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by

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ABSTRACT

We analyze games between two countries that use the tariff as a threat to induce each other to follow monetary policies equivalent to those that would obtain under a cooperative game. The analysis shows that under certain assumptions concerning the shares of tariff revenues that the countries spend on imports, the punishment structure, and the discount factors, the outcome of the games converges to a cooperative-equivalent equilibrium, with zero tariffs and optimal monetary policies. It is suggested that the model could be applied to current relations between the US, Germany and Japan.

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1. INTRODUCTION

In recent years countries have groped for international economic cooperation with less than full success. Relapses into conflicting policies have been frequent. Progress appears to be easier to achieve in certain areas, such as the monetary field, than in others, such as the commercial field.

This may be due to closer and more frequent contacts that, at the international level, are institutionally possible among monetary authorities than among fiscal and commercial authorities. It could also be due to the greater independence from Parliaments and from other less internationally oriented pressure groups, that the former authorities enjoy. Thus, the uneven progress toward international monetary cooperation and its occasional interruption could be explained by interaction among authorities placed at different levels and with different propensities toward international cooperation.

Another explanation could be found in the use of policy instruments graduated in a way to make cooperation at the "lower" level enforceable by the threat that, were it to fail, "higher" level instruments would be used non-cooperatively. Thus, contemporary international economic relations between the US, Germany, and Japan, could be interpreted as resulting from a confrontation in which the main deficit country (the US) tries to induce the two main surplus countries (Germany and Japan) to cooperate through their demand policies (by lowering interest rates or adopting less stringent fiscal stands), under the threat that, in absence of cooperation in this field, the US will adopt commercial policies (dollar depreciation or protectionism) aimed at redressing its current account.

While the two representations -- different levels of policy

authorities vs. different levels of policy instruments -- may be complements rather than substitutes in explaining the current strains in international economic relations, this paper takes the second one as the hypothesis around which to frame its theoretical model ⁽¹⁾.

Indeed, recent crises in international coordination of economic policies appear to be related to both explanations. The unwillingness of the US Administration and Congress to take measures consistent with stabilization of the dollar, as advocated cooperatively at the international level by the monetary authorities, including the US ones, at the Louvre meeting and after, are on one side of the picture. From this side, the crises seem to be explainable in terms of uneven degrees of cooperation among different authorities within countries and internationally. However, from the other side of the picture, the crises can also be interpreted as the up to now unsuccessful result of a US attempt to force cooperation in the field of demand policies -- and more specifically to force monetary and fiscal expansion in Germany and Japan-- under the threat that depreciation of the dollar and other protective measures will be taken in case of unsatisfactory reply.

In section 2 we present a simple model of two countries that trade their respective products under floating exchange rates. In order to discuss policy games in this model, we assume that each government sets policies to maximize the level of utility enjoyed by a 'representative' agent. Given this objective function, we show in section 3 that the two countries have an incentive to adopt restrictive monetary policies: the Nash equilibrium that is established is Pareto inefficient, with the supply of money in both

countries lower than its full employment level. This conclusion is followed in section 4 by a preliminary restatement of a well established result: with a discount factor high enough, the equilibrium that results from repeating the non cooperative games indefinitely is equivalent to the equilibrium that would be reached with monetary cooperation.

New ground is covered in the following sections. In section 5 it is shown that even a one-shot non cooperative game may admit an equilibrium characterized by overall full employment, if each country can credibly threaten the other with a tariff. For this threat to be credible a critical assumption is that the whole of the tariff revenue be spent in the domestic product. The resulting equilibrium is characterized by the optimal quantities of money and yet by zero tariffs. Section 6 shows first that, when the critical assumption about the tariff revenue is relaxed, a one-shot non cooperative game will fall back into a suboptimal equilibrium characterized by unemployment as in section 3, with the threatened tariffs being left unexploited at zero level. However, section 6 also shows that the conclusion of section 5, i.e. that a Pareto-efficient solution may result from waging the threat of a tariff war, could hold even when the critical assumption about expenditure of the tariff revenue is dropped. In fact, it is shown that, with a specific structure of punishment, an infinite repetition of the game leads to Pareto efficiency, characterized by the optimal supply of money and zero levels of the tariffs, regardless of the discount rate. For this situation to arise, however, it is necessary that the threatened tariff be unbounded, so that each country can push the other country's payoff to zero via a sufficiently high tariff. As this appears

unreasonable, it becomes natural to explore whether a cooperative-equivalent equilibrium, characterized by free trade and optimal supplies of money, can still obtain if finite upper bounds are imposed on the tariffs: it can indeed be shown that the minimum discount factors which induce the two countries to "cooperate" tend to zero together with the shares of tariff expenditures on imports by the two countries. This means that, even if the tariffs are bounded from above, the game with tariffs converges to monetary cooperation "more quickly" than the game without tariffs, at least for a range of parameter values. Thus waging the threat of protection appears to be an effective way to induce countries to behave in a cooperative-equivalent way with respect to monetary, and eventually also commercial, policies.

Finally, the results suggest situations under which the tariff threats may fail to induce monetary cooperation. In particular, if one country is relatively impatient (has a low discount factor), then the other country may find it impossible to induce it to cooperate under a tariff threat. Conversely, the patient country may also find its own threat incredible when the foreign country is very impatient. This is suggestive of current failures on the part of the US (the impatient country?) to induce Germany and Japan (the patient countries?) to cooperate in the field of demand policies, with the reverse frustration being felt also on the side of these two countries.

Section 7 indicates lines for further research, and some conclusive remarks.

2. THE MODEL

This section sets up the scenario of the policy games analyzed in the following sections. We describe the behaviour of consumers and firms, and solve both for the Walrasian equilibrium of the model, and for the fixed-price Keynesian equilibrium with unemployment. Finally, assuming benevolent governments, we derive the objective functions of the countries involved in the policy games.

We consider a two-country, two-good overlapping generations economy. There is complete specialization: the home country produces good 1 and the foreign country produces good 2. Both countries consume both goods. We denote by capital letters all variables pertaining to the foreign country, and those of the home country by the corresponding lower case letters.

