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Endogenous Formation of Strategic Alliances in Oligopolistic Markets

von

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Abstract

This paper analyzes the incentives of oligopolistic firms to form strategic alliances and the effects of the endogenously derived alliance structure on product market competition. A three-stage-game is considered: In the first stage the firms decide about forming strategic alliances, in the second stage each alliance designs a strategic contract, and in the third stage alliance members and outsiders compete in the product market. In a linear Cournot oligopoly with less than five firms the alliance formation process leads to a perfect cartel; with more than five firms at least two alliances will form and competition will be enhanced.

JEL-classification: D21, D43, L13, L41

Key words: strategic alliances, oligopoly, strategic contracts

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1 Introduction

So called "strategic alliances" are becoming increasingly common in oligopolistic markets. While the management literature discusses almost all aspects of strategic alliances,[1] most of the economics literature concentrates on R&D cooperation.[2] Following *Porter/Fuller (1986)* a strategic alliance can be defined as a coalition, where partners remain independent firms which coordinate some of their activities while being competitors in other areas. But what is "strategic" about strategic alliances? In industrial economics the term "strategic" is used if firms take some action in stage 1 in order to influence the actions in stage 2 — the period 1's actions form a commitment for period 2. It is possible to distinguish between commitment through investment and commitment through contracting. Based on this idea, the term "strategic alliance" may be defined as the cooperation of at least two actual or potential competitiors in an oligopolistic market with perceived interdependence, where strategic investments (e. g. R&D investments) are coordinated and/or the alliance contract is used as a strategic device to change the incentives in the following stages (see *Welzel (1995)* for a similar concept).

The first aspect, coordinating strategic investments in order to internalize technological and competitive spillovers, has been discussed extensively in the literature on R&D cooperation.[3] In contrast my paper will concentrate on the second aspect: A strategic alliances aims to influence the behavior in product market competion by the means of a strategic contract between alliance members.[4]

Most of the literature about R&D cooperation and other forms of strategic alliances assume that all firms in the industry cooperate. In reality, however, cooperative aggreements tend to involve only part of the industry. There exist some papers where the decision to cooperate is endogenized.[5] However, with the exception of *Bloch (1992)* it is assumed that onlj' one alliance will form. Based on my formulation of strategic alliances this restriction would not be appropriate: The members of a strategic alliance may have an incentives to block the entry of another firm into the alliance; given this, the outsiders will be better off if they form a further alliance. Therefore an alliance formation process will be assumed where more than one alliance may form.

The remainder of the paper is organized as follows; In section 2 the concept of strategic alliances will be developed by discussing the following questions: How

[1] See for example the papers in *Contractor/Lorange (1988).*

[2] Notable exceptions are *Reynolds/Snapp (1986)* and *Kwoka (1992)* which both analyze production joint ventures.

[3] Most of this literature is based on the seminal contribution of *D'Aspremont/Jaquemin (1988)',* see the introduction of *Kamien/Muller/Zang (1992)* for an overview.

[4] For an analysis which integrates both aspects see *Morasch (1994, sections 3.2., 4.1 and 5.2).*

[5] See the seminal contribution by *Kat: (1986)* and the papers by *Bloch (1992),Combs (1993)* and *De Bondt/\Vu 1994-*

could the members of an alliance increase their profits by commiting to certain strategies in the production stage? How could such a commitment be achieved by designing an appropriate alliance contract? How will a given alliance structure affect the product market equilibrium? Based on this, in section 3 the incentives of firms to form a strategic alliance will be discussed, and the alliance structure which would result if firms can freely decide on forming strategic alliances will be derived.

2 Basic Concept of "Strategic Alliances"

In whatever way firms in an oligopolistic industry cooperate, this will affect product market competition. However, when some oligopolists form a cartel, a joint venture or merge, it is not assured that the profits of the member firms will rise relative to the initial equilibrium. Assuming quantity competition, joint profit maximization of the member firms calls for output reduction relative to the Cournot equilibrium. This, however, leads to an unintended strategic effect: Non–members will expand output which will negatively affect the profits of the member firms.[6] A strategic alliance — as defined in this paper — differs insofar from traditional cartels, joint ventures and mergers that the member firms are aware of this strategic effect and may use the alliance contract as a strategic commitment device.[7]

2.1 Effects of an Exogenous Change of Strategic Variables

When analyzing the incentives to join a strategic alliance, it is of central interest whether the members of the alliance will expand or contract output relative to the Cournot equilibrium: While expanding output hurts the outsiders, contracting output is beneficial to them. Therefore, the following problem will be discussed: Consider an oligopolistic industry composed of n firms in a Cournot equilibrium. Designate a subset of $k \leq n$ firms and marginally expand the outputs of the firms in the subset. If the remaining firms simultaneously make the best reply to this exogenous change, under what circumstances will the profits of the firms in the designated subset increase?

