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Cooperation among primary exporters: A theoretical framework

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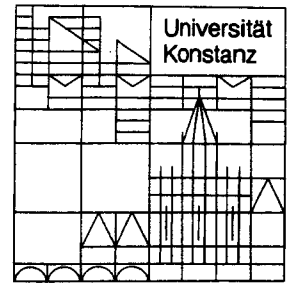
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Sonderforschungsbereich 178
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Diskussionsbeiträge



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Cooperation Among Primary Exporters
A Theoretical Framework

Cooperation Among Primary Exporters

- A Theoretical Framework

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ABSTRACT

We study the possibility of cartel formation among primary exporters who face an inelastic world demand for their exports. By constructing an appropriate infinitely repeated export game, we show that varying country sizes will pose difficulties in sustaining the collusive behaviour.

Introduction

This paper tries to provide an analytical framework to discuss 'south-south' cooperation in the field of primary exports. There is a general opinion about the vulnerability of terms-of-trade of the developing countries, which mainly export primary products such as agricultural goods, minerals and agro-based products. Empirical evidence in recent years suggests a significant decline in the unit value of exports of many developing nations mainly due to the drive to push the level of primary exports.¹ Countries which cannot readily switch to the exports of manufacturing goods try to improve the performance of traditional exports in the face of a severe balance of payments crisis. When a group of southern countries (a term often used in the literature to denote the less developed countries or the LDCs) tries to promote their exports, terms-of-trade are likely to worsen quite a bit, given a low elasticity of demand for their exports. The end result might be where each of them faces further deterioration in their balance of payment situations.² This is a classic example of the "prisoner's dilemma" problem in game theory. If any member of the exporting group pursues an active policy of export promotion while the others remain passive, it can do a lot better by not affecting the terms of trade significantly. But if everybody tries to better their positions, everyone might get worse off. A natural remedy of such a paradox must lie in the possibility of cooperation among the countries belonging to the southern bloc. The objective of a collusive agreement should be to control output and jack up prices of the exportables in the world market. However, sustainability of such a collusive structure stands out as the most fundamental question. Our paper builds on the above scenario.

¹ See Sarkar (1990).

² See the references in Sarkar (1990).

We first develop a simple game-theoretic structure and characterize the "prisoner's dilemma" type equilibrium in terms of elasticity measures. In fact, a situation where countries individually promote their exports and loose is shown to constitute a dominant strategy equilibrium of a non-cooperative game. Later we extend the structure in the context of an infinitely repeated game where countries decide on their respective export decision every period ad infinitum. This allows the countries to form a collusion and design punishment strategies in case someone deviates from the collusive equilibrium. We particularly focus our attention on the 'trigger strategy' equilibrium where, if one of the partners cheats, the other one falls back on the non-cooperative equilibrium of the stage game to execute the threat.³ The main result of the paper is that the greater the difference in the initial export shares, the harder it is to sustain such collusions. It is also shown that 'smaller' nations are likely to be the 'bandits'. To sustain the cooperative outcomes, the 'benefits and costs' of collusion faced by each of the trading partners must not differ a 'lot'. In fact, our discussion reveals that 'collusion' is most likely to form when countries are identical in terms of their size.

The paper is divided into three sections. In the first we develop the basic model and characterize the equilibrium in the non-cooperative game. The second section discusses the cooperative outcome of the game. Concluding remarks are provided in section III.

³ For useful discussions on collusions in repeated games see Shapiro (1989), Tirole (1988) and Kreps (1990a, b).

Section I

The Basic Framework

Consider two countries selling a common export good x in the world market. x_1 is sold by country 1 and x_2 is sold by country 2. $x_1 + x_2 = x$ is the total supply of this good in the world market. P is the relative price of this product, and all other prices (mainly of import goods) are held fixed in our analysis. We also fix the level of imports of each country, so that we can focus only on the value of their exports. Let λ_i , $i = 1, 2$ be the share of x going to the i th country and we assume $\lambda_1 > \lambda_2$. Such an assumption refers to the relative size of each exporting nation. The price elasticity of demand for x in the world market is given by $\varepsilon < 1$. We superimpose a very simple objective function for these countries. We assume that they are only bothered about their trade balance and hence the value of their exports. We restrict the strategy space of these countries to a couplet (A, B) . A indicates the strategy of raising their exports at a rate g . B is the strategy of maintaining a status quo in their respective levels. The following condition is assumed to make the subsequent game an interesting one:

$$\varepsilon > \lambda_i, \quad i = 1, 2 \quad (1)$$

Added to our previous assumption, (1) implies:

$$1 > \varepsilon > \lambda_i, \quad i = 1, 2 \quad (2)^4$$

We are now in a position to write down the following pay-off matrix for these economies. Π_{jk}^i denotes the pay-off to the i th country when the first country chooses the j th strategy and the second one chooses the k th strategy, $j = A, B$, $k = A, B$.

