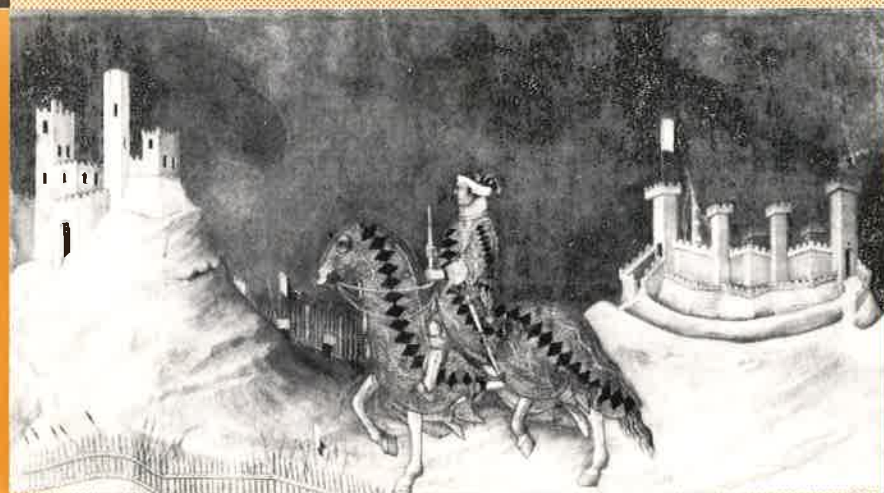
58

UNIVERSITA' DEGLI STUDI DI SIENA
Facoltà di Scienze Economiche e Bancarie

QUADERNI DELL'ISTITUTO DI ECONOMIA

Daniele Checchi

THE INTERNATIONAL COORDINATION OF COUNTER-CYCLICAL POLICIES



QUADERNI DELL'ISTITUTO DI ECONOMIA

Alla presente Collana "gialla" di quaderni l'Istituto di Economia affianca una Collana "celeste" di monografie. I numeri pubblicati a tutt'oggi sono i seguenti:

1) GIUSEPPE DELLA TORRE, Istituzioni Creditizie ed Accumulazione del Capitale in Italia (1948-81), 1984.
2) SANDRO GRONCHI, Tasso Interno di Rendimento e Valutazione dei Progetti: una Analisi Teorica, 1984.
3) ALDINO MONTI, La Proprietà Immobiliare a Bologna in Età Napoleonica (1797-1810), 1984.
4) GIULIO CIFARELLI, Equilibrium and Disequilibrium Interpretations of Inflation, 1985.

• Redazione: Istituto di Economia della Facoltà di Scienze Economiche e Bancarie - Piazza S. Francesco, 17 - 53100 Siena - tel. 0577/49059

• La Redazione ottempera agli obblighi previsti dall'Art. 1 del D.L.L. 31.8.45 n. 660

• Le richieste di copie della presente pubblicazione dovranno essere indirizzate alla Redazione

• **I Quaderni dell'Istituto di Economia dell'Università di Siena** vengono pubblicati dal 1979 come servizio atto a favorire la tempestiva divulgazione di ricerche scientifiche originali, siano esse in forma provvisoria o definitiva. I **Quaderni** vengono regolarmente inviati a tutti gli istituti e dipartimenti italiani, a carattere economico, nonché a numerosi docenti e ricercatori universitari. Vengono altresì inviati ad enti e personalità italiane ed estere. L'accesso ai **Quaderni** è approvato dal Comitato Scientifico, sentito il parere di un referee.

Daniele Checci

THE INTERNATIONAL COORDINATION OF COUNTER-CYCLICAL POLICIES

Siena, ottobre 1986

Daniele Checchi is a research student in the Department of Economics of the University of Brescia

A desire for policy coordination is by itself insufficient to insure successfull collaboration
(B. Eichengreen 1985)

In this paper* I discuss the conditions for a successful international economic policy coordination, using some results taken from the theory of dynamic games. In the most recent literature the informational aspects of the equilibrium determination have been deeply analyzed by means of static or steady-state models. Following a different line of research, I study the problem of policy coordination in a cyclical environment. A very simple dynamic 2-country model is studied and the informational requirements for an optimal monetary policy are analyzed. The well known non Pareto optimality of the Nash equilibria is used as a point in favour of policy coordination. But further elements can be obtained from the theory of repeated games, where coordination is also the rationally optimal result of noncooperative equilibria in a supergame with infinite horizon with discounting. In case of finite horizon, two side uncertainty and/or punishment costs are necessary to insure cooperative results. Differences in the payoff functions of the two players lead to very different results in the "world" output dynamics.

(*) Paper presented to the third conference on "Teoria dei giochi e applicazioni" held in Florence, may 1986. I thank G. Schwödiauer, M. Polo and P. Opromolla for helpful suggestions.

I am also indebted with an anonymous referee for pointing out an error. All the remaining mistakes are of course mine.

1. The problem of coordination

The world stagflation in the 80's has given rise to a growing literature on the reasons of the long duration of the recessive phase, expecially when compared to the short slumps of the previous decades (Boltho 1983, Emerson 1984, Bruno-Sachs 1985). Some authors have identified one of the reasons of this phenomenon in excessively contractionary policies in several countries (Buiter-Marston 1985). These conclusions are usually obtained with models of intertemporal utility maximization (by governments or private agents), whereas the transmission mechanisms change according to the policy instrument which are under analysis.

Ordinarily the transmission is assured by the effects of term of trade changes on consumption via a wealth effect (Hodrick 1980, Corden in Buiter-Marston 1985) or by a reallocation of factors in national production functions (Svensson 1984, Bruno-sachs 1985). The financial aspects of transmission are usually solved with the assumption of perfect international capital markets (Dornbusch 1980), which allows the exclusion of the relative variables from the solution; wide use is made of the saddle-path analysis in the mathematical solution (Lipton-Sachs 1983). The main advantage of this procedure is that of avoiding the inner instability implied by the nature of financial price of the exchange rate (Obsfeld-Stockman and Levich in Jones-Kenen 1985).

The presence of interdependence poses new problems for the policy

maker (Cooper in Jones-Kenen 1985). When deciding its own optimal policy, he has to take into account the optimal policy of the others (Hamada 1976): here is where the concept of Nash equilibrium shows its utility. When private agents are assumed to hold rational expectations, the model becomes dynamical, because of the forward looking character of those variables. In this case the optimal policy is obtained with optimal control techniques, but care must be used in order to avoid time inconsistent solutions (Oudiz-Sachs, Miller-Salmon and Currie-Levine in Buiter-Marston 1985).

But the process of achieving coordination does not seem to have been deeply analyzed. From the optimal control approach used in the solution of dynamic game of optimizing the monetary policies, the only possible conclusion about coordination is that the level of welfare improves when a sovranational coordinator controls the national monetary policies. From a qualitative point of view, some authors point out that in a 2-country set-up, the intertemporal disinflationary policies can be less restrictive (Miller-Salmon in Buiter-Marston 1985, Giavazzi-Giovannini 1985). This approach can not go much further because it contains an intrinsic limitation: on one side there are perfectly rational agents who are able to maximize from now to infinite; on the other side they are unable to implement an adequate device to obtain Pareto optimal results from coordination. It has been said that the main justification of this result relies in the credibility of any kind of agreement that are reached among different nations. In such a case the problem of coordination would be only a political one, and the economist would be left out. In other words, the noncooperative approach would be justified by the istitutional framework of the actual world economy (Cooper in Jones-Kenen 1985).

We also know from another branch of the game theory that cooperative solutions can be obtained as a result of noncooperative supergames (the "silent gentleman's agreement of Aumann 1959 - see also Luce-Raiffa 1957, Friedman 1977, Kurz 1978, Smale 1980 and Schotter 1981). Quoting from Radner 1981:

> " ... The theory of repeated games explores in a formal way another piece of conventional wisdom, namely that when members of an organization have long-lasting relationships they can encourage and maintain cooperative behaviours (without the device of binding commitments) by signalling intentions to punish defectors from informal agreements" (p.1128).