Each country is populated by a fixed number (n, N) of identical agents who live for two periods. Since n and N are parameters that do not affect the qualitative features of the model, to save on notation we set $n = N = 1$. Each agent works only in the first period of his life and consumes only in the second period. There are no bequests. For analytical convenience, we postulate utility and production functions of the Cobb-Douglas variant. Thus, the utility function of a representative agent of the home country is:

$$u = (1-l)^a c_1^b c_2^{1-b} \quad (1)$$

where l denotes labor supply (so that $1-l$ denotes leisure, having normalized to 1 the fixed endowment of time of the young agent), and c_1 and c_2 denote consumption of good 1 and 2, respectively; a and b are positive parameters with $b < 1$.

Since young agents do not consume, all their income is saved in

the form of government issued fiat money, which is the only asset in our economy (3). In the second period of their life, agents spend all their money so as to purchase the consumption goods. This implies that the utility function (1) is maximized in two stages: in the first stage, labor supply and money demand are chosen under the constraint

$$wl + y \geq m^d \quad (2)$$

where w is the money wage rate, y denotes non labor income and m^d is the demand for money. (We assume that all profits are instantaneously distributed to young agents, so that they receive the whole national income.) In the second stage, consumption goods are purchased subject to the budget constraint

$$p_1 c_1 + p_2 c_2 \leq m^d \quad (3)$$

where p_1 and p_2 are the consumer prices of the two goods. We consider a stationary economy with prices, money supply, etc., constant over time. From the above maximization problem it follows that labor supply is:

$$l = \frac{1}{1+a} \left(1 - a \frac{y}{w} \right) \quad (4)$$

A similar relation holds for the foreign country.

Notice that the utility function is homothetic, which implies that aggregate demand is independent of income distribution. Therefore, we can proceed as if there were only one agent in each country. When he is in the second period of his life, the representative agent holds the total stock of money. Then, assuming

equilibrium in the money market, the demand functions for the consumption goods can be expressed as

$$c_1 = \frac{bm}{p_1} \quad (5)$$

$$c_2 = \frac{(1-b)m}{p_2} \quad (6)$$

where m is the fixed supply of money. Analogous relations hold for the foreign country.

In each country, production takes place in a large number of competitive firms. Labor is the only variable factor. The aggregate production functions are:

$$x_1 = l^\alpha \quad (7)$$

$$x_2 = L^\alpha \quad (7')$$

where x_1 is the quantity of good 1, which is produced in the home country, and x_2 is the quantity of good 2, which is produced in the foreign country. Perfect competition and profit maximization imply that labor demands are determined by the following conditions:

$$l^{1-\alpha} = \frac{sp_1}{w} \quad (8)$$

$$L^{1-\alpha} = \frac{SP_2}{W} \quad (8')$$

Furthermore, Cobb-Douglas production functions imply constant shares of non labor income out of national income, i.e.

$$y = (1-s) p_1 x_1 \quad (9)$$

The exchange rate e is perfectly flexible and is instantaneously adjusted so as to equilibrate the trade balance. Each country may use an ad-valorem tariff on imports, denoted t and T . It is assumed that the tariff revenue is wholly spent on domestic output and that public expenditure is completely unproductive, so that it does not affect private demand. These crucial assumptions will be relaxed in section 6. It follows that the trade balance is in equilibrium if

$$C_1 p_1 = c_2 P_2 e \quad (10)$$

By definition, the following relations hold:

$$P_1 = \frac{p_1}{e} (1+T) \quad (11)$$

$$p_2 = P_2 e (1+t) \quad (12)$$

From (10), (11) and (12) it follows:

$$e = \frac{(1-b) m (1+T)}{B M (1+t)} \quad (13)$$

We now turn to the determination of the equilibrium conditions in the goods market. Total demand for good 1 is obtained adding up three components: private domestic demand (c_1), private foreign demand (C_1), and public expenditure, which equals the tariff revenue on imports ($tP_2 e c_2$) divided by the price of the consumption good (p_1). In view of the hypothesis of an equilibrated trade balance, it can be shown that aggregate demand can be expressed simply as m/p_1 , so that the equilibrium condition in the goods market of the home

country becomes:

$$x_1 = \frac{m}{p_1} \quad (14)$$

Since in our model the velocity of circulation of money is constant and equal to one, equation (14) can be interpreted as Fisher's quantity of money equation. A symmetrical condition holds for product 2.

The Walrasian equilibrium of the economy can now be obtained by equating labor supply and labor demand in both countries, under the assumption that money wages are perfectly flexible. This gives:

$$l = \frac{s}{s + a} \quad (15)$$

$$w = (a + s) m \quad (16)$$

$$p_1 = \left[\frac{a + s}{s} \right]^s m \quad (17)$$

From (16) and (17) it is clear that money is neutral. The equilibrium values of all other variables can be obtained substituting (16) and (17) into the formulae given above. Symmetric results hold for the foreign country.

Let us now assume that money wages are fixed at higher levels than those corresponding to the Walrasian equilibrium (in other words, $w > (a+s)m$ and $W > (A+S)M$) and are rigid downward. However, we continue to assume that money prices of consumption goods and the exchange rate are flexible (*). This implies that the

consumption good markets are always in equilibrium, but there is Keynesian unemployment in the labor market of both countries. It follows that actual employment is determined by labor demand (the short side of the market). In order to be able to continue to speak of a representative agent, we also assume that jobs are allocated through a symmetric rationing scheme.

We can now solve for the fixed-price equilibrium à la Drèze (1975) of our economy, obtaining:

$$p_1 = k_1 w^{\alpha} m^{1-\alpha} \quad (18)$$

$$p_2 = k_2 m \left[\frac{W}{M} \right]^S (1+T) \quad (19)$$

$$l = \frac{s m}{w} \quad (20)$$

where k_1 and k_2 are positive constants which depend on the parameters b , s , B , and S . Symmetric relations hold for the foreign country. Now it is clear (cf. equation (20)) that an increase in the money supply in the home country has expansionary effects on the domestic level of employment, but (as a consequence of the assumed perfect flexibility of the exchange rate) leaves unaffected the employment level in the foreign country (and vice-versa). However, equations (18) and (19) show that an expansionary monetary policy deteriorates the terms of trade. Hence, an increase in the money supply of the home country has two contrasting effects on the home country itself, and a positive effect on the foreign country.

