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# INTERNATIONAL TRANSFERS: STRATEGIC LOSSES AND THE BLOCKING OF MUTUALLY ADVANTAGEOUS TRANSFERS*

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Recent studies indicate the possibility that, in the more-than-two-country model, a coalition may block a competitive equilibrium by means of mutually advantageous transfers among its members. This study demonstrates that even the equilibrium which is to be established after a mutually advantageous transfer may be blocked. In order to form a blocking coalition, a country may take a strategic loss, i.e., give or receive a transfer which reduces its own utility. This provides a possible reason why a country may, not out of benevolence, give or receive a transfer which it knows to reduce its own utility.

## 1. INTRODUCTION

In the standard framework of bargaining, as is well-known, a competitive equilibrium is in a core; that is, no coalition can block it. Recent studies have, however, established that a coalition may block even a competitive equilibrium if possible payoffs to agents are limited to utilities in the competitive equilibrium established after agents carry out certain strategies. One way of blocking is to make a *mutually advantageous transfer*,[2] a transfer which increases the utility of every member in a particular coalition. Because all members would agree to make such a transfer, the coalition can prevent a no-transfer equilibrium (see Gale 1974, Guesnerie and Laffont 1978, Safra 1983, and Leonard and Manning 1983).[3] I

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[2] Another way of blocking an equilibrium is to destroy part of a coalition's resources, as discussed by Aumann and Peleg (1974) and Postlewaite (1979). Such a blocking may be attributed to the reverse phenomenon of immizerizing growth (see Edgeworth 1894, Johnson 1953 and Bhagwati 1958).

[3] In the literature, it is known that a transfer may reduce its recipient' utility and/or increase its donor's utility; such a phenomenon is called a transfer paradox. A mutually advantageous transfer is a type of such transfer paradox. The literature on the transfer paradox, which has rapidly developed recently, can be traced back to Johnson (1960), who considered countries with more than one class of consumers. Komiya and Shizuki (1967) gave an analytical characterization to Johnson's result. Independently, Brecher and Bhagwati (1981) obtain a similar characterization.

Independently, Gale (1974) presented an example of a mutually advantageous transfer in a fixed coefficient model, in which there is no substitution effect. Two lines of studies have followed Gale's work. One is concerned with mutually advantageous transfers; this includes the studies cited above. The other is concerned with the possibility and characterization of the general transfer paradox. By an example similar to that of Gale (1974), Chichilnisky (1980, 1983) points out that a country may reduce its utility by receiving a transfer; her example is further examined by Geanakoplos and Heal (1983), Gunning (1983), Ravallion (1983), Saghafi and Nugent (1983), and Srinivasan and Bhagwati (1983). Polemarchakis (1983), de Meza (1983), and Postlewaite and Webb (1984) make further extensions.

demonstrate that even a mutually advantageous transfer can sometimes be blocked, i.e., an equilibrium established after a mutually advantageous transfer can be blocked.

In blocking a mutually advantageous transfer, a country that is concerned with only its own utility may sometimes be willing to pay or receive a transfer which it knows to reduce its own utility. Such a country may be considered to take a *strategic loss*. Suppose that a country, say A, knows that a certain pair of foreign countries can make a mutually advantageous transfer between them, and that the transfer would reduce A's own utility. Country A will try to stop the transfer. It may propose a transfer with one of the two participants which increases that participant's utility more and reduces A's own utility less. Since that participant will certainly accept this proposal, A can block the initial transfer; A takes a strategic loss, giving or receiving a transfer which reduces its own utility.

Even in the more-than-three-country case, a country may be able to block a mutually advantageous transfer by taking a strategic loss, although the analysis is complicated by its need to account for the reactions of countries outside the coalition and the importance of the income redistributional effect among those countries. If more than three countries are playing a transfer game, a pair of countries thinking of forming a coalition must consider the reaction of the remaining countries. For example, countries will block a mutually advantageous transfer if they decide that once they block the transfer, the remaining countries will not be able to agree to make a subsequent transfer.

Strategic loss taking and blocking mutually advantageous transfers are analyzed in terms of substitution and income effects. The income redistributional effect is similar to that which Johnson (1960) and Yano (1983) point to as a cause of the transfer paradox in the three-country model. Jones (1984, 1985) sharpens their arguments, focusing on the price change which compensates the direct effect of a transfer on a country's income. In the three-country case, the substitution effect plays the critical role in strategic loss taking and blocking transfers. In the more-than-three-country case, a two-country transfer has an income redistributional effect on the remaining countries that affects the phenomena. I extend Jones's argument to the more-than-three-country case and explain the blocking of mutually advantageous transfers and the taking of strategic losses.

