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CONSERVATIVE CENTRAL BANKERS IN A TWO-COUNTRY WORLD

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ABSTRACT

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In a closed economy framework Rogoff has developed the argument that it can be beneficial for society to appoint a "conservative" central banker. We extend this analysis to a two-country world in order to take into a account the strategic interaction between the monetary authorities of the two countries. We show that conservative central bankers may now deteriorate the situation of both countries, and that the distinction between symmetric and asymmetric shocks becomes crucial : while symmetric shocks weaken the case for conservative central bankers, asymmetric shocks strengthen it.

Considering some alternative specification of the model, we again emphasize the importance of the distinction between symmetric and asymmetric shocks for our issue, but argue that these shocks may switch their roles, depending on the value of some parameter of the model.

Finally, we underline that the symmetry-asymmetry distinction is also crucial for the issue of counterproductive cooperation. However, in the context of the present model, such a distinction should be applied to the initial structural situations of the two countries.

RESUME

BANQUES CENTRALES CONSERVATRICES DANS UN MODELE A DEUX PAYS

Dans le cadre d'une économie fermée Rogoff a développé l'argument qu'il peut être bénéfique pour la société d'avoir une banque centrale "conservatrice". On étend cette analyse à un modèle à deux pays afin de prendre en compte l'interaction stratégique entre banques centrales des deux pays. On montre alors qu'il devient tout-à-fait crucial de faire la distinction entre les chocs qui affectent les pays de manière symétrique ceux qui les affectent de manière asymétrique: alors que les premiers sont défavorables à la mise en place de banques centrales conservatrices, les seconds y sont au contraire favorables.

Considérant une spécification différente du modèle, on met de nouveau en évidence l'importance de la distinction entre chocs symétriques et chocs asymétriques, mais on montre aussi que ces chocs peuvent échanger leur rôle lorsque varie la valeur d'un paramètre du modèle.

Enfin, on souligne que la distinction symétrie-asymétrie est également cruciale lorsque l'on considère la question de savoir si la coopération internationale peut-être néfaste. Cependant, dans le cadre du présent modèle, une telle distinction doit s'appliquer à la situation structurelle initiale des deux pays.

Mots Clefs : Conservative central bankers - Counterproductive international cooperation - Symmetric and assymetric shocks.

Banques centrales conservatrices - Coopération internationale contre productive - Chocs symétriques et asymétriques.

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1 - Introduction

Rogoff (1985a) has shown that it can be beneficial for society to appoint a conservative central banker, who does not share the social utility fonction, but puts a greater weight on inflation-rate stabilization (and a lower one on employment stabilization). The reason is that this will induce less inflationary wage bargains,and therefore lessens the loss associated with the time consistency problem which arises when the government has some incentive to inflate in order to reduce unemployment, but cannot commit itself to predetermined rules for monetary policy[1].

The analysis was developed in a closed economy context, and therefore did not take into account the effect that appointing conservative central bankers may have on the strategic monetary game between the different countries. In this paper we will consider such an issue.We will ask whether, in a two-country world, it may be beneficial for society as a whole to have conservative central bankers, when we take into account the games between central bankers and wage setters in each country as well as the game between central bankers of the two countries.

The extension of the closed economy analysis to a two-country model gives the following results. First we will see that, in some cases, conservative central bankers worsen the situation for both countries. The basic reason is that by putting more weight on the inflation objective, policymakers are more willing to engage in a harmful competitive appreciation or depreciation[2].

Second, we will show that, despite the above argument against conservative central bankers, adding the strategic interaction between countries to the closed economy analysis, may on the contrary strengthen the case for conservative central bankers. This finding is related to the public good feature of exchange rate stabilization which was developed in Laskar (1986).

Third, as a consequence, the final result will depend on the type of shocks which affect the world economy and, in that respect, the crucial distinction will be between shocks which are symmetric and those which are asymmetric relatively to the two countries. Thus, while relevant symmetric shocks will be shown to weaken the case for conservative central bankers, asymmetric shocks tend to strengthen it. (Of course, as in a closed economy context, labor market distortions which are at the source of the time consistency problem in each country, always strengthen it).

The different roles played by symmetric and asymmetric shocks in the analysis are worth emphasizing, and in a subsequent section of the paper we consider complementary issues which are directly linked to this symmetry-asymmetry distinction. First, we will examine the robustness of the results and, for that, we will consider an alternative specification of the model which underlines an other channel of interdependence between countries. In that case we find that the distinction between symmetric shocks and asymmetric shocks is still a key point for our issue, but that the specific roles given to these two types of shocks become ambiguous : depending on some parameter of the model these two types of shocks will switch their roles.

Second, we will try to see how our analysis may have some bearing on the issue of whether international cooperation may be counterproductive or not, an issue which has been raised elsewhere in the literature, as in Rogoff (1985b). On that question we will underline that the symmetry-asymmetry distinction is again crucial but that, in the context of the present model, such a distinction should be applied to the initial structural situation of the two countries.

Section 2 presents the framework. Section 3 considers the non-cooperative equilibrium between central bankers. Section 4 calculates the corresponding social loss functions and derives the results. Section 5 considers the complementary issues. Section 6 summarizes the results and makes some concluding comments.

2 - The framework

The framework of analysis is that of Rogoff (1985a and b). Therefore, there is no need repeating it in detail, and in this section we will simply describe its main features and write down the specific equations we need for our purpose. In order to facilitate the comparison we will try to use the same notations as in these two reference articles.

2.1 - The two-country model

The two-country model we use is directly taken from Rogoff (1985b). It is particularly suited for our purpose because it was precisely designed to study the game between countries at the same time as the games between wage setters and central bankers in each country. It is a stochastic, two-good, two-country macro-model which incorporates rational expectations and wage contracting ; each country is specialized in the production of one good ; and uncovered interest rate parity holds. In order to simplify the algebra, the sizes and structures of the two countries are assumed to be same, and therefore the corresponding coefficients will always be identical accross countries.

In each country firms hire labor until the marginal value product of labor equals the nominal wage rate. This nominal wage rate is set one period in advance[3], and workers agree to supply whatever amount of labor is demanded by firms in the current period. This leads to the following employment equations:

$$(1a) \quad n_t = \bar{n} + \gamma(p_t - \bar{w}_t) + \gamma z_t + \gamma \frac{\delta_t}{2} \qquad \gamma > 0$$

$$(1b) \quad n_t^* = \bar{n} + \gamma(p_t^* - \bar{w}_t^*) + \gamma z_t - \gamma \frac{\delta_t}{2}$$

A star is attached to variables of country 2, and lower case letters represent logarithms of the corresponding variables ; n_t and n_t^* are the emploment variables and $\bar{n}$ is a constant which, without loss of generality, will be taken to be equal to the target employment rate of wage setters in each country ; p_t and p_t^* are the nominal prices in period t of the goods produced by country 1 and 2 respectively, and $\bar{w}_t$ and $\bar{w}_t^*$ are the nominal wage rates contracted in period t-1 ($\bar{w}_t$ and p_t, and $\bar{w}_t^*$ and p_t^*, are expressed in the currency units of the corresponding country). z_t is a serially independent zero-mean productivity shock which is common to the two countries, and δ_t is an analogous relative supply shock.