Following this approach, as I will do later on, one yields the conclusion that coordination is the result of long horizon in policy planning or low interest rates in future discounting. In some cases, it can also be the result of imperfect information or nearby rationality (Kreps et oths 1982, Kreps-Wilson 1982b, Milgrom-Roberts 1982). The limit of this approach is given by

the ad-hoc character of the strategies of the two players in each game (correlated strategies) which enforces the cooperative result: tit-for-tat strategies, trigger strategies, review strategies (Axelrod 1984, Radner 1981 and 1985).

The results of these two approaches are complementary, in the sense that they show that cooperative behaviours are the result of far-sightedness of agents and credibility of the other players' strategies.

One more and last aspect can be stressed. In the international economics literature the problem of coordination is analyzed with respect to static or steady-state models (where the steadiness is given by the condition: pefectly anticipated inflation = rate of growth of money). These aspects are mainly justified by the mathematical difficulties of solving dynamically the optimal control problem. But these assumptions are very restrictive. In the sequel I will make use of a very simple dynamical model of a two-country economy with endogenous national cycles; and I will study the problem of coordinating the optimal stabilizing policies in this set-up. Very similar conclusions to the static case are obtained, but optimal policies are proved to exhibit countercyclical patterns.

2. *Optimal policies*

A simple macro model, analogous to Dornbusch 1976, is assumed here.

Only two countries are considered, each one described in a keynesian manner by an IS-LM equilibrium with a Phillips curve. The main difference is due to the absence of financial sectors. The Phillips curve is a cumulated error one: not only the most recent errors matter (like in Dornbusch 1976, where the persistence was given by an adaptive expectation mechanism), but the whole serie of deviations from long run output affects current inflation (an identical formalization is offered by Miller-Salmon in Buiter-Marston 1985). This leads the system to exhibit typical keynesian features, like unemployed capacity and cyclical behaviour of prices; from this point of view, I retain Dornbusch's idea that labour and goods markets clear slowlier than asset markets. As in the original model, the nominal interest rate is inserted in the output equation: this excludes feedbacks from the output onto itself via the Phillips equation, and makes the system more easily solvable. In each country there is a rational policy maker who controls the money supply of his country. The exchange rate is assumed to be fixed and the two countries affect each other only through the trade balance; given the absence of financial sectors, expectations do not play relevant role in this model, and consequently they are excluded.

I am concerned in coordination of countercyclical policies, that is to say the attempt of the economic policy to stabilize as much as possible the inner instability of the economy: thus the existence of cycles is taken for granted and not explained (for reference see Zarnovitz 1985). The endogenous cycles in each country are generated by the interrelation between price and outputs, as clearly stressed by Tobin 1975.

The transmissione mechanism works through two channels:

- the terms of trade affect negatively the current output
- domestic inflation is influenced by foreign inflation via the import share on domestic consumption (the traditional imported inflation channel - Fielecke 1978).

Since the exchange rate is fixed, the "beggar-thy-neighbour" policies (a contractionary monetary policy leads to an apreciation of the exchange rate and exports inflation abroad) are not possible, whereas the "locomotive" policies (a contractionary monetary policy reduces output and inflation at home, thus affecting negatively foreign output) are the policies under analysis.

The model is loglinear and all variables are zero-mean. Starred variables indicate the foreign country (from now on defined as country 2). The exchange rate is constant and set equal to 1, so that it does not appear explicity.

The model

COUNTRY 1		COUNTRY 2	
(1)	$m - p = ay - br$	(5)	$m^* - p^* = hy^* - ir^*$
(2)	$y = -cr - d(p-p^*) + v'$	(6)	$y^* = -lr - n(p-p^*) + v^{*\prime}$

(3) $\dot{p} = fz + g\dot{p}^*$ (7) $\dot{p}^* = oz^* + j\dot{p}$

(4) $z(t) = \int_0^t y(s)\, ds$ (8) $z^*(t) = \int_0^t y^*(s)\, ds$

which solved in terms of y and $\dot{p}$ yields

(9) $\dot{z} = -a_1 p + a_2 p^* + a_3 m + v$

(10) $\dot{p} = a_4 z + a_5 z^*$

(11) $\dot{z}^* = a_6 p - a_7 p^* + a_8 m^* + v^*$

(12) $\dot{p}^* = a_9 z + a_{10} z^*$

where

$\dot{z} = y$ = real output

p = output price

r = interest rate

v = output shock

$a_1 = (cdb/(b+ca) = a_2 + a_3$	;	$a_7 = (1+ni)/(1+lh) = a_6 + a_8$
$a_2 = db/(b+ca)$	;	$a_6 = ni/(1+lh)$

$a_3 = c/(b+ca)$	;	$a_8 = l/(1+lh)$
$a_4 = f/(1-gj)$	;	$a_9 = jf/(1-gj)$
$a_5 = go/(1-gj)$	;	$a_{10} = o + go/(1-gj)$
$v = v'b/(b+ca)$	;	$v^* = v^{*\prime} i/(1+lh)$

Consider in addition that the policy maker tries to stabilize output and prices at their long run equilibria, displacing the money supply from its equilibrium value as less as possible, with an elasticity cost equal to $1/\varphi$.

(13) $U = -\int_0^T \exp(-\delta s)\, 1/2\, [p^2 + z^2 + m^2/\varphi]\, ds$

(14) $U^* = -\int_0^T \exp(-\delta s)\, 1/2\, [p^{*2} + z^{*2} + m^{*2}/\varphi]\, ds$

I ignore in this context the problem of consistency implied by the policy making of periodically elected governments. In other words, I assume that the initial government can precommit itself and all its followers to an entire sequence of moves or to a policy rule. Thus optimal control techniques are sufficient.

I can now prove three propositions:

Proposition 1: the optimal monetary policy of a single country, which maximizes its objective function in absence of any information about the other country, is a countercyclical policy. It is an optimal stabilizing policy (i.e. it is able to lead the economy to its long run equilibrium) in case of a closed economy.

Proof: we have to solve the problem of

$$(15) \quad \max_{m(t)} - \int_0^T -1/2 \ (p^2 + z^2 + m^2/\varphi) \ ds \quad \text{s.t.}$$

$$(16) \quad \dot{z} = -a_1 p + a_3 m + E(a_2 p^* + v| \Omega_1)$$

$$(17) \quad \dot{p} = a_4 z + a_5 E(z^* | \Omega_1)$$

where Ω is the information set of country 1. The future is not discounted because the hamiltonian would yield a nonautonomous differential system and it would not be solvable; for semplicity the governmental rate of future discount is set equal to 0.

The cost of modifying the money supply from an intended level is introduced explicitly in the welfare function of the government, the reason being that it prefers as less as possible the deviation from assigned targets. This assumption makes the solution easier, but it is not essential to the demonstration of the proposition. From the exclusion of nominal money from

eq. 15, it is possible to solve dynamically the system 16-17 thus obtaining

$$z = \sum_{i=1}^{2} c_i \exp(\tau_i t) + a_3 / a_1 m$$

$$p = \sum_{i=1}^{2} k_i \exp(\tau_i t)$$

which once inserted into the objective function yields an equation similar to 15 with a linear term added.

The Pontryagin's maximum principle ordinarily yields only necessary conditions; in this case the same conditions are also sufficient, since the hamiltonian is a concave function of the state variables. Nonetheless we are not guaranteed about the uniqueness of such a solution (Intriligator 1971).

The hamiltonian is

$$(18) \quad H = -1/2 \ (p^2 + z^2 + m^2/\varphi) +$$

$$+ w_1 \left[-a_1 p + a_3 m + E(a_2 p^* + v|\Omega_1) \right] +$$

$$+ w_2 \left[a_4 z + a_5 E(z^* | \Omega_1) \right]$$

where the w's are costate variables. The first order conditions are

(19) $\delta H/\delta m = -m/\varphi + w_1 a_3 = 0$

(20) $\delta H/\delta w_1 = \dot{z} = -a_1 p + a_3 m + E(a_2 p^* + v|\Omega_1)$

(21) $\delta H/\delta w_2 = \dot{p} = a_4 z + a_5 E(z^*|\Omega_1)$

(22) $\delta H/\delta z = -\dot{w}_1 = w_2 a_4 - z$

(23) $\delta H/\delta p = -\dot{w}_2 = -a_1 w_1 - p$

and the second order conditions are satisfied since the hessian matrix is negative definite:

$$\delta^2 H/\delta m^2 = -1/\varphi < 0$$

From (19) we get the optimal monetary policy

(24) $m^0 = w_1 a_3 \varphi$

and w_1 can be obtained as a solution of the differential system defined by 20-24, making use of 20. Note that the w's can be interpreted as the sensitivities of the objective functional to variations in the corresponding state

variables z and p.

