On the Impact of Import Quotas on a Quantity-Fixing Cartel in a Two-Country-Setting

Der Einfluß von Importquoten auf die Stabilität eines Mengenkartells – Eine Analyse im Rahmen eines Zwei-Länder-Modells

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Summary

In a static supergame context, a model is presented in which a foreign and a domestic firm form a cartel for selling a homogeneous good. In order to maximize joint cartel profit, the two firms have agreed to restrict sales to their own home market. Due to transfer costs, this market split pareto-dominates other cartel solutions. Side payments are assumed to be feasible. The introduction of an import quota may affect cartel stability as measured by a so-called critical interest rate. The two-country setting and the feasibility of side payments lead to results very different from previous findings that mild import regulations foster cartelization whereas severe restrictions destabilize quantity-setting cartels.

Zusammenfassung


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1. Introduction

The study of oligopolistic market structures in an international trade setting seems to have caught the fancy of economists in the early 1980’s. One branch, the so-called strategic trade policy literature, works out different cases in which trade restrictions may actually prove beneficial to the restriction-imposing country although it is not “large” in the sense of the optimal tariff argument. An argument in possible favour of import restrictions is that they might lower the stability of cartels and thus increase competition to the benefit of consumers.

Davidson (1984) seems to be the first published paper on this topic. In his article, Davidson considers a model where domestic and foreign firms agree on monopolizing the domestic market of a homogeneous good in a static supergame. Inverse market demand is assumed linear in the form \( p = 1 - x \), and costs are set equal to zero. The cartel outcome is enforced by a punishment scheme: If anybody does not abide by the cartel agreement, an eternal return to the Cournot-Nash equilibrium will be triggered. The purpose of the paper is to investigate how an import tariff may affect the stability of the cartel. Davidson’s result is that the introduction of a tariff gradually first increases cartel stability and then reduces it again. However, there seem to be several drawbacks concerning his model: a) the lack of a clearly defined measure of cartel stability, b) the reliance on one particular specification of the demand function, c) the ad-hoc assumption that joint cartel output is set constant regardless of the tariff level when it is clearly not profitmaximizing for the cartel to do so. In fact, without assumption c), the result in a two-firm setting would be that an increase in tariffs lowers cartel stability monotonically (Matschke 1997). This is also Fung’s (1987) result for the case of import tariffs in a two-firm international duopoly with heterogeneous goods. He, however, only considers cartel production that maximizes joint profits given that the cartel is indeed successful, but does not allow for any production share changes to stabilize the cartel when a tariff is imposed. Rotemberg/Saloner (1986) extend Davidson’s analysis to import quotas. They maintain the linear inverse demand assumption in the general form \( p = a - bx \), but reduce the number of firms to one domestic and one foreign that are completely symmetric in costs and time preference/discount factors. Cartel stability is now explicitly measured by the critical discount factor of firms: for lower discount factors, firms would choose to defect from the cartel solution, for higher or equal discount factors, firms would want to collude. Confronted with an import quota, the firms redistribute production shares in such a way that their critical discount factors are equal. Given the symmetry of firms, this is useful to solve the problem of aggregating two critical discount factors into a single measure of cartel stability. In the case of Cournot-Nash punishment, Rotemberg/Saloner’s result is that mild quotas enhance cartel stability while severe quotas gradually reduce it again, thus paralleling Davidson’s result. For the case of Bertrand-Nash punishment (Rotemberg/Saloner (1989)), quotas are found to decrease cartel stability.

In order to determine whether these models provide enough evidence that under quantity competition, mild import restrictions enhance international cartel stability while high import barriers reduce it again, it seems appropriate to compare the model structure with real world cartels. Nowadays, open cartelization of markets is not frequent given that most industrialized nations have declared cartels illegal. The work of antitrust authorities, however, reveals again and again that secret cartelization is still a matter of concern. Even if the activity of such secret cartels is discovered, it is not clear
whether the entire mechanism structure of the cartel will be revealed to the public. Historical examples from the second half of the 19th and the first half of the 20th century, however, provide us with a rich source of evidence on cartel behaviour. Historically, it appears that many international cartels possessed two major features that distinguish them from the theoretical models described so far:

1. They regulated interaction on more than one market and often included exclusive selling rights for a firm in its own domestic market;

2. They frequently used side payments.

A good illustration for this is the behaviour of the International Steel Cartel (ISC) of 1926 between German, French, Belgian and Luxemburgian steel producers. A fine description of the ISC can be found in Daniel Barbezat (1989). In this cartel, members set total production limits and restricted exports into member countries. For instance, German firms were not allowed to export to France, and France was only allowed to export steel to Germany up to 3.75% of the German steel production. The side payments were linked to the production quotas; overproduction was penalized, while underproduction was rewarded in cash. The side payments can, in fact, be viewed from two different perspectives: as punishment for cartel disloyalty or as payments to keep other cartel members in line. The German steel producers “were very impatient to have an international agreement. This impatience led the group ... to accept a production quota far smaller than was potentially feasible in the years of growth in the Weimar republic” (Barbezat p. 440). In other words, the German steel industry was willing to pay penalties/side payments in order to come to an agreement with other steel producers who were less eager to join the cartel than the Germans.

In our paper, a simple model is presented which includes both side payments and exclusive market agreements. Two firms form a cartel for selling a homogeneous good. Firm 1 is located in domestic country A, and firm 2 is located in foreign country B. Entry barriers block the appearance of other competitors in the markets. Both firms have perfect knowledge of the demand parameters in the two countries and the cost function of both firms. The time horizon is assumed to be infinite. The model is static in the sense that demand and cost functions do not change over time. To simplify computations, as in the existing literature, linearity of cost and demand is assumed, however, firms no longer necessarily face the same marginal costs. In order to maximize their profits, the two firms agree to restrict their sales to their own country so that each firm can act as a monopolist in its own home market. Due to transfer costs, this market split pareto-dominates other cartel solutions in which firms export part of their production. The feasibility of side payments makes it possible to change the distribution of the joint cartel profit without violating the pareto-optimality of the cartel solution. For both firms, there exist incentives to deviate from the cartel equilibrium by also selling in the foreign market. Furthermore, as cartels are often forbidden by law, firms cannot sue a deviator in court for having broken the cartel contract. In a supergame setting, however, it is possible to embed a punishment strategy into the cartel agreement which can successfully prevent a deviation by reducing the gain from cheating (Friedman (1971)). In our paper, the standard Cournot-Nash punishment is used to achieve this goal. The basic setting is thus comparable to the model in Fung (1991) for homogeneous goods where he discusses collusive intra-industry trade. The introduction of an import quota by a country can alter the advantages and disadvantages for abiding by the cartel agreement, as perceived by the cartelists, and thus affect the stability of the cartel. By internal profit transfers, the firms can fix one firm’s willingness to abide by
the cartel agreement. This willingness can be measured by employing microeconomic investment considerations leading to a so-called critical interest rate. The change in the other firm’s willingness to remain in the cartel can then be used to measure cartel stability as a function of the import quota. The concept of critical interest rate is explained in detail (section 2.5.) as such a discussion seems to be missing in previous literature. The objective of our article is to show that two-country setting and feasibility of side payments may lead to results very different from earlier findings that mild import regulations foster cartelization while strict import barriers destabilize quantity-setting cartels.

