

Note that this implies that firm 2 has a "stronger" incentive to make a greenfield investment, since $t_2 > t_1$.

3.1.3. Period 1

Lemma 2 establishes that the firm with the highest valuation obtains the state assets. Moreover, from the analysis in period 2, we know that it is meaningful to divide the t_1, t_2 space into three intervals: (1) $t^G > t_2 > t_1$, where neither of the firms prefers greenfield investment to exports, (2) $t_2 > t^G > t_1$ where firm 2 but not firm 1 prefers greenfield investment to exports, and (3) $t_2 > t_1 > t^G$ where both firm 1 and firm 2 prefer greenfield investment to exports.

Firm i's valuation in the first interval is denoted $v_{ij}(1)$, in the second $v_{ij}(2)$, and in the third $v_{ij}(3)$. The value for the firms of obtaining the state assets is then:

(1) $t^G > t_2 > t_1$

$$v_{ij}(1) = \pi_i^{k_S,0}(0, t_j) - \pi_i^{0,k_S}(t_i, 0), \; t^G > t_2 > t_1$$

In this interval neither of the firms prefers greenfield investments to exports. Consequently, the winner of the auction faces an exporting rival.

(2) $t_2 > t^G > t_1$

$$v_{12}(2) = \pi_1^{k_S,k}(0,0) - \pi_1^{0,k_S}(t_1,0), t_2 > t^G > t_1$$
$$v_{21}(2) = \pi_2^{k_S,0}(t_1,0) - \pi_2^{k,k_S}(0,0) - G, t_2 > t^G > t_1$$

Firm 2 will now prefer greenfield investment to exports. Recall that firm 2 faces a higher trade cost and thus has more to gain from a greenfield investment.

(3) $t_2 > t_1 > t^G$

$$v_{ij}(3) = G,\ t_2 > t_1 > t^G$$

Both firms prefer greenfield investment to exports in this interval.

The following Proposition identifies the equilibrium buyer and the equilibrium auction price in the different intervals.

Proposition 1. *In the TCS Model under A1, the equilibrium buyer and the equilibrium price are:*

(i): Firm 1 obtains the assets at a price $v_{21}(1)$ *for* $t^G > t_2 > t_1$ *if* $t_1 \geq t^*$ *or if* $t_1 < t^*$ *and* $t_2 > t^{**}(t_1)$

(ii): Firm 2 obtains the assets at a price $v_{12}(1)$ *for* $t^G > t_2 > t_1$ *if* $t_1 < t^*$ *and* $t_1 < t_2 < t^{**}(t_1)$

(iii): Firm 2 obtains the assets at a price $v_{12}(2)$ *for* $t_2 > t^G > t_1$

(iv): Firm 1 or firm 2 obtains the assets at a price G for $t_2 > t_1 > t^G$

Proof. See the Appendix. ■

Proposition 1 illustrates several noteworthy features. First, a central idea in the literature on FDI is the notion that high trade barriers induce firms to become international, i.e. to invest abroad. The Proposition suggests, however,

that this, depends on the entry mode. In the case with high greenfield costs, i.e. when $t^G > t_2 > t_1$, the Proposition shows that for sufficiently large trade cost differences, the firm facing the lower trade cost obtains the state assets. To see this, first note that when the costs of setting up a new plant are prohibitively high, i.e. $t^G > t^{\max}$, Lemma 3 applies. It then follows that aggregate profits are larger in the low trade costs structure, only if the difference in trade costs is not too large. Once the trade cost of the high trade cost firm becomes sufficiently high, the direct cost saving effect is dominated by the anti-competitive effect and the business stealing effect. Consequently, the low trade cost firm then obtains the state assets.

Second, in the case with medium high greenfield costs, i.e. when $t_2 > t^G > t_1$, the Proposition shows that the high trade cost firm obtains the state assets. The high trade cost firm will now switch from exports to greenfield production in the case where it has not obtained the state assets. This implies that the low trade cost firm can no longer prevent the high trade cost firm from becoming a tough competitor. However, the high trade cost firm can prevent the low trade cost firm from entering the market by acquiring the state assets. There has thus been a change of roles. In this situation, however, the market structure with the higher ex post trade cost will be the equilibrium market structure. Intuitively, the profit for the firm with the state assets is higher when the competitor faces a trade cost. Moreover, the profit for the firm without the state assets is also higher, which follows from the fact that it is not profitable for the firm without the state assets to invest, when facing the lower trade cost. Consequently, the structure with the trade cost is always the equilibrium market structure.[23]

[23]Note that one more effect is at work when comparing the two structures in this situation: the greenfield cost effect. In order to reach the ex post low trade cost structure, the ex ante high trade cost firm must invest greenfield, which reduces the aggregate profit in the ex post

Finally, in the case with low greenfield costs, i.e. when $t_2 > t_1 > t^G$, the low trade cost firm would also prefer entering greenfield instead of exporting. Consequently, neither firm can affect the market structure by obtaining the state assets and thus, the price falls to the level of greenfield investment costs.

It has been argued that firms may buy state assets in a privatization procedure with the single purpose of liquidating.[24] In the TCS model, it turns out that a firm could actually buy the state assets with the single purpose of liquidating, in order to prevent entry as is shown in the following Corollary:

Corollary 1. *In the TCS model under A1 and if* $t^G > t_2 > t_1$, $t_2 > t^{**}(t_1)$, *and* $t_1 = 0$, *then (i) the equilibrium buyer is firm 1, and (ii) firm 1 will liquidate the state assets.*

3.2. The Variable Cost Saving Model

A main motivation for firms to acquire state assets in a privatization procedure is the strategic value of the assets allowing early entry into the market. The early entry might be used to gain future competitive advantages through the learning of market specific characteristics, which could either lead to lower costs or improved product quality. Another motivation for acquiring the state assets is that they are complementary to the assets created by the greenfield investment. Acquisition of the state assets followed by additional investments will then create a competitive advantage.

These aspects are captured in a very basic form by the following assumption:

low trade cost structure.

[24]Such concerns were expressed in the sale of Ikarus, a Hungarian manufacturer. The Hungarian authorities argued that a European strategic investor would have been interested in running down Ikarus in order to eliminate a competitor. The assets were therefore sold to a domestic buyer at a lower price.

a firm possessing both the state assets and new assets faces a lower cost than a firm possessing either the state assets or new assets only. More specifically, it is assumed that the marginal cost of production can be reduced from the level of c to zero if new assets are combined with the state assets. Hence, the strength of learning or complementariness is simply measured by the marginal cost, c. To simplify, trade costs are assumed to be prohibitively high and demand to be linear. To summarize, we assume that

Assumption A2 $c_S = c_N = c > c_{SN} = 0$, $P = 1 - Q$ and $t_i = \infty$, $i = 1, 2$.