We must choose between an open-loop solution (the optimal money is decided at the beginning of the period) or a closed-loop one (the optimal money is function of contemporaneous state variables).

In case of closed-loop solution, it is known that the solution will be linear in the state variables because solution of a linear quadratic maximization (Basar-Olsder 1982, p. 228) and will be informatinally not unique (Basar 1979). The solution procedure is to postulate a linear relation between costate and state variables (i.e. $w_i = b_{i1} z + b_{i2} p$, i=1,2), substitute repeatedly into 19-24 and obtain the Riccati matrix equation which determines the b_{ij}'s. Then the substitution into 24 gives the optimal monetary rule $m^0 = m^0(z,p)$.

The case of open-loop solution is time inconsistent in the presence of uncertainty and expectations in the model (Miller-Salmon in Buiter-Marston 1985); on the contrary, in the present case it coincides with the closed-loop case, and I follow this second approach in order to obtain an explicit solution.

We start with the dynamical system given by 19-24, which in matrix notation is

(25) $\dot{X} = AX + B$

where

$$A = \begin{bmatrix} 0 & -a_1 & \varphi a_3^2 & 0 \\ a_4 & 0 & 0 & 0 \\ 1 & 0 & 0 & -a_4 \\ 0 & 1 & a_1 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} E(a_2 p^* + v \mid \Omega_1) \\ E(a_5 z^* \mid \Omega_1) \\ 0 \\ 0 \end{bmatrix}$$

The charasteristic equation is

$$\tau^4 + \tau^2(2a_1a_4 - \varphi a_3^2) + a_4^2(a_3^2\varphi + a_1^2)$$

and the roots are

$$(26) \quad \tau_j = \pm 1/\sqrt{2}\left\{ +(\varphi a_3^2 - 2a_1a_4) \pm \left[3a_1^2a_4^2 + \varphi^2 a_3^4 - 4\varphi a_3^2 a_4 (a_1 + a_4) \right] \right\}^{1/2}$$

or using polar notation and De Moivre's Theorem

$$(27) \quad \tau_j = \pm \mu^{1/2} \left[\cos 1/2\, \Theta \pm\ i \operatorname{sen} 1/2\, \Theta \right]^{1/2}$$

where

$$\mu = 2\,\{ (\varphi a_3^2 - 2a_1a_4)^2 + [\, 3a_1^2a_4^2 + \varphi^2 a_3^4 - 4\varphi a_3^2 a_4\, (a_1 + a_4)\,] \}^{1/2}$$

$$\Theta = \arccos\ [\, (\varphi a_3^2 - 2a_1a_4)\, /\mu]$$

Except the case of $\Theta = 2k\pi$, k=0,1,2,3,... (which is not generic), some roots are complex, and the homogemeous solution component will oscillate. The particular solution is easily obtained from the system 25. Since B is a vector of constants, the particular solution $X = X^0$ is tried (Gandolfo 1971, p. 268). The system becomes

$$(28) \quad 0 = AX^0 + B$$

and the particular solution which satisfies it is

$$(29) \quad X^0 = -A^{-1}B = \begin{bmatrix} z^0 \\ p^0 \\ w_1^0 \\ w_2^0 \end{bmatrix} = \begin{bmatrix} -E(z^* \mid \Omega_1)(a_4/a_5) \\ a_1 E(a_2 p^* + v \mid \Omega_1) \,/\, a_1^2 + a_3^2 \varphi) \\ -E(a_2 p^* + v \mid \Omega_1) \,/\, (a_1^2 + a_3^2\varphi) \\ -E(z^* \mid \Omega_1)\,(a_5/a_4) \end{bmatrix}$$

The complete solution for m^0 is consequenttly

$$(30) \quad m^0 = a_3 \varphi w = a_3\varphi \left[\sum_{i=1}^{4} c_i \exp(\tau_i t) - (a_1^2 + a_3^2\varphi)^{-1}\, E(a_2 p^* + v \mid \Omega_1) \right]$$

In the welfare function (15) I have not explicitly assumed a terminal condition. But when considering the case of elected governments, it does make sense to think that they are concerned with the final values of economic performance within the period. In such a case, ed. 15 can be rewritten as

$$(15') \quad \max_{m(t)} \int_0^T -1/2(p^2+z^2+m^2/\varphi)dt \; + \; h_1 z(T) \; + \; h_2 p(T)$$

and the first order conditions are augmented with two more terminal conditions

$$(22') \quad w_1(T) \; = \; h_1$$

$$(23') \quad w_2(T) \; = \; h_2$$

Since the terminal conditions are finite values, the optimal money is obtained by solving backward the eq. 30, and the c_i's are consequently obtained. From a backward solution, only complex roots with positive real parts are convergent to an initial equilibrium position.

The final formula for the optimal policy is

$$(31) \quad m^0(t) = a_3\varphi\{c_1\exp[(\alpha+i\beta)t] + c_2\exp[(\alpha-i\beta)t] - (a_1^2+a_3^2\varphi)^{-1} E(a_2p^*|\Omega_1)\}$$

where

$\alpha = \pm\mu^{1/2}\cos(1/2\Theta)$

and

$\beta = \pm\mu^{1/2}\,\mathrm{sen}(1/2\Theta)$

and after some transformations

$$(32) \quad m^0(t) = a_3\varphi[\exp(-\alpha t)]\,[(c_1+c_2)\cos\beta t + (c_1-c_2)\, i\, \mathrm{sen}\,\beta t] \; +$$

stabiliz. comp. cyclical component

$$- (a_3\varphi) / (a_1^2+a_3^2\varphi)E(a_2p^* + v\,|\Omega_1)$$

up-to-dating component

with

$$m^0(T) \; = \; a_3\varphi h_1$$

I can now make the following remarks:

i) in case of a closed economy $[a_2=a_5=0]$ the optimal policy works countercyclically in order to lead the system to the long rum equilibrium. The constant or steady growth money is suboptimal in such a case.

ii) In case of a small country which receives cyclical impulses from abroad

$$[E(p^*|\Omega_1) \; = \; \sum_{i=1}^{n} c_i(\cos b_i t + \mathrm{sen}\, d_i t)]$$

the stabilizing policy is modified in its periodicity, because it has to stabilize a different kind of cycle. This fact has strong implications. When in fact country 1 assumes that country 2's output is stationary, whereas it behaves cyclically, country 1 is risking to enter a spiral (vicious or cirtuous) which follows an unstable path. As an example, consider contry 1 in an expansion phase (output and inflation are rising); if the price elasticities of the outputs are low in both countries, the depressing effects of rising prices are delayed and expansion in each country stimulate the expansion of the other. If 1's monetary policy reacts only to 1's dynamics, it will be insufficient to counteract its fluctuations, and this will cumulate dynamic instability. On the contrary, even in absence of a policy maker in country 2, if the policy maker of country 1 foresees exactly the cyclical dynamics in both countries, it can stabilize both outputs and prices of this small "world" economy.

iii) If the shock v is a browian motion such that $E(v|\Omega)=0$, the policy is still optimal. But when the policy maker is not perfectly informed [it is the case of ε-delayed closed-loop perfect state information: $\Omega(t)=v(t-\varepsilon)$; see Basar-Olsder 1982, p. 212] or even memory-less [$\Omega(t)=v(0)$] it might reach the case of destabilizing policies.

iv) The monetary instrument is less changed the higher is its perceived cost of modification from the long run equilibrium (the lower is φ).

v) Any positive (negative) shock coming from abroad ($dp^*>0$) or exogenously ($dv>0$) and perfectly anticipated reduces (increases) the optimal policy necessary to stabilize.

Observations i) and ii) are the contents of Proposition 1.