The rest of this paper is organized as follows: Section 2 explains the transfer game and derives a basic lemma. Section 3 characterizes the blocking of mutually advantageous transfers and strategic loss takings in a three-country economy. Section 4 explains the role of substitution and income effects in the case in which only three countries play a transfer game in a four-country economy and, then, discusses strategic loss taking in the case in which all four countries play the game.

Bhagwati, Brecher, and Hatta (1983) and Yano (1983) characterize the transfer paradox in the three-country model. Dixit (1983), Jones (1984, 1985), Majumdar and Mitra (1985), and Safra (1983b) extend their results.

## 2. THE TRANSFER GAME

Describe the economy underlying transfer games by the four-country, two-good trade model. The market is perfectly competitive. Let $q(\equiv p_1/p_2)$ be the relative price of good 1 in terms of good 2. The preference of country $i$, $i = 1, 2, 3, 4$, is represented by a single utility function $u^i(D_1^i, D_2^i)$, where $D_r^i$ denotes country $i$'s consumption of good $r$. Country $i$'s compensated demand function of good $r$ is $D_r^i(q, u^i)$; i.e., $(D_1^i, D_2^i) = [D_1^i(q, u^i), D_2^i(q, u^i)]$ minimizes $qD_1^i + D_2^i$ subject to $u^i(D_1^i, D_2^i) = u^i$. Country $i$'s indirect utility function is $v^i(q, Y^i)$; i.e., $v^i(q, Y^i) = \max u^i(D_1^i, D_2^i)$ subject to $qD_1^i + D_2^i = Y^i$. Country $i$'s supply function of good $r$ is $X_r^i(q)$; i.e., $(X_1^i, X_2^i) = [X_1^i(q), X_2^i(q)]$ maximizes $qX_1^i + X_2^i$ along the production possibility frontier of country $i$. Denote by $t_1$ the transfer from country 1 to country 2, by $t_2$ that from 2 to 3, and by $t_3$ that from 3 to 1. Thus, country $i$'s income can be written as

$$Y^i(q, t) = qX_1^i(q) + X_2^i(q) - t_i + t_k \tag{1}$$

for $(i, k) = (1, 3), (2, 1)$, and $(3, 2)$, where $t = (t_1, t_2, t_3)'$. Assume, for the moment, that country 4 neither gives nor receives a transfer (this assumption will be relaxed in Section 4.2); its budget equation is

$$Y^4(q, t) = qX_1^4(q) + X_2^4(q). \tag{2}$$

The following system characterizes a market equilibrium:

$$\sum_i D_1^i(q, v^i(q, Y^i(q, t)) = \sum_i X_1^i(q). \tag{3}$$

Denote by $q(t_i)$ the equilibrium which will be established after transfer $t_i$.

As in Gale (1974), assume that the strategy of a coalition is to make transfers among members. The returns to members are their utilities in the equilibrium which will be established after the transfers are made. Take a transfer between 1 and 2, $t_1$, and consider equilibrium $q(t_1)$. Coalition $\{i, j\}$ can *block* equilibrium $q(t_1)$ [by a transfer $\tau$ between $i$ and $j$], if the shift from equilibrium $q(t_1)$ to the equilibrium which will be established after transfer $\tau$ increases the utility of either $i$ or $j$ without reducing that of the other. In particular, if either $i$ or $j$ is a nonparticipant in transfer $t_1$, I say that the nonparticipant can *block* transfer $t_1$ [by transfer $\tau$]. If, moreover, a nonparticipant block transfer $t_1$ by transfer $\tau$ and if transfer $\tau$ reduces the nonparticipant's utility relative to the no-transfer equilibrium, I say that the nonparticipant takes a *strategic loss*. A transfer is *mutually advantageous* if the transfer increases the utilities of both its donor and its recipient, relative to the no-transfer equilibrium.[4]

It is intractable to characterize the effect of a large transfer in a general equilibrium model, so I focus on infinitesimal transfers, $dt \equiv (dt_1, dt_2, dt_3)'$.[5] Define

[4] This transfer is similar to an advantageous reallocation of initial resources in the terminology of Guesnerie and Laffont (1978).