The inflation rates π_{It} and π_{It}^* are defined in terms of price indices p_{It} and p_{It}^* where each good enters with a weight 1/2. Introducing the real exchange rate, which will be a key variable, and is defined by $q_t = e_t + p_t^* - p_t$ where e_t is the nominal exchange rate (the country 1 currency value of one unit of country 2 currency), we have :

$$(2) \qquad \pi_{It} = p_{It} - p_{It-1} \quad ; \quad \pi_{It}^* = p_{It}^* - p_{It-1}^*$$

$$(3) \qquad p_{It} = p_t + \frac{1}{2} q_t \quad ; \quad p_{It}^* = p_t^* - \frac{1}{2} q_t$$

The rest of the model specifies equilibria in the market for each good, the equalities between supply and demand for money in each country, and uncovered interest rate parity. Expectations are rational and, at each period, all present and past variables are supposed to be known to everybody[4].

The model is solved through a two-step procedure. First, static expectations are assumed for real variables, for the rate of change of the nominal exchange rate and for the inflation rates. Without loss of generality the model is normalized in such a way as to have some of these constant expectations like that of the real exchange rate equal to zero. Second, it will be proved that these static expectations are rational for the solutions we will obtain later on, and for which we assume that the monetary authorities take as given these expectations of the private sector. This two-step procedure is indeed an appropriate way to get a time consistent equilibrium[5] .

We will need the solutions for p_t, p_t^* and q_t. It is possible to write them under the following compact form[6]:

(4a) $$p_t = \bar{w}_t + a_1 \mu_t + a_2 \mu_t^* + \xi_t$$

(4b) $$p_t^* = \bar{w}_t^* + a_2 \mu_t + a_1 \mu_t^* + \xi_t^*$$

(4c) $$q_t = b(\mu_t - \mu_t^*) + \varrho_t$$

In these equations, ξ_t, ξ_t^*, and ϱ_t are serially independent zero-mean random variables which depend on the supply and demand shocks which affect the two economies. It is important to note that because there are relative supply shocks (δ_t) and relative demand shocks (relative shifts in the demand for the two goods), in general we have $\xi_t \neq \xi_t^*$ and $\varrho_t \neq 0$. As we will see later, these relative shocks will play an important role in our analysis.

The variables μ_t and μ_t^* are defined by

$$\mu_t = m_t - \bar{w}_t + \lambda \bar{\pi}_I - v_t \qquad \lambda > 0$$

$$\mu_t^* = m_t^* - \bar{w}_t^* + \lambda \bar{\pi}_I^* - v_t^*$$

where m_t and m_t^* represent the money supplies, and v_t and v_t^* are the corresponding money demand shocks. The variables $\bar{\pi}_I$ and $\bar{\pi}_I^*$ are (constant) expected inflation rates in each country. In that respect we must note two things. First, in order to complete the proof that static expectations are rational, it will remain to show that $E_{t-1}\, \pi_{It}$ and $E_{t-1}\, \pi_{It}^*$ are constant for

the non-cooperative solution we will find later on. (E_{t-1} is the expectation conditional on information available at t-1). Second, we will see that $\bar{\pi}_I$ and $\bar{\pi}_I^*$ depend on the type of central bankers who are in charge of monetary policy in each country.

Because the shocks of the current period are known, controlling the money stock m_t (or m_t^*) is equivalent to controlling the variable μ_t (or μ_t^*). Therefore, we can consider that the policy variable, or strategy, available to central bankers at period t is the variable μ_t(or μ_t^*). Note that money demand shocks (v_t and v_t^*), which enter the system only through the variables μ_t and μ_t^*, do not play any role : they are fully compensated by changes in the corresponding money supplies (m_t and m_t^*).

It can be shown that the coefficients a_1, a_2, and b of equations (4) satisfy the following inequalities[7]:

(5) $\quad a_1 > 0,\ b > 0,\ |a_2| < a_1$

This means that an increase in the money supply in one country raises the price of output of this country and depreciates the real exchange rate. The sign of the effect on the price of output of the other country is ambiguous (a_2 is positive or negative) but its absolute value is inferior to the increase in the domestic price of output ($|a_2| < a_1$).

1.2 - The role of conservative central bankers

The target employment level for wage setters is $\bar{n}$ in each country. Taking a quadratic loss function around $\bar{n}$, then from (1) we see that the nominal wage rates are set at the levels

(6) $\quad \bar{w}_t = E_{t-1}\, p_t \quad ; \quad \bar{w}_t^* = E_{t-1}\, p_t^*$

This actually implies that the expected value of employment is always equal to $\bar{n}$:

$$(7) \qquad E_{t-1}\, n_t = E_{t-1}\, n_t^* = \bar{n}$$

Because of distortionary factors like taxes, the society's target rate for employment in each country $\tilde{n}$ is larger than the target rate $\bar{n}$ for wage setters[8] . Society also cares about inflation,and $\tilde{\pi}_I$(or $\tilde{\pi}_I^*$) is the target inflation rate[9] (We will allow for $\tilde{\pi}_I \neq \tilde{\pi}_I^*$ because this does not lead to any complication in the algebra). The social loss functions are respectively the following :

$$(8a) \qquad \Lambda_t = (n_t - \tilde{n})^2 + \chi(\pi_{It} - \tilde{\pi}_I)^2 \qquad \chi > 0$$

$$(8b) \qquad \Lambda_t^* = (n_t^* - \tilde{n})^2 + \chi(\pi_{It}^* - \tilde{\pi}_I^*)^2$$

As we already know, the game between the wage setters and policymakers who set monetary policy in order to minimize the social loss function,leads to a time consistent solution where inflation is too high. This happens because wages are set at a level which, in the absence of disturbances, makes the cost of further inflation (relative to the corresponding employment gain) high enough to deter the monetary authorities from engaging in such a policy. Society would be better off if the wages were set at a lower level and if policymakers did not systematically inflate either, but such a solution would not be time consistent.

Thus, we need to find ways to improve on the too inflationary time consistent equilibrium. One solution would be to set a constitutional reform which makes it possible for the monetary authorities to commit themselves to not systematically inflate. However, because there are shocks in the economy, the money supply should also be let free to respond to these shocks. As explained in Rogoff (1985a), this may be very difficult to achieve in pratice. This would require specifying a rule where the money supply would be contingent

on the shocks. But, in the real world, to be able to specify in advance all the different shocks which might occur in the future and the corresponding responses of the money supply does not seem an easy task. Therefore, Rogoff (1985a) suggested an alternative way to improve on the time consistent solution. In a closed economy context, he showed that if the monetary authorities do not share the social loss functions but instead put a larger weight on the inflation rate objective than society does, then, through a suitable choice of this new weight,social welfare could be improved. This result is compatible with the fact that central bankers are in general "conservative", and mainly committed to an inflation target. As indicated in the introduction, we will consider the same kind of issue in the two-country framework.

Therefore we will clearly distinguish between the social loss functions Λ_t and Λ_t^* defined in (8) and the loss functions of the central bankers who are in charge of monetary policy. These loss functions are respectively

$$(9a) \quad I_t = (n_t - \tilde{n})^2 + (\chi + \varepsilon)(\pi_{It} - \tilde{\pi}_I)^2$$

$$(9a) \quad I_t^* = (n_t^* - \tilde{n})^2 + (\chi + \varepsilon)(\pi_{It}^* - \tilde{\pi}_I^*)^2$$

In each country the weight given to inflation relative to employment by the monetary authorities is $(\chi+\varepsilon)$ instead of χ (where we must have $\varepsilon > -\chi$). Conservative central bankers will correspond to the case $\varepsilon > 0$[10]. The preferences of the agents appointed to the central banks (given by parameter ε) are assumed to be known with certainty. Also we rule out the possibility that these agents can be changed unexpectedly after the wages have been set by the private sector[11].