We can now make use of the result of 30 to discuss the case of a common shock (say the "oil" schock) on a 2-country economy.

Let us consider first the case of two policy makers who solve their maximization problem and keep their expectations on the other's variables constant. So doing they take into account the fact of interdependence (Cooper in Jones-Kenen 1985), but they ignore both the structure of the other country (including its inner dynamics) and the presence of another rational maximizer in it. This could be seen as the result of a lack of information (due to absence of exchange of reciprocal information) and/or incapability to extract signals from the data available on the other country.

Proposition 2: In case of complete absence of information about the other government policies, the optimal policy in each country does not guarantee the stabilization. In fact, in the case of a common shock hitting both countries without perfect information about the other player's behaviour, the likely effect is an overreaction at the "world" level, due to the cumulative effects of the two policies.

Proof: the first part of the statement is selfevident. The optimal policy for a policy maker who ignores the presence (or does not trust the rationality of the second policy maker) is to maximiza its objective function on a constrained vector field in R^4, representing the structure of both the economies. But the existence of a second policy maker affects the vector field; periodical solutions are still very likely, but with a changed period.

Thus the maximization of the first agent will be suboptimal, and we can not guarantee that even in the very long run the economy is going to be stabilized at the equilibrium values.

The second part of the statement is an application of the first one. It reflects a shared opinion that the inflationary period after the first oil shock and the stagflationary period after the second are partly due to inadequate policy responses in each country which ignored or understimated the induced effect of the others' reactions in an interdependent context. This can be seen as a result of the decentralized decision of policies under imperfect information about the policy making structure (Bruno-Sachs 1985, Giavazzi-Giovannini 1985).

If each country follows an "imperfectly informed" maximization, they end with a result analogous to 32, where the cyclical component is more complex (4 state variables imply 8 characteristic roots) but still declining because of the transversality condition. From

$$(33) \quad \max \int_0^T -1/2\,(p^2 + z^2 + m^2/\varphi)\,ds \qquad \text{s.t.}$$

$$\dot{z} = -a_1 p + a_2 p^* + a_3 m + E(v|\Omega_1)$$

$$\dot{p} = a_4 z + a_5 z^*$$

$$\dot{z}^* = a_6 p - a_7 p^* + a_8 E(m^*|\Omega_1) + E(v^*|\Omega_1)$$

$$\dot{p}^* = a_9 z + a_{10} z^*$$

one gets the open-loop solution

$$(34) \quad m^0(t) = m^0_{cyc}(t) + H[\,a_2 a_8 E(m^*|\Omega_1) + a_2 E(v^*|\Omega_1) + a_7 E(v|\Omega_1)\,]$$

where

$$m^0_{cyc}(t) = \sum_{i=1}^{8} c_i \exp(\tau_i t)$$

$$H = [\,a_7 + (1 - a_3 a_6)(a_2 a_6 / a_7 - a_1)^{-1}\,] \leq 0$$

H is assumed to be ≤ 0 (the opposite case would be possible ad well) in analogy with the economic content of the previous case. The case of the second country is similar.

We can make the following observations:

i) note that many elasticities of country 2 enter in the maximization of country 1: this shows how much care requires in terms of information the problem of the optimal policy in an international and interdependent environment.

ii) Consider the case of a negative "oil" shock which hits the outputs of both countries and is perfectly anticipated. The optimal policy should be expansionary, according to the magnitude of the terms of trade elasticities in both countries a_2 and a_7. If the other government is not taken into account$[E(m^*|\Omega_1)=0]$ or it is considered not perfectly rational$[E(m^*|\Omega_1) < m^*]$, the monetary policy in the first country will underestimate the expansionary push coming from abroad and will end in an overexpansionary policy. If the same occurs in the second country, the "world" economy will be driven on unstable spirals.

iii) Similar non-stabilizing policies are the result of imperfect information state like the following: policy maker 1 takes into account policy maker 2, but ignores that the latter is maximizing without taking into account policy maker 1.

The previous discussion has shown the relevance of the information requirements in the optimal dynamic policy decision. There is no need to say that the optimal policy becomes almost impossible in practice when the number of countries is increased. Let us do a further step in the analysis of coordination.

Proposition 3: Under perfect information, a Nash equilibrium exists. Such a solution is however not Pareto optimal since a sovranational institution could lead to better results for both countries.

Proof: From the definition of Nash equilibrium, we have to find m^0 and m^{*0} such that

$$U(m^0,m^{*0}) \geq U(m,m^{*0})$$

and

$$U^*(m^0,m^{*0}) \geq U^*(m^0,m^*).$$

Writing the dynamic system in a block matrix manner

$$(35) \quad \dot{X} = AX + BM$$

where

$$X = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} z \\ p \\ z^* \\ p^* \end{bmatrix}, \quad A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}; \quad B = \begin{bmatrix} B_1 \\ B_2 \end{bmatrix}; \quad M = \begin{bmatrix} M_1 \\ M_2 \end{bmatrix} = \begin{bmatrix} m \\ 0 \\ m^* \\ 0 \end{bmatrix}$$

we have that:

- $\dot{X} = AX$ defines a linear mapping and is consequently continous in $t \varepsilon [0,T]$ for any X.
- $\dot{X} = AX+BM$ is uniformly Lipschitz in X and M. In fact denoting with $\| \ \|$ the Eucledeian norm

$$\| AX_i + BM_i - AX_j - BM_j \| \leq k \{ \| X_i - X_j \| + \| M_i - M_j \| \}$$

is always satisfied for k=4 $\sup\{a_{ij}, b_{ij}\}$. In fact

$$\|A(X_i-X_j) + B(M_i-M_j)\| \leq \|A(X_i-X_j)\| + \|B(M_i-M_j)\| =$$

$$= \|A\| \ \|X_i-X_j\| + \|B\| \ \|M_i-M_j\|$$

$$\leq \sup\left\{\|A\|, \|B\|\right\} (\|X_i-X_j\|+\|M_i-M_j\|) =$$

$$= 4 \sup\left\{| a_{ij} |, | b_{ij}|\right\} (\|X_i-X_j\| + \|M_i-M_j\|) .$$

- The optimal feedback control (closed-loop solution) m^0 and m^{*0} are continuous in X and t through the Riccati matrix and are assumed to be uniformly Lipschitz in X.

Then the differential system admits a unique solution (i.e. a unique state trajectory for m^0 and m^{*0}, so that $m^0=m^0(t,X)$ and $m^{*0}=m^{*0}(t,X)$ and furthermore this trajectory is continuous (Basar-Olsder 1982, p. 212).

Now let us compare the Nash solution with the sovranational planner case. Here again I must assume that the sovranational planner is able to precommit his followers, in order to use the optimal rule. It has been proved, however, that when temporal consistency is considered, the monetary policy is less contractionary, both at the national and at the international level (Oudiz-Sachs in Buiter-Marston 1985). In the Nash case the procedure is the following. For semplicity I assume $\varphi=1$.

(36) $$\max_{M_1(t)} H = \max_{M_1(t)} -1/2(X_1'X_1 + M_1'M_1) + Y'(AX + BM)$$

(37) $$\max_{M_2(t)} H^* = \max_{M_2(t)} -1/2\,(X_2'X_2 + M_2'M_2) + Z'(AX + BM)$$

The first order conditions of player 1 are

(38) $$\delta H/\delta M_1 = -M_1 + Y'B_1 = 0$$

(39) $$\delta H/\delta Y = \dot{X} = AX + BM$$

(40) $$\delta H/\delta X = -\dot{Y} = -X_1' + A'Y$$

Player 2's first order conditions are similar. Looking for an optimal feedback control we use the Riccati transformation

(41) $$M_1^0 = KX = B'Y_1 = B_{11}'Q_{11}X_1 + B_{12}'Q_{12}X_2$$

where Q_{11} and Q_{12} are blocks of the solution matrix of the Riccati matrix equation

$$(42) \quad \dot{Q}X + QAX + A'QX + QB \begin{bmatrix} \dfrac{B_{11}Q_{11}X_1 + B_{21}Q_{12}X_2}{M_2} \end{bmatrix} - X_1 = 0$$