2. The Model Under Free Trade Conditions

2.1. Demand and Cost Functions

Throughout this paper, it is assumed that the demand functions for the homogeneous good in both countries are linear and symmetric. The fact that there are two demand functions implies that the markets are separable in the first place. By linearity and symmetry, the inverse demand function may be written as

\[ p_j(x_j) = a - b \cdot x_j \]  

where \( a, b > 0 \) and \( x_j \) denotes the product quantity sold in country \( J \). The firms are thought to decide on quantities rather than on prices. The price simply reflects the firms’ sales decision for this country. The production cost functions are also assumed to be linear in output in the form

\[ C_j(x_j) = F_j + c_j \cdot x_j \]  

where \( F_j \geq 0, c_j > 0 \) for \( j = 1,2 \) where \( x_j \) is the quantity produced by firm \( j \), \( c_j \) is the marginal cost of production, and \( F_j \) is the fixed cost of firm \( j \). Without loss of generality, fixed cost \( F_j \) is set zero in the subsequent analysis as market exit will not be discussed. In addition, a producer incurs transfer costs when shipping goods to a foreign market. These include costs of shipment as well as tariffs. For simplicity, it is assumed that these transfer costs do not contain any fixed costs, are linear with respect to the quantity shipped abroad and do not vary with the country. This means that shipping one unit of the homogeneous good from country \( A \) to country \( B \) costs as much as shipping one unit from country \( B \) to country \( A \). \( t > 0 \) denotes this constant per unit transfer cost. Hence, firm \( j \) incurs total costs of

\[ C_j(x_j) + T_j(x_j,k) = c_j \cdot (x_{j,j} + x_{j,k}) + t \cdot x_{j,k} \]  

where \( c_j, t > 0 \), \( x_{j,j} \): quantity sold by \( J \)-based firm \( j \) in its domestic market \( J \), \( x_{j,k} \): quantity sold by \( J \)-based firm \( j \) in its export market \( K \). The firms’ constant marginal costs \( c_j \) may differ from one another. We, however, restrict the magnitude of their variation by assuming that the variable costs for one product unit sold in country \( J \) are less if the product is produced by the firm indigenous to country \( J \), i.e. \( c_1 + t > c_2 \) and \( c_2 + t > c_1 \) or as a result:

\[ t > |c_2 - c_1| \]
The marginal cost difference is thus bounded by the per unit transfer cost. By imposing this restriction, each firm should sell its monopoly output in its home market in order to maximize the joint cartel profit.

2.2. Cartel Profits

According to the cartel agreement, each firm acts as a monopolist in its own home market. Calculating the corresponding cartel profits is thus straightforward. Firm $j$ receives a profit of

$$\Pi_{j,C} = \frac{(a - c_j)^2}{4 \cdot b}$$

(5)
in its home market $J$ by selling

$$x_{j,C} = \frac{a - c_j}{2 \cdot b}.$$  (6)

This production split leads to the highest joint cartel profit that can be achieved by the firms. If, for instance, firm 1 shipped additional quantities into country B, the additional cost incurred would exceed the revenue increase. This must be true because firm 1's marginal costs for delivery in country B were assumed to be higher than the marginal costs for firm 2. These in turn would already exceed marginal revenues if firm 2 marginally increased its sales in country B. The maximal joint cartel profit can be arbitrarily distributed among the firms if side payments are allowed. Certainly, side payments offer strong evidence for cartelization so that firms openly using side payments can easily get into conflict with antitrust authorities if cartelization is illegal. There are, however, ways to conceal the nature of these payments (for example, by connecting them with other transactions: declaring them as part of interest payments, payments for inventories etc.) so that side payments are possible even now, as opposed to being a mere historical curiosity. For simplicity, we assume that the side payments are made directly after the production game of a period. Any division of the maximal joint cartel profit is pareto-optimal, i.e. given one firm's profit, the other firm achieves the maximal profit possible under this restriction. Not every profit split $(\Pi_{1,C}, \Pi_{2,C})$ satisfying the condition

$$\Pi_{1,C} + \Pi_{2,C} = \Pi_{1,C}^* + \Pi_{2,C}^*$$

(7)
can, however, be achieved under a cartel regime if cartel formation is on a voluntary basis. A producer will not accept a cartel profit that is lower than the profit that he can collect in the non-cooperative equilibrium (individual rationality requirement). As quantity competition was assumed, this requirement can be restated by saying that a firm's cartel profit may not be lower than its Cournot-Nash profit: $\Pi_{j,C} \geq \Pi_{j,N}$ for $j = 1,2$.

2.3. Cheating Profits when Deviating from Agreed Market Division

Since a model with perfect information is being considered, there is no reason for a defecting firm to cheat only marginally. Once a firm has defected, it is certain that
this defection will be known in the periods to follow. Optimal deviation can thus only be a deviation that gives the maximal one-shot cheating profit.

Two possibilities exist how a firm can defect from the cooperative equilibrium. First, it is possible to ship goods to the foreign market and sell them there. This deviation from the cartel equilibrium results in an overall loss in joint cartel profit. The deviating firm, however, unilaterally benefits from this defection. Calculating the maximal extra profit that firm j can achieve by this deviation (given that the other firm sells its monopoly output in its home market) yields

$$
\Pi_{j,Ch,K} = \frac{(a + c_k - 2 \cdot c_j - 2 \cdot t)^2}{16 \cdot b}
$$

by selling

$$
x_{j,Ch,K} = \frac{a + c_k - 2 \cdot c_j - 2 \cdot t}{4 \cdot b}
$$

A second possibility to increase a firm's profit beyond the cartel level is to retain the side payment. It is clear that only the firm that is actually supposed to pay the side payment according to the cartel agreement possesses this cheating opportunity. It is furthermore reasonable to assume that a firm that cheats by shipping goods to the foreign market will not receive a side payment from its rival because side payments are made directly after the production game of the period.

