

Cooperative and noncooperative delegation in international monetary and fiscal policy games

Pierre Faure^{a, b, *}

^aCEFI, Château Lafarge, Route des Milles, 13290 Les Milles, France

^bERUDITE, University of Paris 12, 61 Avenue du Général de Gaulle, 94010 Créteil, France

Abstract

Even if there are no longer time inconsistency problems, governments still have an incentive to appoint independent central bankers with a different output-inflation trade-off when policies are implemented without cooperation in a multi-country framework with both monetary and fiscal spillover effects. If the delegation game is noncooperative, the appointment of conservative individuals is not always justified. Entrusting monetary policy to a weight-liberal central banker is a strictly dominant strategy when fiscal spillovers are sufficiently strong. Moreover, the cooperative design of central banks does not allow the joint optimum to be achieved and can even be ineffective for improving welfare if fiscal policies are not coordinated internationally.

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1. Introduction

The usual starting point of the theoretical studies on central bank independence and on the governor's optimal degree of inflation aversion is the classic phenomenon of time inconsistency and the lack of credibility of monetary policy announcements (Kydland and Prescott (1977), Barro and Gordon (1983)). An obvious solution to such a problem consists in entrusting the control of monetary policy to an individual who does not share the preferences of the public and who is more averse to inflation: a "conservative" central banker reduces equilibrium inflation at no cost in terms of average output. This famous solution suggested by Rogoff (1985), which is certainly one of the most notable contributions in the literature on

* Tel.: 00 33 (0)4 42 93 59 93; fax: 00 33 (0)4 42 38 95 85.

E-mail address: pierre-henri.faure@wanadoo.fr (P. Faure).

commitment problems, has had in an incontestable way a great influence on the institutional arrangements for monetary policy in many countries over the past years, and has, in fact, become the major theoretical justification for central bank independence. The robust negative relationship between the degree of independence and the level and variance of inflation highlighted by empirical studies and the absence of correlation between central bank independence and real growth have widely contributed to that consensus.

Nonetheless, independence and conservatism are not necessarily equivalent, as Hayo and Hefeker (2002) rightly point out. Several theoretical arguments have been put forward to call into question the rationale for a conservative central banker, especially within the context of the European Monetary Union (EMU), on account of seigniorage for undisciplined member states with relatively high financing requirements (Beetsma and Bovenberg (2000)), or because monetary “anticonservatism” reduces national governments’ fiscal activism in the absence of fiscal cooperation (Pina (1999), Faure (2001)). Other authors also maintain that the Rogoff (1985) solution may be suboptimal in a closed economy: Cukierman and Lippi (1999) and Guzzo and Velasco (1999) show that a “radical-populist” central banker (i.e., who cares not at all about inflation) maximizes welfare when wage setters dislike inflation and are Stackelberg leaders with respect to the monetary authority. However, in a recent paper, Jerger (2002) emphasizes the importance of the assumption relating to the solution concept used to describe strategic interactions in such models, and shows that monetary conservatism is again socially optimal if every player moves simultaneously in a Nash game.

Another explanation for the choice of monetary conservatism refers to the spillover effects of monetary policy in a multi-country setup, irrespective of any commitment problem. Dolado, Griffiths and Padilla (1994) demonstrate that the authorities of interrelated economies always have an incentive to appoint independent, conservative central bankers in the absence of international cooperation. When monetary spillovers are positive, money growth rates are too low in the noncooperative equilibrium, since each country is aware of the beneficial effect of a monetary expansion abroad on home employment, and so expands less than it would in the absence of the foreign country’s action. In that case, appointing a governor *à la* Rogoff is ex ante seen as a way to force foreign countries to engage in more expansionary policies. Such a strategy nevertheless turns out to be ineffective ex post and only exacerbates the policy conflict, as every player reasons the same way. When spillovers are negative, monetary policies are, on the contrary, too expansionary in the Nash equilibrium. Monetary conservatism then allows the inflationary bias to be reduced and enhances welfare. The incentive to choose conservative central bankers still exists when monetary policies are coordinated afterwards and, in fact, can become stronger. In particular, in a world with positive spillovers, cooperation entails more expansionary policies and thus higher inflation rates, so governments pretend to dislike inflation to a larger extent with the aim of compelling the others to increase their money supply more. This analysis is interesting because a standard result of the theoretical literature is rediscovered in a different modelling framework: delegation is a strictly dominant strategy¹ for a government even if the commitment problem no longer arises.²

However, the conclusion of the last three authors crucially depends on their assumption according to which central bankers are selected in a noncooperative way by governments that just consider their welfare function. Negrete (2000) argues that delegation can be an international coordination device if the objective functions of monetary authorities are

¹ In the terminology of game theory.

² This seems to us to be precisely the case for many countries nowadays. See McCallum (1995) for whom it is inappropriate to presume that central banks would repeatedly engage in fruitless attempts to surprise private economic agents, and more recently Artus (2001) who criticizes the resort to the Barro-Gordon model and the relevance of the framework based on time inconsistency to describe the monetary decision-making process.

designed collectively. The cooperative design of central banks always implies electing conservative persons when spillovers are negative in order to reduce money creation. In contrast, in the case of positive externalities, the optimal central banker is now “anticonservative” (i.e., less inflation averse than society): each government then internalize that a rise in the money supply is of benefit to the neighbouring country, which leads it to elect a person who is more willing to stabilize output at the cost of increasing inflation. Thus, delegation permits the cooperative solution to be attained in a decentralized way, in the sense that monetary policies are set unilaterally in the next stage.

However, monetary policy is not conducted in a vacuum, nor is the degree of monetary conservatism generally exogenous to other policies. The purpose of the present paper is to question the results obtained by those authors by using the same type of model putting aside the problem of time inconsistency deliberately, but with the difference that the spillover effects of fiscal policy are now also taken into account. The extension of their model enables us to consider a more general setting for exploring the consequences of international policy linkages among countries as regards the optimal monetary arrangement, and for dealing with the welfare implications of central bank independence. Some results mentioned above are modified when fiscal policy is included into the analysis. More precisely, this paper will make two main points.