Since Q_{ij} will be linea in M_2 (say $Q_{ij} = Q_{ij}(t)M_2$), we will get

$$(43) \quad M_1^0 = B'_{11}Q_{11}(t)M_2X_1 + B'_{21}Q_{12}(t)M_2X_1$$

$$(44) \quad M_2^0 = B'_{12}Q_{21}(t)M_1X_2 + B'_{22}Q_{22}(t)M_1X_2$$

and after reciprocal sobstitution, we obtain the required non linear function

$$(45) \quad M_1^0 = \mathcal{F}_1(t, X_1, X_2, M_2^0)$$

$$(46) \quad M_2^0 = \mathcal{F}_2(t, X_1, X_2, M_1^0)$$

which by construction satisfies the properties of a Nash equilibrium. Once solved we can interpret the Nash procedures as a joint maximization of 36 and 37 under the further constraints given by 45 and 46, which can also be seen as a unique constraint in implicit form

$$(47) \quad M_1^0 - \mathcal{F}_1 \left[t, X_1, X_2, \mathcal{F}_2(t, X_1, X_2, M_1^0) \right] = 0$$

Thus a sovranational agentwho maximizes the sum of the national welfare functions

$$(48) \quad \max_{M_1, M_2} H + H^* = \max_{M} x - 1/2(X'X + M'M) + W(AX + BM)$$

is expected to obtain a higher level of national welfare, because he is not constrained by a decentralized policy making represented by the constrained 47. One must recall that the optimal controls obtained via the Riccati transformation are not unique when the Riccati functions are not Lipschitz.

The previous approach does not provide any more informations on the distribution of the results of the implicit cooperative approach. To be more precise, one should specify which kind of solution of the cooperative game he is thinking of (Luce-Raiffa 1957, Friedman 1977). For our purposes, however, it is sufficient to assume that the gains are equally distributed between the two countries. This proves that the Nash equilibrium in policy making can be Pareto suboptimal.

In all the previous analysis I have not made use of hierarchical (Stackelberg) solutions concepts. Doubts have been raised about the efficiency of such a tool, since it has been proved that under this approach the relative gains of the follower are greater than those of the leader. In an international framework, this ends in the absence of leadership as a rational outcome of a noncooperative game (chicken game - see Eichengreen in Buiter-Marston 1985); this does not provide very helpful insight for the analysis of coordination.

3. *Repetition effects*

In the previous analysis, we have seen that the informational requirements for the dynamic noncooperative game are very high. But the differential game implied by this model does not allow us to see the role of future discounting and of the uncertainty in the process of coordination. To see it is useful to make reference to the theory of repeated games. In order to transform the differential game into a repeated game, one has to carry out the following steps and to make the following assumptions:

a) the first step is to transform the original continous time model into a discrete time one. To do it, it is necessary to assume that the eigenvalues of the matrix $(I-A)^{-1}$ must be in absolute value ≤ 1. Then

$$(49) \quad \dot{X} = AX + BM$$

can be rewritten as

$$(50) \quad X_t - X_{t-1} = AX_t + BM_t$$

or

$$(51) \quad X_t = (I-A)^{-1}X_0 + BM_t(I-1)^{-1}\left[I-(I-A)^{-1}L \right] = K+B(L)M_t$$

where K is a matrix which is dominated by its maximum eigenvalue for t large enough, and B(L) is a matrix polynomial of the lag operator. This indicates that the current values of output and prices in both countries fully depend on the past history of the monetary policies in both countries.

b) the payoff function for each country is rewritten accordingly as

$$(52) \quad U_t = \sum_{i=0}^{T} -\delta^i \, 1/2 \, (X'_{t+i}X_{t+i} + M'_{t+i}M_{t+i})$$

and using eq. 51

$$(53) \quad U_t = H - 1/2 \sum_{i=0}^{T} -\delta^i \left[M'_tB'K + K'BM_t + M'_t(B'B + I)M_t \right]$$

where $H = 1/2\left[(1-\delta^{t+1}) / (1+\delta) \right] K'K$.

To assume that the current monetary policy is the only relevant for the evaluation of current welfare is equivalent to assume that B(L)=B costant. In such a case I can obtain the payoff of the constituent game as a quadratic function of the two strategy variables, m and m*.

c) If one wants to find a reasonable explicit version of the payoff represented by ed. 53, it is necessary to recall the underlying structure of the game, described above (pp. 4-5). From there, one knows that each country likes contractionary policies inland and expansionary policies abroad, in order to avoid as much as possible domestic inflation and output expansion over the natural rate. This desire can be represented by the following equation, which is a particular case of eq. 53 under assumption b.

$$(54) \quad U_{it} = \left[A - (m_j - B)^2 - (m_i - C)^2 + D\, m_i m_j \right]$$

where A, B, C, D are positive constants.

d) Again for semplicity sake, let us assume that the choice set available to both players has only two possibile values: a contractionary monetary policy (tight money, call it T, and set equal to -1) and an expansionary one (easy moner, call it E, set equal to +1). Moreover, their payoff functions coincide. Then the possible outcomes of the interdependence of choices can be represented by this payoff matrix. The matrix is time invariant, i.e. the payoffs are unmodified by their repeated attainment.

1 \ 2	T	E
T	a,a	c,d
E	d,c	b,b

where

$$a = A - (1+B)^2 - (C-1)^2 + D$$

$$b = A - (B-1)^2 - (1+C)^2 + D$$

$$c = A - (B-1)^2 - (C-1)^2 - D$$

$$d = A - (1+B)^2 - (1+C)^2 - D$$

I consider the case of a finite number of repetitions of the constituent game, with a future discounting at the same interest rate for both agents $[r = r^* = (1-\delta)/\delta]$. Side payments are excluded. Both agents are rational and perfectly informed about the rationality of the other player. Mixed strategies are excluded.

From the theory of repeated games it is known that the Pareto optimal set can be reached as the noncooperative equilibrium, using "trigger" strategies (i.e. play the optimal strategy as long as the other player does the same, and the security strategy otherwise) (Friedman 1977, Axelrod 1984). So, any one of the four possible outcomes of the constituent game can become the supergame equilibrium, according to the values of the four parameters A, B, C, D, the duration of the game τ and the discount factor δ.

Analyzing the possible outcomes from an economic viewpoint one can make the following observations:

(a,a) : both countries undertake contractionary policies. The depressing effect can be strengthened by mutual interdependence. The result in the context of the previous model given by eq. 9-12 is price deflation and unemployment (output below the natural rate).

(b,b) : both countries use expansionary monetary policies. Higher incomes are associated with higher inflation rates. This situation can be or can not be associated to higher welfare than (a,a) according to the policy maker's preferences.

(c,d) : country 1 adopts contractionary policies when country 2 is expanding. Country 1 is likely to experience high income without inflation, while country 2 faces trade deficit and price inflation without output expansion.

(d,c) : the previous situation applies with inverted roles.

The game is made symmetrical for semplicity. In the case of analogous situations leading to significantly different payoffs for the two countries, different results might be obtained, but the essence of the analysis would be unmodified. I will consider four significant cases:

Case 1 - "Keynesian"

It applies when both countries strictly prefer the outcome (E,E) to (T,T), but this is not the dominant strategy in the constituent game. The noncooperative outcome in a single play is (T,T). Formally $b > a$, $d \leq 0$ and $(c+d) < 2b$. A possible realization of the payoff matrix for A=10, B=2, C=1 and D=1 is

		2: T	2: E
1	T	2,2	8,-4
	E	-4,8	6,6

where the first figure is country 1's payoff and the second is country 2's payoff. For these values of the parameters eq. 54 represents a continous version of the well known prisoners' dilemma (Luce-Raiffa 1957, Kurz 1977, Smale 1980, Radner 1981, Kreps et oth. 1982, Axelrod 1984). Many definitions of equilibria are possible for this situation: "quasi equilibria" (Luce-Raiffa 1957), perfect equilibrium (Selten 1975), sequential equilibrium (Kreps-Wilson 1982a and 1982b), perfect ε-equilibrium (Radner 1981 and 1985). I will adopt the balanced temptation equilibrium proposed by Friedman 1977 (pg. 180).