Furthermore, it is apparent from (20) that the employment levels of both countries do not depend on the tariffs levied by either

country, and the equilibrium prices in the home (foreign) country do not depend on its own tariff, but only on the tariff levied by the foreign (home) country. Some of these features of the model depend on the assumption that the tariff revenue is wholly spent on domestic output, as we shall see in section 6, where this assumption is relaxed.

The model developed so far provides the necessary foundations for the policy games analyzed in the next sections. Specifically, we assume a benevolent government that aims at maximizing the equilibrium level of utility enjoyed by a representative agent. Substituting (18) and (19) into the demand functions (5) and (6) one gets the equilibrium level of c_1 and c_2 ; then, substituting the equilibrium values of l , c_1 and c_2 into the utility function (1), one gets:

$$u = k \left[1 - \frac{sm}{w} \right]^a m^{bs} \left[\frac{M^s}{1+T} \right]^{1-b} \quad (21)$$

where k is a positive constant which depends on the parameters of the model, including the money wage rates. A glance at (21) reveals that the welfare of a representative agent in the home country does not depend on the tariff on domestic imports. The reason is that a tariff on imports improves the terms of trade, but creates a distortion in consumption: these two contrasting effects completely offset each other under our hypotheses. It is also clear that the home (foreign) country prefers an expansionary monetary policy of the foreign (home) country, and, quite obviously, prefers low values of the tariff on its own exports. On the other hand, the effect on social welfare of an

increase in the domestic supply of money is ambiguous. Differentiating (21) we get:

$$\frac{\delta u}{\delta m} = \left[- \frac{as}{w - sm} + \frac{bs}{m} \right] u \quad (22)$$

Clearly, u is an increasing function of m for m low enough; however, the term inside square brackets is a decreasing function of m and therefore may change sign as m increases. Evaluating the derivative at the full employment equilibrium, one finds

$$\frac{\delta u}{\delta m} = (b - 1) \cdot \frac{s}{m} u < 0 \quad (23)$$

Hence, the maximum of u will be reached before full employment is attained.

The intuition behind this result is that, starting from a full employment position, a contraction in the money supply has two contrasting effects on social welfare. On one hand, it improves the terms of trade; on the other hand, it shifts the economy away from the Walrasian position. (This effect can be evaluated assuming that the foreign country reduces its money supply to keep the nominal exchange rate fixed.) In a neighborhood of full employment, the latter effect is negligible, so that the total effect of a monetary contraction is positive.

3. NON COOPERATIVE MONETARY POLICIES

In this section we assume that the tariffs are fixed at constant values. The only variable that the governments of the two countries

can control is money supply. We formalize international interaction as a one-shot game where each country's strategy consists in choosing a value of the supply of money, and we study the Nash equilibrium of the game.

As a benchmark for the subsequent analysis, we first consider the full employment equilibrium given by

$$m^* = \frac{w}{a+s} \quad (24)$$

with M^* defined in a similar way. We shall refer to the full employment equilibrium as the "cooperative solution". As Proposition 2 below shows, this terminology is justified because the "cooperative solution" is indeed Pareto-efficient; one should bear in mind, however, that there exist many Pareto-efficient combinations of monetary policies.

Obviously, it is pointless to increase money supply beyond m^* and M^* . This may be clarified observing that formulae (18)-(23) hold in a regime of Keynesian unemployment. When full employment has been reached, a further increase in money supply is entirely offset by a proportional change in money prices and the exchange rate (recall that money wages are supposed to be rigid downward but flexible upward) and therefore has no real effect. The relationship between the welfare level of the home country and the levels of money supply in both countries is illustrated in figure 1. Clearly, the home country (a symmetric argument holds for the foreign country) would be indifferent between any value of m greater than or equal to m^* , as well as between any value of M greater than or equal to M^* . Thus, in what follows, we shall assume that the money supply is never increased beyond the full

employment levels m^+ and M^+ .

[figure 1 about here]

If the two countries cannot reach binding agreements, each of them will have an incentive to adopt a restrictive monetary policy. Specifically, since the sign of $\delta u/\delta m$ does not depend on M (symmetrically, the sign of $\delta U/\delta M$ does not depend on m), each country has a dominant strategy, which is obtained setting $\delta u/\delta m = 0$ (resp., $\delta U/\delta M = 0$). This yields:

$$m^- = \frac{b}{a + bs} w \quad (25)$$

with M^- defined in a similar way.

It follows that the Nash equilibrium of the monetary policy game entails a positive level of unemployment in both countries. Specifically, the employment level turns out to be

$$l = \frac{bs}{a + bs} \quad (26)$$

which is lower than the Walrasian level of employment given by (15). As Proposition 1 below states, this equilibrium is Pareto-inefficient. On the other hand, the full employment equilibrium is Pareto-efficient (Proposition 2).

Proposition 1. The Nash equilibrium m^- , M^- of the monetary policy game is Pareto-inefficient.

Proof. Since at the Nash equilibrium $\delta u/\delta m = \delta U/\delta M = 0$, whereas $\delta u/\delta M > 0$ and $\delta U/\delta m > 0$, a small increase in both m and M must increase the welfare level of both countries. ■

Proposition 2. The "cooperative solution" given by m^+ and M^+ is Pareto-efficient.

The proof is obvious, since the cooperative solution coincides with the Walrasian equilibrium of the economy.

4. THE SUPERGAME WITHOUT TARIFFS

In this section, the game analyzed in section 3 is infinitely repeated. As is well known, in a supergame the cooperative outcome can be sustained as a perfect equilibrium if the players do not discount future payoffs too much.