We will successively consider the following questions. First, find the non-cooperative equilibrium of the game where central bankers have loss functions I_t and I_t^*. Second, evaluate the expected social loss functions $E_{t-1}\,\Lambda_t$ and $E_{t-1}\,\Lambda_t^*$ (and not $E_{t-1}\,I_t$ and $E_{t-1}\,I_t^*$) at this non-cooperative

equilibrium. Third, see whether or under what conditions $\varepsilon > 0$ would be better than $\varepsilon = 0$.

3 - The non-cooperative equilibrium

We will consider the (Nash) non-cooperative equilibrium[12] : at period t the central banker of country 1 (or country 2) takes as given the monetary policy μ_t^* (or μ_t) of the other country, the nominal wage rates and the expectations of the private sector, and chooses monetary policy μ_t(or μ_t^*) in order to minimize the loss function I_t(or I_t^*). The results we obtain which will be relevant for our issue are the following (see Appendix 1 for their derivations). First, the variance of the variable $(q_t - \delta_t)$, which will play a key role, is given by :

$$(10) \quad Var_{t-1}(q_t - \delta_t) = \left[\frac{s + \gamma^2}{((a_1 - a_2) + b)s + (a_1 - a_2)\gamma^2}\right]^2 4\,\sigma_\eta^2$$

In this expression σ_η^2 is the variance of a zero-mean serially independent random variable η_t which is a linear function of both relative demand shocks and relative supply shocks. This function does not depend on ε and we have $\sigma_\eta^2 = 0$ when there are no such relative shocks. The parameter s is defined by :

$$(11) \quad s = (\chi + \varepsilon)\left(1 + \frac{1}{2}\frac{b}{a_1}\right)$$

s is positive and is an increasing function of ε. The greater s is, the more conservative the central bankers are.

In order to interpret the expression (10), we will first consider the case where there are no relative supply shocks ($\delta_t = 0$). Then, two points may be noted from (10). First, the variance of the real exchange rate increases with the variance of the relative demand shifts, which is not suprising.

Second, differentiating (10) with respect to s and using inequalities(5) we see that $Var_{t-1}(q_t - \delta_t)$ decreases with s. Therefore, the more conservative the central bankers are, the less the real exchange rate fluctuates.

This last result can be explained as follows. First, it is straightforward to see that in order to interpret the unexpected values of the relevant variables, we can as well assume that the monetary authorities try to minimize the weighted sum (with relative weight $\chi + \varepsilon$) of the fluctuations of employment and the inflation rate around their mean values[13]. Then, consider a relative demand shift in favor of country 2 output which, in order to keep the initial levels of employment, would require a depreciation of the real exchange rate. This would increase the fluctuations of the price levels of both countries through the corresponding variations of import prices and, therefore, central bankers will also take actions in order to stabilize the inflation rate. Thus, country 1 will decrease its money supply in order to reduce its price level fluctuation. From (3), (4a) and (4c) this will occur both through a decrease of its output price and through a reduction of the initial real exchange rate depreciation. For the same reason country 2 will engage in the opposite policy of a money supply increase. The more conservative central bankers are, the larger will be these corrective monetary policies and, consequently, the lower will be the real exchange rate fluctuations.

When there are relative supply shocks ($\delta_t \neq 0$) we have the same results as before except that the variable $q_t - \delta_t$ should replace the variable q_t, and that the variance of $q_t - \delta_t$ also increases with the variance of relative supply shifts which is implicit in σ_η^2. The reason why the variable $q_t - \delta_t$ is the relevant variable in case of a relative supply shock is the following. In order to keep employment constant in the two countries, as equations (1) show, the prices of outputs have to change : p_t has to decrease by an amount $\delta_t/2$ and p_t^* to increase by $\delta_t/2$. Therefore, from (3), the effect on the inflation rate π_{It} will be equal to $\frac{1}{2} q_t - \frac{1}{2} \delta_t$, and the effect on π_{It}^* equal to $- \frac{1}{2} q_t + \frac{1}{2} \delta_t$ Therefore, the previous argument will concern a modified real exchange rate variable $(q_t - \delta_t)$ instead of q_t.

Finally, we find that the expected inflation rates $E_{t-1}\ \pi_{It}$ and $E_{t-1}\ \pi^*_{It}$ are indeed constant as was assumed, and that they are equal to $\bar{\pi}_I$ and $\bar{\pi}^*_I$ given by

(12a) $\bar{\pi}_I = \tilde{\pi}_I + \frac{\gamma}{s}(\tilde{n} - \bar{n})$

(12b) $\bar{\pi}^*_I = \tilde{\pi}^*_I + \frac{\gamma}{s}(\tilde{n} - \bar{n})$

As in Rogoff (1985a) the more conservative the central bankers are, the lower the expected rate of inflation is.

4 - <u>The social loss functions</u>

We want to evaluate the expected social loss functions of the two countries (and not the loss functions of central bankers) at the previous non-cooperative equilibrium. Because this equilibrium depends on the loss functions of central bankers (I_t and I^*_t) and therefore on the parameter ε, the social loss functions (Λ_t and Λ^*_t) evaluated at this non-cooperative equilibrium will depend on ε (or equivalently on s). Making the simplifying assumption that the common supply shock is independently distributed with relative supply or demand shocks ($E_{t-1}\ z_t\ \eta_t = 0$), we get (see Appendix 1):

$$(13)\quad E_{t-1}\Lambda_t = (\tilde{n} - \bar{n})^2 + \chi(\bar{\pi}_I - \tilde{\pi}_I)^2 + \frac{\gamma^2\,(s^2 + \chi\,\gamma^2)}{(s+\gamma^2)^2}\left[\sigma_z^2 + \frac{Var_{t-1}(q_t - \delta_t)}{4}\right]$$

Where σ_z^2 represents the variance of the common supply shock.

If we consider country 2, then we have $E_{t-1}\ \Lambda_t = E_{t-1}\ \Lambda^*_t$. This arises simply because (except for the inflation objectives $\tilde{\pi}_I$ and $\tilde{\pi}^*_I$) the model is completely symmetric in expected values with respect to the two countries, and

because, as (12) indicates, $\bar{\pi}_I - \tilde{\pi}_I = \bar{\pi}^*_I - \tilde{\pi}^*_I$. Therefore, we are interested in minimizing $E_{t-1}\Lambda_t$. Using (10) and (12), (13) becomes :

$$(14)\quad E_{t-1}\Lambda_t = (\tilde{n} - \bar{n})^2 + \chi\frac{\gamma^2}{s^2}(\tilde{n} - \bar{n})^2 + \frac{\gamma^2(s^2+\chi\gamma^2)}{(s+\gamma^2)^2}\sigma_z^2 + \frac{\gamma^2(s^2+\chi\gamma^2)}{[((a_1-a_2)+b)s+(a_1-a_2)\gamma^2]^2}\sigma$$

There are four terms in the expression given by (14). The first one is equal to the amount of distortions in the labor market and cannot be changed here. The second term represents the loss due to the time consistency aspect of the game between central bankers and wage-setters in each country. It is proportional to the amount of distortions in the labor market and is minimized for s infinite and therefore also ε infinite. This would require extremely conservative central bankers who give no weight to employment and only care about the inflation rate. This is indeed not new and was also obtained in Rogoff (1985a).