[5] Komiya and Shizuki (1967), Brecher and Bhagwati (1981), Bhagwati, Brecher, and Hatta (1983), Yano (1983), Dixit (1983), and Jones (1984, 1985) are concerned with local characterizations.

by $dy^i = qdD_1^i + dD_2^i$ a change in country $i$'s *real income*.[6] Since $q = u_1^i/u_2^i$ by the optimization of consumers, $du^i = u_2^i dy^i$, where $u_r^i \equiv \partial u^i/\partial D_r^i > 0$. This implies that a change in real income is positive if and only if utility $u^i$ increases. Let $E^i(q, u^i) \equiv D_1^i(q, u^i) - X_1^i(q)$. Then, by the definition of $dy^i$,

$$qdE^i = -s^i dq + \mu^i dy^i \tag{4}$$

for $i = 1, 2, 3, 4$, where $\mu^i \equiv q(\partial E^i/\partial u^i)\, u_2^i$ and $s^i \equiv -q\partial E^i/\partial q > 0$. Equation (4) indicates that $\mu^i$ is a marginal propensity to consume good 1 and that $s \equiv \Sigma_i s^i > 0$ captures the substitutability between the goods; call $s$ an (absolute) index of substitution. Define

$$\Delta \equiv s + E^1\mu^1 + E^2\mu^2 + E^3\mu^3 + E^4\mu^4. \tag{5}$$

Condition $\Delta > 0$ is often called the Marshall-Lerner condition. It guarantees Walrasian stability around equilibrium $q(0)$. Let $dy \equiv (dy^1, dy^2, dy^3)'$.

LEMMA 1. *Let $\Delta \neq 0$. At equilibrium $q(0)$, $dy = (1/\Delta)W\,dt$ holds, where*

$$W = \begin{bmatrix} -[\Delta + E^1(\mu^2 - \mu^1)] & -E^1(\mu^3 - \mu^2) & \Delta - E^1(\mu^1 - \mu^3) \\ \Delta - E^2(\mu^2 - \mu^1) & -[\Delta + E^2(\mu^3 - \mu^2)] & -E^2(\mu^1 - \mu^3) \\ -E^3(\mu^2 - \mu^1) & \Delta - E^3(\mu^3 - \mu^2) & -[\Delta + E^3(\mu^1 - \mu^3)] \end{bmatrix}.\text{[7]} \tag{6}$$

PROOF. Let $\mu \equiv (\mu^1, \mu^2, \mu^3)$ and $E \equiv (E^1, E^2, E^3)'$. Since $Y^i = qD_1^i + D_2^i$, $dy^i = dY^i - D_1^i dq$. Since $qdX_1^i + dX_2 = 0$ by the producers' optimization, (1) implies $dY^i = X_1^i dq - dt_i + dt_k$. These facts imply the following relationships:

$$dy = -E\,dq + T\,dt; \tag{7a}$$

$$dy^4 = -E^4\,dq \tag{7b}$$

where

$$T = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix}.$$

By $\Sigma_i\, dE^i = 0$ in equilibrium, (4) and (7b) give $\mu dy = sdq + E^4\mu^4 dq$. By using (7a) in this expression,

$$dq = \frac{1}{\Delta}\,\mu T\,dt, \tag{8}$$

which implies $dy = (1/\Delta)(\Delta I - E\mu)T\,dt$ by (7a). Q.E.D.

[6] This concept is often used in trade theory (see Caves and Jones 1985, p. 485). It is similar to the real income indices of Laspeyres and Paasche in that it measures a change in consumption by means of the base price system.

[7] This extends the characterizations of Komiya and Shizuki (1967), Brecher and Bhagwati (1981), Bhagwati, Brecher, and Hatta (1983), and Yano (1983).

## 3. STRATEGIC LOSSES AND BLOCKING MUTUALLY ADVANTAGEOUS TRANSFERS

This section demonstrates the possibilities of blocking a mutually advantageous transfer and taking a strategic loss by focusing the three-country case ($E^4 = 0$). Let $dt_{1*} > 0$ be a transfer (infinitesimal) from country 1 to country 2. Let $w^{ij}$ be the $(i, j)$ element of matrix $W$. Transfer $dt_{1*}$ is mutually advantageous if and only if $w^{11}/\Delta > 0$ and $w^{21}/\Delta > 0$. For a vector of agents utilities, $u$ (which could be 2- or 3-dimensional in this study), denote $u > 0$ if all the components of $u$ are nonnegative and $u \neq 0$. The following lemma characterizes the blocking of a mutually advantageous $dt_{1*}$.

LEMMA 2. *Let $E^4 = 0$, $w^{11}/\Delta > 0$ and $w^{21}/\Delta > 0$.*

A. *Coalition* $\{3, 1\}$ *can block equilibrium $q(dt_{1*})$ by transfer $dt_3 > 0$ if and only if $s/w^{13} > 0$.*

B. *Coalition* $\{2, 3\}$ *can block equilibrium $q(dt_{1*})$ by transfer $dt_2 > 0$ if and only if $s/w^{22} > 0$.*

NOTE. Although case B is a possibility, it is less intuitive than case A. Realistically speaking, it may not be likely that country 2, a member of the coalition in which a mutually advantageous transfer is to be made, initiates blocking of that mutually advantageous transfer by giving a transfer to country 3.