In the previous section we have seen that the two countries have no incentive to cooperate, even if this could benefit both of them. Assuming that each country can only use two strategies (m^+ , m^- and M^+ , M^-), the normal form of the game can be represented as follows.

	m^+	m^-
M^+	u^{++}, U^{++}	u^{+-}, U^{+-}
M^-	u^{-+}, U^{-+}	u^{--}, U^{--}

We know that each country prefers expansionary monetary policy in the other country (i.e., $u^{+-} > u^{--}$ and $u^{++} > u^{-+}$, and $U^{+-} > U^{--}$ and $U^{++} >$

U^{--}) and each country's dominant strategy is to set money supply at m^-, M^- (i.e., $u^{--} > u^{+-}$ and $u^{+-} > u^{++}$, and $U^{--} > U^{+-}$ and $U^{+-} > U^{++}$). Notice that when $u^{++} > u^{--}$ (and $U^{++} > U^{--}$) the game has the typical structure of the prisoner's dilemma: in this case the cooperative solution (m^+, M^+) Pareto-dominates the non cooperative solution (m^-, M^-) . However, we cannot be sure that the payoff functions have this structure: all we know from Proposition 1 is that there exists a pair (m^*, M^*) that Pareto-dominates the non cooperative solution. Then, a prisoner's dilemma would arise if we restricted attention to the pure strategies m^- and m^* for the home country, and M^- and M^* for the foreign country. To fix ideas, in what follows we shall assume that $u^{++} > u^{--}$ and, symmetrically, $U^{++} > U^{--}$.

To enforce cooperation, we know from game theory that two routes are available: the first one amounts to repeating the game an infinite number of times (supergame); the second one is to invoke some form of incomplete information. Since it appears (see Fudenberg and Maskin, 1986) that, loosely speaking, the two approaches are equivalent, in what follows we shall concentrate on the supergame approach. Assume, therefore, that the game described in section 3 is infinitely repeated; the payoffs of the supergame are the discounted sums of those of the one-shot constituent game (5), with discount factor $d < 1$.

$$z = \sum_t u_t d^{t-1} \quad (27)$$

Obviously, as d and D approach zero, the supergame payoffs tend to coincide with those of the one-shot game. Following Friedman (1971), we assume that if the foreign country deviates from the "cooperative

solution", and sets $M = M^-$, the home country punishes it by setting $m = m^-$ for ever. The foreign country's best response to this punishment is to play $M = M^-$ for ever. Being aware of this, the foreign country will be induced to stick to the "cooperative solution" if and only if the one period gain from cheating ($U^{+-} - U^{++}$) is lower than the loss of being stuck to the inefficient Nash solution from period 2 onwards ($\sum_{t=2}^{\infty} (U^{++} - U^{+-})d^{t-1}$). It follows immediately that there will exist a d^* such that monetary cooperation is a solution of the supergame for $d \geq d^*$, i.e., when the country is patient enough, whereas if $d < d^*$ the solution of the supergame coincides with that of the one-shot game.

5. MONETARY COOPERATION UNDER THE THREAT OF TARIFFS

In this section, we suppose that the game is played in two steps: in the first one players choose the level of money supply, in the second one they fix the tariffs. We show that this game admits multiple subgame perfect equilibria. However, we argue that the only sensible equilibrium is the one with cooperative monetary policies and free trade.

To provide some intuition of what is going on, we present the extensive form of the game assuming that each country has only two (pure) monetary strategies, m^+ and m^- (resp. M^+ and M^-) and two commercial strategies: free trade ($t = T = 0$) and protection (that is, a value of tariff sufficiently high so as to reduce the payoff of the opponent below the lowest level it could reach under free trade).

Notice also that the overall game can be split into two independent branches: the choice of M and t on one side, and the

choice of m and T on the other side. The multiplicative structure of the payoff functions (see eq. (21)) implies that there is no interaction between these two branches of the game.

To fix ideas, we consider the branch of the game that concerns the choice of M on part of the foreign country and the choice of t on part of the home country. (The numerical values of the payoffs are arbitrary, only the ordinal ranking of the outcomes matters.) The foreign country moves first, and can choose to "Cooperate" (i.e. set $M = M^+$) or "Not cooperate" (i.e. set $M = M^-$). The home country plays after having observed the monetary policy of the foreign country, and can choose between "Free trade" and "Protection". The extensive form of the game is represented in figure 2, where the upper number in each final node is the payoff to the home country, and the lower number is the payoff to the foreign country.

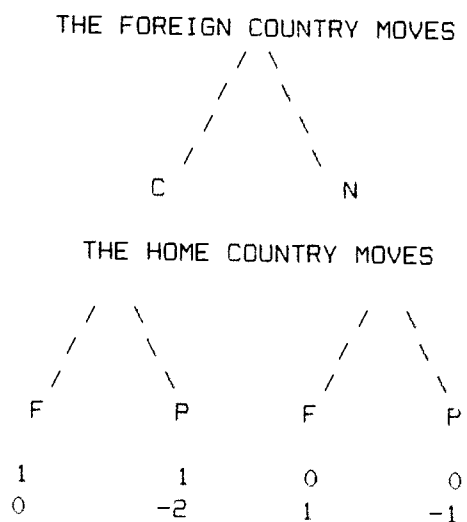


figure 2

The normal form of the game is represented in the following table. Notice that the home country plays once it has observed the

move of the foreign country; hence, a pure strategy for the home country must specify its response to every possible choice of the foreign country. Thus, the home country has in fact four pure strategies: always play P (PP), always play F (FF), play F if the other country has played C and play P if it has played N (FP), and play P if the other country has played C and F if it has played N (PF).

	PP	FF	FP	PF
C	1, -2	1, 0	1, 0	1, -2
N	0, -1	0, 1	0, -1	0, 1

There are four Nash equilibria, which are represented in the table by boldface payoffs. Looking at figure 2 one can easily convince oneself that all these equilibria are subgame perfect in the sense of Selten (1975). However, we claim that the only sensible equilibrium is (C,FP).

To justify this claim, we assume that some pre-play activity takes place. Specifically, the home country can announce that it will play FP, and this announcement is credible because the home country is indifferent between the four alternative strategies in its strategic set. In other words, the possibility of announcing one's strategy, coupled with the fact that the home country is indifferent between all its strategies, gives it a sort of leadership in the choice of one of the many (subgame perfect) Nash equilibria. Then, the obvious choice is that of the only equilibrium where the foreign country cooperates

at the monetary level.