The last two terms of (14), however, bring new insights to the issue. Before analyzing them in more details we can note that these two terms are actually independent of the value of $\tilde{n} - \bar{n}$. Consequently, they would be the same in the case $\tilde{n} - \bar{n} = 0$ (no labor market distortions) where both targets (employment and inflation) are attained in each country in the absence of any disturbance, and where as a consequence the central bankers try to minimize the deviations of employment and inflation from there mean values (with a relative weight $\chi + \varepsilon$). This should be kept in mind when we try to interpret the results below, because we will implicitely refer to this case where stabilization around the mean values is the aim of central bankers when they face some given shocks.

The third term of (14), which is proportional to the variance of the common supply shock which affect the two countries, is minimized for a value

$$s_1 = \chi$$

From (12) the corresponding value ε_1 is given by

$$(15) \quad \frac{\chi}{\chi+\varepsilon_1} = 1 + \frac{1}{2} \frac{b}{a_1} > 1$$

Therefore we have

$$-\chi < \varepsilon_1 < 0$$

The consequence is that, in order to minimize this term, we would need "anti-conservative" central bankers who attach "too less" weight to the inflation rate objective. The reason lies on a "competitive appreciation" or "competitive depreciation" type of argument that can be found in the existing litterature (see footnote 2), and is the following. The effect of a supply shock on the price level and employment in each country disturbs the previous trade-off between these two objectives, and consequently leads to a change in monetary policies. Suppose, for example, that in response to a common supply shock the central banks want to raise employment at the expense of more inflation, and therefore increase the corresponding money supplies. Taking as given the money stock of the other country, each central banker will believe that such an expansionary policy will depreciate the real exchange rate (although because of the symmetry of the shock this will not occur), and the inflationary consequence of this depreciation through the rise of import prices will put a break on such a policy. Because in the absence of cooperation the favorable external effect of the exchange rate change on the other country price level is not taken into account (it would lower its inflation rate), the monetary expansion in each country will not be sufficient if central bankers shared the social utility functions. In that case it would be better to have in charge of monetary policy someone who cares too much about the employment and too less about the inflation rate. This would have lessened the present inefficiency, which may be considered as the result of a "competitive appreciation" in order to decrease inflation. (In the case of a willingness to

decrease the money supply in each country, which would occur with a supply shock of opposite sign, we would have an inefficient "competitive depreciation" in order to stabilize the inflation rate at its mean level).

Finally, the last term of expression (14) is proportional to σ_η^2 which is an indicator of relative demand and supply shocks. If we minimize this term with respect to s we find the value

$$s_2 = \chi \left(1 + \frac{b}{a_1 - a_2}\right)$$

which according to (11) gives the corresponding value of ε :

$$(16) \qquad \varepsilon_2 = \chi \frac{b}{2\,a_1+b} \frac{a_1+a_2}{a_1-a_2} > 0$$

This means that important relative supply or demand shocks tend to make conservative central bankers (with $\varepsilon=\varepsilon_2$) improve the working of the system. The reason of this result, as in Laskar (1986), relies on the fact that stabilization of the real exchange rate can be seen as a public good[14]. For, if we go back to the expression (13), we see that, for a given level of $Var_{t-1}(q_t - \delta_t)$ the effect of a change in s is precisely the same as that required by common supply shocks: we would need "anti-conservative" central bankers. Consequently the whole argument in favor of conservative central bankers in case of relative shocks must rely on the fact that, as we saw in section 3 (equation (10)), this real exchange rate variable fluctuates less. The basic reason why real exchange rate stabilization is a public good is that in the absence of international cooperation, each country does not take into account the favorable effect that such a reduction of the real exchange rate fluctuation will have on the social utility of the other country through a smaller price level variation. Consequently, at the non-cooperative equilibrium with $\varepsilon = 0$ this real exchange rate variable fluctuates too much, and conservative central bankers who reduce such fluctuations can be beneficial[15].

Then, it is straightforward to see that, in the absence of common supply shocks there is some $\bar{\varepsilon} > \varepsilon_2$ such that conservative central bankers with any ε belonging to $]\ 0, \bar{\varepsilon}\ [$ will always be beneficial (i.e better than $\varepsilon = 0$). On the other hand, if supply shocks are large enough conservative central bankers, with any $\varepsilon >, 0$ will be detrimental to the system (i.e worse than $\varepsilon = 0$)[16].

The previous analysis implies that the crucial distinction for our issue is between shocks which are symmetric (common to both countries) and those which are asymmetric (relative shocks between countries). Among symmetric shocks we only find common supply shocks because common demand shocks do not matter[17]. Also, we should remember that money demand shocks, symmetric or asymmetric, are without any importance here. Consequently, we obtain the result that relevant symmetric shocks weaken the case for conservative central bankers, and that relevant asymmetric shocks strengthen it.

5 - Complementary issues

Our analysis has emphasized the importance of the symmetry-asymmetry distinction. In this section we will make some additional remarks on that point. First, we will consider some aspects of the robustness of our results. Second, we will try to transpose our argument in terms of the issue of whether cooperation can be counterproductive or not. The mains steps of the corresponding calculus and proofs are given in Appendix 2, and in the text below we will only give the results.

5.1 - Robustness

In this subsection we want to argue that while the importance of the distinction between symmetric and asymmetric shocks may be robust, the roles given to symmetric and asymmetric shocks can be quite sensitive to the specification of the model. To see that, we will examine how the previous analysis is modified when we change the objective functions in the following way : instead of being concerned with the rate of inflation, society is supposed to be concerned with the money growth rate of the current period, as

in Canzoneri and Gray (1985). The social loss functions become (instead of Λ_t and Λ_t^* given by (8)) :

$$(17a) \quad \Lambda_t^1 = (n_t - \tilde{n})^2 + \chi(m_t - m_{t-1})^2 \qquad \chi > 0$$

$$(17b) \quad \Lambda_t^{1*} = (n_t^* - \tilde{n})^2 + \chi(m_t^* - m_{t-1}^*)^2$$

The loss functions of the central bankers I_t^1 and I_t^{1*} are correspondingly defined, the weight $\chi + \varepsilon$ being substituted to χ in (17).

Now, if we do the same kind of analysis as in sections 3 and 4 we find the same three basic points : first, for some shocks conservative central bankers may be detrimental to the system ; second, for some other shocks, the strategic interaction between central bankers will on the contrary strengthen the case for conservative central bankers ; third, the crucial distinction is between symmetric and asymmetric shocks[18]. However, it is not possible any more to give an unambiguous answer concerning the specific roles given to symmetric and asymmetric shocks. When there is a positive international transmission of monetary policy ($a_2 > 0$ in (4)) we find the same results as before : symmetric shocks tend to weaken the case for conservative central bankers and asymmetric shocks tend to strengthen it. But, when monetary policy is negatively transmitted ($a_2 < 0$ in (4)), we have the opposite results that asymmetric shocks weaken the case for conservative central bankers and symmetric shocks strenghten it. The relevant distinction is still between symmetric and asymmetric shocks, but these shocks will witch their roles depending on the sign of the transmission mechanism of monetary policy between countries.