In the first place, the appointment of central bankers worrying more about inflation is no longer inevitably a dominant strategy in the noncooperative delegation regime, contrary to what is suggested in Dolado et al. (1994). The type of central banker selected at the time of delegation crucially depends on the relative magnitude of monetary and fiscal externalities. The argumentation in favour of conservatism remains valid provided that monetary spillovers are the strongest. In contrast, a country has an incentive to appoint an anticonservative central banker when it is affected above all by foreign fiscal policy, whatever the sign of fiscal spillovers. The intuition behind this result is in fact very simple and similar to that of Dolado et al. (1994). When fiscal externalities are positive, public spending is too low in the noncooperative equilibrium, because each government would like to benefit from foreign policy to contain the budget deficit. If domestic monetary and fiscal policies are strategic substitutes, appointing a “weight-liberal” governor (i.e., a person willing to pursue a more expansionary monetary policy) automatically increases the government’s leeway to reduce its own expenditure still further, so as to force the other country to act as a locomotive bearing the costs of a fiscal expansion. When fiscal spillovers are negative, fiscal policies are, on the contrary, too expansionary in the Nash game; in that case, the choice of weight-liberal central bankers allows the spending bias to be reduced.

In the second place, unlike Negrete’s (2000) paper, the cooperative design of monetary institutions no longer permits the joint optimum to be achieved in the (likely) case where fiscal policies remain uncoordinated internationally. The basic problem is that governments cannot internalize monetary and fiscal externalities at the same time by means of delegation. In our model, such an arrangement is only a second-best mechanism for internalizing the external effects of policies. But the cooperative delegation process may also be useless. If the effects of fiscal and monetary policies exactly cancel one another, the optimal central banker has the same preferences as the government. In that case, delegation cannot help countries to coordinate policies internationally, and the welfare level is the same with or without delegation. More generally, we show that the welfare gain provided by central bank independence might eventually be quite small when both fiscal and monetary policy instruments are either strategic substitutes or strategic complements at the international level.

The reason is that a process aimed at reducing the bias characterizing one policy in a noncooperative setting can worsen the bias of the other policy.³

The rest of the paper is as follows. The basic model is presented in section 2. The case for monetary anticonservatism in the noncooperative delegation regime is analysed in section 3. The welfare implications of the cooperative delegation regime are discussed in section 4. We conclude in section 5.

2. A simple model

We consider a very simple extension of the standard two-country model of Canzoneri and Gray (1985) that allows for a dependence of home output on the level of public spending abroad. The model is highly stylized and directly expressed in reduced form.⁴ The details concerning the diverse transmission mechanisms of each policy can be omitted in this formalization, for they are not needed to express our ideas.

Two countries, A and B, are economically and strategically interdependent. Domestic output (y) depends on domestic and foreign money growth rates (m) and public expenditure levels (g):

$$y_i = (\alpha_0 m_i + \beta_0 g_i) + (\alpha_1 m_j + \beta_1 g_j) \quad (1)$$

where $i, j = A, B$ and $i \neq j$; $\alpha_0 > |\alpha_1| \geq 0$ and $\beta_0 > |\beta_1| \geq 0$.

Monetary policy is no longer subject to time inconsistency problems. Output in each country increases with the domestic money supply and level of public spending.⁵ On the other hand, both monetary and fiscal policies have ambiguous effects abroad because of their diverse transmission channels, depending on the institutional and structural features of the economies involved: a foreign monetary expansion can either increase domestic output (i.e., $\alpha_1 > 0$) or have a beggar-thy-neighbour effect and reduce domestic income (i.e., $\alpha_1 < 0$); likewise, a foreign fiscal expansion can either stimulate domestic activity (i.e., $\beta_1 > 0$) or reduce domestic output (i.e., $\beta_1 < 0$).⁶

For convenience, we make the usual simplifying assumption that the inflation rate (π) of country i ($i = A, B$) is directly given by its money growth rate and is the control variable of the monetary player:

³ The present paper resembles to some extent that of Levine and Pearlman (2002), who also explore the issue of monetary delegation in a framework with both monetary and fiscal spillovers. Unlike ours, their model—which is much more complicated—includes supply shocks and still considers the usual credibility problem, as the mechanism through which the intercountry externalities of both monetary and fiscal policies occur is a surprise real exchange effect. The degree of monetary conservatism appears to depend crucially on the correlation of shocks in their analysis. The last two authors also distinguish the noncooperative delegation game from the cooperative one and show, by means of numerical simulations, that an anticonservative governor may be chosen under some circumstances. But this result seems to be rather a special case in their article, and they do not dwell on it. They focus more on the risk of delegating the control of monetary policy to an overconservative central banker, and stress the fact that the noncooperative design of monetary institutions can be counterproductive.

⁴ Dolado et al. (1994) and Negrete (2000) use the same type of model.

⁵ Furthermore, it is supposed that domestic policies always have a larger impact on domestic output.

⁶ We shall not consider in what follows the special cases in which the sign of the spillover effects of monetary or fiscal policy differs across the world (i.e., $\alpha_1 > 0$ or $\beta_1 > 0$ in country i and $\alpha_1 < 0$ or $\beta_1 < 0$ in country j ; $i, j = A, B$ and $i \neq j$). The assumption of symmetric externalities for each policy seems to us reasonable in view of the increasing globalization of the world economy, involving a reduction in asymmetries among countries.

$$\pi_i = m_i \quad (2)$$

We assume that every government is benevolent and represents society as a whole. Hence, its quadratic loss function measures social welfare. The government (i.e., the fiscal policymaker) of country i ($i = A, B$) has a production target $\bar{y} > 0$ (which can be seen as the employment level desired by the public), an objective of price stability ($\pi = 0$) and a spending target normalized to zero.⁷ Moreover, it is supposed that both countries share the same preferences to simplify the algebra a little:

$$L_i^S = (y_i - \bar{y})^2 + p\pi_i^2 + dg_i^2 \quad (3)$$

where the superscript S stands for society.

Welfare losses increase in the deviations of output, inflation and government spending from their targets. The positive parameters p and d denote the weights of the price stability and government spending objectives, respectively, relative to the weight of the output objective (which is normalized to unity). It is important to note that p represents the *true* degree of inflation aversion of society.

Monetary authorities pursue the same goals as governments, but the weight, denoted by \tilde{p}_i ($i = A, B$), they attach to price stability can differ:⁸

$$L_i^M = (y_i - \bar{y})^2 + \tilde{p}_i\pi_i^2 + dg_i^2 \quad (4)$$

where the superscript M is used for the monetary player.