PROOF. By definition, $\{1, 3\}$ can block $q(dt_*)$ by $dt_3$ if and only if

$$\begin{bmatrix} w^{13}/\Delta \\ w^{33}/\Delta \end{bmatrix} dt_3 > \begin{bmatrix} w^{11}/\Delta \\ w^{31}/\Delta \end{bmatrix} dt_{1*}. \tag{9}$$

Since, by (6), $\Sigma_i\, w^{i1}/\Delta = 0$, $w^{31}/\Delta < 0$. Thus, (9) holds for some $dt_3$ if and only if $w^{31}/w^{11} < w^{33}/w^{13}$. By $\Sigma_i E^i = 0$ and (6), $0 < w^{33}/w^{13} - w^{31}/w^{11} = \Delta s/w^{13}w^{11}$. Thus, $s/w^{13} > 0$ by $w^{11}/\Delta > 0$. If $\{1, 3\}$ can block $q(dt_*)$, by (9), $dt_3 > 0$. Statement A is proved. Statement B can be proved in a similar manner. Q.E.D.

Without loss of generality, assume $\mu^1 > \mu^2$; the underlying trade model is symmetric between goods 1 and 2. The next lemma completely characterizes a mutually advantageous transfer.

LEMMA 3. *Let $E^4 = 0$, $\mu^1 > \mu^2$ and $\Delta > 0$.*

A. *If $\mu^3 > \mu^1 > \mu^2$, the transfer $dt_{1*}$ is mutually advantageous if and only if $-s/(\mu^3 - \mu^1) < E^3 < -s/(\mu^3 - \mu^2)$.*

B. *If $\mu^1 > \mu^3 > \mu^2$, the transfer $dt_{1*}$ is mutually advantageous if and only if $E^3 < -s/(\mu^3 - \mu^2)$.*

C. *If $\mu^1 > \mu^2 > \mu^3$, the transfer $dt_{1*}$ is not mutually advantageous.*

The following theorems hold:

THEOREM 1. *Let $E^4 = 0$, $s > 0$, $\Delta > 0$ and $\mu^1 > \mu^2$. Suppose that the infinitesimal transfer from 1 to 2, $dt_{1*} > 0$, is mutually advantageous.*

A. *If* $\mu^3 > \mu^1 > \mu^2$, *then coalition* {3, 1} *can always block equilibrium* $q(dt_{1*})$. *The transfer* $dt_3$, *by which* {3, 1} *can block* $q(dt_{1*})$ *must be from* 3 *to* 1 ($dt_3 > 0$) *and decrease* 3′ *real income.*

B. *If* $\mu^1 > \mu^3 > \mu^2$, *then coalition* {3, 1} *can block equilibrium* $q(dt_{1*})$ *if and only if* $E^2 < s/(\mu^3 - \mu^2)$. *The transfer,* $dt_3$, *by which* 3 can block $q(dt_{1*})$ *must be from* 3 *to* 1 ($dt_3 > 0$). *It reduces* 3*'s real income if and only if* $E^2 < s/(\mu^1 - \mu^2)$.

PROOF. By $\Sigma_i E^i = 0$, $E^4 = 0$, $\mu^3 > \mu^2$, the following relationships hold:

$$w^{13} > 0 \Leftrightarrow E^3 > -s/(\mu^3 - \mu^2) - E^1; \tag{10}$$

$$w^{33} < 0 \Leftrightarrow E^3 > -s/(\mu^1 - \mu^2) - E^1; \tag{11}$$

$$\Delta > 0 \Leftrightarrow E^3 > -s/(\mu^3 - \mu^2) - E^1(\mu^1 - \mu^2)/(\mu^3 - \mu^2). \tag{12}$$

Given $s > 0$ and $\Delta > 0$, Lemma 2 implies statement B. If $\mu^3 > \mu^1 > \mu^2$, by (10) and (12), $\Delta > 0$ implies $w^{13} > 0$, and by (10) and (11), $w^{13} > 0$ implies $w^{33} < 0$. Thus, statement A holds. Q.E.D.