When analyzing the two extremes, $k = n$ and $k = 1$, it can be seen that the answer to this question depends on the relative strength of two opposing forces: With $k = n$ we have a perfect cartel of all firms and a contraction of output would be benefical — when playing Cournot–Nash the firms do not take into consideration that expanding

[6]See *Salant/Switzer/Reynolds (1983)* and *Farrell/Shapiro (1990)* for mergers, *Reynolds/ Snapp (1986)* for joint ventures and *D'Aspremont et. al. (1983)* for cartels.

[7]Using contracts as commitment devices has also been discussed in the context of managerial compensation (see *Fersthman/Judd, 1987*).

the own output has a negative external effect on the profits of the other oligopolists; this negative external effect will be internalized by a cartel. On the other hand, with $k = 1$ the firm should expand output as a Stackelberg leader does — if a firm commits to a higher output level, the other firms will reduce their output levels; this strategic effect leads to higher profits for the Stackelberg leader. If $1 < k < n$ either the first or the second effect may dominate.

As shown by *Gaudet/Salant (1991)* in a Cournot model with symmetric firms, it depends on cost and demand conditions whether a given number of alliance members would prefer to expand or contract output.[8] In this section I will derive the relevant conditions for a homogenous good Cournot oligopoly with asymmetric costs (insofar extending the analysis of *Gaudet/Salant, 1991*). Following *Farrell/Shapiro (1990)* I use the traditional model of a Cournot oligopoly with homogenous goods. Demand is given by $p(X)$, where p is price, X is industry output, and $p'(X) < 0$. There are n firms with cost functions $c_i(x_i)$. In order to assure stability of the Cournot equilibrium it is assumed that each firms reaction curve slopes downward [i. e. $p'(X) + x_i p''(X) < 0$] and that each firms residual demand curve intersects its marginal cost curve from above [i. e. $c_i''(x_i) > p'(X)$].

In order to analyze the effect of an exogenous change of output by the alliance members, I will make use of a basic comparative static property of the Cournot model (see *Farrell/Shapiro, 1990*): Consider the effect of a change in rivals aggregate output x_{-i} on firm i's output, which is given by the slope of the reaction curve of firm i:

$$\frac{dx_i}{dx_{-i}} \equiv R_i' = -\frac{p' + x_i p''}{2p' + x_i p'' - c_i''} \tag{1}$$

The stability conditions assure that $-1 < R_i' < 0$: If its rivals jointly expand production, a firm contracts its output, but by less than its rivals' expansion. The relation between the change of industry output and the change of firm i's output is given by $dx_i = -\lambda_i dX$ with

$$\lambda_i \equiv -\frac{R_i'}{1 + R_i'} = -\frac{p' + x_i p''}{c_i'' - p'}. \tag{2}$$

$\lambda_i > 0$ because $-1 < R_i' < 0$. In the following discussion it will prove easier to work with λ_i instead of R_i'.

Let X_α denote the aggregate output of the alliance members $\sum_{i=1}^k x_i$, Π_α their aggregate profits $\sum_{i=1}^k \pi_i$ and X_ω the aggregate output of outsiders $\sum_{i=k+1}^n x_i$. Furthermore it will be assumed that all alliance members change output proportionally, i. e. $dx_\alpha = 1/k\, dX_\alpha$. As discussed in *Morasch (1995)* this is the optimal strategy

[8] *Gaudet/Salant (1991)* did also show that the basic insights of the Cournot case are transferable to other specifications as long as the relevant variables are strategic substitutes. With strategic complements, however, a marginal expansion of the variable is always preferable.

as long as the marginal costs of member firms c'_α are identical and constant in the neighbourhood of the initial Cournot equilibrium (otherwise, changing the output mix within the alliance could be beneficial). If the alliance members marginally change their outputs relative to the Cournot equilibrium, their joint profits will change according to

$$\frac{\partial \Pi_\alpha}{\partial X_\alpha} = \left[p'(X) + p'(X)\frac{dX_\omega}{dX_\alpha}\right] X_\alpha + p(X) - \frac{1}{k}\sum_{i=1}^{k} c'_i \,. \tag{3}$$

Notice that dX_ω, the reaction of outsiders, is not given by the sum of individual reactions but by re–establishing a new Cournot equilibrium among the outsiders based on the exogenous change by the alliance firms. The term $1/k \sum_{i=1}^{k} c'_i$ results from the fact that the marginal costs of a firm are only affected by its own output changes $dx_i = 1/k dX_\alpha$. Summing up the first order conditions of the initial Cournot equilibrium for all alliance members leads to

$$p'(X)X_\alpha + kp(X) - \sum_{i=1}^{k} c'_i = 0. \tag{4}$$

Based on this, the term $p(X) - 1/k \sum_{i=1}^{k} c'_i$ in equation (3) may be substituted by $-1/k\, p'(X)X_\alpha$ and accordingly the equation may be rewritten as

$$\frac{\partial \Pi_\alpha}{\partial X_\alpha} = p'(X)X_\alpha \left[\left(1 - \frac{1}{k}\right) + \frac{dX_\omega}{dX_\alpha}\right]. \tag{5}$$