Given the simmetry of the game, it is sufficient to analyze the strategy set of one player. When both players play T at any stage of the game, each one gets.

$$(55) \quad U_T = \sum_{i=1}^{\tau} \delta^i a = [\,(1-\delta^{\tau+1}) / (1-\delta)\,]\ a$$

while with playing E at any stage, they get

$$(56) \quad U_E = \sum_{i=1}^{\tau} \delta^i b = [\,(1-\delta^{\tau+1}) / (1-\delta)\,]\ b > U_T$$

Since binding agreements are excluded by the noncooperative nature of the game, any agreed strategy at time 0 offers an incentive to defect. When each player expects the other to play T after a defection for the remaining of the game, the payoff for a defection at time k is

$$(57) \quad U_{dk} = \sum_{i=0}^{k-1} \delta^i b + \delta^k c + \sum_{i=k+1}^{\tau} \delta^i a =$$

$$= \sum_{i=0}^{k} \delta^i b + \delta^k (c-b) + \sum_{i=k+1}^{\tau} \delta^i a =$$

$$= \sum_{i=0}^{\tau} \delta^i b + \delta^k (c-b) - \sum_{i=k+1}^{\tau} \delta^i (b-a) =$$

$$= U_E + \delta^k \left(c + a\frac{\delta-\delta^{\tau-k+1}}{1-\delta} - b\frac{1-\delta^{\tau-k+1}}{1-\delta}\right) =$$

$$= U_E + P_{k\tau}$$

where $P_{k\tau}$ is the premium for defecting at time k in a game of duration τ. In order to get a strong equilibrium point, the defection premium must be negative at the first stage and for all the following ones (Aumann 1959, p. 298).

In case of an infinite horizon ($\tau \rightarrow \infty$), the premium is negative when

$$(58) \quad (b-a) > (1-\delta)(c-b)$$

In such a case it is clear that exists always a δ^0 such that 58 is satisfied. In this case, once international relationships are considered as longlasting, the possibility of cooperation strongly depends on the degree of "myopia" (proxied by the discount factor) of both countries. In this case the enforceability of the agreement is guaranteed by the full rationality of both players.

But things complicate a lot when considering a finite horizon. The condition $P_{k\tau} < 0$ is neither necessary nor sufficient. To analyze the necessarity, consider

$$(59) \quad \delta P_{k\tau}/\delta k = \underset{-}{\log(\delta)} \cdot \underset{\pm}{\delta^k} [\, c-b-(b-a)(1-\delta)^{-1} \underset{\pm}{\delta^{\tau-k}}\,] \gtreqless 0 \ ;$$

if it exists a $k^0 > 1$: $\delta P_{k\tau}/\delta k=0$ it is clear that

$$\delta P_{k\tau}/\delta k \mid_{k<k^0} > 0$$

and

$$\delta P_{k\tau}/\delta k \mid_{k>k^0} < 0 \ .$$

It is now clear that when we start with a situation where $P_{k\tau} \mid_{t=0} < 0$, the incentive declines with the game going on. But if a $k^0 < \tau$ is reached, it is possible that $P_{k\tau}$ becomes positive before the end of the game.

But it is also not sufficient: since only a perfect equilibrium (Selten 1975) is reasonable in this situation, it is convenient to defect at the last stage of the game and reasonong recursively, the only possible equilibrium of the supergame remains (T,T). A few solutions have been proposed to this case:

i) in case of imperfect information about the other player's rationality, cooperation is still an outcome, even if the end of the game is uncertain (Kreps et oth. 1982).

ii) each player can commit himself to cooperate, in order to insert punishment costs (sunk costs) in the payoff function (Dixit 1982). In the international context, these costs could be represented by costs of implementing international institutions for coordination scopes, like GATT, IMF and similars.

iii) assuming uncertainty about the duration of the game. In this case the players cannot evaluate the effective cost of defecting and they rely on a probability assignement to the duration τ. Another way to see it is to think of a third player (say the nature) which decides how long will be the game, according to a probability distribution which is known to the players; the infinite duration must be the limiting case of such an uncertainty, otherwise this king of uncertainty is completely irrelevant.

Case 2 - "Monetarist"

It applies when both countries strictly prefer the outcome (T,T) to (E,E) and there is low reward for incentivating the other to deviate. Formally $a > b$, $d \leq 0$ and $(c+d) < 2a$. A possible realization of the payoff matrix for A=10, B=1, C=2 and D=1 is

		2: T	2: E
1	T	6,6	8,-4
	E	-4,8	2,2

The fact that $C > B$ implies a stronger preference for contractionary policies inland than in case 1. In this case T is the dominant strategy for both players in the constituent game and against any other strategy of the supergame. (T,T) is a Nash equilibrium at each stage and consequently it is also a perfect Nash equilibrium for the supergame, independently of the finite or infinite duration (Kurz 1978). Both countries are satisfied with deflationary policies and they keep on adopting them as long as welfare evaluations are unmodified.

Case 3 - "Keynesian vs Monetarist"

This is a mix of the previous two cases: country 1 prefers expansionary policies and country 2 prefers deflationary ones. Formally $b>a$, $d\leq 0$, $(c+d)<2b$ and the payoff matrix is

2

		T	E
1	T	a,b	c,d
	E	d,c	b,a

like, for example, the following realization fod $A_1=A_2=10$, $B_1=2$, $B_2=1$, $C_1=1$, $C_2=2$ and $D_1=D_2=1$

2

		T	E
1	T	1,2	3,-2
	E	-2,3	2,1

For player 1 the T strategy is dominant, but he could achieve better results by playing E in a coordination scheme. For player 2 the T strategy is dominant and he can not achieve a better result by playing any other strategy.

In this case player 2 has an advantage because by choosing T he is assuring to himself the optimal result. Viceversa, player 1 has no means to force player 2 to play E, because so doing he is exposing himself to higher losses without any gain; in other words, he does not have any credible strategy to punish the other player. Also in this case, the only possible equilibrium in the costituent game is (T,T) and its repetition is the equilibrium in the supergame. This equilibrium is not unique, since more complicated strategies could be the optimal result for different payoff parameters and discount factor (Aumann 1959). If the same game is analyzed following a cooperative approach and side payments are allowed, other results are also possible.

From the point of view of the economic meaning, in absence of international institutions with enforcement powers, deflationist countries impose their policies to expansionist ones. This is due to the actual transmission mechanism, according to which the gains of an expansion are spread around the other trading partners.

Case 4 - "Alternations"

In this case, independently of the attitudes of both countries, the gain from alternating the policies are higher. This is known in the literature as the "sex game" (Schotter 1981). Formally, I assume for simplicity a=b and (d+c) > 2a=2b. A possible realization of the payoff matrix is for A=10, B=C=1 and D=-1

		2: T	2: E
1	T	5,5	11,3
	E	3,11	5,5

The economic intuition behind this example is the following: when cyclical dynamics is strongly pronounced in each country, it is convenient to take advantage of desynchronization of cycles, since international trade works as an endogenous stabilizer. It is evident in the example that once again (T,T) is a possible equilibrium, but both players would improve their long run welfare by implementing a scheme of alternating choices

(T,E) , (E,T) , (T,E) , (E,T) ...

where (T,E) is played at any odd number stage and (E,T) at any even stage.

But many problems arise when implementing such a solution. The first one is that the country wich starts playing T has an higher payoff than the other, with $\delta < 1$. The second one is that with high interest rates (low δ) and/or very short horizon the incentive to defect could be very high.

I can conclude this example by stating that when international relationships are expected to last long enough ($\tau \to \infty$) and/or governments have a sufficiently long horizon (δ, which can also be interpreted as the probability of surviving for the next play, is close to 1), the coordinated alternation of contractionary and expansionary policies is the rational noncooperative result of the supergame. On the contrary, for high discount rates, high costs for leaving the other contracting (d), low incentives to enter a coordination scheme (c-a), the coordination scheme can not be enforced because the incentives to default are positive. SInce the security strategies are (T,T), we end again with the continuous repetition of this strategy as the only equilibrium of the game.

4. Concluding remarks

In the previous paragraphs I have tried to analyze in details the components of a process of coordinating the economic policies in a dynamic framework.