THEOREM 2. *Keep the setting of Theorem 2.*

A. *If* $\mu^3 > \mu^1 > \mu^2$, *then coalition* {3, 2} *can block equilibrium* $q(dt_{1*})$ *if and only if* $E^1 > s/(\mu^3 - \mu^1)$. *The transfer,* $dt_2$, *by which* {3, 2} *can block* $q(dt_{1*})$ *must be from* 2 *to* 3 *and mutually advantageous.*

B. *If* $\mu^1 > \mu^3 > \mu^2$, *then* {3, 2} *cannot block equilibrium* $q(dt_{1*})$.

PROOF. By (6) and $\Sigma_i E^i = 0$, the following relationships hold:

$$w^{22} > 0 \Leftrightarrow s + E^1(\mu^1 - \mu^3) < 0; \tag{13}$$

$$w^{32} < 0 \Leftrightarrow s + E^1(\mu^1 - \mu^2) < 0. \tag{14}$$

Since $\mu^1 > \mu^2$ and $w^{11} > 0$ imply $E^1 > 0$, the theorem readily follows. Q.E.D.

The following corollary completely characterizes strategic loss taking.

COROLLARY 1. *Let* $E^4 > 0$ *and* $s > 0$. *Suppose that one of the following two sets of conditions is satisfied:*

$$E^3 > -s/(\mu^3 - \mu^2) + E^1(\mu^1 - \mu^2)/(\mu^3 - \mu^2) \quad \textit{and} \quad -s/(\mu^3 - \mu^1) < E^3 < -s/(\mu^3 - \mu^2) < 0; \tag{15}$$

$$E^3 > -s/(\mu^1 - \mu^2) - E^1 \quad \textit{and} \quad E^3 < -s/(\mu^3 - \mu^2) < 0 < -s/(\mu^3 - \mu^1). \tag{16}$$

*Then, the following statements hold:*

A. *The no-transfer equilibrium is locally Walrasian stable* ($\Delta > 0$);

B. *An infinitesimal transfer from* 1 *to* 2 *is mutually advantageous;*

C. *Country* 3 *takes a strategic loss by giving a transfer to* 1.

*If, conversely, statements* A, B *and* C *hold, either* (15) *or* (16) *holds, given* $\mu^1 > \mu^2$.

PROOF. Conditions (15) and (16), respectively, imply $\mu^3 > \mu^1 > \mu^2$ and $\mu^1 > \mu^3 > \mu^2$. The corollary follows from the proofs of Theorems 1 and 2. Q.E.D.

COROLLARY 2. *Let* $E^4 = 0$, $s > 0$, $\Delta > 0$, *and* $\mu^1 > \mu^2$. *Suppose that an infinitesimal transfer from* 1 *to* 2 *is mutually advantageous. Country* 3 *cannot block the transfer if and only if* $\mu^1 > \mu^3 > \mu^2$ *and* $E^2 > s/(\mu^3 - \mu^2)$.

PROOF. Obvious from Theorems 1 and 2. Q.E.D.

The following conclusions follow from the above result:

1. A country sometimes can block a mutually advantageous transfer between other countries.
2. In the three-country case the nonparticipant may take a strategic loss only by giving a transfer; this transfer must be received by the country designated as the donor of the mutually advantageous transfer to be blocked.
3. In the three-country case, a country may block a mutually advantageous transfer between the other countries by giving a mutually advantageous transfer to the country designated as the donor of the transfer to be blocked or by receiving a mutually advantageous transfer from the country designated as the recipient of the transfer to be blocked.
4. If, in the three-country economy, there is no substitution effect ($s = 0$), a country cannot block a mutually advantageous transfer between the other two countries, although it is possible to make a mutually advantageous transfer (this follows from Lemmas 2 and 3).

These conclusions hold in the case in which the market is Walrasian stable around the no-transfer equilibrium.

## 4. STRATEGIC LOSS TAKING IN THE MORE-THAN-THREE-COUNTRY ECONOMY

One important feature in the more-than-three-country case, as distinct from the three-country case, is that in deciding whether to block a mutually advantageous transfer, two countries thinking of forming a coalition must consider the response of the remaining countries. (Such consideration is not necessary in the three-country case; if two countries form a coalition, the third player can make no transfer by itself.) Another important feature in the more-than-three-country case is that a transfer which two countries use to block a mutually advantageous transfer will have an income redistributional effect on the rest of the players. The first half of this section focuses on the working of this income redistributional effect in the case in which only three countries play a transfer game in a four-country economy. The second half discusses strategic loss takings in the four-country game. Throughout this section, assume $\mu^1 > \mu^2$, and that the infinitesimal transfer from 1 to 2, $dt_{1*}$, is mutually advantageous and will reduce 3's utility. Focus on coalition $\{3, 1\}$'s blocking transfer $dt_{1*}$.