Summarizing these arguments, firm j's cheating profit may be written as

$$
\Pi_{j,Ch} = \frac{(a + c_k - 2 \cdot c_j - 2 \cdot t)^2}{16 \cdot b} + \frac{(a - c_j)^2}{4 \cdot b}
$$

There is an implicit assumption behind this expression, namely that the extra profit achieved by shipping goods to the foreign market exceeds the side payment that a firm is supposed to receive according to the cartel agreement. If this is not the case, the corresponding firm does not have an incentive to deviate from the cartel equilibrium.

2.4. Punishment Profits: Cournot-Nash Punishment

In supergames, it is possible to make deviation inconvenient by threatening a punishment in future periods if the discount factor of the firms is high enough, i.e., future profits matter enough for the firms (Fudenberg/Tirole 1989). The more severe this punishment is, the lower the discount factor may actually be without threatening the cartel outcome. In this context, it has to be mentioned that with rational players and no information deficiencies, a punishment phase will never actually be observed. If no player is interested in breaking the cartel agreement, cooperative play will arise in each period of the game. If player j has an incentive to cheat, however, his opponent k knows that and j knows that k knows. But player k is not interested in producing his cartel quantity and thus offering j the opportunity to cheat because that would cause him a loss. So the non-cooperative equilibrium will result. The punishment is only used as a threat to make the cooperative outcome feasible for a certain interest rate $i_j = 1/\delta_j - 1$, where $\delta_j$ is the discount factor for firm j.
Very often, the punishment proposition in Friedman (1979) is employed. According to this proposition, the players should answer a defection from the cooperative game by eternally returning to the non-cooperative Nash equilibrium. Such a punishment belongs to the category of "grim trigger punishments" as no return to cooperation is provided for.

The advantages of this kind of punishment are:

1. The Cournot-Nash punishment is independent of the current period of the punishment phase and of the kind the preceding cheating that triggered the punishment. Put differently, the punishment does not depend on the history of the previous play (except that a deviation from the cooperative equilibrium must have occurred). Especially, the analysis of a quota is facilitated because the effects on the feasibility of the punishment are the same in each period.

2. The Cournot-Nash punishment is subgame-perfect (Selten 1965) because it is a Nash equilibrium (NE) in the constituent game, and thus also a NE in every sub-game. It is therefore a credible punishment in the sense of subgame-perfection.

If we apply Cournot-Nash punishment, the Cournot-Nash equilibrium arises in both markets in every period after the defection. The corresponding sales quantities, which are assumed to be strictly positive, are

\[ x_{j,N,J} = \frac{a + c_k + t - 2 \cdot c_j}{3 \cdot b}, \quad (11) \]

\[ x_{j,N,K} = \frac{a + c_k - 2 \cdot c_j - 2 \cdot t}{3 \cdot b}. \quad (12) \]

The corresponding Cournot-Nash profit for firm \( j \) amounts to

\[ \Pi_{j,N} = \Pi_{j,N,J} + \Pi_{j,N,K} = \frac{(a + c_k + t - 2 \cdot c_j)^2}{9 \cdot b} + \frac{(a + c_k - 2 \cdot c_j - 2 \cdot t)^2}{9 \cdot b}. \quad (13) \]

2.5. Concept of Critical Interest Rate

This section introduces the concept of critical interest rate as a measure of cartel stability. This seems to be useful as little attention has been paid to this topic in the current literature. If the cartel is to be successful, abiding by the cartel agreement must pay off for both firms. This means that the present value from deviation must be lower than the present value that can be achieved in the cooperative equilibrium:

\[ \Pi_{j,C,Ch} + \frac{\Pi_{j,N}}{i_j} \leq \Pi_{j,C} + \frac{\Pi_{j,C}}{i_j} \text{ or} \]

\[ i_j \leq \frac{\Pi_{j,C} - \Pi_{j,N}}{\Pi_{j,C} - \Pi_{j,C}} \text{ for } j = 1,2. \quad (14) \]

\( i_j \) is the interest rate used by firm \( j \) to discount future profits. The numerator of the RHS gives the per period profit loss caused by the Cournot-Nash punishment whereas the denominator represents the one-shot advantage from deviation.
The cartelization will be successful if each cartelist considers abiding by all cartel rules to be advantageous. As the punishment equilibrium is a NE in the constituent game, we obtain one condition per firm. More complicated and severe punishment schemes may considerably increase the number n of conditions necessary because in this case, the punishment must be specifically tailored to be credible. The highest interest rate that fulfills all the n conditions is called "firm j's critical interest rate $i^*_j"$ (Matschke (1997)). For interest rates above this value, deviation from the cartel would be advantageous. In our simple Cournot-Nash case, the critical interest rate $i^*_j$ is equal to the RHS of (14). The higher this critical interest rate, the larger the interval of interest rates of firm j for which the cartel is feasible. We may also say that the higher is $i^*_j$, given firm k's critical interest rate $i^*_k$, the more stable is the cartel with regard to changes in firm j's interest rate $i_j$.

Clearly, the critical interest rate of a firm varies with the assumptions made concerning the cartel and punishment equilibrium. Following the usual comparative statics logic, we have to fix the employed equilibria in order to single out the pure effects of the trade restriction. Throughout this paper, we will assume that the cartel agreement is rigid in terms of Cournot-Nash punishment and monopolization of the home markets. Cournot-Nash punishment is employed because it is easy to use, although it is well known (Abreu 1986, Abreu 1988) that there exist more severe punishments that make cartelization feasible in cases where Cournot-Nash punishment would not be sufficient to prevent cheating on the cartel agreement. Side payments can be used to transfer cartel profits to stabilize the cartel in case that one firm's critical interest rate rises and the other firm's critical interest rate declines due to an import quota. It is then possible to construct figure 1 in which the bounds on the firms' interest rates are plotted as functions of the side payment S that the foreign firm 2 pays the domestic firm 1. If S equals zero, no side payment are made, if S is strictly positive, firm 1 receives a side payment from firm 2 in the cooperative solution, and if S is negative, firm 1 has to pay firm 2. The higher S, the higher is the domestic firm 1's cartel profit. Taking into account individual rationality requirements, S is restricted to the following interval:

$$\Pi_{1,N} - \Pi_{1,M} \leq S \leq \Pi_{2,M} - \Pi_{2,N}.$$  \hspace{1cm} (15)

For each firm j, a bound for its interest rate exists which cannot be exceeded if the cartel agreement is to hold. This bound is firm j's critical interest rate $i^*_j$. For all interest rates less than or equal to $i^*_j$, firm j is not interested in cheating on the cartel agreement. $i^*_j$ is a function of the side payment:

$$i^*_1(S) = \frac{\Pi_{1,M} + S - \Pi_{1,N}}{\Pi_{1,Ch} - \Pi_{1,M} - S}$$  \hspace{1cm} (16a)

$$i^*_2(S) = \frac{\Pi_{2,M} - S - \Pi_{2,N}}{\Pi_{2,Ch} - \Pi_{2,M} + S}$$  \hspace{1cm} (16b)

with

$\Pi_{i,M}$: firm j's monopoly profit in its home country,

$\Pi_{i,N}$: firm j's Cournot-Nash profit,

$\Pi_{i,Ch}$: firm j's one-shot cheating profit if deviating from cooperative equilibrium.