When $\tilde{p}_i > p_i$ ($i = A, B$), the central banker is “conservative” in Rogoff’s (1985) sense. When $\tilde{p}_i < p_i$, the monetary policymaker is “anticonservative”. The elected central banker is perfectly representative if $\tilde{p}_i = p_i$. In fact, no delegation occurs in that case: since the optimal central banker has exactly the same output-inflation trade-off as society, the fiscal and monetary loss functions (3) and (4) are identical in all respects, so all happens as if fiscal authorities set themselves the monetary policy instrument.⁹

The timing of events is as follows. Government i ($i = A, B$) first chooses the type of central banker to whom entrust the control of monetary policy, which formally amounts to computing the value of the weighting coefficient \tilde{p}_i that makes it possible to minimize the social loss function appearing in (3). The governor appointed during the first stage then sets monetary policy according to (4). The two countries of the model thus play a two-stage policy game that has to be solved backwards.

⁷ The presence of a term in g^2 in (3) plays the role of a budget constraint: taking into account the cost of the deviations of public expenditure is a way to capture the idea that fiscal policy is difficult to fine tune and cannot be adjusted as quickly as monetary policy (the higher the parameter d , the less the degree of fiscal activism). In particular, governments are reluctant to engage in very expansionary policies in order not to aggravate their budget deficit. As will become clear below, the value of d plays an important role in our analysis.

⁸ It is worth noting that the asymmetry introduced by the parameter \tilde{p}_i into the model is necessary to distinguish the case in which the choice of central bankers is noncooperative from that in which the monetary objective functions are designed collectively, as will be clear below. Under the assumption of similar preferences, wondering whether the appointment of central bankers is cooperative or not would not matter, as welfare losses would then be always equal in countries A and B, so that the optimal inflation aversion would be the same in both cases.

⁹ In other words, central bank independence here means that the governor has a *different* output-inflation trade-off.

3. Noncooperative delegation:

Is monetary conservatism always a dominant strategy?

For the moment, delegation is noncooperative: each country is assumed to choose its central banker on the basis of its only social welfare function in the design stage. At the time of the second stage, or implementation stage, both fiscal and monetary policies are set simultaneously in a noncooperative fashion, at the domestic or international level. We thus consider a Nash game among all players in each stage.

3.1. Monetary and fiscal policy interplay in a two-country framework

In the Nash regime, each player sets his control variable without considering the consequences of his choice on the welfare of all other players to minimize his loss function (subject to the economy's constraints (1) and (2)), given the strategy of the other players of the game.

The reaction function of government i to domestic monetary policy and to country j 's monetary and fiscal policies ($i, j = A, B; i \neq j$) is:

$$g_i = \frac{\beta_0(\bar{y} - \alpha_0 m_i - \alpha_1 m_j - \beta_1 g_j)}{\beta_0^2 + d} \quad (5)$$

The best-response function of central bank i to domestic fiscal policy and to country j 's monetary and fiscal policies ($i, j = A, B; i \neq j$) is:

$$m_i = \frac{\alpha_0(\bar{y} - \beta_0 g_i - \alpha_1 m_j - \beta_1 g_j)}{\alpha_0^2 + \tilde{p}_i} \quad (6)$$

Fiscal and monetary policies within each country are strategic substitutes in the sense that the government and the central bank can stimulate the economy by means of an increase in public expenditure or an increase in the money growth rate, respectively (i.e., $(\partial g_i)/(\partial m_i) < 0$ and $(\partial m_i)/(\partial g_i) < 0$).¹⁰ When both monetary and fiscal externalities are positive (i.e., $\alpha_1 > 0$ and $\beta_1 > 0$), monetary and fiscal policies are strategic substitutes at the worldwide level, too: any rise in the money supply or in public expenditure is of benefit to the neighbouring country and leads this one to run a less expansionary monetary (fiscal) policy on account of its other price stability (public spending) objective (i.e., $(\partial m_i)/(\partial m_j) < 0$, $(\partial m_i)/(\partial g_j) < 0$, $(\partial g_i)/(\partial m_j) < 0$ and $(\partial g_i)/(\partial g_j) < 0$). In the case of adverse externalities (i.e., $\alpha_1 < 0$ and $\beta_1 < 0$), monetary and fiscal policies are strategic complements: an increase in the money supply or in the level of government expenditure of a country forces the other to pursue a more expansionary policy to fight unemployment (i.e., $(\partial m_i)/(\partial m_j) > 0$, $(\partial m_i)/(\partial g_j) > 0$, $(\partial g_i)/(\partial m_j) > 0$ and $(\partial g_i)/(\partial g_j) > 0$).

The equilibrium values of policy instruments for $i, j = A, B$ ($i \neq j$) are found by resolving the system of first-order conditions given by (5) and (6) for i and the counterpart for j :

$$g_i^N = \frac{\beta_0(\alpha_0(\alpha_0 - \alpha_1)d + (\beta_0(\beta_0 - \beta_1) + d)\tilde{p}_j)\tilde{p}_i\bar{y}}{\omega} \quad (7)$$

¹⁰ See, for instance, Mélitz (1997) or Wyplosz (1999) for some econometric evidence on this point in Europe.

$$m_i^N = \frac{\alpha_0 d (\alpha_0 (\alpha_0 - \alpha_1) d + (\beta_0 (\beta_0 - \beta_1) + d) \tilde{p}_j) \bar{y}}{\omega} \quad (8)$$

where the superscript N indicates the Nash solution of the game and where:

$$\omega \equiv \alpha_0^2 (\alpha_0^2 - \alpha_1^2) d^2 + \omega_0 (\tilde{p}_A + \tilde{p}_B) + \omega_1 \tilde{p}_A \tilde{p}_B > 0$$

$$\omega_0 \equiv \alpha_0 d (\alpha_0 d + \beta_0 (\alpha_0 \beta_0 - \alpha_1 \beta_1)) > 0$$

$$\omega_1 \equiv \beta_0^2 (\beta_0^2 - \beta_1^2) + (2\beta_0^2 + d) d > 0$$

Substituting the equilibrium values given by (7) and (8) for i and their counterparts for j into equation (1) gives country i 's output ($i, j = A, B; i \neq j$):

$$y_i^N - \bar{y} = - \frac{(\alpha_0 (\alpha_0 - \alpha_1) d + (\beta_0 (\beta_0 - \beta_1) + d) \tilde{p}_j) \tilde{p}_i d \bar{y}}{\omega} \quad (9)$$

Notice that the issue of monetary delegation would become irrelevant if fiscal authorities no longer worried about the level of public expenditure (i.e., $d = 0$). In that case, governments would select their policy according to just the production target \bar{y} (given that they cannot directly influence the inflation rate). Therefore, considering the Tinbergen rule, the production target would inevitably be achieved for every value of other policy instruments (see (9): $y_i^N = \bar{y}$ if $d = 0$; $i, j = A, B$ and $i \neq j$). The optimal monetary policy would then be $m_i = 0$ (see (8)); thus, the price stability objective would always be achieved, whatever the type of central banker elected in the first stage.