⁴ It is easy to check that for $\varepsilon > \frac{1}{2}$ we can always find λ s satisfying the condition (see the Appendix).

Country 1 \ Country 2	Country 2	
	A	$i = 1, 2$ B
A	$\frac{g(\varepsilon-1)}{\varepsilon}, \frac{g(\varepsilon-1)}{\varepsilon}$	$\frac{g(\varepsilon-\lambda_1)}{\varepsilon}, -\frac{\lambda_1 g}{\varepsilon}$
B	$-\frac{\lambda_2 g}{\varepsilon}, \frac{g(\varepsilon-\lambda_2)}{\varepsilon}$	0, 0

Note that

$$\Pi_{AA}^1 = \hat{P} + (\lambda_1 + \lambda_2)g = -\frac{1}{\varepsilon}g + g$$

$$\left[-\varepsilon \hat{P} = g \text{ (for eqm.)}\right] = \frac{g(\varepsilon-1)}{\varepsilon} < 0$$

$$\Pi_{AB}^1 = \hat{P} + g = -\frac{\lambda_1 g}{\varepsilon} + g = \frac{g(\varepsilon-\lambda_1)}{\varepsilon} > 0, \quad \text{by (2)}$$

$$\Pi_{AB}^2 = -\frac{\lambda_1 g}{\varepsilon}$$

These pay-offs are calculated on the basis of the fact that when only country 1 grows, its exports grow by g . But the world exports grow by $\lambda_1 g$.

Similarly,

$$\Pi_{BA}^1 = -\frac{\lambda_2 g}{\varepsilon}, \quad \Pi_{BA}^2 = \frac{g(\varepsilon-\lambda_2)}{\varepsilon}$$

and

$$\Pi_{BB}^1 = 0 = \Pi_{BB}^2$$

It is interesting to note that both Π_{AA}^2 and Π_{AB}^2 are negative. However, given country 1 goes for A , country 2 would always opt for A .

This is given by

$$|\Pi_{AA}^2| < |\Pi_{AB}^2| \quad (3)$$

as

$$\frac{g(1-\varepsilon)}{\varepsilon} - \frac{\lambda_1 g}{\varepsilon} = \frac{g(\lambda_2 - \varepsilon)}{\varepsilon} < 0 \quad (4)$$

By symmetry, it is also true for 1.

Proposition 1:

(A,A) is the dominant strategy equilibrium of the export game described above.

Proof: Studying the pay-offs, it is fairly obvious that

$$\Pi_{AA}^1 > \Pi_{BA}^1, \quad \Pi_{AB}^1 > \Pi_{BB}^1$$

and

$$\Pi_{BA}^2 > \Pi_{BB}^2, \quad \Pi_{AA}^2 > \Pi_{AB}^2$$

QED

The implication of proposition 1 is that in such a game both countries loose relative to the status-quo where they continue to earn the initial export income. What we designed

so far is a simple version of the classic 'prisoner's dilemma' problem.⁵ Since (B, B) promises a better pay-off to either of these countries, one might look for a mechanism to sustain (B, B) as a cooperative outcome. As it always happens, even in a finitely repeated version of the game, (B, B) cannot be sustained as a collusive equilibrium of the game.

Section II

The Cooperative Equilibrium

Consider the export game either repeating for an infinite number of times or not having a certain known terminal date. In that case we look for (B, B) as an equilibrium when each of the countries can punish the other by falling back on the non-cooperative equilibrium of the stage game in case the other deviates from (B, B) . Let δ be the common rate of discount. Following the usual logic of calculating the 'net benefit' from 'deviation' we argue that country i will not deviate from (B, B) provided (5) holds.

$$\frac{g(\varepsilon - \lambda_i)}{\varepsilon} + \frac{\delta}{1 - \delta} \frac{g(\varepsilon - \lambda_i)}{\varepsilon} < 0 \quad (5)$$

The first term on the left-hand side in (5) suggests the gain from deviation for country i .

⁵ With $\varepsilon < 0$, probably a cut-back in the export volume is a welcome move. We rule out such a strategy by assumption. This might be justified by the fact that a decline in the export volume leads to a contraction in the export sector probably leading to significant unemployment. Such action is politically unsustainable. A status-quo is the worst that could happen here. However, in an extended game, if one allows for symmetric cut-back rates (as reflected in g in the context of growth), (A, A) should turn out to be the equilibrium given somebody is cutting back, the other can get further incentive to expand. The interested reader can work this out.