Let us now turn to the general case. The strategy set for the home country is the Cartesian product $[0, m^*] \times V$, where V is the set of real and non negatively valued functions defined on $[0, M^*]$; the strategy set of the foreign country is defined in a similar way. In other words, the strategy of each country consists in choosing a value of the money supply and a function that links its tariff to the supply of money chosen by the other country. These functions ($t = t(M)$ for the home country and $T = T(m)$ for the foreign country) represent the threat that each country wages upon the other ⁽⁶⁾. This threat is credible because under our current hypotheses the level of its own tariff does not enter the country's payoff function.

Formally, one can interpret the tariff as a punishment strategy: if a country deviates from the cooperative solution, the other country can punish it by levying a tariff that diminishes its payoff. This means that the home (foreign) country can choose its most preferred value of M (m) using the threat of a sufficiently strong retaliation through the tariff. Obviously, the most preferred value of M (m) by the home (foreign) country is M^* (resp., m^*). (Again, a greater value of the money supply would only have the effect of increasing nominal prices, without affecting real variables). From equation (21) it follows easily that a sufficient condition ⁽⁷⁾ for the threat to be effective is

$$t(M) \geq \left[\frac{W}{M(A+S)} \right]^S - 1 \quad (28)$$

We have therefore proved the following:

Proposition 3. In the two-stage game with tariffs, there exists a subgame perfect Nash equilibrium with free trade and full employment.

Furthermore, even if there are other subgame perfect Nash equilibria of the game, by an argument similar to the one used in the discussion of the simplified version of the game it follows that the only sensible equilibria of the two-stage game are those where the supplies of money of the home and the foreign country are m^* and M^* , respectively, which implies full employment in both countries. There is, however, another source of multiplicity of solutions, i.e., the level of the tariff threats. To show this, it suffices to note that the own tariff does not enter the payoff of a country, which is therefore indifferent between different levels of its own tariff. It follows that if we multiply $(1 + t)$ by a constant greater than 1 in the equilibrium strategy of the home country, or if we add to $(1 + t)$ a positive constant (so that (28) still holds), what we get is another equilibrium strategy; the same argument holds for the foreign country. To eliminate this undesirable multiplicity of solutions, we assume that no country wants to damage the other country more than is strictly necessary to pursue its own interest. This reduces the set of equilibria to a singleton characterized by free trade ($t = T = 0$), and "cooperation" at the monetary level, which is the equilibrium described in Proposition 3.

The intuition behind this result is fairly clear: the very possibility of using a tariff on trade makes the two-stage game equivalent to a game where the home country chooses M and the foreign country chooses m . Since each country unambiguously prefers an expansionary policy in the other country, overall full employment

results (B).

6. EXTENSIONS

The solution obtained in section 5 depends on a number of simplifying assumptions. Looking at the "reduced form" of the model (i.e. the payoff functions of the two countries), the crucial properties which Proposition 3 relies upon are: (i) a tariff levied by a country reduces the other country's payoff, but leaves unaffected its own payoff; (ii) by levying a sufficiently high tariff, each country can reduce the other country's payoff below any fixed positive level. Property (i) guarantees the credibility of the threat of retaliation at the commercial level; property (ii) guarantees its effectiveness.

In this section we shall analyze the robustness of the model. For sake of simplicity, we retain the Cobb-Douglas structure of the economy, but we relax in three different ways the hypothesis that the tariff revenue is wholly spent on domestic output. We first assume that in each country a fixed proportion of the tariff share is spent on the other country's good. This implies that property (i) no longer holds because now a tariff levied by a country reduces its own payoff, as we shall see below. Secondly, we postulate that there are finite upper bounds on tariffs; this will allow us to capture the case (possibly arising with non Cobb-Douglas utility functions) in which there is a prohibitive tariff, so that raising the tariff above this critical level would not further affect payoffs. Thirdly, we assume that (with unbounded tariffs) the tariff revenue in each country is redistributed to that country's consumers; this is a standard

hypothesis in the optimal tariff literature. In this case it turns out that a tariff levied by a country increases its own payoff, so that property (i) above is violated again, although in the opposite direction.

6.1 We now assume that the home country spends a fraction h ($0 \leq h \leq 1$) of its tariff revenue on the good produced by the foreign country, and the foreign country spends a fraction H ($0 \leq H \leq 1$) of its tariff revenue on the good produced by the home country (19). The equilibrium condition for the trade balance now becomes

$$(1 + HT) C_1 p_1 = (1 + ht) c_2 P_2 e \quad (29)$$

so that the equilibrium exchange rate is now

$$e = \frac{(1+ht)(1+T)(1-b)m}{(1+t)(1+HT)BM} \quad (30)$$

Aggregate demand for good 1 is now made up of four components: private domestic demand, private foreign demand, public expenditure of the home country (a fraction $(1-h)$ of its tariff revenue), and public expenditure of the foreign country (a fraction H of its tariff revenue). Lengthy calculations show that the equilibrium condition in the goods market is still equation (14), i.e. $x_1 = m/p_1$. Analogously, the equilibrium condition in the market for good 2 can still be reduced to (14'), i.e. $X_2 = M/P_2$. This implies that equations (18), (19) and (20), and their counterparts for the foreign country continue to hold, so that the payoff functions can be expressed as follows:

$$u = k' \left[1 - \frac{sm}{w} \right]^a m^{bs} \left[\frac{M}{1+T} \right]^{1-b} \left[\frac{1+HT}{1+ht} \right]^{1-b} \quad (31)$$

where k' is a positive constant which depends on the parameters of the model. Notice that property (ii) still holds, i.e., by increasing T sufficiently, the foreign country can reduce the home country's payoff to zero. However, property (i) no longer holds, and now the home tariff affects negatively the home payoff.

Now suppose that h and H are strictly positive parameters. Then, the equilibrium described by Proposition 3 is still a Nash equilibrium of the game (in other words, the strategy of each country is the best response to that of the other country), but it is no longer a perfect equilibrium. To show this, notice that what induces each country to choose a high level of money supply is the threat of the other country's retaliation; in equilibrium, however, monetary cooperation occurs so that the threat is not carried out. However, suppose restrictive monetary policies were chosen in the first stage of the game; then, no country would have an incentive to carry out the retaliation, given that an increase in its tariff reduces its own welfare. Being aware of this, each country realizes that it should not take into serious consideration its opponent's threat, and chooses a restrictive monetary policy in the first stage of the game. We have, therefore, the following

Proposition 4. If h and H are strictly positive exogenous parameters, then the unique perfect equilibrium of the one-shot game is m^* , M^* and free trade ($t = T = 0$).