Use equations (7), (8) and (9) to obtain the social loss for country i ($i, j = A, B; i \neq j$) for the Nash equilibrium in the implementation stage:

$$(L_i^S)^N = \frac{[\alpha_0 (\alpha_0 - \alpha_1) d + (\beta_0 (\beta_0 - \beta_1) + d) \tilde{p}_j] [\alpha_0^2 d p + (\beta_0^2 + d) \tilde{p}_i^2] d \bar{y}^2}{\omega^2} \quad (10)$$

Accordingly, the bliss point of each country would be attained if governments put no weight on the control of public spending (i.e., $(L_i^S)^N = 0$ if $d = 0$). In that case, fiscal authorities would solely focus on output stabilization in the setting of their policy instrument, while central banks would set monetary policy to achieve the price stability objective.

3.2. The noncooperative delegation game

Let us get to the first stage of the game, which is the election by each government of the central banker. Since delegation is noncooperative, the optimal type of monetary policymaker for country i ($i, j = A, B; i \neq j$) corresponds to the value of \tilde{p}_i that minimizes (10). Using an asterisk to denote the optimal value for the weighting coefficient, we find:

$$(\tilde{p}_i^*)^{NN} = \frac{\alpha_0^2 (\omega_0 + \omega_1 \tilde{p}_j) d p}{[\alpha_0^2 (\alpha_0^2 - \alpha_1^2) d^2 + \omega_0 \tilde{p}_j] (\beta_0^2 + d)} \quad (11)$$

where the first superscript for the optimal weight indicates the nature of the game in the delegation stage, and the second superscript the game used to describe the implementation stage.

This first-order condition allows us to derive the following proposition:

Proposition 1. *In the noncooperative delegation regime, both governments appoint conservative central bankers when there are only monetary spillovers (i.e., $\alpha_1 \neq 0$ and $\beta_1 = 0$), and anticonservative central bankers when there are only fiscal externalities (i.e., $\alpha_1 = 0$ and $\beta_1 \neq 0$). When both monetary and fiscal policies generate externalities (i.e., $\alpha_1 \neq 0$ and $\beta_1 \neq 0$), the optimal governor from the standpoint of each country can be either conservative or anticonservative, according to the relative magnitude of monetary and fiscal externalities. No delegation occurs if the two countries are isolated from each other (i.e., $\alpha_1 = 0$ and $\beta_1 = 0$).*

Of course, as in Dolado et al. (1994), monetary delegation only follows from the economic interdependence among countries in this model (once the commitment problem solved). So delegation would be unnecessary if there were no spillover effects (i.e., $\alpha_1 = 0$ and $\beta_1 = 0$).

For highlighting the differences between the results of Dolado et al. (1994) and ours, the simplest is to consider the particular cases, when the externalities of the model result from either monetary policy or fiscal policy exclusively, before the general (and more realistic) case where both monetary and fiscal policies give rise to spillovers abroad.

When only monetary policy generates externalities abroad (i.e., $\alpha_1 \neq 0$ and $\beta_1 = 0$), equation (11) for the weighting coefficient attached to inflation can be rewritten more simply as:

$$(\tilde{p}_i^*)^{\text{NN}} = \frac{(\alpha_0^2 d + (\beta_0^2 + d)\tilde{p}_j)p}{(\alpha_0^2 - \alpha_1^2)d + (\beta_0^2 + d)\tilde{p}_j} > p \quad (12)$$

We find again the result first obtained by Dolado et al. (1994), whether externalities are positive or negative. Delegating the control of monetary policy to a conservative governor is a dominant strategy in that case. Of course, the more averse to inflation are the two countries, the more conservative are the two central banks (i.e., $(\partial \tilde{p}_i^*)^{\text{NN}} / (\partial p) > 0$). When monetary spillovers are positive, the commitment to a tighter monetary policy is ex ante seen as a strategic mechanism for pushing the other country to act as a locomotive bearing the inflationary costs of a monetary stimulation. The new point within our model is that the international monetary policy conflict, in that case, drives each government to increase its budget deficit to offset the destabilizing impact of the restrictive stance adopted by the central bank on home employment. Ex ante, the government's incentive to elect an individual with a greater dislike for inflation means that the distortion of the output-inflation trade-off is directly connected to the monetary conflict at the worldwide level, and not to the domestic policy mix, since delegation worsens the imbalance between fiscal and monetary policies within each country. In contrast, when monetary policy generates adverse externalities, the money growth rates of both countries turn out to be excessive in the Nash equilibrium, which leads governments to cut spending. Committing to a tighter monetary policy then helps against inflation, while the adverse impact on home output is counteracted by the fiscal policymaker's reaction.

Thus, delegation is counterproductive and harms welfare in the former case, as it exacerbates the intrinsic deflationary bias of the world economy and leads to a worse policy mix, but it improves the economic situation in the latter case by refraining from excessive money creation and raising public expenditure.

With the reverse assumption, when only fiscal policy gives rise to externalities (i.e., $\alpha_1 = 0$ and $\beta_1 \neq 0$), equation (11) for the weight placed on the price stability objective can be rewritten as:

$$(\tilde{p}_i^*)^{NN} = \frac{((\alpha_0^2 d + (\beta_0^2 + d)\tilde{p}_j)(\beta_0^2 + d) - \beta_0^2 \beta_1^2 \tilde{p}_j)p}{(\alpha_0^2 d + (\beta_0^2 + d)\tilde{p}_j)(\beta_0^2 + d)} < p \quad (13)$$

As before, each country has an incentive to manipulate its central bank's objective function unilaterally with the aim of obtaining strategic advantages. But the main difference with Dolado et al. (1994) is that the optimal strategy from the standpoint of governments, ex ante, now consists in appointing weight-liberal central bankers, who put less weight on inflation than societies, whatever the sign of fiscal spillovers. Thus, monetary anticonservatism can also be a strictly dominant strategy for countries with interrelated economies. This is the first point we wish to stress in this paper.

The reason behind our result is in fact of the same kind as that put forward by Dolado et al. (1994) in their article for explaining the choice of monetary conservatism. In a world with positive fiscal spillovers, the lack of fiscal policy coordination makes that the level of public spending is too low in every country, and monetary policy tends to be more expansionary to stabilize output. Ex ante, the appointment of a person worrying more about unemployment than society i is seen as a strategic mechanism increasing government i 's leeway to cut public spending still further, since domestic policies are strategic substitutes. Government i thus chooses a weight-liberal central banker on purely strategic grounds, in order to force country j to run a more expansionary fiscal policy to offset the adverse impact on its output of country i 's fiscal contraction, which is profitable to player i ($i, j = A, B; i \neq j$).