Therefore, while the importance of the symmetry-asymmetry distinction is robust to the change in the objective function which has been considered here, the specific roles given to symmetric and asymmetric shocks may change.

The difference with the results obtained in the previous section can be explained as follows. In the case where we had an inflation rate objective (social loss functions (8)) the sign of the parameter a_2 was irrelevant, and we

obtained the same qualitative results as in the case $a_2 = 0$. This clearly appears in (15) where a_2 does not enter, or in (16) where a_2 enters but where inequalities (5) guarantee that ε_2 has the same sign as in the case $a_2 = 0$. This means that the channel of interdependence going through the direct effect of a real exchange rate change on the price level of the other country was the relevant or dominant one for the issue at hand. Here, on the contrary, when we consider a money supply target instead (social loss functions (17)), this channel is eliminated. The only relevant channel of interdependence becomes that on employment of the other country through the effect on its output price. This explains why the sign of the parameter a_2 , which affects the sign of the corresponding external effect, becomes important.

5.2 - Productive and counterproductive cooperation

Appointing independent central bankers (who do not share the social utility function) may be thought to be some kind of substitute for international cooperation between central bankers (who in that case share the social utility function). In fact, it can be shown that in the case where there are only symmetric shocks, it is equivalent to have independent central bankers with $\varepsilon = \varepsilon_1$ given by (15) and to have international cooperation. Also, in the case where there are only asymmetric shocks, and as far the responses to shocks are concerned, it is equivalent to have independent central bankers with $\varepsilon = \varepsilon_2$ defined by (16) and to have international cooperation[19]. In this subsection, we want to exploit this link from a formal point of view and show that the symmetry-asymmetry distinction may also be a crucial factor when one wants to know whether international cooperation may be counterproductive or not. (A more precise definition of what we call international cooperation is given in Appendix 2).

As explained in Rogoff (1985b) the reason why, in such a framework, international cooperation could be counterproductive comes from the fact that international cooperation worsens the time consistency problem in each country, making the wage bargains of the private sector more inflationary. Therefore a first point which should be emphasized is that, for the issue and the model considered here, the right distinction cannot be between symmetric

and asymmetric shocks. For, because of the linear-quadratic structure, the wages, who are equal to expected prices, are simply obtained by making all shocks equal to their mean values (i.e equal to zero). Consequently, the variances of the shocks are completely irrelevant for the wage bargains.

This means that we should rather look for symmetries or asymmetries which affect the expected values. This will be the case if we consider the initial structural situations of the countries. This suggest that beside the case which has been considered, where countries were supposed to be in the same (or "symmetric") initial situation, we may want to look for an "asymmetric" situation and see how the results will differ in that case. For that, we will consider what would happen if the two countries had "opposite labor market distortions"[20], where, instead of $\tilde{n}^* - \bar{n}^* = \tilde{n} - \bar{n}$ we will suppose we have $\tilde{n}^* - \bar{n}^* = -(\tilde{n} - \bar{n})$.

When we consider such an asymmetric initial situation we find that international cooperation can never be counterproductive. This occurs because, contrary to the symmetric situation, international cooperation always lessens the time consistency problem in each country, making wage bargains less inflationary. From a formal point of view this is the counterpart of the result that asymmetric shocks needed conservative central bankers. On the contrary, the fact that, in the case usually considered where countries are in a symmetric situation, international cooperation worsened the time consistency problem, was the formal counterpart of the result that symmetric shocks needed "anti conservative" central bankers.

We can also apply to the issue of counterproductive cooperation the remarks on the robustness of the results made in subsection 5.1 above. This means that the importance of the distinction between symmetric and asymmetric initial situations may be robust, but that the precise roles given to symmetric and asymmetric situations are sensitive to the specification of the model. Thus, if we use the social utility loss functions given by (17) where there is a money supply growth target instead of an inflation rate target, we find that the roles of the symmetric and asymmetric situations are switched when the sign

of the international transmission mechanism (sign of a_2 defined in (4)) changes. We obtain that international cooperation may be counterproductive in the two cases given by : ($a_2 > 0$, symmetric situation) and ($a_2 < 0$, asymmetric situation) ; and that international cooperation is always productive in the other two remaining cases : ($a_2 < 0$, symmetric situation) and ($a_2 > 0$, asymmetric situation)[21].

6 - Conclusion

When we extend the closed economy analysis to a two-country world in order to take into account the strategic interaction between central bankers of the two countries, we find that the case for conservative central bankers may be either weakened or strengthened. This occurs because there are two mechanisms which work into opposite directions. On the one hand, the inefficiency due to competitive real exchange rate appreciation or depreciation is increased but, on the other hand, the loss due to excessive real exchange rate fluctuations is reduced.

Because the first mechanism is triggered by symmetric shocks and the second mechanism by asymmetric shocks, the distinction between symmetric and asymmetric shocks is a key point for our issue. Relevant symmetric shocks (common supply shocks), which create the opportunity for competitive appreciations or depreciations, will make the case worse and therefore, if they are large enough, may make conservative central bankers detrimental to the system. On the contrary, relevant asymmetric shocks (relative demand and supply shocks between countries), which create real exchange rate fluctuations[22], will strengthen the case for conservative central bankers.

While the importance of the distinction between symmetric and asymmetric shocks may be robust, we have emphasized that symmetric and asymmetric shocks may actually switch their roles when we consider some alternative specification of the model. Finally, we have underlined that the symmetry-asymmetry distinction is also crucial for the issue of whether international cooperation can be counterproductive or not. However, in the framework considered, such a distinction should apply to the initial structural situations of the two countries.

To conclude, we will make three additional comments. The first one concerns the two mechanisms just discussed. The existing litterature has actually emphasized a similarity between them. For, both mechanisms call for some international rules which, broadly stated, require more fixity of the exchange rate[23]. Here, on the contrary, we have underlined that they have opposite implications when the role of conservative central bankers is concerned. This in turn emphasizes that the funtion of a fixed exchange rate system of preventing competitive appreciations or depreciations is indeed very different from that of reducing real exchange rate fluctuations.

Second, in the real world, central bankers generally appear to be conservative in the sense used here : they seem to be mainly in charge of the value of money (i.e mainly have an inflation objective), and, for that, may have to resist pressures to manipulate the money supply in order to satisfy other objectives like employment. We may want to interpret this as a way to improve the functionning of the system. But, as we have seen, this is not necessarily so from a theoretical point of view and, therefore, some empirical evaluation would be needed. Also, it is possible that, instead of being an implicit cooperative device, the conservatism of central bankers may be the outcome of a game where, in each country, the government (which can be supposed to share the social utility function), would choose its own central banker in a completely non-cooperative way (see footnote 12). If this were the case, we might want to know whether the non-cooperative solution in this last sense (when neither the central bankers nor the governments cooperate) would always lead to conservative central bankers or not, and further research in that direction may be worthwile.

Third, we have shown that the usefulness of having conservative central bankers as well as that of international monetary policy cooperation depend on the relative situations of the two countries (given by the variances of the shocks, or by the structural initial situations respectively). But, as these situations may be changing through time, the usefulness of conservative central

bankers or of international monetary cooperation may also be changing. Now, suppose that existing institutions are at least in part (see the comment just above) designed to improve the functioning of the system. Because, these institutions are likely to exhibit some inertia, they may not be adequate anymore to the present situations. It is possible, for example, that a large conservativeness of central bankers or some institutionally organized mean to coordinate monetary policies of countries may become unadapted. Our analysis tells us that this will especially happen when countries have moved from an asymmetric to a symmetric corresponding situation or vice versa.