The term dX_ω/dX_α may be expressed as a function of each outsiders λ_i: If a firm behaves according to Cournot, its reaction on a change of output by other firms is given by $dx_i = -\lambda_i dX$; summing up the reactions of all outsiders and considering that $dX = dX_\alpha + dX_\omega$ we obtain $dX_\omega = -\sum_{i=k+1}^{n} \lambda_i(dX_\alpha + dX_\omega)$. Solving with respect to dX_ω/dX_α leads to

$$\frac{dX_\omega}{dX_\alpha} = -\frac{\sum_{i=k+1}^{n} \lambda_i}{1 + \sum_{i=k+1}^{n} \lambda_i}. \tag{6}$$

Notice that $p'(X)X_\alpha < 0$, and thus expanding output will lead to higher profits if

$$\frac{k - 1 - \sum_{i=k+1}^{n} \lambda_i}{k(1 + \sum_{i=k+1}^{n} \lambda_i)} < 0. \tag{7}$$

Because $\lambda_i > 0$, the denominator in (7) always exceeds zero; thus the condition may be reduced to

$$k < 1 + \sum_{i=k+1}^{n} \lambda_i. \tag{8}$$

To sum up: An exogenous expansion of output by a group of Cournot oligopolist will be attractive for these firms as long as the number of firms in the group does not exceed an expression which depends on the number of outsiders and the reactions of these outsiders on an exogenous change of output. With linear demand and cost the critical number is $(n+1)/2$. If the reactions of outsiders are relatively weak $[\sum_{i=k+1}^{n} \lambda_i < n-k)]$, it may be attractive to reduce output even if less than $(n+1)/2$ firms are in the group; if the reaction of outsiders is relatively strong $[\sum_{i=k+1}^{n} \lambda_i > n-k]$, it may be attractive to expand output even if more than $(n+1)/2$ firms are in the group. When analyzing the three-stage-game, a linear Cournot model will be considered: This allows me to explicitly derive the alliance structure as a function of the number of firms in the industry. However, together with the results of this section I am also able to make some statements about the case with general demand and cost conditions.

2.2 Designing a Strategic Contract

In the preceeding section it has been discussed whether an exogenous expansion or contraction of output is profitable for a group of Cournot oligopolists. Now it will be shown how a group of firms — the members of the strategic alliance — may commit to a specific output level by signing a strategic contract: The incentives in the product market will be changed, if the contract somehow stipulates payments between the alliance members which are based on their individual output decisions.[9] The contract has to be binding and must be observed by the other firms in the industry — a secret agreement would not induce any reaction by outsiders.

In order to formally describe the strategic contract, it is necessary to introduce some notation. It is assumed that more than one strategic alliance may form in the first stage of the game. The alliance structure — number and size of strategic alliances — will be expressed by $(n; k_1, \ldots, k_z)$ with z being the number of alliances and $k_j \leq n$ indicating the number of firms which comprise alliance αj (the index j will be used to indicate alliances, while i will be used to indicate firms). The output of firm a i which belongs to an alliance αj will be denoted by $x_i^{\alpha j}$, $i \in \{1, \ldots, k_j\}$.

The alliance contract of alliance αj will stipulate output based payments μ_j.[10] The output based payments to an alliance member i will be shared equally by the other

[9]The strategic contract could also explicitly fix the output decision of each member firm. However, as argued by *Ferstheman/Judd (1987)* in the context of strategic contracts between owners and managers, such "forcing contracts" will be inferior if there is uncertainty about demand or other environmental aspects: The firms are better off if they are able to react to environmental changes.

[10]It will be assumed that the μ_j are identical for all member firms of alliance αj. This is optimal as long as all alliance members have identical and constant marginal costs — with different or changing marginal costs, a change of the output mix within the alliance could lead to efficiency gains. Because I want to concentrate on the competition effect of strategic alliances, I will abstract from this possibility.

$k-1$ member firms: If they are positive, each of the other alliance members will contribute $1/(k-1)$ of the sum; if they are negative, each firm will receive $1/(k-1)$ of the sum. Thus the net transfer to firm i is given by:

$$t_i^{\alpha j}(x_1,\ldots,x_{k_1}) = \mu_j x_i^{\alpha j} - \mu_j \frac{1}{k_j-1}\sum_{\substack{l=1 \\ l\neq i}}^{k_j} x_l \tag{9}$$

How will such a contract change incentives? Positive output based payments μ_j lead an alliance member to expand output relative to the Cournot level, negative payments will induce an output reduction.

In practice it is not common that firms forming a strategic alliance sign a contract which stipulates payments based on production decisions (besides, such contracts may be banned by antitrust legislation). However, the same effect may be achieved if the cooperating firms establish a production joint venture for an intermediate product, agree on an appropriate transfer price, and equally share in the resulting profits or losses of the joint venture. In this case a member firm will reduce output if the transfer price exceeds the marginal costs of the intermediate product and expand output if it has to pay less than the marginal costs. As shown in *Morasch (1994, pp. 90–94)* forming a joint venture with an appropriate transfer price is formally equivalent to signing an alliance contract with output based payments. Furtheron it will be assumed that the alliance members sign an alliance contract, because this formulation is easier to handle in the three–stage–game.