In a world with negative fiscal spillovers, fiscal policy is too expansionary, whereas the money supply is too small in the Nash equilibrium with respect to the joint social optimum. Accordingly, entrusting monetary policy to a central banker who is more willing to stabilize output at the cost of increasing inflation is an optimal strategy: it enables the government to pursue a less expansionary fiscal policy—whose effect on home activity is offset by the monetary relaxation—, thus increasing output abroad, which in turn encourages the foreign country to cut spending.

As in the previous case with monetary spillovers exclusively, delegation is welfare reducing if fiscal externalities are positive and, on the contrary, makes both countries better off in the hypothesis of adverse spillover effects. When fiscal spillovers are positive, designing weight-liberal monetary institutions only aggravates the international fiscal policy conflict and leads to an even worse equilibrium ex post, as every player reasons the same way. The fiscal stance of governments becomes more restrictive, whereas monetary policies are more and more expansionary. On the other hand, delegation improves welfare when fiscal spillovers are negative by reducing the budget deficit without a large cost in terms of output.

Now consider the most realistic situation in which both monetary and fiscal policies generate externalities (i.e., $\alpha_1 \neq 0$ and $\beta_1 \neq 0$). Equation (11) implies:

$$(\tilde{p}_i^*)^{NN} \left\{ \begin{array}{l} > \\ < \end{array} \right\} p \Rightarrow (\alpha_0 \alpha_1 d + \beta_0 \beta_1 \tilde{p}_j)(\alpha_1 d + \beta_0 (\alpha_1 \beta_0 - \alpha_0 \beta_1)) \left\{ \begin{array}{l} > \\ < \end{array} \right\} 0 \quad (14)$$

The type of central banker elected in the design stage depends on the relative magnitude of monetary and fiscal spillovers to a great extent, of course, but it also depends on the importance attached to the control of the budget deficit and on the weight attached to the price stability objective in the foreign country.

If $\alpha_1 > 0$ and $\beta_1 > 0$, or if $\alpha_1 < 0$ and $\beta_1 < 0$, only the term $(-\alpha_0\beta_0\beta_1)$ inside the second bracket appears with a sign different from the others. On the one hand, if monetary spillovers are stronger than fiscal spillovers (i.e., $|\alpha_1| > |\beta_1|$), and if $\alpha_0 \approx \beta_0$ in addition, the optimal monetary policymaker must be conservative (when spillovers are positive, $\alpha_1\beta_0 > \alpha_0\beta_1$, so both brackets in (14) are positive; when spillovers are negative, $\alpha_1\beta_0 - \alpha_0\beta_1 < 0$, so both brackets in (14) are negative). On the other hand, if fiscal spillovers are stronger than monetary spillovers (i.e., $|\alpha_1| < |\beta_1|$), it is easy to check in the same way (with the extra assumption $\alpha_0 \approx \beta_0$) that the elected governor is likely to be anticonservative, at least as long as the value taken by the parameter d is not too large.

The elected central banker is presumably conservative if the cost endured by governments when adjusting the level of public spending is very high (i.e., $d \rightarrow \infty$): a larger value of the weighting coefficient d actually means that fiscal spillovers are reduced all over the world since governments are then reluctant to use the fiscal policy instrument actively. Conversely, for a given value of the coefficient β_1 , the less governments will worry about the level of public expenditure (i.e., $d \rightarrow 0$), the stronger the spillover effects of fiscal policy abroad. Thus, our simple model suggests that the design of conservative monetary policy institutions is more likely in countries desiring to enhance long-run fiscal discipline or seeking to move away from unsustainable fiscal trajectories, which seems more suitable to describe the fiscal decision-making process and the emphasis on balanced budgets nowadays. In contrast, governments devoting far less attention to budget deficits may appoint weight-liberal central bankers.

If $\alpha_1 > 0$ and $\beta_1 < 0$, or if $\alpha_1 < 0$ and $\beta_1 > 0$, the sign of the first bracket in (14) is ambiguous. If $\alpha_1 > 0$ and $\beta_1 < 0$, the sign of the second bracket is positive, so the elected central banker is likely to be conservative when $|\alpha_1| > |\beta_1|$, and anticonservative when $|\alpha_1| < |\beta_1|$, as seen before. When $\alpha_1 < 0$ and $\beta_1 > 0$, the sign of the second bracket is negative and the results are the same. The value taken by the term $\beta_0\beta_1\tilde{p}_j$ inside the first bracket is determining in that case. In fact, an increase in the degree of monetary conservatism in country j (i.e., $\tilde{p}_j \rightarrow \infty$) makes that the appointment of a less inflation averse central banker than society in country i is possible; the decrease in the money growth rate leads government j to raise public expenditure, thus implying stronger fiscal spillovers in country i for any value of β_1 ($i, j = A, B; i \neq j$).

To sum up, the relative magnitude of monetary and fiscal spillovers here plays a crucial role in the design of monetary policy institutions. When monetary externalities are the strongest, countries are induced to appoint conservative central bankers on purely strategic grounds. When fiscal externalities are the strongest, the design of weight-liberal independent central banks can be explained by the same kind of argumentation. In both cases, delegation to independent central banks is welfare improving only if intercountry spillovers are negative.

4. Cooperative delegation:

Is central bank independence always useful?

Let us now turn to the case of cooperative delegation. In the Dolado et al. (1994) model, delegation improves welfare only if spillovers are negative and even in that case it does not deliver the cooperative optimum; the joint implementation of monetary policies (without central bank independence) is always a better arrangement than noncooperative delegation.

Negrete (2000) however argues that the cooperative optimum can be attained otherwise if governments choose central bankers on the basis of a common objective function in the design stage. In that case, delegation is a decentralized coordination device, in the sense that each country's monetary policy can then be set unilaterally in the second stage, as central bankers are already endowed with the optimal output-inflation trade-off. As the last author points out, such a mechanism is likely to be more credible than monetary policy coordination in the implementation stage because an independent central bank is better insulated from political pressure to alter its policy, not to mention that the cost of renegeing on promises is higher for an agreement on the independence of the monetary policy institution than for an agreement on policy targets.