APPENDIX 1

The non-cooperative equilibrium and the social loss functions

Using equalities (1), (2) and (3), the loss functions of the central bankers (9) may be written :

$$(18a)\quad I_t = \left[\gamma z_t + \gamma \frac{\delta_t}{2} + \gamma(p_t - \bar{w}_t) - (\tilde{n}-\bar{n})\right]^2 + (\chi+\varepsilon)\left[p_t - p_{t-1} + \frac{1}{2}(q_t - q_{t-1}) - \tilde{\pi}_I\right]^2$$

$$(18b)\quad I_t^* = \left[\gamma z_t - \gamma \frac{\delta_t}{2} + \gamma(p_t^* - \bar{w}_t^*) - (\tilde{n}-\bar{n})\right]^2 + (\chi+\varepsilon)\left[p_t^* - p_{t-1}^* - \frac{1}{2}(q_t - q_{t-1}) - \tilde{\pi}_I^*\right]^2$$

The Nash equilibrium verifies the first order conditions $\partial I_t / \partial \mu_t = 0$ and $\partial I_t^* / \partial \mu_t^* = 0$. Using (18) and the solutions (4) of the two-country model, these first order conditions can be written (the funtions I_t and I_t^* are quadratic and strictly convex in μ_t and μ_t^* respectively, and therefore these conditions are also sufficient) :

$$(19a)\quad \gamma^2 z_t + \gamma^2 \frac{\delta_t}{2} + \gamma^2 (p_t - \bar{w}_t) - \gamma(\tilde{n}-\bar{n}) + s\left[p_t - p_{t-1} + \frac{1}{2}(q_t - q_{t-1}) - \tilde{\pi}_I\right] = 0$$

$$(19b)\quad \gamma^2 z_t - \gamma^2 \frac{\delta_t}{2} + \gamma^2 (p_t^* - \bar{w}_t^*) - \gamma(\tilde{n}-\bar{n}) + s\left[p_t^* - p_{t-1}^* - \frac{1}{2}(q_t - q_{t-1}) - \tilde{\pi}_I^*\right] = 0$$

Where parameter s is defined by (11) in the text. Taking expectations conditional on the information available at t-1 of equations (19) and substracting to the original equations, we get

$$(20a)\quad \gamma^2 z_t + \gamma^2 \frac{\delta_t}{2} + (\gamma^2 + s)\,\hat{p}_t + s\,\frac{\hat{q}_t}{2} = 0$$

$$(20b)\quad \gamma^2 z_t - \gamma^2 \frac{\delta_t}{2} + (\gamma^2 + s)\,\hat{p}_t^* - s\,\frac{\hat{q}_t}{2} = 0$$

where for any variable x, the variable $\hat{x}_t$ is defined as the innovation $x_t - E_{t-1} x_t$.

Substracting (20a) and (20b) and using (4) we can solve for the value of $\hat{\mu}_t - \hat{\mu}^*_t$ at the non-cooperative equilibrium ; then using (4c) again we can calculate $\hat{q}_t$ and obtain (10) in the text, where the random variable η_t is defined by :

$$(21) \quad 2\,\eta_t = -\,b\,(\varepsilon_t - \varepsilon^*_t) + (a_1 - a_2)\,\varrho_t - ((a_1 - a_2) + b)\,\delta_t$$

If we introduce relative supply shocks in the equations of the two-country model of Rogoff (1985 b) we find that $\varepsilon_t - \varepsilon^*_t$ and ϱ_t in the solution (4) of the model are a linear function of δ_t as well of the relative demand shock. Therefore from (21) we see that η_t is a linear function of both relative demand shocks and relative supply shocks, and does not depend on ε(or s).

Taking expectations, conditional on period t-1 information, of both sides of equations (19a) and (19b) respectively, and using (6) we obtain :

$$(22a) \quad \bar{w}_t = E_{t-1}\, p_t = p_{t-1} + \frac{1}{2}\, q_{t-1} + \tilde{\pi}_I + \frac{\gamma}{s}\,(\tilde{n} - \bar{n}) - \frac{1}{2}\, E_{t-1}\, q_t$$

$$(22b) \quad \bar{w}^*_t = E_{t-1}\, p^*_t = p^*_{t-1} - \frac{1}{2}\, q_{t-1} + \tilde{\pi}^*_I + \frac{\gamma}{s}\,(\tilde{n} - \bar{n}) + \frac{1}{2}\, E_{t-1}\, q_t$$

Substracting (19a) and (19b) and using (4) we can calculate the solution for q_t . Taking its expectation and using (22) we obtain $E_{t-1} q_t = 0$, as was assumed at the first step. Then (22) implies that $E_{t-1}\, \pi_{It}$ and $E_{t-1}\, \pi^*_{It}$ are constant, and are given by (12) in the text.

Using equalities (1), (2), (3) and (8a) the expected social loss function of country 1 can be written :

$$E_{t-1}\,\Lambda_t = (\tilde{n} - \bar{n})^2 + \chi(\bar{\pi}_I - \tilde{\pi}_I)^2 + E_{t-1}\,\gamma^2(z_t + \hat{p}_t + \frac{\delta_t}{2})^2$$

$$+ \chi\, E_{t-1}\,(\hat{p}_t + \frac{1}{2}\,\hat{q}_t)^2$$

Using (20) and the assumption $E_{t-1}\, z_t\, \eta_t = 0$, we obtain (13) in the text.

APPENDIX 2

In order not to repeat fastidious developments we only give the main steps of the proofs. Intermediate calculus is straightforward.

1. Robustness

We consider the social loss functions Λ_t^1 and Λ_t^{*1} given by (17) and the corresponding loss functions I_t^1 and I_t^{*1} of central bankers. Writing down the first order conditions for the Nash equilibrium and solving the system yields :

$$E_{t-1}(m_t - m_{t-1}) = E_{t-1}(m_t^* - m_{t-1}^*) = \frac{\gamma\, a_1}{\chi + \varepsilon}(\tilde{n} - \bar{n})$$

$$\hat{m}_t + \hat{m}_t^* = -\frac{\gamma^2\, a_1}{\gamma^2\, a_1(a_1+a_2) + \chi + \varepsilon}\ \alpha_t^S$$

$$\hat{m}_t - \hat{m}_t^* = -\frac{\gamma^2\, a_1}{\gamma^2\, a_1(a_1-a_2) + \chi + \varepsilon}\ \alpha_t^{AS}$$

where α_t^S is a linear function of symmetric shocks and α_t^{AS} a linear function of asymmetric shocks. They do not depend on ε.

We can calculate the value of the expected social loss functions at this non-cooperative equilibrium. Assuming α_t^S et α_t^{AS} independently distributed we obtain

$$E_{t-1}\,\Lambda_t = E_{t-1}\,\Lambda_t^* = (\tilde{n} - \bar{n})^2 + \chi\ \frac{\gamma^2\, a_1^2}{(\chi + \varepsilon)^2}(\tilde{n} - \bar{n})^2$$

$$+ \frac{1}{2}\gamma^2\ \frac{(\chi + \varepsilon)^2 + \gamma^2\, a_1^2\, \chi}{[\chi + \varepsilon + \gamma^2\, a_1(a_1+a_2)]^2}\ \sigma_S^2 + \frac{1}{2}\gamma^2\ \frac{(\chi + \varepsilon)^2 + \gamma^2\, a_1^2\, \chi}{[\chi + \varepsilon + \gamma^2\, a_1(a_1-a_2)]^2}\sigma_{AS}^2$$

where σ_S^2 and σ_{AS}^2 represent the variance of α_t^S and α_t^{AS} respectively.