3.2.1. Period 3

Let us now turn to the profits in the different market structures:
(i) In structure $M(k_S, 0)$ and $M(0, k_S)$

$$\pi_w^{k_S,0} = \tfrac{(1-c)^2}{4}, \quad \pi_l^{0,k_i} = 0 \text{ for } c \leq 1$$
$$\pi_w^{k_S,0} = 0, \qquad \pi_l^{0,k_S} = 0 \text{ for } c > 1$$

(ii) In structure $M(k_S + k_N, 0)$ and $M(0, k_S + k_N)$

$$\pi_w^{k_S+k_N,0} = \tfrac{1}{4}, \qquad \pi_l^{0,k_S+k_N} = 0$$

(iii) In structure $M(k_S, k_N)$ and $M(k_N, k_S)$

$$\pi_w^{k_S,k_N} = \pi_l^{k_N,k_S} = \tfrac{(1-c)^2}{9} \text{ for } c \leq 1$$
$$\pi_w^{k_S,k_N} = \pi_l^{k_N,k_S} = 0 \text{ for } c > 1$$

(iv) In structure $M(k_S + k_N, k_N)$ and $M(k_N, k_S + k_N)$

$$\pi_w^{k_S+k_N,k_N} = \tfrac{(1+c)^2}{9}, \quad \pi_l^{k_N,k_S+k} = \tfrac{(1-2c)^2}{9} \text{ for } c \leq \tfrac{1}{2}$$
$$\pi_w^{k_S+k_N,k_N} = \tfrac{1}{4}, \qquad \pi_l^{k_N,k_S+k_N} = 0 \text{ for } c > \tfrac{1}{2}$$

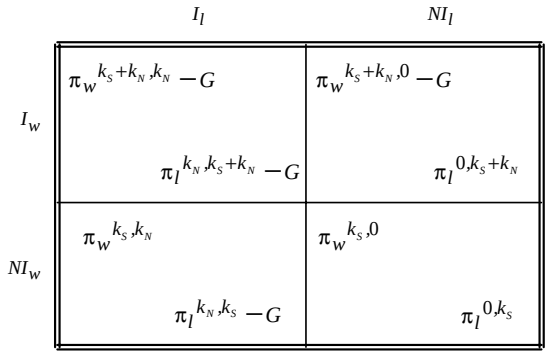

Figure 3.2: The investment game in the VCS model

3.2.2. Period 2

At this stage, firms may undertake a greenfield investment. The investment game is illustrated in a pay-off matrix depicted in figure 3.2: To simplify the presentation, we define the following inequalities:

$w1$: $\pi_w^{k_S+k_N,k_N} - G > \pi_w^{k_S,k_N}$ and $\pi_w^{k_S+k_N,0} - G > \pi_w^{k_S,0}$

$w2$: $\pi_w^{k_S+k_N,k_N} - G < \pi_w^{k_S,k_N}$ and $\pi_w^{k_S+k_N,0} - G < \pi_w^{k_S,0}$

$w3$: $\pi_w^{k_S+k_N,k_N} - G > \pi_w^{k_S,k_N}$ and $\pi_w^{k_S+k_N,0} - G < \pi_w^{k_S,0}$

$w4$: $\pi_w^{k_S+k_N,k_N} - G < \pi_w^{k_S,k_N}$ and $\pi_w^{k_S+k_N,0} - G > \pi_w^{k_S,0}$

$l1$: $\pi_l^{k_N,k_S+k_N} - G > \pi_l^{0,k_S+k_N}$ and $\pi_l^{k_N,k_S} - G > \pi_l^{0,k_S}$

$l2$: $\pi_l^{k_N,k_S+k_N} - G < \pi_l^{0,k_S+k_N}$ and $\pi_l^{k_N,k_S} - G < \pi_l^{0,k_S}$

$l3$: $\pi_l^{k_N,k_S+k_N} - G > \pi_l^{0,k_S+k_N}$ and $\pi_l^{k_N,k_S} - G < \pi_l^{0,k_S}$

$l4$: $\pi_l^{k_N,k_S+k_N} - G < \pi_l^{0,k_S+k_N}$ and $\pi_l^{k_N,k_S} - G > \pi_l^{0,k_S}$

Lemma 5 then describes the investment behavior in equilibrium:

Lemma 5. *In the VCS Model under A2, in equilibrium.*

(1): Both firms invest if (1) w1 and l1, (2) w1 and l3, or (3) w3 and l1 hold.

(2): Only firm w invests if (1) w1 and l2, (2) w1 and l4, or (3) w4 and l2 hold.

(3): Only firm l invests if (1) w2 and l1, (2) w2 and l4, or (3) w4 and l1 hold.

(4): Either firm w, or firm l invests, or both firms mix if w4 and l4 hold.

(5): No firm invests if (1) w2 and l2, (2) w2 and l3, or (3) w3 and l2 hold.

(6): Either both firms invest or no firm invests if w3 and l3 hold.

(7): (1)-(6) exhaust all possible orderings of the profits.

Proof. See the Appendix. ■

3.2.3. Period 1

It follows from Lemma 2 and from the symmetry of the set up that either firm 1 or firm 2 obtains the state assets at the auction. Using this result, the equilibrium market structure (EMS) can be derived for different values of c and G, and is depicted in Fig.3.3. Recall that the marginal cost c measures the learning effect or the complimentarity between the state assets and new assets. Ten regions are traced out in the cG-space. Each region is numbered and the equilibrium market structure is indicated as $M(k_w, k_l)$.

Regions (1)-(4) and (10) constitute an area where the equilibrium market structure involves firm w being a monopolist. In regions (6)-(9), firm l always invests, so that the equilibrium market structure is a duopoly.[25]

[25]The figure illustrates that there might exist multiple equilibria in these types of models, as is shown in area 5.

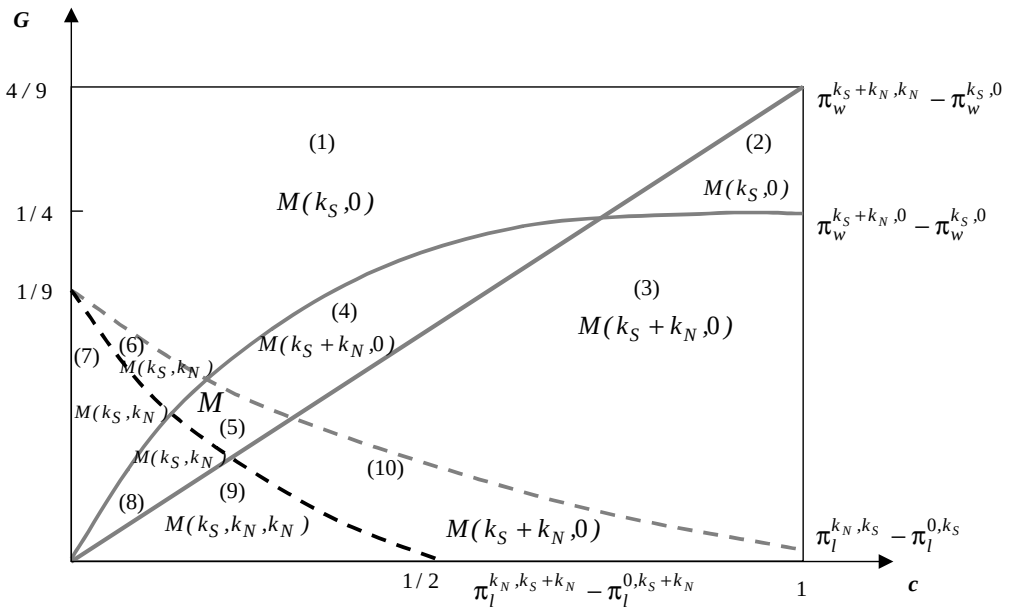

Figure 3.3: The equilibrium market structure in the VCS model.

The figure reveals that the tendency for monopolization when greenfield investment cost are high that is found in the TCS model carries over to the VCS model. For high levels of the greenfield cost, the EMS is also a monopoly in this model. The complimentary between the state assets and the new assets strengthens this result, since it will now be more profitable to obtain the state assets due to the strengthened first-mover advantage. Low levels of greenfield costs tend to give rise to duopolies such as EMS, as in the TCS model. For very strong learning effects or complementaries, however, the strengthened first-mover advantage implies that firm l will not find it profitable to invest greenfield. Consequently, the EMS will be a monopoly.