4.1. The optimal degree of inflation aversion in the cooperative case

In this model, cooperation in the design stage makes that the optimal type of central banker is exactly the same in both countries because governments are assumed to have analogous preferences.¹¹ We now use equation (10) for i and the symmetric expression for j to minimize the sum $(L_i^S)^N + (L_j^S)^N$ with respect to \tilde{p}_i and \tilde{p}_j ($i, j = A, B; i \neq j$).¹² This yields:¹³

$$(\tilde{p}^*)^{CN} = \frac{\alpha_0(\beta_0(\beta_0 + \beta_1) + d)P}{(\alpha_0 + \alpha_1)(\beta_0^2 + d)} \quad (15)$$

where the superscript C is used to indicate the cooperative solution of the delegation game.

This first-order condition allows us to formulate the second proposition below:

Proposition 2. *When the delegation game is cooperative, the distortion of the output-inflation trade-off also depends on the sign of the spillover effects of monetary and fiscal policies (and no longer solely on their relative size). When there are only monetary spillovers, the optimal central banker is conservative if $\alpha_1 < 0$ and anticonservative if $\alpha_1 > 0$. When there are only fiscal spillovers, the optimal governor is conservative if $\beta_1 > 0$ and anticonservative if $\beta_1 < 0$.*

In the presence of only monetary spillovers (i.e., $\beta_1 = 0$), we find again the main result of Negrete's (2000) article:

$$(\tilde{p}^*)^{CN} = \frac{\alpha_0 P}{\alpha_0 + \alpha_1} \quad (16)$$

The optimal monetary arrangement directly depends on the sign of monetary externalities. The Negrete (2000) solution is theoretically interesting because it shows that the socially optimal monetary policymaker can be anticonservative, contrary to what is supported most of the time. In fact, when spillovers are negative, the optimal central banker is even more conservative when chosen jointly because the internalization of the beggar-thy-neighbour effect calls for a stronger decrease in the rate of growth of the money supply (i.e.,

¹¹ Hence, the subscript indicating the country can now be dropped in the expressions for the optimal weighting coefficient attached to inflation and the social loss.

¹² The bargaining powers are equal given that the two countries of the model are symmetric to one another.

¹³ See also appendix A for another way to compute the optimal weight that makes the algebra less cumbersome.

$(\tilde{p}_i^*)^{\text{CN}} > (\tilde{p}_i^*)^{\text{NN}} > p$, $i = A, B$). In contrast, the degree of monetary conservatism is reduced with respect to the Nash solution if externalities are positive, and the optimal central banker now attaches less weight to inflation stabilization than the public, since the internalization of spillovers calls for more expansionary monetary policies (i.e., $(\tilde{p}_i^*)^{\text{NN}} > p > (\tilde{p}_i^*)^{\text{CN}}$).

When there are only fiscal spillovers (i.e., $\alpha_1 = 0$), the optimal monetary arrangement partly depends on the weight d since this parameter affects the selected level of public spending and so the distortions due to players' noncooperative behaviour:

$$(\tilde{p}^*)^{\text{CN}} = \frac{\alpha_0(\beta_0(\beta_0 + \beta_1) + d)p}{\alpha_0(\beta_0^2 + d)} \quad (17)$$

It is straightforward to see, according to (17), that $(\partial \tilde{p}^*)^{\text{CN}} / (\partial d) = (-\beta_0\beta_1 p) / (\beta_0^2 + d)^2$. When $\beta_1 > 0$, the level of public spending is too low in the Nash game; as any increase in d involves the adoption of a still more restrictive fiscal stance, it is better to run a more expansionary monetary policy in order to limit the fall in activity (i.e., $(\partial \tilde{p}^*)^{\text{CN}} / (\partial d) < 0$). In contrast, public expenditure is too high when $\beta_1 < 0$; any increase in d then allows the budget deficit to be contained and it is better to focus on inflation because the money supply increases after a curtailment in public expenditure (i.e., $(\partial \tilde{p}^*)^{\text{CN}} / (\partial d) > 0$).

In the presence of adverse spillovers, the optimal central banker is less inflation averse than in the noncooperative delegation regime. As fiscal policies are too expansionary, the best is to design monetary institutions that are more willing to stabilize output at the cost of higher inflation, so as to encourage governments to cut public expenditure (i.e., $(\tilde{p}_i^*)^{\text{CN}} < (\tilde{p}_i^*)^{\text{NN}} < p$, $i = A, B$). In contrast, when fiscal spillovers are positive, the optimal design of central banks now implies appointing conservative governors: as fiscal policies are not expansionary enough, the adoption of a harsher monetary stance pushes governments to raise public spending in order to counteract its adverse impact on domestic output, which is of benefit to the rest of the world (i.e., $(\tilde{p}_i^*)^{\text{CN}} > p > (\tilde{p}_i^*)^{\text{NN}}$).

In the general case (i.e., $\alpha_1 \neq 0$ and $\beta_1 \neq 0$), we have:

$$(\tilde{p}^*)^{\text{CN}} \begin{cases} > \\ < \end{cases} p \Rightarrow \beta_0(\alpha_0\beta_1 - \alpha_1\beta_0) - \alpha_1 d \begin{cases} > \\ < \end{cases} 0 \quad (18)$$

As seen before, the optimal type of central banker crucially depends on monetary spillovers when fiscal activism becomes very costly (i.e., $d \rightarrow \infty$). The sign of α_1 is determining in that case. On the other hand, when fiscal authorities worry less about the level of public expenditure (i.e., $d \rightarrow 0$), the degree of monetary conservatism depends on the sign and size of fiscal and monetary externalities to a larger extent (see the term $\beta_0(\alpha_0\beta_1 - \alpha_1\beta_0)$ in (18)).

4.2. The welfare implications of cooperative delegation

We now turn to the consequences of the cooperative delegation regime as regards social welfare. The first step is to compute the welfare loss in the Nash game when no delegation occurs. Its derivation is contained in appendix B. The case in which both monetary and fiscal

policies are coordinated internationally (without delegation) is the theoretical welfare benchmark and corresponds to the joint optimum, as all external effects are internalized (see appendix C for its derivation), hence $(L^S)^N > (L^S)^C$.