The coefficients of and σ_S^2 are σ_{AS}^2 minimized for values of ε equal to ε_S and ε_{AS} respectively, and given by

$$\varepsilon_S = - \frac{a_2}{a_1 + a_2} \chi \quad ; \quad \varepsilon_{AS} = \frac{a_2}{a_1 - a_2} \chi$$

We see that ε_S and ε_{AS} are always of opposite signs but that their signs are given by that of coefficient a_2 : when $a_2 > 0$ we have $\varepsilon_S < 0$ and $\varepsilon_{AS} > 0$; and when $a_2 < 0$ we have $\varepsilon_S > 0$ and $\varepsilon_{AS} < 0$. Note that the derivatives of the coefficients of σ_S^2 and σ_{AS}^2 with respect to ε have the sign of $(\varepsilon - \varepsilon_S)$ and $(\varepsilon - \varepsilon_{AS})$ respectively.

2. Productive and counterproductive cooperation

We have to more precisely define what we call international cooperation. We will suppose that at period t-1, but after wages for period t have been set, the central bankers of the two countries meet in order to cooperatively set monetary contingent rules for period t. The fact that the bargaining takes place after wages have been set, leads to the possibility of counterproductive international cooperation. Also,as the bargaining takes place before shocks of period t are known and because of the initial structural situations considered, the expected social losses are the same for the two countries. Therefore the cooperative solution is simply obtained by minimizing $E_{t-1} \Lambda_t + E_{t-1} \Lambda_t^*$. This means that the contingent monetary rules are obtained by finding the values of m_t and m_t^* which minimize $\Lambda_t + \Lambda_t^*$ for any given shocks (even when these shocks are not symmetric). We will always have $E_{t-1} \Lambda_t = E_{t-1} \Lambda_t^*$.

For the issue of counterproductive cooperation we want to compare the cooperative solution to the Nash equilibrium, where in both cases central bankers are now supposed to share the social utility functions. As far as the responses to shocks are concerned, the cooperative solution is always superior to the non-cooperative equilibrium. The issue is actually that of whether international cooperation worsens or lessens the time consistency problem in

each country. The corresponding losses are proportional to $(\bar{\pi}_I - \tilde{\pi}_I)^2$ and $(\bar{\pi}^*_I - \tilde{\pi}^*_I)^2$ in country 1 and country 2 respectively.

In case of the symmetric initial structural situation ($\tilde{n}^* - \bar{n}^* = \tilde{n} - \bar{n}$), we can show that at the cooperative solution we have

$$(23) \quad \left(\bar{\pi}^C_I - \tilde{\pi}_I\right)_S = \left(\bar{\pi}^{*C}_I - \tilde{\pi}^*_I\right)_S = \frac{\gamma}{\chi}(\tilde{n} - \bar{n})$$

At the Nash equilibrium these values are obtained by making $\varepsilon = 0$ in (11) and (12), which gives

$$(24) \quad \left(\bar{\pi}^N_I - \tilde{\pi}_I\right)_S = \left(\bar{\pi}^{*N}_I - \tilde{\pi}^*_I\right)_S = \frac{2\,a_1}{2\,a_1+b}\,\frac{\gamma}{\chi}(\tilde{n} - \bar{n})$$

The comparison of (23) and (24) indicates that international cooperation increases the time consistency loss and therefore can be counterproductive, a result which was found in Rogoff (1985b).

Now consider the case of an asymmetric initial structural situation where $\tilde{n}^* - \bar{n}^* = -(\tilde{n} - \bar{n})$. Then we can show that at the coperative solution we have

$$(25) \quad \left(\bar{\pi}^C_I - \tilde{\pi}_I\right)_{AS} = -\left(\bar{\pi}^{*C}_I - \tilde{\pi}^*_I\right)_{AS} = \frac{a_1 - a_2}{a_1 - a_2 + b}\,\frac{\gamma}{\chi}(\tilde{n} - \bar{n})$$

At the Nash equilibrium we simply have :

$$(26) \quad \left(\bar{\pi}^N_I - \tilde{\pi}_I\right)_{AS} = -\left(\bar{\pi}^{*N}_I - \tilde{\pi}^*_I\right)_{AS} = \frac{2\,a_1}{2\,a_1 + b}\,\frac{\gamma}{\chi}(\tilde{n} - \bar{n})$$

From (25) and (26) we see that the time consistency loss is now less at the cooperative solution than at the Nash equilibrium :

$$\left(\bar{\pi}_I^C - \pi_I\right)^2_{AS} < \left(\bar{\pi}_I^N - \pi_I\right)^2_{AS}$$

Therefore, under the asymmetric situation, international cooperation can never be counterproductive.

If we take the social loss functions (17) instead, the time consistency losses are proportional to $[E_{t-1}(m_t - m_{t-1})]^2$ and $[E_{t-1}(m_t^* - m_{t-1}^*)]^2$ respectively. We obtain :

$$E_{t-1}(m_t^C - m_{t-1})_S = E_{t-1}(m_t^{*C} - m_{t-1}^*)_S = (a_1+a_2)\frac{\gamma}{\chi}(n - \bar{n})$$

$$E_{t-1}(m_t^N - m_{t-1})_S = E_{t-1}(m_t^{*N} - m_{t-1}^*)_S = a_1\frac{\gamma}{\chi}(n - \bar{n})$$

$$E_{t-1}(m_t^C - m_{t-1})_{AS} = -E_{t-1}(m_t^{*C} - m_{t-1}^*)_{AS} = (a_1-a_2)\frac{\gamma}{\chi}(n - \bar{n})$$

$$E_{t-1}(m_t^N - m_{t-1})_{AS} = -E_{t-1}(m_t^{*N} - m_{t-1}^*)_{AS} = a_1\frac{\gamma}{\chi}(n - \bar{n})$$

The results of the text in that case directly follow.

Finally, at the beginning of subsection 5.2 we have given some results relating the response to shocks at the non cooperative equilibrium with independent central bankers, to that at the cooperative solution (with central bankers sharing the social utility function). Writing the first order conditions, the unexpected values of the relevant variables under the cooperative solution can be shown to be the solution of the system :

$$2\gamma^2 z_t + (\gamma^2 + \chi)(\hat{p}_t + \hat{p}_t^*) = 0$$

(27)

$$[\gamma_0^2(a_1-a_2) + \chi(a_1-a_2+b)](\hat{p}_t - \hat{p}_t^*) + \gamma^2(a_1-a_2)\delta_t + \chi(a_1-a_2+b)\hat{q}_t = 0$$

The non-cooperative equilibrium between independent central bankers satisfy the system obtained by adding and substracting (20a) and (20b) of Appendix 1 which gives

$$2\gamma^2 z_t + (\gamma^2 + s)(\hat{p}_t + \hat{p}_t^*) = 0$$

(28)

$$(\gamma^2 + s)(\hat{p}_t - \hat{p}_t^*) + \gamma^2 \delta_t + s\hat{q}_t = 0$$

In the case of only symmetric shocks we see that the two systems (27) and (28) have the same solutions if we take $\varepsilon = \varepsilon_1$ defined by (15). And, in the case of only asymmetric shocks, these two systems have the same solutions if we take $\varepsilon = \varepsilon_2$ defined by (16).