I started showing that an optimal policy in a closed economy with endogenous cycles must be cyclical whenever its objective function includes the stabilization of output and prices.

Then I have proved that it becomes suboptimal when coupled to a second similar economy, unless the government of the first country knows the exact structure of the rest of the world and trusts the rationality of the other government. Neglecting these aspects leads to overreactions of the policy makers to external shocks. The informational requirements of Nash solutions have been consequently shown in details.

But the two governments can do even better if they can coordinate their stabilization policies, because their welfare is increased. The implementation of these schemes poses credibility problems in absence of sovranational institutions.

Later, I have investigated the dynamic aspects of a simplified coordination scheme, and I have proved that synchronization or desynchronization of policies basically depends on the relative gains of the alternating position (the off-diagonal elements of the payoff matrix). A key role in coordination, however, is played by the interest rate used to discount future gains: when uncertainty about international relations is high (low δ and τ), countries are expected to break any old coordination scheme (or not to enter any

new one). This seems to give some grasps for a better understanding of international relationships among western countries in the last 15 years.

From a game theoretical point of view, the results of previous sections can be viewed as complementary. In the case of repeated game models, coordination and cooperation (it is impossibile to separate these two aspects) do not arise because short-sighted or not purely rational players. In the case of optimal control models, coordination does nor appear because of a problem of credibility of the other players who have signed a coordinating agreement.

If one wants to paraphrase the previous statements with respect to the problem of international economic policy coordination, he might say that a national uncoordinated policy making is inefficient. The reasons can be found in the short horizon of elected governments and in the absence of a sovranational institution, able to enforce any agreement by means of delegated powers.

Some further advances in this direction can be found in the game theoretic approach to social institutions (Schotter 1981). In this context one can make use of two concepts:

- a regularity R in the behaviour of members of a population P when they are agents in a recurrent situation S is a social convention if and only if it is true and it is common knowledge in P that:

i) everyone conforms to R;

ii) everyone expects everyone else to conform to R;

iii) everyone prefers to conform to R on the condition that the others do, since S is a coordination problem and uniform conformity to R is a coordination equilibrium in S.

- a social institution is a regularity in social behaviour that is agreed by all members of the society, specifies behaviours in specific recurrent situations, and is either self-policed or policed by some external authority.

If my analysis is correct, we can interpret the coordination solutions of sections 2 and 3 as possible regularity in the behaviours of this simple 2-country economy. In this line, the main problem in international policy coordination is how to enforce coordination equilibria and/or cooperative solutions, either by means of selfenforcing rules (such as compulsory trade credits connected with balance surpluses) or by means of appropriate international institutions.

The foundation of this "neocontractualist" view of institutions has its theoretical background in the neoutilitarian school (Rawls 1972) and adopts a functionalist view-point. Even if it is not the only theory available, it has however a comparative advantage with respect to these kind of problems, since it offers operational definitions which can be somehow helpful in describing the process of creating new institutions.

Favourable opinions to create international institutions to solve the coordination problem can be found in recent papers (Shuntaro 1980, Bradsma-Huges Hallet 1984, Padoa Schioppa in Tsoukalis 1983 and in Buiter-Marston 1985). But historical analysis of past and existing international institutions shows that they are very often "just a collage or an overlapping of different situations" so that the choice of different regulatory system remains a conflicting arena (about international monetary institutions, see Black in Jones-Kenen 1985, Eichengreen in Buiter-Marston 1985).

On a larger scale, there is the unanswered question of why the extension on an international scale of the financial and the production apparatuses (world-economy) has never been accompanied pari passu by an analogous extension of political apparatuses (world-empire); this appears to be a regular feature of the development of capitalism in the last four centuries (Hopkins-Wallerstein 1982, Maddison 1982).

More than theoretical questions, like demand versus supply approaches, the institutional arrangements seem to me the real obstacle to the recent proposals of "restoring Europe's prosperity" (Layard et oth. in Blanchard et oth. 1986, Grilli-La Malfa-Savona 1985). Expecially in Europe's experience, an unchangeable attitude in favour of national sovereignty has always dominated and so far led to failure any serious attempt to coordinate the economic policies (Emerson in Emerson 1984).

References

Aumann R.J., Accetable points in general cooperative n-person games, in Tucker A.W.-Luce R.D. (eds), Contributions to the theory of games, Princeton University Press 1959.

Axelrod R., The evolution of cooperation, Basic Books 1984.

Basar T., Information structure and equilibria in dynamic games, Aoki M.-Marzollo A. (eds), New trends in dynamic systems: theories and economics, Academic Press 1979.

Basar T.-Olsder G.J., Dynamic noncooperative games, Academic Press 1982.

Bradsma A.-Huges Hallet A., The coordination approach to policymaking in interdependent economies, in Artis P. (ed.), The use of international models in the context of economic crisis, Paris 1984.

Blanchard O. et oth. (eds), Restoring Europe's prosperity, Cambridge University Press 1986.

Boltho A. (ed), The European economy: growth and crisis, Oxford University Press 1982.

Bruno M.-Sachs J., Economics of worldwide stagflation, Blackwell 1985.

Buiter W.-Marston R., International economic policy coordination, Cambridge University Press 1985.

Dixit A., Recent developments in oligopoly theory, AER P&P 1982.

Dornbusch R., Expectations and exchange rate dynamics, JPE 1976.

Dornbusch R., Open economy macroeconomics, Basic Books 1980.

Emerson M. (ed), Europe's stagflation, Claredon Press 1984.

Fielenke N., The international transmission of inflation, in AAVV, Manged exchange rate flexibility: the recent experience, Federal Reserve Bank Boston 1978.

Friedman J., Oligopoly and the theory of games, North Holland 1977.

Gandolfo G., Mathematical methods and models in economic dynamics, North Holland 1971.

Giavazzi F.-Giovannini A., Monetary policy interactions under managed exchange rates, mimeo 1985.

Grilli E.-La Malfa G.-Savona P., L'Italia al bivio, Laterza 1985.

Hamada K., A strategic analysis of monetary interdependence, JPE 84/1976.

Hodrick R., Dynamic effects of government policies in an open economy, JME 6/1980.

Hopkins T.-Wallerstein I., World-systems analysis - theory and metodology (vol. 1), Sage Publications 1982.

Intriligator M., Mathematical optimization and economic theory, Prentice Hall 1971.

Jones R.-Kenen P. (eds), Handbook of international economics, North Holland 1985.

Kreps D. et oths., Rational cooperation in the finitely repeated prisoners' dilemma, JET 27/1982.

Kreps D.-Wilson R., Sequential equilibria, Econometrica 50/1982a.

Kreps D.-Wilson R., Reputation and imperfect information, JET 27/1982b.

Kurz M., Altruism as an outcome of social interaction, AER P&P 1978.

Lipton D.-Sachs J., Accumulation and growth in a two country model, Journal of International Economics 15/1983.

Luce D.-Raiffa H., Games and decisions, Wiley 1957.

Maddison A., Phases of capitalist development, Oxford University Press 1982.

Milgrom P.-Roberts J., Predation, reputation and entry deterrence, JET 27/1982.

Radner R., Monitoring cooperative agreements in a repeated principal-agent relationship, Econometrica 49/1981.

Radner R., Repeated principal-agent games with discounting, Econometrica 53/1985.

Rawls J., A theory of justice, Claredon Press 1972.

Sargent T., Macroeconomic theory, Academic Press 1979.

Schotter A., The economic theory of social institutions, Cambridge University Press 1981.

Selten R., Reexamination of the perfectness concept for equilibrium points in extensive games, Journal of Games Theory 4/1975.

Shuntaro S. et oths., A model for the coordination of recovery policies in the OECD region, Journal of Policy Modeling 2/1980.

Smale S., The prisoners' dilemma and dynamical system associated to non cooperative games, econometrica 48/1980.

Tobin J., A general equilibrium approach to monetary theory, JMBC 1969.

Tobin J., Keynesian models of recession and depression, AER P&P 1975.

Tsoukalis L. (ed), The political economy of international money, Royal Institute of International Affairs 1983.

Zarnowitz V., Recent works on business cycle in historical perspective: review of theories and evidence, JEL 23/1985.