4.1. *Three-Country Game in the Four-Country Economy.* Let a pair of a transfer between 3 and 1 and a price change, $(dt_{3o}, dq_o)$, satisfy the following. If country 1 gives up transfer $dt_{1*}$ and receives transfer $dt_{3o}$ from 3, and if price change $dq_o$ occurs after transfer $dt_{3o}$, the real incomes of both 1 and 3 will be exactly the same as in equilibrium $q(dt_{1*})$. That is, $dy_o^i = dy_*^i$ for $i = 1, 3$, where $dy_o^i$ and $dy_*^i$ are defined as follows: $dy_*^1 \equiv -E^1 dq_* - dt_{1*}$, $dy_*^2 \equiv -E^2 dq_* + dt_{1*}$, $dy_*^i \equiv -E^i dq_*$ for $i = 3, 4$, $dq_* \equiv (1/\Delta)\mu\, dt_*$; $dy_o^1 \equiv -E^1 dq_o + dt_{3o}$, $dy_o^3 \equiv -E^3 dq_o - dt_{3o}$, and $dy_o^i \equiv -E^i dq_o$ for $i = 2, 4$. By these definitions, $dy_o^i = dy_*^i$, $i = 1, 3$, implies

$$dq_o = dq_* + \frac{1}{E^1 + E^3}\, dt_{1*}. \tag{17}$$

Call the change from equilibrium $q(dt_{1*})$ to the state associated with $(dt_{3o}, dq_o)$ a *compensatory change*.

This compensatory change has an income redistributional effect between 2 and 4 as well as the substitution effect, which explain the blocking of mutually advantageous transfers and strategic loss takings.[8] Since $\Sigma_i E^i = 0$, $\Sigma_i dy_*^i = \Sigma_i dy_o^i = 0$. By the definition of the compensatory change, $dy_*^i = dy_o^i$ for $i = 1, 3$. Thus, $dy_o^4 - dy_*^4 = -(dy_o^2 - dy_*^2) \equiv R$ captures the extent of this income redistribution. Since $dy_o^4 - dy_*^4 = -E^4(dq_o - dq_*)$, (17) implies

$$R = -\frac{E^4}{E^1 + E^3}\, dt_{1*}. \tag{18}$$

After the compensatory change, the world excess demand for good 1 changes due to this income redistributional effect as well as the substitution effect. Since $qd(\Sigma_i E^i)_o = -sdq_o + \Sigma_i \mu^i dy_o^i = -sdq_o + \Sigma_i \mu^i dy_*^i + \mu^2(dy_o^2 - dy_*^2) + \mu^4(dy_o^4 - dy_*^4)$ captures this change, and since $-sdq_* + \Sigma_i \mu^i dy_*^i = 0$,

$$d\left(\sum_i E^i\right)_o = -s(dq_o - dq_*)/q + (\mu^4 - \mu^2)R/q. \tag{19}$$

Expression (19) indicates that *the blocking of mutually advantageous transfers and strategic loss takings can be attributed to the substitution and income redistributional effects of the compensatory change*. If $s = 0$ and $R = 0$, $d(\Sigma_i E^i)_o = 0$, i.e., the compensatory change establishes equilibrium $q(dt_{3o})$. Because 1 and 3 have the same real incomes in $q(dt_{3o})$ as in $q(dt_{1*})$, for any $dt_3$, the utility of either 1 or 3 must be lower in $q(dt_3)$ than in $q(dt_{1*})$; $dt_{1*}$ cannot be blocked if $s = 0$ and $R = 0$. In the four-country economy in which $E^4 \neq 0$, $R \neq 0$. As the next theorem demonstrates, a strategic loss taking may occur even if $s = 0$.[9]

[8] My method extends that of Jones (1984, 1985). He takes the compensatory price change which offsets the direct effect of a transfer on the income of one country. In the three-country model, unlike in the two-country model, this change has an income redistributional effect on the other countries, which explains the transfer paradox (also see Caves and Jones 1985).

[9] See Yano (1988) for a complete characterization of strategic loss taking in the three-country game played in the four-country economy.

THEOREM 3. *Let* $\mu^1 > \mu^3$, $\mu^1 > \mu^2$, $s = 0$, *and* $0 < E^1 < -E^3$. *Suppose the following conditions are satisfied:*

$$(\mu^1 - \mu^2)E^1 + (\mu^3 - \mu^2)E^3 + (\mu^4 - \mu^2)E^4 > 0; \tag{20}$$

$$(\mu^3 - \mu^2)E^3 + (\mu^4 - \mu^2)E^4 < 0; \tag{21}$$

$$(\mu^3 - \mu^1)E^3 + (\mu^4 - \mu^1)E^4 > 0; \tag{22}$$

$$(\mu^4 - \mu^2)E^4 < 0. \tag{23}$$

*If the transfer game is played by only countries* 1, 2 *and* 3, *the following statements hold:*

A. *the no-transfer equilibrium is locally Walrasian stable* ($\Delta > 0$);
B. *any infinitesimal transfer from* 1 *to* 2 *is mutually advantageous;*
C. *country* 3 *takes a strategic loss by receiving a transfer from* 1.