Thus it would seem that the results of section 5 are not very robust,

since as soon as h and H are different from 0 (more generally, as soon as $\delta u/\delta t < 0$), the "cooperative solution" is no longer a perfect equilibrium.

However, suppose the game analyzed in section 5 is infinitely repeated. As Proposition 5 below shows, irrespective of the level of the discount factor, monetary cooperation and free trade represent a perfect equilibrium of the supergame with tariff. Thus the very possibility of a retaliation at the commercial level makes it easier (10) to enforce cooperation at the monetary level.

Proposition 5. For any $0 < d, D < 1$, a subgame perfect equilibrium of the supergame consisting of infinite repetitions of the one-shot game described in section 5 is given by $m = m^*$, $M = M^*$ and $t = T = 0$.

To prove this proposition, we consider the structure of punishments suggested by Rubinstein (1979): foreign country's deviations from the "cooperative solution" at the monetary level would bring about a punishment by the home country, via a sufficiently high tariff. The home country, in order to be induced to go through with its punishment, is threatened with the prospect that, if it deviates from the punishment strategy, it in turn will be punished by the foreign country in the next period via a sufficiently high tariff (11). Moreover, the foreign country will be punished if it does not punish the home country, and so on. Thus, there is a potential sequence of successively higher order punishments, where the punishment at each level is carried out for fear of the punishment at the next level. (Note that, by choosing a sufficiently high level of the tariff, a country can always reduce the payoff of its opponent below any fixed positive level.) As shown by Rubinstein (1979) and Fudenberg and

Maskin (1986), these strategies represent a perfect equilibrium of the game; notice that in equilibrium monetary cooperation occurs in each time period, so that the punishments are never actually carried out.

6.2 The argument above implicitly assumes that there is no upper bound on the level of the tariffs. Thus, the punishment is effective in that each country can push the other country's payoff to zero. If there is a finite upper bound on t and T , on the contrary, the strategies described in the proof of Proposition 5 would be feasible only if the sequence of threatened tariffs does not increase without limit. Then, existence of a perfect equilibrium characterized by monetary cooperation would no longer follow independently of the value of the discount factor. However, we shall show that, loosely speaking, the minimum discount factors which induce players to "cooperate" tend to 0 as both h and H tend to 0. This implies that, even if t and T are bounded from above, the game with tariffs converges to monetary cooperation "more quickly" than the game without tariffs for a range of parameter values. Furthermore, there is no discontinuity in the solution as h and H tend to 0, since the one-shot game is the limit of the supergame when both d and D go to 0.

Proposition 6. For all $h, H > 0$, if there are finite upper bounds on t and T , there exists a region in the (d, D) -space such that monetary cooperation and free trade represent a perfect equilibrium of the supergame for values of d and D inside this region. Furthermore, the frontier of the 'cooperative' region shifts to the south-west as h and/or H decrease, so that the 'cooperative' region tends to coincide with the unit square $[0,1] \times [0,1]$ as both h and H tend to 0.

Proof. The idea of the proof relies again on Rubinstein's structure of punishments. Before proceeding, however, note that the cardinal structure of the payoffs is irrelevant in the one-shot game, but becomes essential when one considers the supergame where discounted payoffs have to be summed up. For analytical convenience, in what follows we shall take the log of the utility function (31), so that the payoff function for the supergame is

$$z = \sum_t (\log u_t) d^{t-1} \quad (32)$$

Now consider the part of the game that concerns the choice of a monetary policy by the foreign country. We know from (20), (26) and (28) that the foreign country will be discouraged from deviating from cooperation if, in case of deviation, the home country punishes it by setting $t \geq t_1$, where

$$t_1 = \frac{A + BS}{B(A + S)} - 1 \quad (33)$$

Next, for the home country to go through with its punishment, it must be threatened by the other country. Notice, however, that the punishment may occur only in the next period, since the foreign country cannot observe the commercial policy of the home country before deciding its own commercial policy. Then, to induce the home country to go through with its punishment it is necessary to set $T \geq T_1$, where

$$[\log(1 + T_1) - \log(1 + H T_1)] d = \log(1 + h t_1) \quad (34)$$

Next, for the foreign country to go through with its punishment, it must be threatened by the home country with the prospect that, if it

does not, it will be punished with a $t \geq t_2$, where

$$[\log(1 + t_2) - \log(1 + h t_2)] D = \log(1 + H T_1) \quad (35)$$

Then, a necessary and sufficient condition for the sequence of threats to converge or stay constant is $t_2 \leq t_1$.

Thus the condition $t_2 = t_1$ determines, through equations (34) and (35), a decreasing functional relationship between d and D (see figure 3a). It can be easily checked that, given h and H , d tends to a positive value lower than 1 as D tends to 1, and, conversely, D tends to a positive value lower than 1 as d tends to 1. Moreover, given D (d), it can be shown that d (D) is an increasing function of h and H , and tends to 0 as both h and H tend to 0.

[figure 3 about here]

A symmetric argument may be developed with respect to the part of the game that concerns the choice of a monetary policy by the home country. Hence, there exists another decreasing functional relationship between d and D . When d and D lie to the north-east of the outer envelope of the two curves, there exists a subgame perfect equilibrium with monetary cooperation and free trade. The 'cooperative' region is the shaded area in figure 3b. This completes the proof of Proposition 6. ■

The hypothesis of a finite upper bound on t and T may therefore help to explain why in certain circumstances monetary cooperation cannot be enforced. As we have shown, in order to induce the foreign country to cooperate, the home country must threaten it with the prospect of a retaliation at the commercial level in case it does not

cooperate. But figure 3b shows that if the discount rate of the home country is very high (d close to 0) this threat cannot be made credible, and the equilibrium strategy for the foreign country is $M = M^*$. Thus, an impatient government may fail to induce its opponent to cooperate. On the other hand, it is also true that if D is sufficiently close to 0, the home country cannot credibly threaten the foreign country, which implies that it is also more difficult to force an impatient government to cooperate.