Note that the benefits from being the first mover by acquiring the state assets are competed away in the bidding competition among the two potential buyers. Actually, the two firms' net profits are the same in equilibrium, due to the symmet-

ric setting. In an asymmetric setting, a first-mover may have a higher net profit. However, it also holds that when firms are asymmetric, some of the benefits from being the first-mover are competed away in the bidding competition.

4. Welfare

A central question is whether the privatization procedure market mechanism selects the socially most preferable buyer. A fundamental problem in determining the most preferred buyer is that the equilibrium price of the state asset is affected by government policy. In order to have a benchmark case, we assume that the government can make a take-it-or leave it offer to the equilibrium buyer in each market structure, which equals that buyer's maximum willingness to pay.[26] Furthermore, it is assumed that the government cannot affect either the greenfield cost or the trade cost. Using this approach, we will derive the socially most preferred buyer in a simplified version of the TCS Model to throw some light on possible conflicts between private and social incentives. In order to simplify the analysis, we make the following assumption:

Assumption A3 $P = 1 - Q$

Several forces affecting the welfare ranking of the buyers in the TCS Model can be identified. First, there is a trade-off between the productive efficiency entailed by concentration, captured by the increased sales price of the state assets, and the resulting loss of consumer surplus. This trade-off is only part of the picture, since concentration also leads to higher trade costs which, in turn, affect revenues and

[26] As shown above, the willingness to pay does not only depend on the buyer's identity, firm i, but also what will happen to the assets if firm i does not obtain them. Here, we assume that the government can commit to give the state assets to the alternative buyer who maximizes the buyer's willingness to pay.

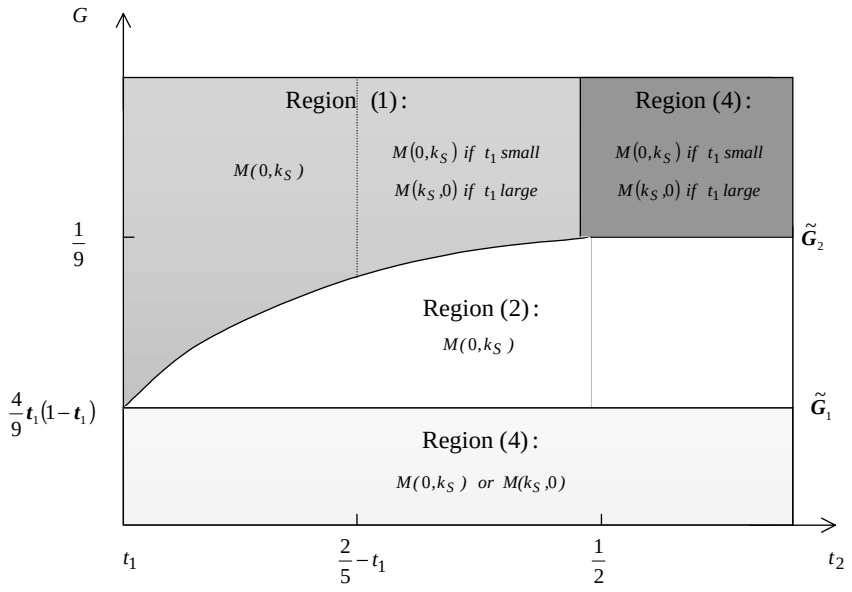

Figure 4.1: Socially most preferred market structure in the TCS model.

consumer surplus. Fig. 4.1 illustrates the pattern of the most preferred buyer for different values of t_i and G in the TCS Model under assumptions A1 and A3.

Several noteworthy features emerge from Figure 4.1. First, when greenfield costs are high — i.e., when one firm exports — the most preferred structure is not necessarily the structure with the low trade cost. The reason is that the sales price might be higher if the government sells to the firm with the lower trade cost, due to the anti-competitive and the business stealing effects. The trade cost effect countervails this effect, however, since the high trade cost firm is willing to pay more for the state assets, as it saves more on costs. Moreover, there is also a countervailing consumer surplus effect, which is negative when the low trade cost firm obtains the state assets. As can be seen in Figure 4.1, the anti-competitive and the business stealing effects dominate the cost saving and the consumer surplus effect for some parameter values.

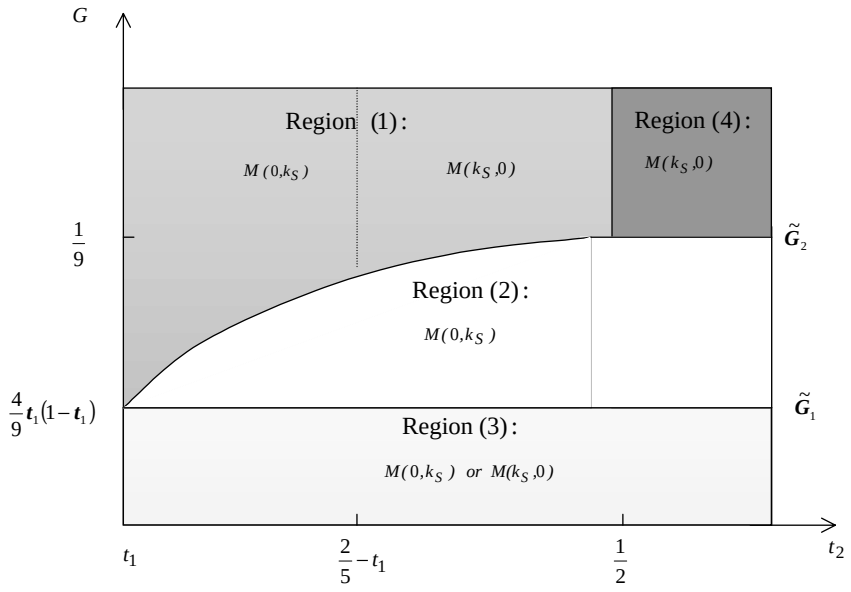

Figure 4.2: Equilibrium market structure in the linear TCS model.

Second, when only the high trade cost firm has an incentive for greenfield investments, one more effect is at work when comparing the two structures: the greenfield cost effect. In order to reach the ex post low trade cost structure, the ex ante high trade cost firm must invest greenfield, which increases the revenues from selling to the high cost firm. The high cost firm turns out to be the most preferred buyer, since the anti-competitive effect, the business stealing effect and the greenfield cost saving effect dominate the trade cost effect and the consumer surplus effect in this interval.

Let us now turn to a comparison between the most preferred buyer and the equilibrium buyer. Fig. 4.2 illustrates the equilibrium buyer for different values of t_i and G in the TCS Model under A1 and A3.

A comparison between the figures depicting the equilibrium buyer with those illustrating the socially most preferred buyer shows that there is a discrepancy between private social incentives for the identity of the buyer for sufficient high

trade cost differences.

5. Privatization and Investment Policy

The above results seem to imply that there is scope for welfare-enhancing policies. The endogenous nature of the buyer and the auction price in the present analysis, as well as the international dimension, imply that the optimal design of policy is very involved. We will therefore make a couple of remarks on policy that might indicate areas worthy of future investigations.