PROOF. By $\Sigma_i E^i = 0$, (20) is equivalent to $\Delta > 0$, given $s = 0$. By Lemma 1, (21) and (22) mean that transfer $dt_{1*}$ is mutually advantageous. Define:

$$C = \{(dt_3, dq) | -E^1 dq + dt_3 > dy^1_*, -E^3 dq - dt_3 > dy^3_*\}; \tag{24}$$

$$Q = \{(dt_3, dq) | dq = (\mu^1 - \mu^3)dt_3/\Delta\}. \tag{25}$$

By the proof of Lemma 1, if $(dt_3, dq)$ is on line $Q$, $dq$ is the price change required to establish the new equilibrium after transfer $dt_3$. If and only if $C \cap Q \neq \phi$, {1, 3} can block $dt_{1*}$ by transfer $dt_3$. Given $\mu^1 > \mu^3$, $\mu^1 > \mu^2$, $0 < \mathrm{E}^1 < -\mathrm{E}^3$, and $\Delta > 0$, it is easy to prove that if and only if $(dt_{3o}, q_o)$ lies above line $Q$, there is $(d\bar{t}_3, d\bar{q}) \in C \cap Q$ such that $d\bar{t}_3 < 0$ and $d\bar{y}^3 = -E^3 d\bar{q} - d\bar{t}_3 < 0$, i.e., 3 takes a strategic loss by receiving a transfer from 1, $d\bar{t}_3 < 0$. Given $\Delta > 0$, if $(dt_3, dq)$ is on $Q$, and if $dq' > dq$, price change $dq'$ creates an excess supply for good 1 after transfer $dt_3$. Thus, by (18) and (19), $(dt_{3o}, dq_o)$ lies above line $Q$ if and only if (23) holds.

Q.E.D.

4.2. *Four-Country Game.* Suppose that all four countries play the transfer game. Countries 1 and 3 are deciding whether to block $dt_{1*}$. If both 1 and 3 will be better off after blocking $dt_{1*}$ than in equilibrium $q(dt_{1*})$, at least one of the other countries must become worse off. If one of them, say 4, will be better off than in $q(dt_{1*})$, it will join the blocking coalition, i.e., coalition {1, 3, 4} can block $dt_{1*}$. If both 2 and 4 will be worse off after the blocking $dt_{1*}$, they may try to stop the blocking by threatening 1 and 3 with a retaliatory transfer between themselves. With respect to 1's and 3's attitudes towards such threats, take the following two polar cases. One is that 1 and 3 believe any threat made by 2 and 4. The other is that the only threats that 1 and 3 believe will be carried out are those which will reduce neither 2's nor 4's real income after the blocking of $dt_{1*}$ (credible threats).

Let $d\tau_4$ be a transfer from 4 to 2 and $dy^i = w^{i4} d\tau_4/\Delta$ capture the effect of $d\tau_4$ on $i$'s real income in the no-transfer equilibrium. A transfer between 2 and 4, $d\tau_4$, is a *credible threat* against 1 and 3 if $w^{24} d\tau_4/\Delta \geq 0$ and $w^{44} d\tau_4/\Delta \geq 0$. After 1 and 3 make transfer $dt_3$ and after 2 and 4 make transfer $d\tau_4$, the changes in countries 2's and 4's real incomes from those in the no-transfer equilibrium can be written as

$$\begin{bmatrix} dy^2 \\ dy^4 \end{bmatrix} = \frac{1}{\Delta}\begin{bmatrix} w^{23} \\ w^{43} \end{bmatrix} dt_3 + \frac{1}{\Delta}\begin{bmatrix} w^{24} \\ w^{44} \end{bmatrix} d\tau_4. \tag{26}$$

Moreover, the joint effect of transfers $dt_3$ and $d\tau_4$ dominates transfer $dt_{1*}$ in coalition $\{1, 3\}$ if and only if, given $\Delta > 0$,

$$\begin{bmatrix} w^{13} \\ w^{33} \end{bmatrix} dt_3 + \begin{bmatrix} w^{14} \\ w^{34} \end{bmatrix} d\tau_4 > \begin{bmatrix} w^{11} \\ w^{31} \end{bmatrix} dt_{1*}. \tag{9'}$$

Suppose $w^{24}w^{44} < 0$. By (26), the effect on 2 and 4 of $d\tau_4$ is independent of that of $dt_3$. Thus, once $dt_{1*}$ is blocked, any transfer between 2 and 4 will increase the utility of either 2 or 4 and decrease that of the other, i.e., create a conflict of interests between 2 and 4, no matter which transfer 1 and 3 will make. The threat of 2 and 4 which will result in such a conflict of interests is not a credible threat.