The loss sustained by each country when the delegation game is cooperative and the implementation game is noncooperative is obtained by substituting the optimal value of the common weight \tilde{p} (see (15)) into equation (A.4) given in appendix A:

$$(L^S)^{CN} = \frac{(\beta_0^2 + d)dp\bar{y}^2}{(\alpha_0 + \alpha_1)^2(\beta_0^2 + d)d + [\beta_0(\beta_0 + \beta_1) + d]P} \quad (19)$$

The comparison of this welfare loss with the losses (B.4) and (C.4) for the Nash and cooperative games without delegation, respectively, leads to:

$$(L^S)^N \geq (L^S)^{CN} > (L^S)^C \quad (20)$$

This result and the inspection of welfare losses lead to the third proposition below:

Proposition 3. *The cooperative design of central banks automatically improves welfare when monetary and fiscal spillovers have an opposite sign, but it is only a second-best form of policy coordination in that case. On the other hand, making central banks independent may be of no use when both monetary and fiscal spillovers are either positive or negative.*

First, note that the cooperative delegation regime no longer permits the joint optimum to be established, unlike Negrete (2000) who considers a setup without fiscal policy. This is simply because a single monetary arrangement cannot deal with every coordination failure at the same time. Delegation requires a compromise between the need for international policy coordination, on the one hand, and the need for cooperation between the government and the central bank within each country, on the other hand. The reason lies in the asymmetry in the loss functions (3) and (4), as the price stability objective is weighted unequally in the delegation case. There is no domestic coordination problem when $p = \tilde{p}$ (i.e., before delegation) because the fiscal and monetary loss functions are exactly the same.¹⁴ The adjustment of the output-inflation trade-off in the objective functions of monetary policymakers then partly resolves the interest conflict among countries, but it is made to the detriment of the domestic policy mix. The problem is the lack of instruments to eliminate all imperfections. Of course, such a result presupposes that governments do not coordinate fiscal policies, which is the most likely scenario for many reasons.¹⁵ The cooperative design of central banks coupled to fiscal policy coordination would obviously establish the joint optimum. In that case, monetary spillovers would be internalized in the design stage, while fiscal externalities would be internalized later on, in the implementation stage. However, the problem is precisely that fiscal policy is set in a noncooperative fashion most of the time. It

¹⁴ Formally, the noncooperative Nash equilibrium between domestic authorities coincides with the cooperative equilibrium.

¹⁵ Empirical evidence indeed shows that fiscal policies are seldom coordinated. The problem with fiscal cooperation, apart from the difficulties due to the temptation to renege on commitments inherent in every cooperative game, has mainly to do with the rigidity in the fiscal decision-making process, or with political business cycle considerations that incite governments with short political horizons to favour domestic interests at the expense of the economic situation abroad.

follows that central bank independence is only a second-best form of policy coordination in our more general setting.

But can delegation be useless? We have to compare the loss in the Nash game without delegation (see equation (B.4) in appendix B) with (19) for examining this possibility. This yields:

$$(L^S)^N \geq (L^S)^{CN} \Rightarrow \alpha_1^2 d^2 + \beta_0^2 (\alpha_0 \beta_1 - \alpha_1 \beta_0)^2 \geq 2\alpha_1 \beta_0 (\alpha_0 \beta_1 - \alpha_1 \beta_0) d \quad (21)$$

If $\alpha_1 > 0$ and $\beta_1 < 0$, or if $\alpha_1 < 0$ and $\beta_1 > 0$, the right-hand side of (21) is always negative, so monetary delegation undoubtedly improves welfare. When monetary and fiscal spillovers have an opposite sign, designing the optimal monetary institution theoretically raises no particular problem. If monetary spillovers are positive, whereas fiscal spillovers are negative, monetary policies are not expansionary enough and, in contrast, fiscal policies turn out to be too expansionary in the worldwide Nash equilibrium.¹⁶ Therefore, the appointment of anticonservative central bankers alleviates the conflict of interest among countries and makes them better off since the rise in the money supply entails spending cuts. If monetary spillovers are negative, whereas fiscal spillovers are positive, the worldwide Nash equilibrium is characterized by excessive money creation and insufficient public expenditure. In that case, appointing central bankers *à la* Rogoff is an optimal strategy and makes both countries better off by reducing the money growth rate and raising public spending.

On the other hand, if $\alpha_1 > 0$ and $\beta_1 > 0$, or if $\alpha_1 < 0$ and $\beta_1 < 0$ (i.e., when both monetary and fiscal policies are strategic substitutes or strategic complements at the worldwide level), governments at first glance face a dilemma at the time of the delegation stage, in the sense that they can in principle pretend to dislike inflation either to a larger extent or to a smaller extent than they truly do. When externalities are of benefit to the foreign country, the international noncooperative game makes that both monetary and fiscal policies are in general not expansionary enough.¹⁷ On the one hand, the appointment of central bankers with a greater dislike for inflation weakens the fiscal policy conflict, by pushing governments to increase spending, but in return it imposes an additional deflationary bias onto the world economy. On the other hand, the appointment of anticonservative central bankers alleviates the international monetary policy conflict, but it aggravates the adverse consequences of uncoordinated fiscal policies by leading to an additional curtailment in public expenditure within each country. The same kind of dilemma exists with adverse spillovers, as both monetary and fiscal policies then tend to be too expansionary. The problem is that delegation reduces the inflationary (deflationary) bias characterizing noncooperative monetary policies at the cost of a stronger expansionary (contractionary) bias of fiscal policies. In that case, the direction of the distortion of the output-inflation trade-off depends on the sign of the strongest spillover effect. As the policy changes due to monetary delegation tend to offset one another, the welfare gain is smaller than that obtained when monetary and fiscal spillovers have an opposite sign.

In particular, when the effects of monetary and fiscal policies cancel one another in the world, delegation is useless since the optimal central banker from the standpoint of each country is then perfectly representative and has the same output-inflation trade-off as the

¹⁶ In that case, the fact that monetary and fiscal policies are strategic substitutes within each country contributes to aggravating the adverse consequences of international policy conflicts, as the expansionary strategy of one player makes the policy of the other even more contractionary.

¹⁷ The conflict concerning each policy at the worldwide level is now alleviated to some extent thanks to the reaction from the other domestic authority. When all spillovers are positive, each player reacts to the strategy of the other with a more expansionary policy, thus limiting the negative consequences of the lack of intercountry cooperation.

government. Formally, the condition to end up in such a situation is $d = \beta_0(\alpha_0\beta_1 - \alpha_1\beta_0)/\alpha_1$ (i.e., $(\tilde{p}^*)^{\text{CN}} = p$ and $(L^S)^{\text{CN}} = (L^S)^{\text{N}}$ in that case, according to (18) and (21)).

5. Conclusion

This paper has discussed the results relating to monetary delegation of Dolado et al. (1994) and Negrete (2000) within a two-country framework in the absence of time inconsistency problems. Unlike those authors focusing solely on monetary externalities, we have considered the spillover effects of fiscal policy in addition. This simple extension of the model has allowed us to highlight two main points.