The strategic contract aims to infuence the behavior in product market competition. Based on the discussion in the last section the optimal contract must balance two effects: The incentive to reduce output because external effects between partner firms are internalized, and the strategic incentive to increase output. Suppose that only one strategic alliance has been formed. If the member firms want to determine the optimal output based payments, they have only to consider the expected reactions of the outsiders. If this is done appropriately, the alliance will behave as a Stackelberg leader relative to outsiders. With more than one alliance the determination of μ_j becomes somewhat more complex: In subsection 2.3 a two–stage game will be analyzed where in the first stage an exogenously given number of strategic alliances simultaneously decide about the output based payments μ_j and in the second stage the members of these alliances and the outsiders compete in a linear Cournot oligopoly.

2.3 Product Market Equilibrium with Strategic Alliances

Suppose there is a given alliance structure $(n; k_1, \ldots, k_z)$ and each alliance αj designs a contract with output based transfer payments μ_j. How will product market competition be affected? The μ_j will change the incentives of the cooperating firms in the same way as a change in marginal costs by the same amount would have done. Further on it will be assumed that all firms have identical cost functions $c_i(x_i) = cx_i$. Thus the profit function of firm i which is member of alliance αj is given by:

$$\pi_i^{\alpha j}(\mu_j) = [p(X) - c]x_i^{\alpha j} + \mu_j x_i^{\alpha j} - \mu_j \frac{1}{k_j - 1} \sum_{\substack{l=1 \\ l \neq i}}^{k_j} x_l \tag{10}$$

This leads to the following first order condition:

$$p(X) + x_i^{\alpha j} p'(X) - c + \mu_j = 0 \tag{11}$$

The equilibrium outputs in a quantity setting oligopoly with strategic alliances are the same as in an asymmetric Cournot oligopoly with marginal costs $c - \mu_j$ for firms which belong to alliance αj and c for outsiders (which will be indicated by the superscript ω). If firms have different marginal costs c_i, the Cournot–Nash equilibrium is implicitly given by

$$x_i^* = -\frac{p(X^*) - c_i}{p'(X^*)}. \tag{12}$$

The market price in equilibrium, p^*, may be derived by summing up the first order conditions of all firms and solving the resulting equation with respect to p. The summation leads to

$$p'(X)X + np(X) - \sum_{i=1}^{n} c_i = 0. \tag{13}$$

In order to solve equation (13), the inverse demand function $p(X)$ has to be explicitly specified. For the sake of simplicity linear demand $p(X) = 1 - X$ will be assumed;[11] thus total output in equilibrium is given by $X^* = (1 - p^*)$. Substituting p and X in equation (13) by p^* and $1 - p^*$, respectively, we obtain p^* as a function of marginal costs:

$$p^* = \frac{1 + \sum_{i=1}^{n} c_i}{n + 1} \tag{14}$$

Substituting $p(X^*)$ in equation (12) by the expression on the right hand side in equation (14) and c_i by $c - \mu_j$ and c, respectively, the equilibrium ouputs in the second stage may be derived as a function of the output based payments:

$$x_i^{\alpha j}(\mu_1, \ldots, \mu_z) = \frac{1 - c + (n+1)\mu_j - \sum_{l=1}^{z} k_l \mu_l}{(n+1)} \tag{15}$$

$$x_i^{\omega}(\mu_1, \ldots, \mu_z) = \frac{1 - c - \sum_{l=1}^{z} k_l \mu_l}{(n+1)} \tag{16}$$

[11] Only the effect on the relative magnitude of profits will be relevant for the decision about forming strategic alliances and thus on the qualitative results on competition. Therefore these results would not be affected if $p(X) = a - bX$ is assumed instead.

If the equilibrium outputs are substituted in equation (10), the profits of alliance members are obtained as a function of the alliance structure $(n; k_1, \ldots k_z)$ and the transfer payments μ_j. Based on this, we can solve the game on the second stage and obtain the subgame perfect Nash–equilibrium transfer payments as follows:

$$\mu_j^* = \frac{(1-c)(n+1-2k_j)}{k_j[(z+1)(n+1) - 2\sum_{l=1}^{z} k_l]} \tag{17}$$

Because $[(z+1)(n+1) - 2\sum_{l=1}^{z} k_l] > 0$, alliance αj will use positive output based payments as long as $k < (n+1)/2$. If there is only one strategic alliance, the member firms of an alliance comprising less than $(n+1)/2$ firms will increase output relative to the initial Cournot equilibrium. However, with more than one alliance this is not assured, because the strategic contracts of the other alliances will also affect the output decision of a member firm of alliance αj.