With (B, B) , each of them gets 0. But if country i deviates and chooses A instead, it gets $\frac{g(\varepsilon - \lambda_i)}{\varepsilon}$. Then from the next period onwards the other country takes recourse to strategy A forcing country i to adopt A and earn negative returns in the amount of $\frac{g(\varepsilon - 1)}{\varepsilon}$ ad infinitum. The net present value from such a deviation must be negative for inducing country i to stick to the cooperative outcome. After little manipulation (5) leads to (6) :

$$\delta > \frac{\varepsilon - \lambda_i}{1 - \lambda_i} \quad (6)$$

Since $\lambda_i < \varepsilon < 1$, one can always find a δ high enough to satisfy (6) and therefore sustain the cooperative outcome. In this case the minimum critical value of δ_i , say, $\tilde{\delta}_i = \frac{\varepsilon - \lambda_i}{1 - \lambda_i}$.

However, the question is how difficult it is to sustain such a collusion. Again adhering to the accepted norms of game theory, one could argue that the higher $\tilde{\delta}_i$, the set of 'possible' δ s that would sustain collusion tend to contain fewer elements. Therefore, higher values of $\tilde{\delta}_i$ make the sustainability problem more severe.

Now treating $\tilde{\delta}_i$ and λ_i as continuous variables one could get for a given ε ,

$$\frac{d \tilde{\delta}_i}{d \lambda_i} = \frac{\varepsilon - 1}{(1 - \lambda_i)^2} < 0 \quad (7)$$

The smaller the share of world exports of country 1, the larger would be the critical value of $\tilde{\delta}_i$.

This would in fact be the guiding factor behind collusion. If $\lambda_1 > \lambda_2$, then $\tilde{\delta}_1 < \tilde{\delta}_2$. For sustaining the collusion it must be the case that

$$\delta > \max(\tilde{\delta}_1, \tilde{\delta}_2) = \tilde{\delta}_2 \quad (8)$$

The intuition behind this result follows directly from (5). The country having a smaller share gains more from cheating than the other, as the extent of gain is determined by $(\varepsilon - \lambda_1)$. Therefore, it needs more severe punishment to fall back in line with the cooperative outcome. However, the extent of punishment common to each other is $\frac{g(\varepsilon - 1)}{\varepsilon}$. Therefore, $\tilde{\delta}$ has to be higher for a 'smaller' country to make the cooperative scheme work. We now have the premise for proving the following proposition.

Proposition 2:

The minimum critical value that δ can assume in this structure, for a given ε , is when $\lambda_1 = \lambda_2 = \frac{1}{2}$ i.e. $\tilde{\delta} = 2\varepsilon - 1$.

Proof: Suppose this is not the case, then $\exists \hat{\delta} < 2\varepsilon - 1$ for $\lambda_1 \neq \lambda_2$. Without loss of generality let us suppose $\lambda_1 > \lambda_2$. Then, $\hat{\delta} = \max(\hat{\delta}_1, \hat{\delta}_2) = \hat{\delta}_2$. But $\hat{\delta}_2 > 2\varepsilon - 1$ since $\lambda_1 > \lambda_2 \Rightarrow \lambda_2 < \frac{1}{2}$. Hence, contradiction. QED.

Proposition (2) suggests that in some sense sustaining collusion is easiest when countries are roughly similar in terms of their shares in the world export market.

As our analysis shows, the elasticity of export demand can also affect $\tilde{\delta}$. In fact, the higher ε , the higher is $\tilde{\delta}$, making cooperation more difficult. Interestingly, though the conventional argument for export-pessimism hinges on $\varepsilon < 1$, which we assume, higher values of ε in the range of $(\varepsilon < 1)$ should not be welcome for cooperation.

Rewriting (5) one gets

$$g \left[\left(1 - \frac{\lambda}{\varepsilon} \right) + \frac{\delta}{1-\delta} \left(1 - \frac{1}{\varepsilon} \right) \right] < 0 \quad . \quad (9)$$

As ε increases, the pay-off from deviation goes up and as $1 - \frac{1}{\varepsilon} < 0$, punishment becomes less severe. On both these accounts $\tilde{\delta}$ must increase to uphold the cooperative outcome. When country shares are identical, i. e. $\lambda_1 = \lambda_2 = \frac{1}{2}$, then $\tilde{\delta} = 2\varepsilon - 1$. Since $\varepsilon > \frac{1}{2}$ for (2) to hold (see the Appendix), cooperative equilibrium would be the outcome for $\varepsilon = \frac{1}{2} + s$ where s is infinitesimally small. For ε very close to $\frac{1}{2}$, $\tilde{\delta}$ would be nearing zero and collusion would be sustained $\forall \delta \in (0, 1)$.

Section III

Conclusion

We have built up a theoretical framework to analyse cartel formation among primary exporters. The model describes a special case where export demand elasticity which is less than one is higher than the share of world exports accruing to each country. This generates the classic case of a "prisoner's dilemma" and forces each country to loose through growth. Incidentally, this also provides some sort of strategic foundation to the theory of immiserizing growth in international trade theory. We then show how a collusive equilibrium could be sustained with infinite repetitions of the game. Ceteris

paribus, similar country sizes - as reflected in the initial share of world exports - tend to facilitate collusion.