This leads to the following proposition:
Proposition 1:
The function \( i_j^*(S) \) has positive slope for \( j = 1 \) (i.e. a higher cartel profit increases firm 1's willingness to be loyal to the cartel) and negative slope for \( j = 2 \) (i.e. a lower cartel profit diminishes firm 2's willingness to be loyal to the cartel).

Notice that side payments can actually eliminate the cheating opportunity for firm 1 (resp. 2) by increasing \( \Pi_{1,M} + S \) (resp. \( \Pi_{2,M} - S \)) above \( \Pi_{1,Ch} \) (resp. \( \Pi_{2,Ch} \)). In this case, the critical interest rate would take on a negative value caused by a negative denominator in (16).

For equal marginal production costs, it is clear that \( i_1^* = i_2^* \) for \( S = 0 \). For differing marginal costs, the intersection point may lie to the right or to the left of the ordinate. Due to the individual rationality requirement, \( i_1^* \) is zero at the lower boundary of the domain and \( i_2^* \) is zero at the upper boundary of the domain.

Figure 1 provides an instance where the domestic firm enjoys a marginal cost advantage. In this example, there are positive side payments at the right end of the domain for which firm 1's cheating incentive is eliminated. For \( S = \Pi_{1,Ch} - \Pi_{1,M} \), firm 1's critical interest rate \( i_1^* \) approaches infinity.

Firm j's critical interest rate function divides the set of interest rates into two parts: For interest rates less than or equal to \( i_j^* \), firm j is willing to abide by the cartel agreement. For interest rates exceeding the critical interest rate, firm j considers cheating advantageous, given the side payment S. A higher critical interest rate \( i_j^* \) implies a larger interval of interest rates for which firm j remains loyal to the cartel. If we assume that the interest rate can take on any positive value, a higher critical interest rate makes it more probable that firm j opts for cartel loyalty. It makes sense to call a two-firm cartel more stable if, ceteris paribus, for a given critical interest rate for firm j, firm k's critical interest rate is higher, i.e. a broader range of firm k's interest rates is in accordance with successful cartelization. The critical interest rate measures the vulnerability of a cartel due to changes in a firm's interest rate. Keep in mind that by using concept, cartel stability may differ although the cartel charges the same per unit price for a product and sells the same amount of product units.

![Diagram](image.png)

Figure 1: Diagramm to determine the firms' critical interest rates as function of side payment S
A closer look at \( i_1^* \) and \( i_2^* \) shows that their graphs intersect at \( S = 0 \) for \( c_1 = c_2 \):

\[
\begin{align*}
i_1^* &= \frac{(a-c_1)^2}{4b} + S \left( \frac{(a+c_2+1-2c_1)^2}{9b} - \frac{(a+c_2-2c_1-2c_2-4)^2}{16b} \right), \\
i_2^* &= \frac{(a-c_2)^2}{4b} - S \left( \frac{(a+c_1+1-2c_1)^2}{9b} - \frac{(a+c_1-2c_1-2c_2-4)^2}{16b} \right).
\end{align*}
\tag{17a}
\tag{17b}
\]

An increase in \( c_1 \) leads to a marginal production cost advantage for the foreign firm. Such an increase brings about a rise in both \( \Pi_{2,N} \) and \( \Pi_{2,Ch} \). Thus, in (17b), the denominator of \( i_2^* \) increases and the numerator decreases. For given side payment \( S \), \( i_2^* \) declines, i.e. \( i_2^* (S) \) shifts downwards. It is more difficult to determine how \( i_1^* \) is affected by an increase in \( c_1 \) because \( \Pi_{1,N} \), \( \Pi_{1,M} \) and \( \Pi_{1,Ch} \) all decrease. It is, however, obvious that the denominator of \( i_1^* \) shrinks. Furthermore, in most cases, the numerator grows. This can be easily established by calculating the derivative of (17a) with respect to \( c_1 \), if we use formula (4) and assume that firm 1 as Stackelberg follower would have strictly positive output in market B. In other words: The reduction in \( \Pi_{1,M} \) is more than offset by the reduction in \( \Pi_{1,N} \). As the denominator of (17a) decreases, \( i_1^* \) increases with growing \( c_1 \). \( i_1^* (S) \) therefore shifts upwards in the diagram. The intersection point between \( i_1^* \) and \( i_2^* \) moves to the left. Similar reasoning can be applied to find that increasing \( c_2 \) shifts the point of intersection to the right. The conclusion is

**Proposition 2:**

For increasing \( c_1 \) (resp. \( c_2 \)), \( i_1^* (S) \) shifts up (resp. down) and \( i_2^* (S) \) shifts down (resp. up). For \( c_1 > c_2 \) (resp. \( c_2 > c_1 \)), the intersection point between \( i_1^* (S) \) and \( i_2^* (S) \) lies to the left (resp. right) of the ordinate.

3. The Model with Import Quota Set by Country A

3.1. Import Quotas between firm 2's Cournot-Nash Quantity and Cheating Quantity in Country A

If country A introduces a quota \( q \), the cheating opportunity for firm 2 as well as the punishment equilibrium may be affected. Comparing firm 2's cheating quantity (9) to its Cournot-Nash quantity (12) in country A shows that the cheating quantity \( x_{2,Ch,A} \) is equal to \( 3/4 \cdot x_{2,N,A}^* \):

\[
x_{2,Ch,A} = \frac{a + c_1 - 2 \cdot c_2 - 2 \cdot t}{4 \cdot b} < \frac{a + c_1 - 2 \cdot c_2 - 2 \cdot t}{3 \cdot b} = x_{2,N,A}.
\tag{18}
\]

This leads to the following result:

**Proposition 3:**

A gradual quota reduction first affects the punishment equilibrium when the import quota drops below the foreign firm's Cournot Nash quantity \( x_{2,N,A} \) in the domestic market A.