The profits of a firm which is a member of alliance αj and of an outsider are given by:

$$\pi_i^{\alpha j} = \frac{n+1-k_j}{k_j} \frac{1}{[(z+1)(n+1) - 2\sum_{l=1}^{z} k_l]^2} \tag{18}$$

$$\pi_i^{\omega} = \frac{1}{[(z+1)(n+1) - 2\sum_{l=1}^{z} k_l]^2} \tag{19}$$

The profits of an alliance members exceed the profits of an outsider if less than $(n+1)/2$ firms are partners of a strategic alliance, i. e. if the alliance uses positive output based payments. This result is of central interest for the question of alliance formation, which will be discussed in the following section.

3 Formation of Strategic Alliances

This section is devoted to the endogenous determination of the alliance structure. In order to analyze the alliance formation process, concepts developed by *D'Aspremont et. al. (1983)* to analyze cartel formation in a model with a competitive fringe and by *Combs (1993)* to analyze R&D cooperation are helpful. If it is assumed that only one alliance will be formed, a direct application of these concepts is possible. However, this assumption may not be realistic if analyzing strategic alliances: A small alliance may restrict entry by another potential partner because participation of another firm would reduce the profits of the existing alliance members. Firms which have been denied entry in the existing alliance may in turn have an incentive to form another alliance.

In 3.1 it will be assumed that only one alliance will form. In this context the concepts internal stability, external stability and entry–blocking will be discussed and the number of firms in the "stable alliance" will be determined. In 3.2 the restriction that only one alliance may form will be removed. In this case the decision process of actual and potential alliance members becomes quite complicated: The stability conditions developed on 3.1 must still be fulfilled; in addition, the possiblility of "group deviation" by some alliances or by a subset of firms within an alliance has to be considered.

3.1 Internal Stability, External Stability and Entry–blocking

Following *D'Aspremont et. al. (1983)* it will be assumed that only one alliance α with $k \leq n$ members will form and that all firms are free to join the alliance. A strategic alliance is *internally stable* if no member of the alliance has an incentive to leave, i. e. $\pi_i^\omega(k-1) \leq \pi_i^\alpha(k)$. The alliance is *externally stable* if an outsider does not have an incentive to join the strategic alliance, i. e. $\pi_i^\alpha(k+1) \leq \pi_i^\omega(k)$. An alliance structure $(n;k)$ is *stable* if both conditions are met. By convention, a situation without an alliance $(k = 1)$ is assumed to be internally stable, while industry wide cooperation $(k = n)$ is assumed to be externally stable. As shown by *D'Aspremont et. al. (1983)* there always exists a stable alliance structure $(n;k)$ with $k \in \{1,\ldots,n\}$ — this proof does not depend on their specification of product market competition.

Following *Combs (1993)* the stable alliance structure may be interpreted in game theoretic terms: The stable alliance structure is a non–cooperative Nash equilibrium of a game where each player chooses from two strategies — to join or not to join the alliance. For given strategies of the other firms the membership decision of an alliance member is privately optimal if the alliance structure is internally stable and the decision of an outsider is privately optimal if the alliance structure is externally stable — if both conditions are fulfilled nobody has an incentive to deviate from the chosen strategies which is exactly the definition of a Nash equilibrium. *Donsimoni et. al. (1986)* showed that the equilibrium of the membership game may not be unique. Therefore the possibility of multiple equilibria will be considered in the following analysis.

As in 2.3 it will be assumed that the firms compete in a Cournot oligopoly with linear demand $p(X) = 1 - X$ and constant average costs c and that the strategic alliance determines optimal output based payments according to (17). Thus the profit of an alliance member and an outsider are given by:

$$\pi_i^\alpha(k) = \frac{1-c}{4k(n+1-k)} \qquad (20)$$

$$\pi_i^\omega(k) = \frac{1-c}{4(n+1-k)^2} \qquad (21)$$

The resulting conditions for internal and external stability are:

$$\pi_i^\omega(k-1) \leq \pi_i^\alpha(k) \iff 4(n+2-k)^2 \geq 4k(n+1-k) \qquad (22)$$
$$\pi_i^\alpha(k+1) \leq \pi_i^\omega(k) \iff 4(k+1)(n-k) \geq 4(n+1-k)^2 \qquad (23)$$

Solving the inequalities on the right hand side with respect to k, we obtain the following condition for a stable alliance structure (k^* is the number of alliance members in the stable alliance):[12]

$$k^* \in \left[\frac{3n+1}{4} - \Theta, \min\left\{\frac{3n+1}{4} + \Theta, \frac{3n+5}{4} - \Theta\right\}\right] \qquad (24)$$
$$\text{with} \quad \Theta = \frac{\sqrt{(n-1)^2 - 8}}{4}$$

As long as $(3n+1)/4 - \Theta$ is not an integer, the stable alliance structure is unique. If $n < 100$ only $n = 4$ leads to an integer solution - in this case $(4;3)$ and $(4;4)$ are both stable alliance structures. If $n \leq 3$ the alliance will comprise the whole industry. For $n > 4$ it can be shown that $[(3n+1)/4 - \Theta] - (n+1)/2 < 1/2$ and therefore the stable alliance structure is given by $(n;(n+2)/2)$ if n is an even number and $(n;(n+3)/2)$ if n is an uneven number.