NOTES

1. The inefficiency of such a time consistent solution has been analyzed in Kydland and Prescott (1977) and Barro and Gordon (1983a and b).

2. The analysis of competitive appreciation or depreciation in a game theoretic framework may be found in Canzoneri and Gray (1985), Melitz (1985), Sachs (1983), and Rogoff (1985b).

3. In Rogoff (1985b) some amount of exogenous wage indexation was also possible. Here, as in the closed economy model of Rogoff (1985a), we consider the case of zero wage indexation, and therefore the period t nominal wage is predetermined at period t-1. Introducing such a wage indexation would actually not change the results.

4. The additional problems due to the existence of private information are examined in Canzoneri (1985) in a closed economy framework.

5. See Cohen and Michel (1986) for a more general analysis of a method to obtain a time consistent equilibrium.

6. These are a rewriting of equations (26) of Rogoff (1985 b). The only difference is that the random variables ε_t, ε_t^* and ϱ_t are also a linear function of the relative supply shock δ_t (there were no relative supply shocks in Rogoff (1985b)).

7. These inequalities can be straightforwardly derived from the equations (26) of Rogoff (1985b).

8. Introducing explicitely a labor supply curve rising with the real wage as in Rogoff (1985 a) may give non constant target levels $\bar{n}_t'$ and $\tilde{n}_t'$ instead of $\bar{n}$ and $\tilde{n}$. But this would leave the analysis unchanged.

9. As there is a large number of agents in the private sector each one thinks he is unable to affect the price level. This is why the inflation rate objective was not introduced into the optimization problem of wage setters considered just above.

10. As in Rogoff (1985a) we can also interpret such a conservatism ($\varepsilon > 0$) by the existence of additional incentives that the central bank has for fulfilling its inflation-rate target.

11. We can assume that central bankers who decide on monetary policy at period t are nominated at period t-1 before wages are set. In case of any subsquent change in the appointement of central bankers occuring at period t-1 after the wages have been set, or at period t, it is still up to the old central bankers to decide on monetary policies of period t, the new ones being able to affect only monetary policies of period t+1.

12. There is lack of cooperation between central bankers of the two countries. Note, however, that there is still some implicit cooperative element in the sense that central bankers are nominated cooperatively (through the choice of ε). What would happen if such a nomination took place in a non-cooperative way, is not considered here.

13. To see that, first note that the two country model for the innovation variables (derived from (1), (2), (3) and (4)) is independent of $\bar{w}_t$, $\bar{w}_t^*$ and $\tilde{n} - \bar{n}$. Second, at the non cooperative equilibrium the unexpected values of the variables, which are given by system (20)in Appendix 1, do not depend on $\bar{w}_t$, $\bar{w}_t^*$ and $\tilde{n} - \bar{n}$ either.Therefore they would be the same as in the case $\tilde{n} - \bar{n} = 0$ (no distortion in the labor market) where, when wages are set at the expected prices, both targets (employment and inflation rate) are attained in the absence of any disturbance (see (7) and (12) below). But, in that case, the objective of central bankers would be simply to minimize the fluctuations of employment and the inflation rate around their mean values.

14. In Laskar (1986) prices of period t were predetermined at period t-1 and, therefore, there were no distinction between real and nominal exchange rate fluctuations. Also, supply shocks did not play any role in the analysis.

15. In our intuitive arguments we have not taken into account the channel of interdependence going through the prices of outputs of the two countries

(we did as if we had $a_2 = 0$ in (4)). In that respect, inequalities (5) are important because they actually guarantee that the same qualitative result is obtained when we do take it into account ($a_2 \neq 0$), as (16) clearly shows.

16. The derivatives of the third and fourth terms of (14) with respect to s have the signs of $s-s_1$ and $s-s_2$ respectively.

We can make a comparison between our results and that obtained by Rogoff (1985a) in a closed economy context. In Rogoff (1985a), the second and third terms of expression (14) were actually identical to those found here except that $(\chi+\varepsilon)$ appeared in place of the variable s defined by (11). Therefore, while this did not change the fact that the second term was minimized for ε infinite, this modified the optimal value of ε in order to stabilize the economy in face of a (common) supply shock. In the closed economy model this required $\varepsilon_1 = 0$, while in the two country model this becomes $\varepsilon_1 < 0$, which may make conservative central bankers worsen the fonctioning of the system. The fourth term of (14) is specific to the two-country analysis.

17. Common demand shocks can be completely neutralized by a change in the world real interest rate, and changes in the money supplies that offset the implied money demand effects of such an interest rate variation [see Rogoff (1985b)].

18. Note that with such social loss functions the variances of all shocks matter (money demand shocks and common demand shocks included).

19. We should make two additional remarks on that point. First, the qualification "as far as the responses to shocks are concerned" is important because the effects on the wage bargains of the private sector are different. Under independent central bankers with $\varepsilon = \varepsilon_2 > 0$, the conservatism of these central bankers leads to less inflationary wage bargains, while on the contrary, as explained in Rogoff (1982 b), international cooperation leads to more inflationary wage bargains. Second, in the case where there are both symmetric and asymmetric shocks, (and still as far as the responses to shocks are concerned), it is not anymore possible to do as well as the cooperative solution through independent central bankers (compare (27) and (28) in Appendix 2).

20. Note that if we have $\tilde{n} > \bar{n}$ we shoud have $\tilde{n}^* < \bar{n}^*$. The existence of an employment target which is lower for society than for wage setters in one country, may not be easy to justify convincingly. For example, if we think of distortionary taxes, we would need negative taxes. Therefore we should keep in mind that, in this subsection, our aim is rather to use our previous analysis in order to make a formal point which may give some insight on the the issue of productive or counterperductive cooperation. Further developments may be needed in order to give a better justification for this case, or to transpose the argument in a framework where a relevant asymmetry between countries may be more realistic.

21. An "additional dimension" of the problem which may decide on whether international cooperation can be counterproductive or not, would be given by the type of time consistency problem involved. In the case considered here, conservative central bankers (who give more weight to the inflation rate or money growth target) decrease the loss due to the time consistency problem because they lead to lower nominal wage bargains. However, this is not necessarily the case in all models, and it is actually the opposite which occurs in Oudiz and Sachs (1985) or Miller and Salmon (1985). In these last models, the source of the time consistency problem lies in the desire of policymakers, through their announcement of future policies, to appreciate the exchange rate in order to decrease the inflation rate. In that case, "anti-conservative" central bankers who attach too less weight to the inflation rate will lessen this time consistency problem. Therefore, ceteris paribus,symmetric and asymmetric shocks or situations should again switch roles when we go from one type of time consistency problem to the other. The recent and preliminary analysis of Miller and Salmon (1986) which considers the issue of counterproductive cooperation in the framework of Oudiz and Sachs (1985) and Miller and Salmon (1985), gives results that seem to be in accordance with these views.

22. As indicated in Section 3, in case of a relative supply shock a modified real exchange rate variable should replace the real exchange rate.

23. See Canzoneri and Gray (1985), Laskar (1986), Melitz (1985) and Sachs (1983).

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