5.1. National Treatment in Privatizations

The National Treatment sets out the commitment of countries to treat foreign-controlled firms operating in their territories no less favorably than domestic enterprises in similar situations. In FDI literature, the National Treatment issue has mostly been discussed in the context of greenfield investments. Here, we will illuminate the concept of national treatment in the context of privatizations. Our first result follows from Lemma 2 and establishes that there is a fundamental difference between National Treatment in the context of privatizations and in the context of greenfield investment:

Corollary 2. *When a foreign firm enters by means of an acquisition in a privatization auction, it partly pays for the crowding out it creates.*

The Corollary illustrates that by selling the state assets to a foreign firm, the host country can capture some of the rents that foreign firms may generate in the host market. Consequently, the issue of national treatment in the context of mergers and acquisitions (M & A) differs from the context of greenfield, since in the former, but not in the latter, some of the crowding out created by the investment is partly paid for by the foreign investor.

This finding does not imply that a National Treatment leads to higher welfare, however. In order to illuminate the welfare issue, we compare two policies: (i) National Treatment: no discrimination between domestic and foreign buyers, and (ii) Protectionism: only domestic buyers are allowed to acquire.

It turns out that the mechanism identified above has implications for the models studied in this paper, as is shown in the following corollary:

Corollary 3. *In the TCS under A1 and in the VCS Model under A2, the National Treatment policy leads to higher welfare than the Protectionism policy, if at least one of the firms is a foreign firm.*

This is due to the fact that by selling the state assets to the foreign firm, the host country captures a share of the foreign firm's profit while also capturing the home firm's profit. By selling to the domestic firm, it still captures the home firm's profit but does not capture the foreign firm's profit. Moreover, the consumer surplus will be at least as high when the foreign firm obtains the assets. Consequently, the foreign firm is the socially preferred buyer.

It should be noted, however, that the strong result is due to the specific assumption in the model. The domestic firm might be the socially preferred buyer, if its acquisition leads to a substantial firm-specific cost saving. However, the Corollary illustrates that by selling the state assets to a foreign firm, the host country can capture some of the rents that foreign firms may generate in the host market. By selling to domestic firms, this possibility is removed.

Moreover, it should be noted that favoring special types of firms in privatizations might also affect future investments. For instance, consider the EMS in the TCS Model where only the firm with the high trade cost has an incentive to invest greenfield. Thus, in equilibrium firm 2 obtains the state assets and firm 1 exports. Suppose that the government makes a credible announcement that it

will not accept firm 2 as a buyer. This implies that firm 1 obtains the state assets and that the investment pattern will change, since firm 2 will invest greenfield in period 2.

5.2. Investment Guarantees

As mentioned in the Introduction, the practice of requiring future investment when selling state assets in order to ensure such investments — so called "Investment Guarantees" — is fairly widespread. Circumstances under which such practises would increase welfare are easily identified, particularly when there is only one potential buyer. When there are several potential investors, the issue is more complicated, however.

There are some immediate implications for this issue in our model. Consider the VCS Model, and assume that we are in the equilibrium where only firm l invests in period 2. Furthermore, assume that it is not profitable for firm l to invest if firm w has invested greenfield. Suppose now that the government requires the buyer of the state assets to invest in period 2. The following Corollary shows that the Investment Guarantee in this situation can reduce welfare:

Corollary 4. *An Investment Guarantee can reduce welfare, since it might prevent future entry.*

Proof. See the Appendix. ■

The intuition is that the Investment Guarantee helps the first-mover prevent the second-mover from entering greenfield by "over investing". This "over-investment" is not credible without the Investment Guarantee.

5.3. Investment policy

Governments can affect investment costs in numerous ways. For instance, location subsides and tax reductions can contribute to lower investment costs. The design of investment policy will be complicated by the fact that it does not only affect the firms' incentives for greenfield investment and exports,[27] but also affects the sales price at the auction. In order to highlight the strategic effects of the investment policy, it is assumed that changing G will not directly affect the government's budget. Fig. 5.1 illustrates the welfare levels in the TCS Model under A1 and A3 for different values of t_2 and G, for $t_1 = 0.1$.

Several noteworthy features emerge from this figure. First, Investment policy might reduce the welfare in the host country, also when it leads to increased investment in the host market and when associated with no direct costs. By inducing greenfield entry, the revenues from selling the state assets decrease, since the value of owning the state assets then decreases. It turns out that, for some parameter values, the loss in revenues dominates the increase in consumer surplus resulting from the higher level of production in the market. Thus, we have the following result:

Corollary 5. *Investment subsidies to foreign firms might reduce welfare, since it leads to a lower sales price of the state assets.*

Second, the highest welfare in the TCS model will be for high greenfield costs and medium high trade cost differences. The reason is that the sales price increases with the trade cost differences in this interval, as it leads to a stronger anti-competitive and business stealing effect and a weaker trade cost saving effect.

[27] See, for instance, Brainard (1997), Markusen (1997) and Sanna-Randaccio (1996) on this issue.

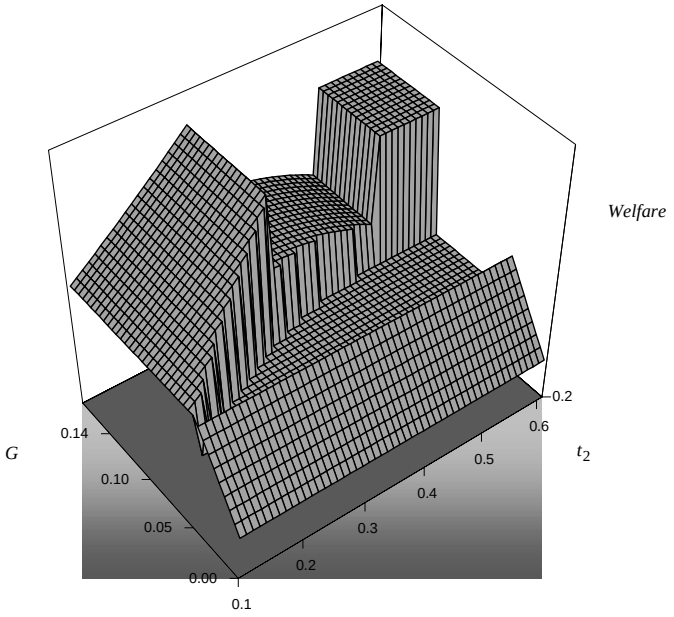

Figure 5.1: Welfare in the linear TCS model.

6. Robustness of results

The model in this paper is obviously restrictive in its use of functional forms. In this section, we show that the mechanisms highlighted in the TCS and VCS Model are also at work in a more general set-up. To this end, consider an oligopoly model with two firms, competing in either Cournot or Bertrand fashion, with the standard stability criteria fulfilled. We then know that Lemma 2 applies and, consequently, that the state assets are sold in equilibrium. Some more notation is need before proceeding: G_i^N refers to the set-up cost for firm $i = w, l$ when not possessing the state assets, and G_i^E is the set-up cost when possessing the state assets. Moreover, the only asymmetry between the firms is assumed to be that

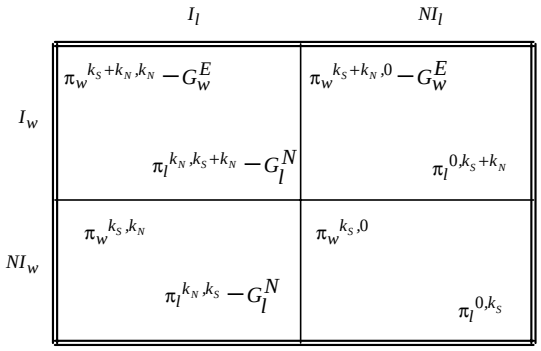

Figure 6.1: The general investment game.