In a Cournot oligopoly we obtain as a general result, which does not depend on the linear specification, that an alliance structure is not externally stable as long as the strategic alliance expands output: If the alliance members expand output the profits of outsiders will be lower than in the initial Cournot equilibrium; because an alliance member always realizes at least as much profit as in the initial equilibrium, an outsider has an incentive to join the alliance. Assuming general cost and demand functions, $k > 1+\sum_{i=k+1}^{n} \lambda_i$ is a necessary though not sufficient condition for a stable alliance structure. Therefore, the output in the industry will always be contracted relative to the equilibrium without an alliance, if firms are free to join a strategic alliance.

In the price-leadership model of *D'Aspremont et. al. (1983)* the cartel members do not have an incentive to block entry of another firm, because their profits would always increase if anther firm joins the cartel. This need not be the case with strategic alliances. In this case the concept of an "entry-blocking-equilibrium" developed by *Combs (1993)* seems to be more realistic: An alliance structure is an "entry-blocking-equilibrium" if it is both internally stable and either externally stable or the entry of another firm reduces the profits of the alliance members, i. e. $\pi_i^\alpha(k+1) < \pi_i^\alpha(k)$.

This concept may also be interpreted in game theoretic terms, however, the possibility of "entry-blocking" leads to a game with a completely different structure:

[12]The square root in the expression Θ does not have a solution in the set of real numbers if $n \leq 3$. In these cases the stable alliance structure is given by $k = n$.

In the first stage the first firm[13] names an integer $k \leq n$, indicating the number of firms which are proposed to be members of the alliance (the firms $\{1, \ldots, k\}$). In the second stage these firms decide whether they actually would like to join the alliance or prefer to remain outsiders. In an equilibrium there is no incentive for the proposed member firms to leave the alliance (the alliance is internally stable) and no incentive for the first firm to name another k (of all internally stable alliances, the proposed alliance leads to the highest profits for an alliance member).

When will the entry of a prospective alliance member be blocked? With linear cost and demand a strategic alliance with k members will block entry if

$$\pi_i^\alpha(k+1) < \pi_i^\alpha(k) \iff 4(k+1)(n-k) > 4k(n+1-k)\,. \tag{25}$$

As long as $n \leq 4$ an alliance comprising at least two firms has no incentive to block entry. With more than four firms in the industry, a two firm alliance will block entry.

As a general result, a two firm alliance will block entry, if an alliance with three members has still an incentive to expand output. Allowing for a Cournot oligopoly with general cost and demand conditions, the stable alliance structure with entry-blocking will be given by $(n;2)$ as long as $\sum_{i=4}^{n} \lambda_i \geq 2$. If the reactions of outsiders are relatively weak ($\lambda_i < 1$), even in markets with more than four firms, a two firm alliance will not necessarily block entry; in contrast, $\lambda_i > 1$ may lead to $(n;2)$ even in an industry with only four firms.

3.2 Determination of the stable alliance structure

If it is possible that more than one alliance may form, the decision process of actual and potential alliance members becomes relatively complicated: An outsider could either join an alliance which does not block entry, form an alliance with other outsiders or remain an outsider. When deciding about blocking, the alliance members must consider whether the outsiders will have an incentive to form another alliance which might have negative effects on the profits of members of the existing alliances.

In this context an alliance structure is said to be stable if the following conditions are fulfilled:

- Each alliance is internally stable, i. e. a member firm could not earn higher profits if it leaves the alliance and becomes an outsider.
- An outsider has no incentive to join an alliance which does not block entry, i. e. an alliance is either externally stable or entry of a single outsider is blocked.

[13]Because all firms are assumed to be identical it does not make any difference which firm is assigned to be the "first".

- When there is more than one alliance, no subset of the alliances could form one larger alliance that is both internally stable and leads to higher profits for each member firm even if the other alliances and outsiders react optimally (e. g. also form a bigger alliance if this in their interest).

- The alliances are internally stable with respect to "group deviation" in the following sense: No subset of alliance members could earn higher profits by leaving the given alliance and forming a smaller one, if all other firms react optimally (i. e. leave their alliance and form a smaller one if this leads to higher profits in the new situation).

When analyzing possible deviations from a given alliance structure, different assumptions are made when considering single firm deviations and formation of a smaller alliance, respectively: It is assumed that a single firm would leave the alliance, if as an outsider it could earn higher profits given that all other firms will not change their decisions ("Nash deviation"). In contrast, a smaller alliance will only be formed it the member firms could expect higher profits even after all other firm have reoptimated their decisions.[14] How could these assumptions be justified? I do not explicitly consider time consuming contracting and reorganization processes in my model. However, single firm deviation and group deviation differ exactly in this respect: When a firm wants to leave a given alliance this may be achieved relatively easily while forming a new alliance is a much more complex and time consuming task. To give this idea an explicit time structure: Suppose the firms decide about alliance formation in period $t = 1$, in $t = 2$ the necessary contracting and reorganization processes take place, and in $t = 3$ the firms compete in the product market. For a single firm it may be possible to leave a given alliance in $t = 2$ and to compete as a Cournot oligopolist in $t = 3$ — therfore an alliance must be internally stable. However, if in $t = 2$ some firms left a given alliance and decided to form another one, these firms would not be able to carry out the contracting and reorganization processes in the same period and thus could not influence the product market competition in $t = 3$ — therefore a deviation from the proposed alliance structure is only feasible in $t = 1$ and in this case the other firms would be able to react accordingly.