6.3 Finally, we consider the case in which the tariff revenue in each country is paid out to the private sector in the form of a lump-sum transfer (see, e.g., Kuga (1973), Nielsen (1987)). Under Cobb-Douglas utility functions, a constant share of the transfer will be spent in each good; thus, the equilibrium of the economy will be the one derived in subsection 6.1, with $h = (1-b)$ and $H = B$ (12). The equilibrium exchange rate will therefore be

$$e = \frac{[1+t(1-b)](1+T)(1-b)m}{(1+TB)(1+t)BM} \quad (36)$$

However, the utility of a representative agent will no longer be given by (31), since now there is no unproductive public expenditure. Through appropriate substitutions the new payoff function turns out to be

$$u = k'' \left[1 - \frac{sm}{w} \right]^a \frac{bs}{m} \frac{s(1-b)}{M} \left[\frac{1+BT}{1+T} \right]^{1-b} \\ [1+(1-b)t]^b \left[\frac{[1+t(1+t)(1-b)]}{1+t(1-b)} \right]^{1-b} \quad (37)$$

where k'' is a positive constant. Notice that now the payoff of the home country depends positively on its own tariff (obviously the same conclusion holds for the foreign country). This implies that each country has a unilateral incentive to use the tariff regardless of the other country's monetary policy.

However, the equivalent of Proposition 5 still holds true because the tariff can be used to punish noncooperative behavior both at the monetary and the commercial level. More precisely, suppose the foreign country deviates from the "cooperative" solution by setting $M < M^*$ and $T > 0$. Then it will be punished by the home country via a tariff high enough as to reduce its payoff sufficiently below the level that would obtain under free trade and monetary cooperation. Again, to induce the home country to go through with its punishment, it is threatened with the prospect that, if it deviates from the punishment strategy, it also will be punished by the foreign country in the next period, and so on. We have then established

Proposition 7. For any $0 < d, D < 1$, a subgame perfect equilibrium of the supergame consisting of infinite repetitions of the one-shot game described in subsection 6.3 is given by $m = m^*$, $M = M^*$ and $t = T = 0$.

However, it is an open question whether this result continues to hold under the hypothesis of finite upper bounds on tariffs. It appears that, to address this issue, monetary threats should be combined with commercial threats. The analysis of the optimal mix of monetary and commercial threats is in the agenda of future research.

7. CONCLUDING REMARKS

In this paper we have built and analyzed a theoretical model of two countries that, by threatening each other with commercial warfare, may end up enforcing an equilibrium equivalent to a cooperative solution with optimal demand (monetary) and relative price (commercial) policies. However, we have also shown that this result may fail to occur when a country discounts future events too heavily. This may happen because that country has a Central Bank that is not independent of political pressures, or because its Government has a short electoral horizon, or for other reasons intrinsic to the preferences of its society. With some degree of fantasy, a jump into reality is made and the model used to suggest that the games described in it may help explaining current strains in the economic relations between the US on one side, and its main economic partners (Germany and Japan) on the other. Both sides are threatening each other with tariffs or other relative price policies -- such as a depreciating dollar on the US side -- in order to induce reciprocal moves toward restrictive fiscal policy (in the US) and expansionary demand policies (in Japan, and particularly in Germany). This situation may be in danger of falling apart, i.e. the game may yield a non-cooperative solution rather than a cooperative-equivalent one, because the US appears to have, for electoral, social and institutional reasons a high discount rate; and the other two countries, particularly Germany, have policy authorities and a social compact that discount less the future benefits and costs of current economic policies.

We are aware that this analysis is afflicted by theoretical limitations. An important, but not uncommon one in models with supergames, is the endemic multiplicity of solutions. In any case, it

would be worth analyzing other structures of punishment that the countries could adopt in case the threatened tariff measures were not actually introduced.

Finally, current events also suggest that actual policy games in this area may be more complicated than the two levels here assumed. For example, instead of considering the tariff as the instrument that is used as a threat to obtain a cooperative solution at the level of monetary policy, the reverse scenario could be analyzed where monetary policy is used as a threat in order to induce cooperation at the commercial level. More generally, both policies, monetary and commercial, could be considered simultaneously as threats to be used in order to reach their joint cooperative equilibrium.

FOOTNOTES

(1) For an attempt to explain different degrees of international cooperation along this route see Basevi, Kind, Poli (1986).

(2) To justify this assumption, one can think of factors of production that are specific of the home (foreign) country, and are necessary for the production of good 1 (resp., 2).

(3) As a matter of fact, since in our model there are firms that make positive profits, it might be thought that there exists an asset alternative to money. One can justify our assumption invoking an institutional set up in which ownership rights are not tradeable, and are automatically transferred from one generation to the next.

(4) This is the easiest way to introduce non neutrality of money into the model. Alternatively, one could assume that the nominal wage is set at a level that is compatible with full employment if there are no disturbances, and unemployment arises if there are disturbances.

(5) When analyzing the repeated game, we assume that in each period the economy fully adjusts to the stationary equilibrium corresponding to the given money supplies. Under non instantaneous adjustment, the game would become intrinsically dynamic (i.e., both the strategy space and the payoff functions in a given period would depend on the history of the game), and would not be a simply repeated game, where the strategies may be history-dependent, but the strategy space and the payoff functions cannot.

(6) The four-tuple $\{m, M, t(M), T(m)\}$ represents a "deterrence scheme" in a sense closely related to Moulin (1981).

(7) To confirm this, substitute (28) as an equation into the equivalent of (21) for the foreign country and check that the derivative of the resulting expression with respect to M is positive.

(8) "... the threat is no more than a communication of one's own incentives, designed to impress on the other the automatic consequences of his act. And, incidentally, if it succeeds in deterring, it benefits both parties" (Schelling (1960), p. 35).

(9) We continue to assume that public expenditure is unproductive and does not affect private demand. Notice also that eq. (29) in the text implicitly assumes that there are no tariffs on public expenditure on the foreign good.