$t_2 > t_1$.The investment game is then illustrated in figure[28] 6.1:

The Lemma then identifies the investment behavior in equilibrium:

Lemma 6. *In equilibrium.*

*(**1**) both firms invest if (1) w1 and l1, (2) w1 and l3, or (3) w3 and l1 hold.*

*(**2**) only firm w invests if (1) w1 and l2, (2) w1 and l4, or (3) w4 and l2 hold.*

*(**3**) only firm l invests if (1) w2 and l1, (2) w2 and l4, or (3) w4 and l1 hold.*

*(**4**) either firm w, or firm l, or both firms use a mixed strategy if w4 and l4 hold.*

*(**5**) no firm invests if (1) w2 and l2, (2) w2 and l3, or (3) w3 and l2 hold.*

*(**6**) either both firms invest or no firm invests if w3 and l3 hold.*

*(**7**) both firms use a mixed strategy if w3 and l4, or w4 and l3 hold.*

*(**8**) (1)-(7) exhaust all possible orderings of the profits.*

Proof. Follows from the proof of Lemma 5. ■

[28]Note that the payoffs in the investment game will depend on which firm obtained the state-assets.

Our aim is to show that the mechanisms identified in the TCS model are not model specific. Lemma 6 establishes the importance of the anti-competitive effect and the business stealing effect as a determinant of the equilibrium market structure also in a more general setting. For a high enough greenfield cost, it follows from Lemma 6 that no firm invests in the greenfield game. Lemma 2 then establishes that firm 1 obtains the assets iff $\pi_1^{k_S,0}(0,t_2)+\pi_2^{0,k_S}(t_2,0) > \pi_2^{k_S,0}(0,t_1)+\pi_1^{0,k_S}(t_1,0)$ and firm 2 obtains the assets iff the inequality is reversed. It then follows that $\pi_1^{k_S,0}(0,t_2)+\pi_2^{0,k_S}(t_2,0) \geq \pi_2^{k_S,0}(0,t_1)+\pi_1^{0,k_S}(t_1,0)$ for a sufficiently large t_2, since firm 1 then becomes a monopolist, if obtaining the state assets. In most oligopoly models, a monopoly profit is larger than two duopoly profits. Thus, the finding that the low-trade cost firm obtains the state assets when the trade cost difference is large and greenfield is not an option also holds under more general assumptions about costs, demand, and mode of competition.

Second, the reverse order effect is not specific to the TCS model either. To see this, consider the situation where firm 2, but not firm 1, would invest greenfield if the other firm obtained the state assets, and where no firm would make an additional investment. It then follows from Lemma 2 that firm 2 obtains the assets iff $\pi_2^{k_S,0}(0,t_1)+\pi_1^{0,k_S}(t_1,0) > \pi_1^{k_S,k_N}(0,0)+\pi_2^{k_N,k_S}(0,0)-G_2^N$. Using that $\pi_1^{k_N,k_S}(0,0)=\pi_2^{k_S,k_N}(0,0)$ and $G_1^N=G_2^N$ implies that (i) $\pi_1^{0,k_S}(t_1,0)-(\pi_2^{k_N,k_S}(0,0)-G_2^N)=\pi_1^{0,k_S}(t_1,0)-(\pi_1^{k_N,k_S}(0,0)-G_1^N)>0$, since firm 1 does not find it profitable to make a greenfield investment, and (ii) $(\pi_2^{k_S,0}(0,t_1)-\pi_1^{k_S,k_N}(0,0))=(\pi_2^{k_S,0}(0,t_1)-\pi_2^{k_S,k_N}(0,0))>0$ if $\frac{d\pi_j^{k_j,k_i}}{dt_j}>0$. Consequently, $\pi_1^{0,k_S}(t_1,0)-(\pi_2^{k_N,k_S}(0,0)-G_2^N)+(\pi_2^{k_S,0}(0,t_1)-\pi_1^{k_S,k_N}(0,0))>0$, and thus the firm with the credible greenfield investment (firm 2) obtains the state assets.

7. Concluding discussion

This paper determines the equilibrium buyer and the equilibrium market structure in an international oligopoly opened up by a privatization. It is shown that market power is an important determinant of the equilibrium market structure when greenfield investment costs are high. The results thus suggest the importance of taking the risk of monopolization into account when privatizing in an open economy. When the costs of greenfield investments are low, however, the risk of monopolization decreases.

Furthermore, the paper establishes that the extent to which the tariff jumping argument, i.e. that high trade barriers induce firms to invest abroad, is valid depends on the entry mode: when entry takes place through an acquisition, i.e. when greenfield costs are high, the firm facing the lower trade cost obtains the state assets. In the case with low greenfield costs, on the other hand, higher trade costs make entry more profitable.

Furthermore, we show that the bidding behavior in the privatization procedure and the incentives for greenfield investment and exports interact. For instance, the paper shows that the potential negative effects of a National Treatment through crowding out is partly mitigated in privatizations, since the negative externalities on domestic firms created by the acquisition are partly paid for by the foreign investor in the bidding competition over the state assets. It is also shown that "Investment Guarantees" can be counterproductive, in the sense of leading to more concentrated markets. The intuition is that the Investment Guarantee helps the buyer of the state assets prevent other investors from entering greenfield by "over investing".

Another complicating factor for the design of privatization policy is the fact that potential buyers might have an incentive to obstruct the selling of the state

assets. The stronger are the negative externalities exerted by the state assets, the higher is the price the firms are willing to pay. But, the buyer's net profit does not increase by the same amount in relation to the initial situation, absent the state assets. This is due to the fact that the buyer then mainly pays a high price in order to prevent other buyers from using the assets and less to increase his profit relative to the situation without the assets.

In the specific models used in this paper, the valuations of the state assets are positive, and thus imply a positive equilibrium price. If the state assets are sufficiently less efficient than the new assets, however, the state assets might exert positive externalities. To see this, assume that it is profitable for firm l but unprofitable for firm w, to invest greenfield. Firm l then prefers the state assets to stay in the market, since this prevents the competitor from investing in new, more efficient, technology. Actually, it might be the case that the positive externalities imply that a firm's willingness to pay is less than zero. Consequently, the government must pay the buyer for obtaining the assets.

A. Appendix: The privatisation process

A.1. Proof of Lemma 1

In this proof and in the proof of Lemma 2, we will use the following more general notation of the valuation of the state assets: Generally, the valuations of the state assets do not only depend on the identity of firm i, but also on the identity of the firm obtaining the assets, firm j, and on the identity of the firm that will obtain the assets if firm j does not, that is, firm h. Some notation is required in order to define a firm's valuation. Let $\mathbf{K} \equiv (k_1, k_2, k_s)$. Let $\mathbf{K}^j$ denote the vector of capital stocks after firm j has obtained the state assets and $\pi_i(\mathbf{K}^j)$ denote the profit made by firm i when firm j has acquired the state assets. Then, the valuation for firm i, v_i^{jh}, is defined: $v_i^{jh} \equiv \pi_i(\mathbf{K}^j) - \pi_i(\mathbf{K}^l)$

Consider selling rule α and a vector of bids, $\mathbf{b}$. (i) $b_i \geq \max_j v_i^{ij}$. We have two cases to consider: (A) The case where firm i has made a bid such that it obtains the state assets. (B) The case where firm i does not obtain the state assets. (1) Let $b_i > b_{j^*}$, $\forall j^*$, where j^* is all j : if $b_j > b_i$, buyer i will not obtain the assets. Buyer i's payoff is $v_i^{i0} - b_i$. But buyer i might then deviate, bidding b_i', and not decrease his payoff for if $b_i' > b_{j^*}$ $\forall j^*$, he still obtains the assets but pays less, and if $b_i' < b_{j^*}$, for some j^* he improves his payoff, since $v_i^{j^*0} - (v_i^{i0} - b_i) > -v_i^{ij^*} + b_i > 0$. (2) Let $b_i < b_{j^*}$, for some j^*. Buyer i's payoff is $v_i^{j^*0}$. But buyer i might then deviate, bidding b_i', without changing his payoff.