Elenco dei Quaderni pubblicati

n. 1 (febbraio 1979) **MASSIMO DI MATTEO**, Alcune considerazioni sui concetti di lavoro produttivo e improduttivo in Marx
n. 2 (marzo 1979) **MARIA L.RUIZ**, Mercati oligopolistici e scambi internazionali di manufatti. Alcune ipotesi e un'applicazione all'Italia
n. 3 (maggio 1979) **DOMENICO MARIO NUTI**, Le contraddizioni delle economie socialiste: una interpretazione marxista
n. 4 (giugno 1979) **ALESSANDRO VERCELLI**, Equilibrio e dinamica del sistema economico-semantica dei linguaggi formalizzati e modello keynesiano
n. 5 (settembre 1979) **A. RONCAGLIA - M. TONVERONACHI**, Monetaristi e neokeynesiani: due scuole o una?
n. 6 (dicembre 1979) **NERI SALVADORI**, Mutamento dei metodi di produzione e produzione congiunta
n. 7 (gennaio 1980) **GIUSEPPE DELLA TORRE**, La struttura del sistema finanziario italiano: considerazioni in margine ad un'indagine sull'evoluzione quantitativa nel dopoguerra (1948-1978)
n. 8 (gennaio 1980) **AGOSTINO D'ERCOLE**, Ruolo della moneta ed impostazione antiquantitativa in Marx: una nota
n. 9 (novembre 1980) **GIULIO CIFARELLI**, The natural rate of unemployment with rational expectations hypothesis. Some problems of estimation
n. 10 (dicembre 1980) **SILVANO VICARELLI**, Note su ammortamenti, rimpiazzi e tasso di crescita
n. 10 bis (aprile 1981) **LIONELLO F. PUNZO**, Does the standard system exist?
n. 11 (marzo 1982) **SANDRO GRONCHI**, A meaningful sufficient condition for the uniqueness of the internal rate of return
n. 12 (giugno 1982) **FABIO PETRI**, Some implications of money creation in a growing economy
n. 13 (settembre 1982) **RUGGERO PALADINI**, Da Cournot all'oligopolio: aspetti dei processi concorrenziali
n. 14 (ottobre 1982) **SANDRO GRONCHI**, A Generalized internal rate of return depending on the cost of capital
n. 15 (novembre 1982) **FABIO PETRI**, The Patinkin controversy revisited
n. 16 (dicembre 1982) **MARINELLA TERRASI BALESTRIERI**, La dinamica della localizzazione industriale: aspetti teorici e analisi empirica
n. 17 (gennaio 1983) **FABIO PETRI**, The connection between Say's law and the theory of the rate of interest in Ricardo
n. 18 (gennaio 1983) **GIULIO CIFARELLI**, Inflation and output in Italy: a rational expectations interpretation
n. 19 (gennaio 1983) **MASSIMO DI MATTEO**, Monetary conditions in a classical growth cycle
n. 20 (marzo 1983) **M. DI MATTEO - M.L. RUIZ**, Effetti dell'interdipendenza tra paesi produttori di petrolio e paesi industrializzati: un'analisi macrodinamica
n. 21 (marzo 1983), **ANTONIO CRISTOFARO**, La base imponibile dell'IRPEF: un'analisi empirica
n. 22 (gennaio 1984) **FLAVIO CASPRINI**, L'efficienza del mercato dei cambi. Analisi teorica e verifica empirica
n. 23 (febbraio 1984) **PIETRO PUCCINELLI**, Imprese e mercato nelle economie socialiste: due approcci alternativi
n. 24 (febbraio 1984) **BRUNO MICONI**, Potere prezzi e distribuzione in economie mercantili caratterizzate da diverse relazioni sociali
n. 25 (aprile 1984) **SANDRO GRONCHI**, On investment criteria based on the internal rate of return
n. 26 (maggio 1984) **SANDRO GRONCHI**, On Karmel's criterion for optimal truncation
n. 27 (giugno 1984) **SANDRO GRONCHI**, On truncation "theorems"
n. 28 (ottobre 1984) **LIONELLO F. PUNZO**, La matematica di Sraffa
n. 29 (dicembre 1984) **ANTONELLA STIRATI**, Women's work in economic development process
n. 30 (gennaio 1985) **GIULIO CIFARELLI**, The natural rate of unemployment and rational expectation hypotheses: some empirical tests.
n. 31 (gennaio 1985) **SIMONETTA BOTARELLI**, Alcuni aspetti della concentrazione dei redditi nel Comune di Siena
n.32 (febbraio 1985) **FOSCO GIOVANNONI**, Alcune considerazioni metodologiche sulla riforma di un sistema tributario
n. 33 (febbraio 1985) **SIMONETTA BOTARELLI**, Ineguaglianza dei redditi personali a livello comunale
n. 34 (marzo 1985) **IAN STEEDMAN**, Produced inputs and tax incidence theory
n. 35 (aprile 1985) **RICHARD GOODWIN**, Prelude to a reconstruction of economic theory. A critique of Sraffa
n. 36 (aprile 1985) **MICHIO MORISHIMA**, Classical, neoclassical and Keynesian in the Leontief world
n. 37 (aprile 1985) **SECONDO TARDITI**, Analisi delle politiche settoriali: prezzi e redditi nel settore agroalimentare
n. 38 (maggio 1985) **PIETRO BOD**, Sui punti fissi di applicazioni isotoniche.
n. 39 (giugno 1985) **STEFANO VANNUCCI**, Schemi di gioco simmetrici e stabili e teoremi di possibilità per scelte collettive.
n. 40 (luglio 1985) **RICHARD GOODWIN**, The use of gradient dynamics in linear general disequilibrium theory.
n. 41 (agosto 1985) **M. MORISHIMA** and **T. SAWA**, Expectations and the life span of the regime.
n. 42 (settembre 1985) **ALESSANDRO VERCELLI**, Keynes, Schumpeter, Marx and the structural instability of capitalism.
n. 43 (ottobre 1985) **ALESSANDRO VERCELLI**, Money and production in Schumpeter and Keynes: two dichotomies
n. 44 (novembre 1985) **MARCO LONZI**, Aspetti matematici nella ricerca di condizioni di unicità per il Tasso Interno di Rendimento.

n. 45 (dicembre 1985) **NIKOLAUS K.A. LAUFER**, Theoretical foundations of a new money supply hypothesis for the FRG.

n. 46 (gennaio 1986) **ENRICO ZAGHINI**, Una dimostrazione alternativa dell'esistenza di equilibri in un modello di accumulazione pura

n. 47 (febbraio 1986) **ALESSANDRO VERCELLI**, Structural stability and the epistemology of change: a critical appraisal

n. 48 (marzo 1986) **JOHN HICKS**, Rational behaviour: observation or assumption?

n. 49 (aprile 1986) **DOMENICO MARIO NUTI**, Merger conditions and the measurement of disequilibrium in labour-managed economies

n. 50 (maggio 1986) **SUSAN SENIOR NELLO**, Un'applicazione della Public Choice Theory alla questione della riforma della Politica Agricola Comune della CEE.

n. 51 (maggio 1986) **SERENA SORDI**, Some notes on the second version of Kalecki's Business Cycle Theory

n. 52 (giugno 1986) **PIERANGELO GAREGNANI**, The classical theory of wage and the role of demand schedules in the determination of relative prices

n. 53 (luglio 1986) **FRANCO BIRARDI**, Crescita, sviluppo ed evoluzione: l'affermazione dei nessi strutturali sistematici e la combinazione di scienza, tecnologia ed economia nelle prime industrializzazioni

n. 54 (agosto 1986) **M. AMENDOLA - J.L. GAFFARD**, Innovation as creation of technology: a sequential model

n. 55 (settembre 1986) **GIULIO CIFARELLI**, Exchange rates, market efficiency and "news". Model specification and econometric identification

n. 56 (settembre 1986) **ALESSANDRO VERCELLI**, Technological flexibility, financial fragility and the recent revival of Schumpeterian entrepreneurship

n. 57 (ottobre 1986) **FABIO PETRI**, The meaning of the Cambridge controversies on capital theory: an attempt at communication