In order to explicitly determine the stable alliance structure the following game theoretic formulation will be used (see *Bloch, 1992* for a similar approach): The n players are ordered and the first player names an integer k_1, the number of firms which are supposed to be part of alliance a_1, the player $k_1 + 1$ names an integer k_2, the number of firms which are part of the alliance a_2, and this process will continue until $\sum k_i + 1 \geq n$. Each firm which is supposed to be part of an alliance a_j could deny to join the alliance. This would be the case if the firm could earn higher profits either by becoming an outsider or by forming a smaller alliance with

[14]For a similar approach see the concept of "far-sighted strong equilibrium" of *Li (1992)*.

some other alliance members. If only one alliance has been formed, the process stops here. Otherwise there will be another round where the game played between single firms in the first step is now played between alliances and remaining outsiders. In this case the process finally stops a further round would not lead to a change in the alliance structure.[15]

Given the assumptions about stable alliance structures and the game of alliance formation, the alliance formation process has been analyzed for a linear Cournot oligopoly. The stable alliance structures have been explicitly derived for $n \leq 10$. To obtain these results, the equilibrium profits for all possible alliance structures have been computed for $p(X) = 1 - X$ and $c = 0$. Based on this information it is possible to construct the extensive form (the "game tree") of the game of alliance formation and to solve the game by applying the concepts of single firm and group deviation. In the following it will be explained how the stable alliance structures have been derived for $n \leq 7$. Thereby some principles will emerge, which also apply to a linear Cournot oligopoly with more than seven firms and to Cournot models with general demand and cost conditions:

- If there are no more than four firms in the industry, an alliance comprising all firms will be formed: If $n = 2$ the firms will prefer a perfect cartel $(2;2)$ to Cournot competition. If $n = 3$, a two firm alliance would not change the initial equilibrium; therefore a perfect cartel $(3;3)$ will result. If $n = 4$, the alliance formation process will also lead to a perfect cartel: The alliance structure $(4;2)$ is not stable because the two outsiders have an incentive to form another alliance. However, $(4;2,2)$ is pareto dominated by $(4;3)$. The alliance members are better off if the remaining outsider joins the alliance while the outsider is indifferent $[\pi_i^{\omega}(4;3) = \pi_i^{\alpha 1}(4;4)]$. Alliance structure $(4;4)$ will result because it leads to a pareto improvement relative to $(4;3)$.

- If $n = 5$, the stable alliance structure is given by $(5;4)$: The alliance structures $(5;2)$ and $(5;3)$ are not stable, because two outsiders would have an incentive to form another alliance. The alliance structures $(5;2,2)$ and $(5;3,2)$[16] are pareto dominated by $(5;4)$. The remaining outsider has no incentive to join the alliance $[\pi_i^{\omega}(5;4) = \pi_i^{\alpha 1}(5;5)]$.

- If $n = 6$ the alliance structure $(6;3,2)$ is stable: The alliance structure $(6;5)$ is not internally stable. $(6;4)$ and $(6;3)$ are not stable because two outsiders would have an incentive to form another alliance. $(6;4,2)$ is not stable because

[15] This formulation for the game of alliance formation will lead to a alliance structure which fulfills the stability conditions. If more than one stable alliance structure exists, pareto dominated alliance structures will usually be eliminated.

[16] Because all firms are identical, $(5;3,2)$ and $(5;2,3)$ describe the same result; by convention the larger alliances will be named first

the members of alliance $\alpha 1$ would prefer to form two independent alliances. $(6;3,3)$ is not stable because two members of an alliance would have an incentive to leave this alliance and form a smaller one. The members of both alliances prefer $(6;3,2)$ to $(6;2,2,2)$; thus the first firm would name $k_1 = 3$ and the fourth firm woulc in turn name $k_2 = 2$. However, note that except for the members of alliance $\alpha 1$ all firms are worse off relative to the situation without an alliance.