(ii) $b_i \leq b_i'$. Let $b_i > b_{j^*}, \forall j^*$. Buyer i's payoff is $v_i^{i0} - b_i$. Then, we cannot find a b_i'' such that $\Pi_i(\mathbf{b}'') \geq \Pi_i(\mathbf{b})$ $\forall \mathbf{b}$, for if $b_i'' > b_i$, $\Pi_i(\mathbf{b}'') < \Pi_i(\mathbf{b})$, and if $b_i'' < b_i$, firm j^* might obtain the assets and that $b_{j^*} \leq v_i^{ij^*}$. Thus, $\Pi_i(\mathbf{b}'') < \Pi_i(\mathbf{b})$ and b_i is not dominated. ■

A.2. Proof of Lemma 2

Let $v_i^{ij} > v_j^{ji}$ without loss of generality. First, consider the equilibrium candidate where firm i acquires the state assets. Consider the equilibrium candidate $\mathbf{b}^*$, where $b_i^* > b_j^*$, $j \neq i$. Let owner i be the owner obtaining the state assets. Note that $b_i^* > v_i^{ij}$ is a weakly dominated strategy, since no owner will post a bid over its maximum valuation of obtaining the assets. If $b_i^* < v_j^{ji}$, firm j benefits from deviating to $b_j^{**} = b_i^* + \varepsilon$, since it then obtains the assets according to Definition 2 and pays a price for the assets which is lower than its valuation of obtaining them. Last, consider candidate $b_i^* = v_j^{ji}, .b_j^* = v_j^{ji} - \varepsilon$. Then, no owner has an incentive to deviate. Thus, this is a Nash equilibrium and the only NE where firm i obtains the assets.

Let us now show that this is the only Nash equilibrium.

First consider the situation where firm j obtains the assets. Consider the equilibrium candidate $\mathbf{b}^*$, where $b_j^* > b_i^*$, $j \neq i$. But we know that in equilibrium, $b_j^* < v_j^{ji}$, since firm j is otherwise playing a weakly dominated strategy. But if $b_j^* < v_j^{ji}$, firm i benefits from deviating to $b_i^{**} = b_j^* + \varepsilon$, since it then obtains the assets according to Definition 2 and pays a price for the assets which is lower than its valuation of obtaining them. Thus, firm j obtaining the assets it is not an equilibrium.

Second, note that the situation where neither firm i nor firm j obtains the assets cannot happen if there is no reservation price at the auction. ■

B. Appendix: The TCS model

B.1. Derivation of (3.1)

Aggregate profit, $\Pi = \pi_w + \pi_l$, where

$$\pi_w = P(q_w + q_l)q_w - t_w q_w \tag{B.1}$$

$$\pi_l = P(q_w + q_l)q_l - t_l q_l \tag{B.2}$$

The FOCs are:

$$\frac{\partial \pi_w}{\partial q_w} = P + P'q_w - t_w = 0 \tag{B.3}$$

$$\frac{\partial \pi_w}{\partial q_w} = P + P'q_w - t_l = 0 \tag{B.4}$$

Differentiating (B.3) (B.4) wrt q_w, q_l, and t_l and solving for $\frac{dq_w}{dt_l}$, $\frac{dq_l}{dt_l}$ and $\frac{dQ}{dt_l}$ implies

$$\frac{dq_w}{dt_l} = -\frac{P' + P''q_w}{D} > 0, \qquad \frac{dq_l}{dt_l} = \frac{2P' + P''q_w}{D} < 0, \qquad \frac{dQ}{dt_l} = \frac{P'}{D} < 0 \tag{B.5}$$

where $D = P'[3P' + P''Q] > 0$ and $Q = q_w + q_l$. We can then define aggregate profits as a function of t_l:

$$\Pi(t_l) = \pi_w(q_w(t_l), q_l(t_l), t_l) + \pi_l(q_w(t_l), q_l(t_l), t_l) \tag{B.6}$$

Taking the total derivative in t_l and using (B.1), (B.2), (B.3) and (B.4), (B.6) can be written:

$$\frac{d\Pi}{dt_l} = P'q_w\frac{dq_l}{dt_l} + P'q_l\frac{dq_w}{dt_l} - q_l \tag{B.7}$$

Using the first-order conditions (B.3) and (B.4) and that $\frac{dQ}{dt_l} = \frac{dq_w}{dt_l} + \frac{dq_l}{dt_l}$ must hold, (B.7) can be rewritten as:

$$\frac{d\Pi}{dt_l} = P'q_w\frac{dQ}{dt_l} + (t_l - t_w)\frac{dq_w}{dt_l} - q_l \tag{B.8}$$

■

B.2. Proof of Lemma 3

First, we rewrite $\Pi(t_l)$ by inserting (B.5) into (B.7). Defining the elasticities $\varepsilon_Q = \frac{P''}{P'}Q$ and $\varepsilon_{q_w} = \frac{P''}{P'}q_w$, (B.7) can be written:

$$\frac{d\Pi}{dt_l} = \frac{q_w}{3+\varepsilon_Q} + \frac{1+\varepsilon_{q_w}}{3+\varepsilon_Q}(q_w - q_l) - q_l \tag{B.9}$$

We then proceed by deriving the following Lemma:

Lemma 7. *(i)* $\frac{d\Pi}{dt_l}(t_l = 0) < 0$*, (ii)* $\Pi(t^{\max}) > \Pi(t_l = 0)$*, and (iii)* $\Pi(t_l)$ *is convex in* t_l *if demand is linear.*

Proof. (1) If demand $P(Q)$ is strictly concave $\varepsilon_Q \geq 0$ and $\varepsilon_{q_w} \geq 0$, since $P' < 0$ and $P'' \leq 0$.[29].

(i) Then, if $t_l = 0 = t_w$ we must have $q_w = q_l = q$, which implies $\frac{d\Pi}{dt_l}(0) = -q\frac{2+\varepsilon_Q}{3+\varepsilon_Q} < 0$.

(ii) At $t_l = t^{\max}$, firm w becomes a monopolist and thus $\Pi(t^{\max}) > \Pi(t_l = 0)$

(iii) If demand is linear, $P' < 0$ and $P'' = 0$, this implies $\varepsilon_Q = 0$ and $\varepsilon_{q_w} = 0$. Inserting into (B.9) implies:

$$\frac{d^2\Pi}{dt_l^2} = \frac{10}{9b} > 0 \tag{B.10}$$

■

From Lemma 7, it follows that there exists a unique minimum, which we denote t^*. Moreover it follows that for $t_l' < t^*$ there exists a larger $t_l = t^{**} < t^{\max}$: $\Pi(t^{**}) > \Pi(t_l')$. ■

[29]Note that stability in the Cournot model demands that each firm's reaction function slopes downwards, that is, $P' + q_h P'' < 0$ for $h = w, l$. This condition holds if industry marginal revenue also slopes downwards or $P' + QP'' < 0$. Rewriting these conditions, we can establish that $\varepsilon_Q > -1$ and $\varepsilon_{q_w} > -1$ must hold. Our assumption of concave demand surely satifies these conditions.