THEOREM 4. *Let* $\mu^1 > \mu^3$, $\mu^1 > \mu^2$, $s = 0$, *and* $E^1 + E^3 < 0$. *Suppose that inequalities* (20) *through* (23) *as well as the following hold:*

$$(\mu^4 - \mu^1)E^1 + (\mu^4 - \mu^3)E^3 < 0. \tag{27}$$

*Once* $dt_{1*}$ *is blocked, any transfer between* 2 *and* 4 *will create a conflict of interests between* 2 *and* 4. *Suppose that* 1 *and* 3 *believe that any threat made by* 2 *and* 4 *will actually be carried out only if it is credible. Then, statements* A, B *and* C *of Theorem* 3 *hold.*

PROOF. By (20), $\Delta > 0$. Lemma 1 suggests $w^{24} = \Delta - E^2(\mu^2 - \mu^4)$. Thus, $w^{24}) = -(E^1(\mu^4 - \mu^1) + E^3(\mu^4 - \mu^3))$; $w^{24} > 0$ by (27). Similarly, $w^{44} = -(\Delta + E^4(\mu^2 - \mu^4)) = -(E^1(\mu^1 - \mu^2) + E^3(\mu^3 - \mu^2))$; $w^{44} < 0$ by (20) and (23). Thus, the only $d\tau_4$ satisfying the definition of a credible threat is $d\tau_4 = 0$. The condition under which $\{1, 3\}$ can block $dt_{1*}$ coincides with that in Theorem 3. Q.E.D.

Suppose that 1 and 3 believe any threat made by 2 and 4. Country 3 is unlikely to be able to block transfer $dt_{1*}$ by taking a strategic loss. If $w^{13}w^{33} < 0$ and if $w^{14}w^{34} \neq 0$, countries 2 and 4 can choose $d\tau_4$ so that there is no $dt_3$ such that $d\tau_4$ and $dt_3$ satisfy (9'). So long as small transfers are concerned, country 3 cannot block $dt_{1*}$ by taking a strategic loss.[10]

4.3. *Summary.* Suppose that countries 1 and 3 are deciding whether to block a mutually advantageous transfer from 1 to 2, $dt_{1*}$, and that both 2 and 4 will be worse off once the transfer is blocked. The following conclusions follow from the results in this section.

1. By taking a strategic loss, 3 can sometimes block the transfer, $dt_{1*}$, if both 1 and 3 believe that 2 and 4 will not be able to make a transfer between themselves.

[10] In the framework of local analysis, it cannot be established that a certain transfer cannot be blocked. In contrast, local analysis suffices in order to demonstrate that a certain type of transfer can be blocked.

2. One reason why 1 and 3 may believe that 2 and 4 will be unable to make a transfer is that 1 and 3 may know that once they block the transfer, $dt_{1*}$, any transfer between 2 and 4 will create a conflict of interests between 2 and 4, and they therefore believe that 2 and 4 will not be able to make such a transfer. Another possible reason is, simply, that 4 may not be not a player of the transfer game.

3. 3 may take strategic loss by receiving a transfer; in the three-country economy, in contrast, 3 may take a strategic loss only by giving a transfer.

4. 3 may take a strategic loss even if there is no substitution effect, unlike in the three-country economy.

5. These differences between the three-country and four-country economies may be explained by the income redistributional effect which a transfer between 1 and 3 has on the remaining countries.

6. If 1 and 3 believe any threat of 2 and 4 to make retaliatory transfer, 1 and 3 are unlikely to be able to block the transfer, $dt_{1*}$.

An extensive analysis of transfer games in the four-country economy is beyond the scope of this study. Several interesting issues are left for future research. One such issue is to consider whether 3 may take a strategic loss in the case in which 2 and 4 will be able to make a mutually advantageous transfer after the blocking of $dt_{1*}$. A related issue is to completely characterize strategic loss takings under the ex-post credibility belief with respect to threats. With respect to the credibility of threats, this section considers only polar cases. It is important to examine the relationships between various alternative assumptions on the credibility of threats and the possibility of strategic loss takings.

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