Now, the foreign producer exhausts his quota for sufficiently small domestic production quantities in the non-cooperative equilibrium (Harris 1985). He can no longer
follow his original reaction function for the market in country A, but if he did not exhaust his quota, his loss would be even greater. Figure 2 illustrates this graphically. The foreign firm’s reaction function achieves a kink at the quota level (thick line represents the new reaction function). The domestic firm maximizes its profit by choosing the quantity at which the quota line becomes tangent to one of its isoprofit contours. As the quota line runs vertically in the quantity diagram, it will be tangent to firm 1’s isoprofit contour at the rightmost point of the contour (if the domestic firm’s quantity appeared on the abscissa, this would be an isoprofit contour maximum). This means that this point of tangency lies on the domestic firm’s reaction function. With Cournot-Nash solution, the domestic firm produces according to its reaction function. As the foreign firm produces its quota quantity, the domestic firm’s production quantity for the home market is thus

\[ x_{1,N,A}(q) = \frac{a - b \cdot q - c_1}{2 \cdot b}. \]  

Substituting into the domestic firm’s profit function yields:

\[ \Pi_{1,N,A}(q) = \frac{(a - b \cdot q - c_1)^2}{4 \cdot b}. \]  

Now, differentiating \( \Pi_{1,N,A} \) with respect to \( q \) gives

\[ \frac{d \Pi_{1,N,A}}{dq} = -\frac{a - b \cdot q - c_1}{2} < 0. \]  

Therefore, the domestic firm’s profit increases with a tightening of the import quota because \( q < x_{2,N,A} \) and
\[
\frac{a - b \cdot x_{2,N,A} - c_1}{2} = \frac{a + c_2 + t - 2 \cdot c_1}{3} = -b \cdot x_{1,N,A} < 0
\]  
\tag{22}
\]

as \(x_{1,N,A}\) is assumed to be strictly positive. It is also clear that \(\Pi_{1,N,A}(q)\) is strictly convex in \(q\) as \(\Pi''_{1,N,A}(q) = b/2\). When \(q\) is lowered, the growth rate of the domestic firm 1's Cournot-Nash profit in its home market increases.

The foreign firm's profit with Cournot-Nash solution in country A can be calculated as

\[
\Pi_{2,N,A}(q) = \frac{(a + c_1 - 2 \cdot c_2 - 2 \cdot t - b \cdot q)}{2} \cdot \frac{q}{2};
\]

\[
\frac{d \Pi_{2,N,A}}{dq} = \frac{a + c_1 - 2 \cdot c_2 - 2 \cdot t - 2 \cdot b \cdot q}{2} > 0.
\]

The foreign firm 2's marginal profit must be positive because the import quota is smaller than firm 2's Cournot-Nash quantity \((a + c_1 - 2 \cdot c_2 - 2 \cdot t)/(3 \cdot b)\) in country A without restriction. This means that an import quota tightening leads to a decrease in the foreign firm's profit. It is also evident that \(\Pi_{2,N,A}(q)\) is strictly concave in \(q\) as \(\Pi''_{2,N,A}(q) = -b\).

Finally, it can easily be checked that the sum of Cournot-Nash profits in the quota-distorted market increases with growing quota restrictiveness. Given that \(\Pi_{2,N,A}(q)\) is more concave than \(\Pi_{1,N,A}(q)\) is convex, this growth rate is declining.

As the only profits affected are the punishment profits, the shifts in the \(i_j^s\)-functions are clear:

**Proposition 4:**

A quota \(q\) below the foreign firm 2's Cournot-Nash quantity \(x_{2,N,A}\), but not below its cheating quantity \(x_{2,Ch,A}\) on the domestic market A, leads to a downward shift in \(i_1^s\) and an upward shift in \(i_2^s\). For a given side payment \(S\), the domestic firm 1's cartel loyalty decreases and the foreign firm 2's cartel loyalty increases.

This is illustrated in figure 3.

The formulae describing this shift are:

\[
i_1^s(S) = \frac{\Pi_{1,M} + S - \Pi_{1,N}(q)}{\Pi_{1,Ch} - \Pi_{1,M} - S},
\]

\[
i_2^s(S) = \frac{\Pi_{2,M} - S - \Pi_{2,N}(q)}{\Pi_{2,Ch} - \Pi_{2,M} + S} \text{ for } x_{2,Ch,A} \leq q < x_{2,N,A}.
\]

Furthermore, the quota shifts the domain of \(S\) to the right as both the lower boundary \(\Pi_{1,N} - \Pi_{1,M}\) and the upper boundary \(\Pi_{2,M} - \Pi_{2,N}\) increase.

These shifts (figure 3) by themselves do not answer the question of how cartel stability is affected. To obtain such a result, we have to find out how firm 2's critical interest rate \(i_1^*\) is affected for a constant \(i_1^s\). Mind, however, that it is not always possible to stabilize one interest rate at its initial level. For example, in figure 3, high values of \(i_2^s\) at the left end of the domain cannot be stabilized by picking a different \(S\). The same problem could also arise for \(i_1^s\) at the right end of the domain if a different parameter constella-
tion was considered. In figure 3, however, this cannot be the case because $i_1^*$ ($q$) can take on all values from 0 to infinity. It is important to note that no assumption has been made about the initial side payment in the free trade equilibrium. Apart from the boundary problems, the analysis is independent of the initial $S$. In order to find out how cartel stability is affected, we take the original critical interest rates as determined by the initial $S$ as granted, fix $i_1^*$ by choosing a new $S$ and see how $i_2^*$ changes. This is one possible solution to the problem of aggregating two critical interest rates into one measure of cartel stability. Setting $i_1^*$ in (25a) constant and solving for $S$ gives:

$$S(q) = \frac{i_1^* \cdot \Pi_{1,Ch} - \Pi_{1,M} + \Pi_{1,N}(q)}{1 + i_1^*} \quad \text{for} \quad q < x_{2,N,A}.$$  

(26)

Notice that in this expression, only $\Pi_{1,N}(q)$ or more precisely $\Pi_{1,N,A}(q)$ is a function of $q$. From formula (21), we know that $\Pi_{1,N,A}^\prime(q) < 0$ so that the following result is evident:

**Proposition 5:**

The side payment $S$ must rise with declining quota if the domestic firm 1's critical interest rate is to be held constant.