B.3. Proof of Proposition 1

Lemma 2 implies that the firm with the highest valuation, firm i, obtains the assets at a price v_{ji}.

(**1**) $t^G > t_2 > t_1$. In this interval, none of the firms will undertake a greenfield investment. It then follows from Lemma 3 that firm 1 obtains the assets at a price $v_{21}(1)$ for $t^G > t_2 > t_1$ if $t_1 \geq t^*$ or if $t_1 < t^*$ and $t_2 > t^{**}(t_1)$, firm 2 obtains the assets at a price $v_{12}(1)$ for $t^G > t_2 > t_1$ if $t_1 < t^*$ and $t_1 < t_2 < t^{**}(t_1)$.

(**2**) $t_2 > t^G > t_1$. In this interval, only firm 2 will undertake a greenfield investment and the values are thus $v_{12}(2) = \pi_1^d(0,0) - \pi_1^d(t_1,0)$ and $v_{21}(2) = \pi_2^d(t_1,0) - (\pi_2^d(0,0) - G)$. It then follows that $v_{21}(2) > v_{12}(2)$ since $v_{21}(2) - v_{12}(2) = \pi_1^d(t_1,0) - (\pi_2^d(0,0) - G) + (\pi_2^d(t_1,0) - \pi_1^d(0,0)) > 0$. This follows from (i) $\pi_1^d(t_1,0) - (\pi_2^d(0,0) - G) = \pi_1^d(t_1,0) - (\pi_1^d(0,0) - G) > 0$, since firm 1 does not find it profitable to make a greenfield investment, and (ii) $\pi_2^d(t_1,0) - \pi_1^d(0,0) = \pi_2^d(t_1,0) - \pi_2^d(0,0) > 0$, since $\frac{d\pi_i^h}{dt_j} > 0$.

(**3**) $t_2 > t_1 > t^G$. In this interval, both firm 1 and firm 2 will undertake a greenfield investment and the values are thus $v_{12}(3) = \pi_1^d(0,0) - (\pi_1^d(0,0) - G) = G = v_{21}(3)$ Thus, either firm 1 or firm 2 obtains the assets at a price G.

B.4. The linear TCS model

This section proves the statements in section 4 and section 5. Besides using A1 and A3, we shall assume that trade costs are $t_1 < t^{\max} = 0.5$.

B.4.1. Period 3

Quantities and profits in the eight market structures are given in Figure B.1.

	$M(k_S,0)$		$M(0,k_S)$	$M(k_S+k_N,0)$		$M(0,k_S+k_N)$	$M(k_S,k_N)$	$M(k_N,k_S)$	$M(k_S+k_N,k_N)$	$M(k_N,k_S+k_N)$
	$t_2<t^{max}$	$t_2>t^{max}$		$t_2<t^{max}$	$t_2>t^{max}$					
q_1	$\frac{1+t_2}{3}$	$\frac{1}{2}$	$\frac{1-2t_1}{3}$	$\frac{1+t_2}{3}$	$\frac{1}{2}$	$\frac{1-2t_1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
q_2	$\frac{1-2t_2}{3}$	0	$\frac{1+t_1}{3}$	$\frac{1-2t_2}{3}$	0	$\frac{1+t_1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
Q	$\frac{2-t_2}{3}$	$\frac{1}{2}$	$\frac{2-t_1}{3}$	$\frac{2-t_2}{3}$	$\frac{1}{2}$	$\frac{2-t_1}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$
π_1	$\left(\frac{1+t_2}{3}\right)^2$	$\left(\frac{1}{2}\right)^2$	$\left(\frac{1-2t_1}{3}\right)^2$	$\left(\frac{1+t_2}{3}\right)^2-G$	$\left(\frac{1}{2}\right)^2$	$\left(\frac{1-2t_1}{3}\right)^2$	$\frac{1}{9}$	$\frac{1}{9}-G$	$\frac{1}{9}-G$	$\frac{1}{9}$
π_2	$\left(\frac{1-2t_2}{3}\right)^2$	0	$\left(\frac{1+t_1}{3}\right)^2$	$\left(\frac{1-2t_2}{3}\right)^2$	0	$\left(\frac{1+t_1}{3}\right)^2-G$	$\frac{1}{9}-G$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}-G$

Figure B.1: Quantities and profits in the linear TCS model.

B.4.2. Period 2

From the information in Fig. B.1, it can be shown that the combination of Greenfield costs and trade costs at which each firm is indifferent between setting up a new plant and exporting is given by:

$$\tilde{G}_2 = \begin{cases} \frac{4}{9}t_2(1-t_2) & \text{if } t_2 < \frac{1}{2} \\ \frac{1}{9} & \text{if } t_2 > \frac{1}{2} \end{cases} \tag{B.11}$$

$$\tilde{G}_1 = \frac{4}{9}t_1(1-t_1) \tag{B.12}$$

There are four regions to consider. In Fig. 4.1, these are drawn in the $\triangle tG$-space and indicated (1)-(4). Region (1) consists of combinations of t_2 and G above the line $\tilde{G}_2$ for $t_2 < \frac{1}{2}$. Region (2) consists of combinations of t_2 and G between lines $\tilde{G}_2$ and $\tilde{G}_1$. Region (3) consists of combinations of t_2 and G below lines $\tilde{G}_2$ and $\tilde{G}_1$. Region (4) consists of combinations of t_2 and G above the line $\tilde{G}_2$, where $t_2 > \frac{1}{2}$.

B.4.3. Period 1

Figure B.2 summarizes the firms' valuations v_{21} and v_{12}, the winning firm w, consumer surplus CS_w and sales revenues for the government R_w in the four regions.