In the course of our analysis we have other two interesting cases left,

$$(a) \quad 1 > \lambda_1 \gtrless \lambda_2 > \varepsilon$$

$$(b) \quad 1 > \lambda_1 > \varepsilon > \lambda_2 \quad .$$

By following the arguments already developed in the paper and constructing the relevant pay-off matrix it can be shown that in situation (a), (B, B) constitutes the dominant strategy equilibrium.

In other words, one does not have to worry about sustaining (B, B) as an equilibrium in the one-shot game. Therefore, the problem is trivially solved. Hence, if ε is very low, chances are high that countries would choose no-growth as a strategy insulating themselves from losses. The literature on export-pessimism puts the blame on ε being very small. But we find this would in fact enforce the so-called collusive outcome in this case.

Case (b) makes the countries quite asymmetric as their shares and ε are differently related. In this case the Nash-equilibrium is (B, A) . Hence, the 'larger' country loses unambiguously. There is no other equilibrium of the game preferred by both at the same time. We think both cases (a) and (b) further supplement the basic result with interesting insights. It is quite transparent that 'being large' can create problems while other members of the group are 'small'. The 'small' can inflict losses on the 'large' by overselling and slashing prices, in this case the terms of trade. The very foundation of a 'trading bloc' among nations exporting to a volatile market gets weaker if country sizes vary a lot. It would probably be interesting to generalize the paper by bringing more than two

countries and study coalition formations within the group of exporting nations. An interesting case to study would be to consider n countries each commanding $\frac{1}{n}$ fraction of the total exports. A conjecture in this case might be that, *ceteris paribus*, collusion would be extremely hard to sustain as n gets larger. When there are many countries the country with the 'minimum share' should be prevented from cheating. That should automatically guarantee the support of a larger member or a coalition of members of the group for the collusive equilibrium.

APPENDIX

Feasibility of $1 > \varepsilon > \lambda_i$, $i = 1, 2$.

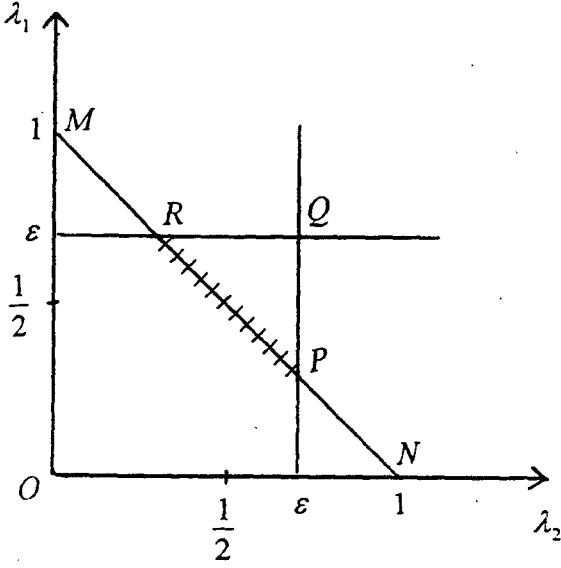


Fig. 1

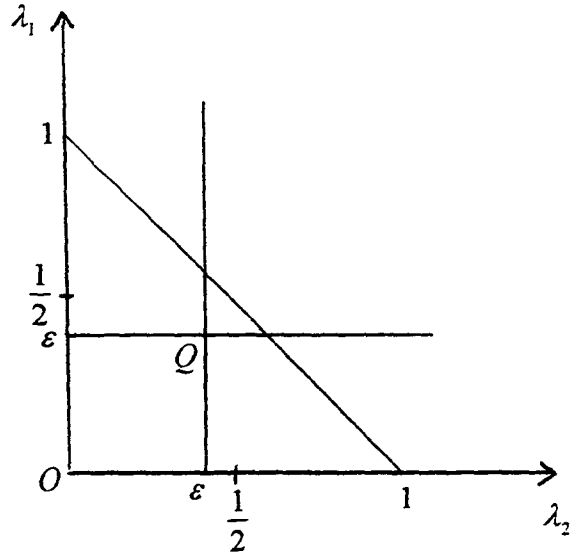


Fig. 2

(2) is feasible, i.e. given $\varepsilon < 1$ one can find λ_1, λ_2 satisfying (2) and $\lambda_1 + \lambda_2 = 1$, provided a point such as Q lies outside the triangle OMN . As figure 1 shows, this is possible if $\varepsilon > \frac{1}{2}$. The feasible set of λ_1, λ_2 are shown by PR . An equivalent condition is that a triangle such as RQP exists. Figure 2 depicts a case where $\varepsilon < \frac{1}{2}$ and (2) does not hold.

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