According to proposition 5, when cheating becomes relatively more advantageous for the home firm due to higher profits in the noncooperative equilibrium, the side payment must be increased to keep the domestic firm's critical interest rate $i_1^*$ constant. We can now insert $S(q)$ into formula (25b) to examine how $i_2^*$ changes as $q$ decreases:

$$i_2^*(q) = \frac{X(q)}{Y(q)} = \frac{\Pi_{2,M} - S(q) - \Pi_{2,N}(q)}{\Pi_{2,Ch} - \Pi_{2,M} + S(q)} \quad \text{for} \quad x_{2,Ch,A} \leq q < x_{2,N,A}.$$  

(27)

Several properties of $X(q)$ and $Y(q)$ will now be derived. It should be kept in mind that these expressions have very intuitive interpretations: $Y(q)$ is firm 2's one-shot advantage of defecting from the cartel agreement, while $X(q)$ is firm 2's per period loss from defection in the punishment phase compared to cartelization.

**Useful Result 1:**

For the relevant range $x_{2,Ch,A} \leq q < x_{2,N,A}$, firm 2's one-shot advantage of defecting from the cartel agreement
Y(q) = \frac{(a + c_1 - 2 \cdot c_2 - 2 \cdot t)^2}{16 \cdot b} - \Pi_{1,M} + \frac{i^*_1 \cdot \Pi_{1,Ch}}{1 + i^*_1} + \frac{\Pi_{1,N,B}}{1 + i^*_1} + \frac{(a-bq-c_1)^2}{4b} \frac{1 + i^*_1}{1 + i^*_1} \tag{28}

is a strictly convex quadratic function and grows with decreasing q.

Proof: This is obvious because \(\Pi_{1,N,A}(q)\) and thus S(q) are strictly monotonically decreasing in q (i.e. they increase for decreasing q) and strictly convex. The minimum of Y at a quota level of

\[ ZY = \frac{(a - c_1)}{b} \tag{29} \]

lies outside (to the right of) the domain as it always exceeds \(x_{2,N,A}\).

By useful result 1, the one-shot defection advantage \(Y(q)\) increases as q is lowered.

**Useful Result 2:**

The numerator

\[ X(q) = \Pi_{2,M} + \Pi_{1,M} - \frac{i^*_1 \cdot \Pi_{1,Ch}}{1 + i^*_1} - \frac{\Pi_{1,N,B}}{1 + i^*_1} - \frac{(a-bq-c_1)^2}{4b} \frac{1 + i^*_1}{1 + i^*_1} \tag{30} \]

of \(i^*_2(q)\) is a strictly convex quadratic function.

Proof: The function \(X(q)\) has the same convexity properties as \(-(\Pi_{1,N,A}(q)/(1 + i^*_1) + \Pi_{2,N,A}(q))\). \(\Pi_{2,N,A}(q)\) was more strongly concave than \(\Pi_{1,N,A}(q)\) was convex. The result follows for \(i^*_1 \geq 0\).

For quotas higher than

\[ ZX = \frac{(a + c_1 - 2 \cdot c_2 - 2 \cdot t) \cdot i^*_1 - 2 \cdot (c_2 + t - c_1)}{b \cdot (1 + 2 \cdot i^*_1)} \tag{31} \]

firm 2's per-period defection disadvantage \(X(q)\) in the punishment phase is lowered, while for lower quotas, it increases again if we assume that \(ZX\) lies in the relevant domain, that is between \(x_{2,N,A}\) and \(x_{2,Ch,A}\). This, however, need not be the case, so that \(X(q)\) may well be strictly monotone. We are now able to draw conclusions regarding cartel stability as measured by \(i^*_1 = X(q)/Y(q)\).

First, consider the case that \(i^*_1\) is relatively small in the sense that \(ZX \leq x_{2,Ch,A}\). These two statements are equivalent given that \(ZX\) is strictly increasing in \(i^*_1\). \(X(q)\) decreases with declining q. This means that if the domestic firm's interest in the cartelization is weak, stabilizing its critical interest rate for decreasing quota reduces the foreign firm 2's per period disadvantage of cheating. Firm 2 has to increase its side payment to firm 1 by more than the reduction of its Cournot-Nash profit \(\Pi_{2,N,A}\). As \(X(q)\) decreases and \(Y(q)\) increases, cartel stability is gradually lowered with increasing restrictiveness of the quota.

Next, the case is examined where \(i^*_1\) is relatively high (i.e. \(ZX \geq x_{2,N,A}\)). When \(i^*_1\) approaches infinity, \(\lim ZX = 3/2 \cdot x_{2,N,A}\), so \(ZX \geq x_{2,N,A}\) is possible. For high \(i^*_1\), \(X(q)\) increases with decreasing q in the entire domain. As both \(X(q)\) and \(Y(q)\) increase, the change in \(i^*_2(q)\) depends on whether \(X(q)\) or \(Y(q)\) grows relatively more.
Finally, if $i_1^*$ is such that $x_{2,Ch,A} < ZX < x_{2,N,A}$, $X(q)$ declines with decreasing quota until a quota of $ZX$ is reached and then rises again. As long as $X(q)$ decreases, we are back to the case of decreasing cartel stability. When $X(q)$ rises again, the change in $i_2^*(q)$ depends on whether $X(q)$ or $Y(q)$ grows at a higher rate.

To find out more about the case when both $X(q)$ and $Y(q)$ increase, the following properties of $Y(q)$ and $X(q)$ are useful to know:

**Useful Result 3:**

a) $ZX$ is always smaller than $ZY$.

Proof: We calculate the difference $ZY-ZX$. From $x_{1,N,A} > 0$ and $c_2 + t > c_1$ by equation (4), the result is evident.

b) $X'(q) \cdot Y - X \cdot Y'(q)$ is a strictly concave function of $q$.

Proof: Calculating the expression, we obtain a quadratic function where the coefficient of $q^2$ is negative given that $x_{1,N,A} > 0$ and $c_2 + t > c_1$.

c) At $ZX$, $X'(q) \cdot Y - X \cdot Y'(q)$ is strictly positive.

Proof: For $X'(q) = 0$, $X'(q) \cdot Y - X \cdot Y'(q) = -X \cdot Y'(q)$ is obviously positive given that $X > 0$ and $Y'(q) < 0$.

When both $X(q)$ and $Y(q)$ are increasing, the sign of the expression $X'(q) \cdot Y - X \cdot Y'(q)$ determines whether $X(q)$ or $Y(q)$ grows faster. If $q$ is such that $X'(q) \cdot Y - X \cdot Y'(q) > 0$, $Y(q)$ grows faster as $q$ decreases, and cartel stability declines. Given that $X'(q) \cdot Y - X \cdot Y'(q)$ is a strictly concave function and given that at $ZX$, we have a positive value, cartel stability declines for relatively high quotas. For small quotas at which $X'(q) \cdot Y - X \cdot Y'(q) < 0$, cartel stability increases. The quota that separates the two regions is labelled $L$. Therefore $X'(L) \cdot Y(L) - X(L) \cdot Y'(L) = 0$. Obviously, $L$ is strictly smaller than $ZX$.