- If $n = 7$ two alliance structures fulfill the stability conditions: $(7;2,2,2)$ and $(7;3,3)$. However, the game of alliance formation will result in $(7;3,3)$ which pareto dominates $(7;2,2,2)$. As in the case of $n = 6$ alliance structures with only one alliance could not be stable: Either the alliance is not internally stable $[(7;6)]$ or some outsiders have an incentive to form another alliance (all other cases). All alliance structures with more than one outsider $[(7;2,2)$ and $(7;3,2)]$ could not be stable because the outsiders would have an incentive to form another alliance. The alliance structures without an outsider $[(7;5,2)$, $(7;4,3)$ and $(7;3,2,2)]$ could not be stable, because a subset of $k_j - 1$ firms in an alliance αj with $k_j \geq 3$ will always have an incentive to form a smaller alliance (respectively: the entry of the last outsider into an existing alliance would always be blocked). In case of $(7;4,2)$ the members of alliance $\alpha 1$ have an incentive to form two smaller alliances. Therefore only alliance structures $(7;3,3)$ and $(7;2,2,2)$ remain. The proposed game of alliance formation will result in $(7;3,3)$ because this result is pareto preferred to $(7;2,2,2)$: The firms 1 and 4 will earn higher profits if they name $k_1 = 3$ and $k_2 = 3$. However, note that relative to the equilibrium without alliances all firms are worse off.

The following general results emerge from the analysis of the alliance formation process:

- A situation with one alliance could only be a stable alliance structure if $n \leq 5$: For $n \geq 6$ an alliance with $n - 1$ firms is not internally stable and given an alliance with less than $n - 1$ firms the outsiders have an incentive to form another alliance.

- If there are no outsiders in an alliance structure with at least two alliances, a subset of $k_j - 1$ firms in an alliance αj with $k_j \geq 3$ will always have an incentive to form a smaller alliance. Because two outsiders would always have an incentive to form another alliance if they were blocked by the members of other alliances, in equilibrium there will be one outsider at most: If the number of firms in the industry is uneven, there will be exactly one outsider for industries with more than three firms; if the number is even an alliance structure with $n/2$ two–firm alliances may be stable, however, usually will be pareto dominated by another stable alliance structure (this is true for $n = 6$, 8 and 10).

- If more than one alliance structure fulfills the stability conditions, the best situation from the point of view of the alliance members is an alliance structure $(n; (n-1)/2, (n-1)/2)$ if the number of firms in the industry is even and $(n; n/2, (n-2)/2)$ if the number is uneven. Because it is assumed that firms forsee the reaction of their competitors, it seems realistic to expect this to be the "solution" of the game: The first firm would earn the highest profits if it proposes a number of member firms which finally leads to this alliance structure (this expectation is confirmed by the results for $n \leq 10$).

- In markets with more than six firms all firms are better off if no alliance is formed. In these cases the question remains: Why should the firms form strategic alliances at all? As with the different assumptions concerning single firm and group deviations, this may be justified by referring to the time structure: Suppose all firms refrain from forming an alliance in the first place. In this case two firms will have an incentive to secretly form an alliance and to start the contracting and reorganization process. After some time elapsed, they would openly present their contract. The other firms which did not form an alliance in the first place would be to late to form another alliance. To avoid this unfavorable situation, each firm has an incentive to participate in the alliance formation process.

Based on these considerations the following results are obtained: If an oligopolistic industry with linear cost and demand does not comprise more than five firms, the possibility to form strategic alliances will lead to cartelization of the industry. However, if the industry comprises more than five firms, the alliance formation process will result in competing alliances which leads to "more competition" relative to the Cournot outcome. Allowing for general cost and demand conditions the alliance formation process will lead to cartelization if $n \leq 3 + \sum_{n-1}^{n} \lambda_i$ with $n-1$ and n being the least efficient firms in the industry. If the reactions of the outsiders are relatively weak ($\sum_{n-1}^{n} \lambda_i < 1$), in an industry with four firms a strategic alliance comprising two firms will have an incentive to reduce output and therefore a three–firm–alliance may not be internally stable — this in turn would lead to an alliance structure $(4; 2, 2)$. However, in contrast to the results with linear cost and demand, as long as $\lambda_1 + \lambda_2 < 1$ both alliances will reduce output relative to the Cournot outcome. With strong reactions of outsiders ($\lambda_i > 1$), even in markets with more than five firms the alliance formation process may lead to cartelization: If a strategic alliance does not comprise almost all firms of the industry, it will have an incentive to expand output (e. g. this will be the case in an industry with declining marginal costs).

4 Conclusion

It has been shown that a strategic alliance may be used as a means to affect product market competition: The alliance members may commit to a certain output level by signing a contract which stipulates output based payments between the member firms. Alliances which are small relative to the number of firms in the industry will expand output relative to the Cournot level, while an alliance comprising almost all oligopolists will reduce output. Thus the effects of a strategic alliance on outsiders and on competition depend crucially on the number of member firms: Small alliances will hurt outsiders and enhance competition while large alliances will result in positive externalities for outsiders and reduced aggregate output.

If firms are free to form strategic alliances, the results depend on the number of firms in the industry and on cost and demand conditions. Assumig a linear Cournot oligopoly with identical costs the following results are obtained: As long as the number of firms in the industry does not exceed five only one alliance will form; in these cases the alliance will reduce output relative to the Cournot outcome. If there are at least six firms in the industry the alliance formation process will lead to more than one alliance and competition will be enhanced.

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