	Region 1		Region 2	Region 3	Region 4
	$t_2 < \frac{2}{5} - t_1$	$t_2 > \frac{2}{5} - t_1$			
v_{12}	$\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$	$\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$	$\left(\frac{1}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$	$\left(\frac{1}{3}\right)^2 - \left(\left(\frac{1}{3}\right)^2 - G\right)$	$\left(\frac{1}{2}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$
v_{21}	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\left(\frac{1}{3}\right)^2 - G\right)$	$\left(\frac{1}{3}\right)^2 - \left(\left(\frac{1}{3}\right)^2 - G\right)$	$\left(\frac{1+t_1}{3}\right)^2 - 0$
w	*Firm 2*	*Firm 1*	*Firm 2*	*Firm 1 or Firm 2*	*Firm 1*
CS_w	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2$	$\frac{1}{2}\left(\frac{2-t_2}{3}\right)^2$	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2$	$\frac{1}{2}\left(\frac{2}{3}\right)^2$	$\frac{1}{2}\left(\frac{1}{2}\right)^2$
R_w	$\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2$	$\left(\frac{1}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$	G	$\left(\frac{1+t_1}{3}\right)^2$
W_w	$\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2 + \frac{1}{2}\left(\frac{2-t_1}{3}\right)^2$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2 + \frac{1}{2}\left(\frac{2-t_2}{3}\right)^2$	$\left(\frac{1}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2 + \frac{1}{2}\left(\frac{2-t_1}{3}\right)^2$	$\frac{1}{2}\left(\frac{2}{3}\right)^2 + G$	$\left(\frac{1+t_1}{3}\right)^2 + \frac{1}{2}\left(\frac{1}{2}\right)^2$
CS_l	$\frac{1}{2}\left(\frac{2-t_2}{3}\right)^2$	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2$	$\frac{1}{2}\left(\frac{2}{3}\right)^2$	$\frac{1}{2}\left(\frac{2}{3}\right)^2$	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2$
R_w^*	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2$	$\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\left(\frac{1}{3}\right)^2 - G\right)$	G	$\left(\frac{1}{2}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2$
R_{21}	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2 - \left[\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2\right]$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\frac{1-2t_2}{3}\right)^2 - \left[\left(\frac{1+t_2}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2\right]$	$\left(\frac{1+t_1}{3}\right)^2 - \left(\left(\frac{1}{3}\right)^2 - G\right) - \left[\left(\frac{1}{3}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2\right]$	0	$\left(\frac{1+t_1}{3}\right)^2 - \left[\left(\frac{1}{2}\right)^2 - \left(\frac{1-2t_1}{3}\right)^2\right]$
CS_{21}	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2 - \frac{1}{2}\left(\frac{2-t_2}{3}\right)^2$	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2 - \frac{1}{2}\left(\frac{2-t_2}{3}\right)^2$	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2 - \frac{1}{2}\left(\frac{2}{3}\right)^2$	0	$\frac{1}{2}\left(\frac{2-t_1}{3}\right)^2 - \frac{1}{2}\left(\frac{1}{2}\right)^2$
W_{21}	$R_{21} + CS_{21}$	$R_{21} + CS_{21}$	$R_{21} + CS_{21}$	0	$R_{21} + CS_{21}$

Figure B.2: Additional information to the linear TCS model.

In addition, it shows what the consumer surplus would have been, had the losing firm obtained the state assets CS_l and the winning firm's valuation R_w^*. Under the assumption that the government can make a take it or leave it bid to each firm, we also derive the difference in sales revenue when the government compares such bids to firm 2 and firm 1. This variable is defined $R_{21} = v_{21} - v_{12}$. Similarly, the difference in consumer surplus is calculated as $CS_{21} = CS_2 - CS_1$. Finally, we calculate the difference in welfare from selling the state assets to firm 2 as compared to selling the state assets to firm 1, $W_{21} = R_{21} - CS_{21}$.

B.4.4. Socially most preferred market structure

The information can be used to derive the socially preferred market structure, which can then be used as a benchmark to evaluate the equilibrium market structure. Firm 2 is the preferred buyer whenever $W_{21} > 0$, whereas firm 1 is the

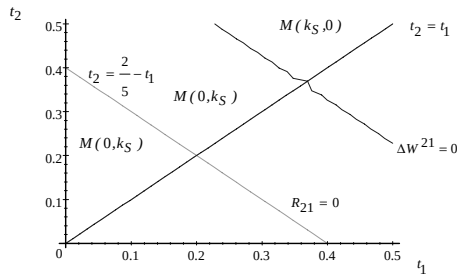

Figure B.3: Socially preferred market structure in Region 1.

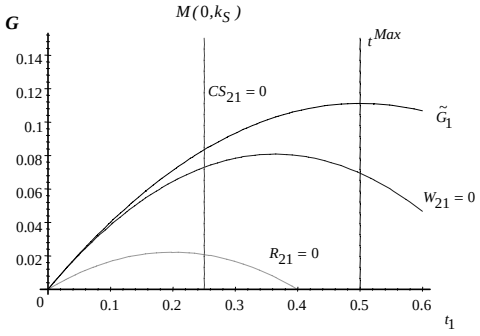

Figure B.4: Socially preferred market structure in Region 2.

preferred buyer whenever $W_{21} < 0$.

In region (1), $R_{21} = -\frac{1}{9}(t_2 - t_1)(5t_2 + 5t_1 - 2)$, $CS_{21} = -\frac{1}{18}(t_2 - t_1)(t_2 + t_1 - 4)$ and, finally, $W_{21} = -\frac{1}{18}(t_2 - t_1)(11t_2 + 11t_1 - 8)$. These expressions are plotted for region (1) in figure B.3. Note that region (1) consists of combinations of t_1 and t_2 below the line $t_2 = \frac{2}{5} - t_1$. This implies that $CS_{21} > 0$ in this region. In region (2), $R_{21} = \frac{1}{9}t_1(-2 + 5t_1) + G$, $CS_{21} = \frac{1}{18}t_1(-4 + t_1)$ and, $W_{21} = \frac{1}{18}t_1(-8 + 11t_1) + G$. These curves are drawn in figure B.4. In region (3), $R_{21} = CS_{21} = W_{21} = 0$. In region (4), $R_{21} = \frac{1}{36}(10t_1 + 1)(2t_1 - 1)$, $CS_{21} = \frac{1}{72}(2t_1 - 1)(2t_1 - 7)$ and, finally, $W_{21} = \frac{1}{72}(22t_1 - 5)(2t_1 - 1)$. These curves are drawn in figure B.5.

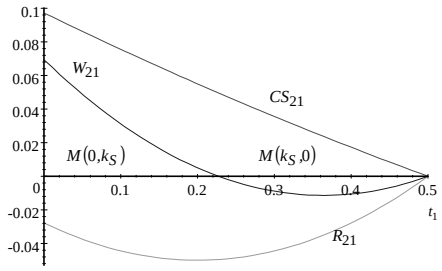

Figure B.5: Socially preferred market structure in Region 4.

C. Appendix: The VCS-model

C.1. Proof of Lemma 5

In order to derive the equilibria in the investment game, we use the inequalities $w1$-$w4$ and *l1-l4* defined in section 3.2.2. Sixteen combinations can arise and each combination is checked. We start by specifying the conditions giving rise to different types of equilibria These are depicted in Table C.1, where $\{I, NI\}$ denotes the equilibrium where firm w invests and firm l does not invest and so on, and $\{X^*, Y^*\}$ refers to a mixed strategy equilibrium.

In order to depict the equilibrium market structure in the cG space, each inequality is rewritten as a relationship between the greenfield cost G and the marginal cost c, where the following equalities are used

$$\begin{aligned}
\pi_w^{k_S+k_N,k_N} - \pi_w^{k_S,k_N} &= \tfrac{4c}{9} \\
\pi_w^{k_S+k_N,0} - \pi_w^{k_S,0} &= \tfrac{c}{4}(2-c) \\
\pi_l^{k_N,k_S+k_N} - \pi_l^{0,k_S+k_N} &= \tfrac{1}{9}(1-2c)^2 \\
\pi_l^{k_N,k_S} - \pi_l^{0,k_S} &= \tfrac{1}{9}(1-c)^2
\end{aligned}$$

The results are presented in Table C.1, which translates these conditions into

	{I,I}	{NI, NI}	{I, NI}	{NI, I}	{I, NI} {NI, I} {x*, z*}	{NI, I} {I, NI} {x*, z*}	{x*, z*}
Conditions: Region:	w1, l1 (9)	w2, l2 (1)	w1, l2 (3)	w2, l1 (7)	w4, l4 (5)	w3, l3 (-)	w4, l3 (-)
Conditions: Region:	w1, l3 (-)	w2, l3 (-)	w1, l4 (10)	w2, l4 (6)			w3, l4 (-)
Conditions: Regions:	w3, l1 (-)	w3, l2 (2)	w4, l2 (4)	w4, l1 (8)			

Figure C.1: The equilibrium of the investment game in the VSC model.

a region in figure 3.3.

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