Figure 4 combines the findings of Useful Results 1 to 3.

**Figure 4:** Change in cartel stability for gradual quota reduction between $x_{2,N,A}$ and $x_{2,Ch,A}$
If \( x_{2,Ch,A} < L < x_{2,N,A} \) and \( x_{2,Ch,A} < ZX < x_{2,N,A} \), the range of \( q \) can be divided into three disjoint intervals/zones. If either \( L \) or \( ZX \) are not within the domain, figure 4 still provides all the necessary information to determine how cartel stability changes as \( q \) changes, just some zones do not apply. The three zones may be described as follows: a) In the interval \((ZX, x_{2,N,A})\), cartel stability declines with decreasing \( q \) because a rise in firm 2’s one-shot defection advantage \( Y(q) \) is accompanied by a fall in firm 2’s per-period defection disadvantage \( X(q) \) in the punishment phase. b) In the interval \((L, ZX)\), cartel stability also declines. Both \( Y(q) \) and \( X(q) \) rise, but \( Y(q) \) grows at a higher rate than \( X(q) \). c) In the interval \((x_{2,Ch,A}, L)\), both \( Y(q) \) and \( X(q) \) grow, but now \( X(q) \) grows at a faster rate than \( Y(q) \). Hence cartel stability increases.

The results of this section are summarized in proposition 6.

**Proposition 6:**

If \( x_{2,N,A} > q \geq ZX \geq x_{2,Ch,A} \) holds, firm 2’s critical interest rate and thus cartel stability declines. For quotas \( ZX > q \geq x_{2,Ch,A} \), \( i^*_2(q) \) for constant \( i^*_1 \) at first declines with decreasing quota. For small enough quotas, \( i^*_2(q) \) may reach a minimum and then rise again. Cartel stability thus declines at first and then may grow again if the import quota becomes more restrictive.

Which case will actually occur depends crucially on the parameters, in particular on the position of \( L \) and \( ZX \). The analysis of this chapter answered the question how cartel stability changes when a quota is gradually lowered in the interval between \( x_{2,Ch,A} \) and \( x_{2,N,A} \). The case \( q < x_{2,Ch,A} \) will now be examined.

### 3.2. Import Quotas Below Firm 2’s Cheating Quantity in Country A

If the quota falls below \( x_{2,Ch,A} \), the Cournot-Nash equilibrium is further altered in favor of the domestic firm. In addition, firm 2’s gain from cheating on the cartel agreement is reduced. This means that a quota reduction causes the domestic firm’s \( i^*_1 \)-curve to shift downwards and the foreign firm’s \( i^*_2 \)-curve to shift upwards. The shift for firm 2 is this time more pronounced than for a quota reduction in the domain \( x_{2,Ch,A} \leq q < x_{2,N,A} \). The side payment \( S(q) \) that stabilizes the domestic firm’s critical interest rate \( i^*_1 \) does not change its functional form, whereas \( i^*_2(q) \) may now be written as

\[
i^*_2(q) = \frac{X(q)}{Y(q)} = \frac{\Pi_{2,M} - S(q) - \Pi_{2,N}(q)}{\Pi_{2,Ch}(q) - \Pi_{2,M} + S(q)} \quad \text{for } q < x_{2,Ch,A} \tag{32}
\]

with

\[
X(q) = \frac{(a - c_2)^2}{4 \cdot b} - S(q) - \frac{(a + c_1 + t - 2 \cdot c_2)^2}{9 \cdot b} - \frac{q}{2} \cdot (a + c_1 - 2 \cdot c_2 - 2 \cdot t - b \cdot q), \tag{33}
\]

\[
Y(q) = \frac{q}{2} \cdot (a - 2 \cdot b \cdot q + c_1 - 2 \cdot c_2 - 2 \cdot t) + S(q), \tag{34}
\]

where the first expression on the RHS in (34) is firm 2’s quota-reduced cheating profit \( \Pi_{2,Ch,A}(q) \).
Useful Result 4:

X(q) for q < x_{2,Ch,A} does not change as compared to equation (30). The denominator Y(q), however, is now a strictly concave function with maximum

\[
ZY2 = \frac{\bar{i}_1^* \cdot (a + c_1 - 2 \cdot c_2 - 2 \cdot t) - 2 \cdot (c_2 + t - c_1)}{b \cdot (3 + 4 \cdot \bar{i}_1^*)}.
\] (35)

It can be easily checked that ZY2 is strictly increasing in \( \bar{i}_1^* \).

Proof: Strict concavity follows from the fact that \( Y'(q) \) is linear with negative slope. If \( \bar{i}_1^* \) is relatively small (i.e. \( ZY2 \leq 0 \)), the one-shot deviation advantage \( Y(q) \) increases with decreasing quota. The intuition behind this is that the decrease in the foreign firm’s cheating profit is more than offset by the increase in the side payment to the domestic firm. If in addition \( ZX \leq 0 \) holds, the per-period disadvantage (in the punishment phase) from deviation declines with decreasing q. Cartel stability thus unambiguously declines.

Now consider a relatively large \( \bar{i}_1^* \). As \( \bar{i}_1^* \) goes to infinity, \( \lim_{\bar{i}_1^* \to \infty} ZY2 = x_{2,Ch,A} \). This means that for relatively large \( \bar{i}_1^* \) such that \( ZY2 > 0 \), a gradual quota tightening first increases the one-shot deviation advantage for firm 2 and then decreases it again. The discussion of how cartel stability changes follows the same pattern as in section 3.1. Let us define L2 as the quota for which the relative change in X(q) and Y(q) are equal. Then the following result helps explain the change in cartel stability:

Useful Result 5:

a) ZY2 is smaller than ZX.

Proof: Comparing ZX in (31) and ZY2 in (35) shows that the two expressions have the numerator in common, but the denominator of ZY2 is higher, establishing the inequality.

b) At ZX, the expression X'(q) \cdot Y(q) - Y'(q) \cdot X(q) is equal to - Y'(q) \cdot X(q) and is thus strictly positive. At ZY2, the expression X'(q) \cdot Y(q) - Y'(q) \cdot X(q) is equal to X'(q) \cdot Y and is thus strictly negative. By continuity of X'(q) \cdot Y(q) - Y'(q) \cdot X(q), its zero L2 therefore lies between ZY2 and ZX.