(10) Recall from section 4 that in the infinitely repeated version of the purely monetary game, cooperation would emerge if and only if future payoffs are not discounted too much.

(11) See Fudenberg and Maskin (1986). As is well known, the analysis of supergames is plagued by an inherent multiplicity of subgame perfect equilibria. While the focus of this paper is on those equilibria which entail monetary cooperation, there may well be other equilibria where the cooperative outcome cannot be sustained. A possible source of multiple solutions may lie in the specification of the punishment structure. For instance, one could conceive of the case where a threatened country can counter-threaten its opponent at the commercial level.

(12) This implicitly assumes (see footnote 9) that the purchase of the foreign good out of the lump-sum transfer is not taxed. However, this entails no loss of generality, as the standard case in which the whole private expenditure is taxed can be obtained in our model through a simple redefinition of the tariff rate.

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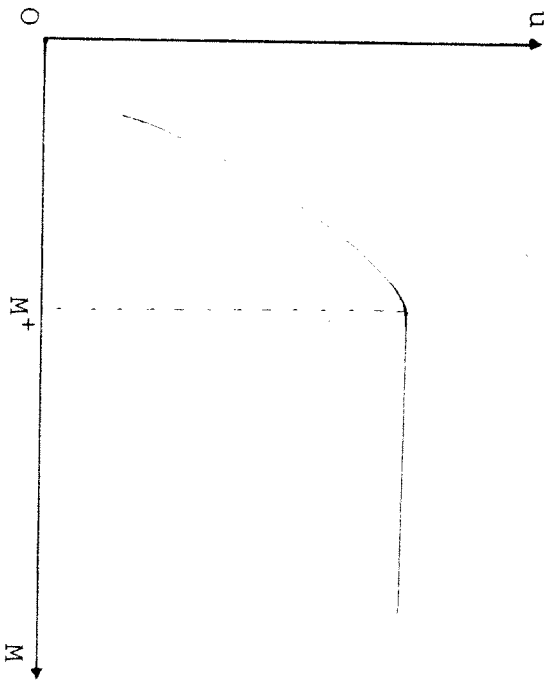
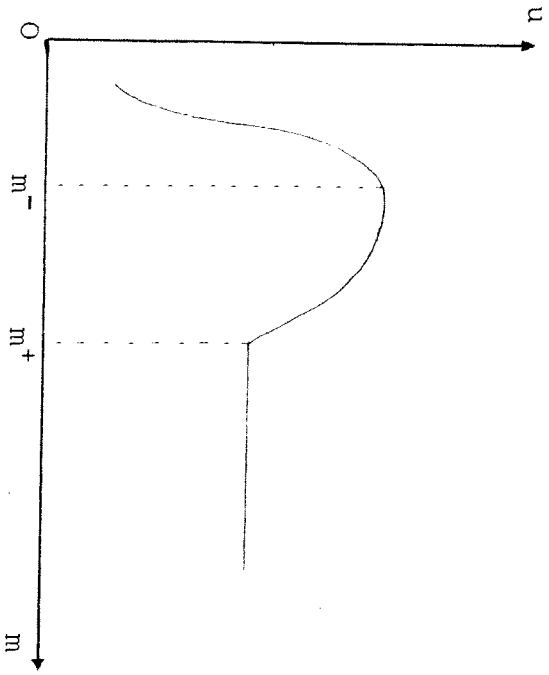
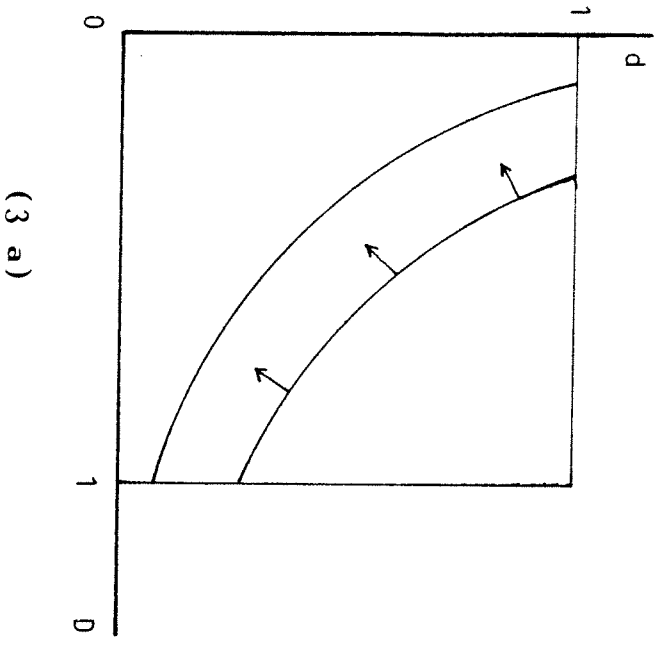
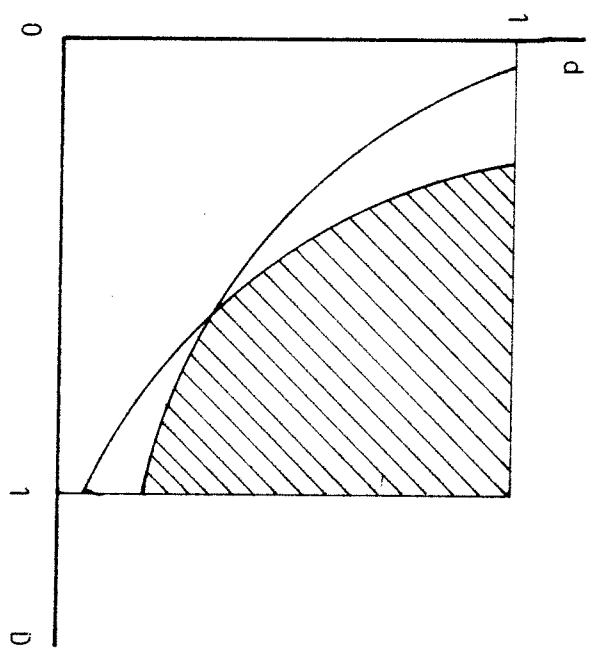


figure 1



(3 a)



(3 b)

Figure 3