Proof: This follows directly from the parabola form of Y(q) and X(q). At ZX, X'(q) = 0, X(q) > 0 and Y'(q) < 0 hold, given that ZY2 < ZX. At ZY2, we have Y'(q) = 0, Y(q) > 0 and X'(q) < 0 for the same reason.

Results 4 and 5 can be used to construct figure 5.

This time, at most four disjoint intervals can be distinguished. a) In the interval (ZX, x_{2,Ch,A}), the foreign firm’s per period defection disadvantage X(q) during the punishment period falls while the one-shot defection advantage Y(q) rises as the quota is reduced. Cartel stability thus declines, b) In the interval (L2, ZX), both X(q) and Y(q) increase, but given that Y(q) grows at a higher rate than X(q), cartel stability still declines. c) In the interval (ZY2, L2), X(q) and Y(q) grow. This time, however, X(q) grows faster than Y(q) so that cartel stability increases. d) Finally, in the interval (0, ZY2), X(q) grows, but Y(q) declines. Therefore cartel stability increases.

The following proposition 7 sums up these results:

Proposition 7:

For \( x_{2,Ch,A} > q \geq ZX \), \( \bar{i}_2^*(q) \) declines if the quota is diminished, i.e. cartel stability is reduced. For \( q < ZY2 \), cartel stability as measured by \( \bar{i}_2^*(q) \) increases. For \( ZX > q \)
≥ ZY2, cartel stability as measured by $i_2^*(q)$ first reaches a minimum and then increases again when the import quota is gradually lowered.

The actual change in cartel stability depends on the position of ZX, L2 and ZY2. For example, ZX cannot lie in the interval $(0, x_{2,Ch,A})$ and in the interval $(x_{2,Ch,A}, x_{2,N,A})$ at the same time, so that not all zones described in section 3 can be relevant.

4. Conclusion

Although the results in this paper depend upon the parameter values, some general conclusions can be drawn:

1. A firm's cheating quantity in the export market is shown to be always smaller than its Cournot-Nash quantity in the same market. This holds independently of the linear demand assumptions, as long as we assume quantity competition and as long as the cartelization includes exclusive selling rights for firms in their home markets. In this case, a gradual quota reduction first influences the punishment equilibrium. This relationship would be reversed if we assumed a one-country setting and a production split according to the Nash bargaining solution (for equal marginal costs, this would imply equal market shares). A gradual quota reduction would then first reduce the foreign firm's cheating advantage, and cartel stability would consequently rise for mild quotas.

2. An increase in the marginal cost difference between firms increases the collusion incentive for the firm whose cost is relatively increased and lowers the incentive for the other firm. It is also true that a firm's willingness to collude depends on the value of the side payment that it receives or has to pay. If the side payment is held constant at the free trade level, introducing a quota reduces the domestic firm's interest in cartelization because its Cournot-Nash profit increases in the quota-distorted market. By contrast, the foreign firm's willingness to engage in cartelization increases due to a reduction in its Cournot-Nash profit and/or cheating profit.
3. The change in cartel stability depends on how the critical interest rate of one firm (here firm 2) changes, given that the critical interest rate of the other firm (here firm 1) is fixed at its original level. Holding firm 1’s critical interest rate $i_1$ constant requires increasing side payments to the domestic firm. If the fixed $i_1$ is very low, a quota introduction requires a relatively large increase in the side payment to firm 1. Consequently, firm 2 will suffer a decrease in its critical interest rate, and cartel stability declines.

4. In the real world, our model suggests that there are cases when trade liberalization may be harmful for the stability of international cartels. In the model, a quota reduction may induce a gradual increase in cartel stability for two different reasons: a) This increase may occur when the per-period defection disadvantage in the punishment phase for firm 2 increases at a higher rate than the one-shot deviation advantage in the cheating period. b) For quotas close to zero, a decline in the one-shot defection advantage may be accompanied by an increase in the per-period defection disadvantage in the punishment phase.

5. In the real world, the model also suggests that there are cases when trade liberalization may actually increase the stability of international cartels. Paralleling 4., a decline in cartel stability may have two different causes: a) The one-shot advantage of deviation in the cheating period increases faster than the per-period disadvantage of defection in the punishment phase. b) The increase in the one-shot defection advantage is accompanied by a fall in the per-period defection disadvantage in the punishment phase.

6. The case where both the one-shot advantage from deviation and the per-period deviation disadvantage in the punishment phase decrease is never observed.

It must be emphasized that sections 3.1. and 3.2. mostly refer to the situation where the stabilization of one firm’s critical interest rate is possible. It should not be forgotten that this might present a problem at the boundaries which are imposed by the individual rationality requirements of the firms (compare figure 3).

We can compare the results above to those of Rotemberg/Salon (1986, section III) where cartel stability is also measured by critical interest rates (more precisely: by critical discount factors). They calculate a common critical discount factor for two symmetric firms in a one-country setting without transportation costs and find that relatively mild quotas foster cartelization whereas severe quota restrictions gradually reduce cartel stability again, maybe even below the free trade level. In this paper, however, we find that mild quotas may well lower cartel stability while restrictive quotas may enhance cartel stability again, maybe even above the original level. One major reason for this difference is that Rotemberg/Salon rule out side payments. Thus, profit transfers can only be achieved by changing the firms’ sales quantities. In the Rotemberg/Salon model, quotas may severely limit the set of feasible production splits, whereas in our model, each firm only produces for its own home market so that this production split in itself cannot be affected by an import quota.

In this paper, cartel stability was measured by the change in one firm’s critical interest rate due to a gradual quota reduction, keeping fixed the critical interest rate of the other firm. Generally, the critical interest rate of firm $j$ is defined as the minimum of interest rates that may not be exceeded if firm $j$ is to prefer to abide by the cartel agreement. The higher firm $j$’s critical interest rate, the larger is the range of $j$’s interest rates for which it will choose to remain loyal to the cartel, given that this is also true for
the rival. Cartel stability may be affected by a quota even if the quantities sold and the market prices remain unaltered. A lower cartel stability then simply means that the cartel is more prone to failure due to interest rate changes. In fact, changes in the cartel agreement, including the punishment rules, were ruled out by assumption in this paper in order to determine changes in cartel stability due to a quota introduction alone. Certainly, it may be possible to restore a successful cartelization by changing the cartel agreement in terms of the prices and quantities in the cooperative equilibrium or in the punishment equilibrium. Changing the cooperative equilibrium will result in lower prices and a lower joint cartel profit. However, cartel stability may well decrease without any visible price or quantity changes.

References


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