First, when the delegation game is noncooperative, the conclusion according to which the appointment of central bankers *à la* Rogoff is a dominant strategy for governments in the presence of international monetary spillovers may no longer hold if there are fiscal spillovers, too. It has been shown that the optimal type of central banker depends on the relative magnitude of monetary and fiscal externalities. When the spillover effects of fiscal policy turn out to be the largest, governments prefer to design independent, weight-liberal monetary institutions on purely strategic grounds. However, the case for anticonservative central bankers is less strong if governments are constrained in their use of the fiscal policy instrument. Furthermore, in a world with positive externalities, the noncooperative delegation process is always counterproductive; the delegation game actually fits a prisoner's dilemma in that case. Delegation enhances welfare solely when policies produce adverse spillover effects.

Second, taking fiscal policy into account makes that delegation is a partial commitment (i.e., a commitment by countries only to a given monetary policy) and so cannot be an optimal intercountry coordination device any longer. One monetary arrangement cannot eliminate all policy distortions due to players' noncooperative behaviour. As fiscal policies are most likely to remain uncoordinated, the cooperative design process, at best, improves welfare with respect to the Nash game in each stage, but never enables governments to attain the joint optimum. In particular, it has been shown that the welfare gain brought by central bank independence might be quite small if both monetary and fiscal policy variables are either strategic substitutes or strategic complements at the worldwide level.

Nonetheless, this analysis of monetary delegation based on the existence of externalities is questionable as well. The main criticism that can be formulated against such a model is that it seems difficult to link the major decision to make central banks independent of political authorities, which is a constitutional matter that is in keeping with the long-term goal of monetary policy, and so which cannot be easily reversed afterwards, to the spillover effects of monetary and fiscal policies, given that the size as well as the sign of those spillovers vary in time, not to mention the fact that there is little empirical consensus on that topic among economists. On the other hand, the merit of the model used here, from a theoretical point of view, is to provide another rationale for central bank independence, irrespective of the problem of time inconsistency.

Appendix A. Cooperative delegation and noncooperative policy implementation

Another (less tedious) way of computing the optimal value of the weight that should be placed on the price stability objective in the cooperative delegation regime is as follows. As governments have exactly the same preferences, the cooperative manipulation of the monetary objective functions means, ex ante, that the monetary policymaker's output-inflation trade-off must be the same in both countries. Hence, the model is symmetric (and the subscript indicating the country can be dropped in the expressions for equilibrium values for notational convenience).

Since policies are set in a noncooperative fashion afterwards, we have to solve $\partial(L_i^S)/\partial g_i = 0$ for fiscal policy and $\partial(L_i^M)/\partial m_i = 0$ for monetary policy ($i = A, B$), which gives the best-response functions (5) and (6) in the text with the sole difference that $\tilde{p}_i = \tilde{p}$ now.

In the equilibrium, $g_A^N = g_B^N = g^N$ and $m_A^N = m_B^N = m^N$. Thus, we have:

$$g^N = \frac{\beta_0 \tilde{p} \bar{y}}{\alpha_0 (\alpha_0 + \alpha_1) \mathcal{A} + \beta_0 (\beta_0 + \beta_1) \tilde{p} + d \tilde{p}} \quad (\text{A.1})$$

$$m^N = \frac{\alpha_0 d \bar{y}}{\alpha_0 (\alpha_0 + \alpha_1) \mathcal{A} + \beta_0 (\beta_0 + \beta_1) \tilde{p} + d \tilde{p}} \quad (\text{A.2})$$

Likewise, $y_A^N = y_B^N = y^N$. Using the results above, we find:

$$y^N - \bar{y} = - \frac{d \tilde{p} \bar{y}}{\alpha_0 (\alpha_0 + \alpha_1) \mathcal{A} + \beta_0 (\beta_0 + \beta_1) \tilde{p} + d \tilde{p}} \quad (\text{A.3})$$

Substituting (A.1), (A.2) and (A.3) into (3) gives the social loss in the Nash game for the second stage. We have $(L_A^S)^N = (L_B^S)^N = (L^S)^N$ by symmetry. This yields:

$$(L^S)^N = \frac{(\alpha_0^2 d p + (\beta_0^2 + d) \tilde{p}^2) \mathcal{A} \bar{y}^2}{[\alpha_0 (\alpha_0 + \alpha_1) \mathcal{A} + \beta_0 (\beta_0 + \beta_1) \tilde{p} + d \tilde{p}]^2} \quad (\text{A.4})$$

It is easy to check that the value of \tilde{p} minimizing this loss is given by equation (15) in the text.

Appendix B. Nash equilibrium without delegation

As no delegation occurs, the loss functions (3) and (4) in the text are now identical in all respects. The assumption of similar preferences makes that policies and losses are the same in both countries in the equilibrium. Government i sets both fiscal and monetary policy instruments to minimize its loss without taking into account country j 's welfare ($i, j = A, B$ and $i \neq j$). The first-order conditions of the problem are still given by (5) and (6) in the text with the sole difference that now $\tilde{p}_i = p$ in equation (6).

In the equilibrium, $g_A^N = g_B^N = g^N$ and $m_A^N = m_B^N = m^N$. Hence:

$$g^N = \frac{\beta_0 p \bar{y}}{\alpha_0 (\alpha_0 + \alpha_1) d + \beta_0 (\beta_0 + \beta_1) p + dp} \quad (\text{B.1})$$

$$m^N = \frac{\alpha_0 d \bar{y}}{\alpha_0 (\alpha_0 + \alpha_1) d + \beta_0 (\beta_0 + \beta_1) p + dp} \quad (\text{B.2})$$

Likewise, $y_A^N = y_B^N = y^N$. Using the results above, we obtain:

$$y^N - \bar{y} = -\frac{dp \bar{y}}{\alpha_0 (\alpha_0 + \alpha_1) d + \beta_0 (\beta_0 + \beta_1) p + dp} \quad (\text{B.3})$$

Substituting (B.1), (B.2) and (B.3) into (3) gives the social loss in the Nash game without delegation. We have $(L_A^S)^N = (L_B^S)^N = (L^S)^N$ by symmetry. This yields:

$$(L^S)^N = \frac{(\alpha_0^2 d + (\beta_0^2 + d) p) dp \bar{y}^2}{[\alpha_0 (\alpha_0 + \alpha_1) d + \beta_0 (\beta_0 + \beta_1) p + dp]^2} \quad (\text{B.4})$$

Appendix C. Fiscal and monetary policy coordination without delegation

The case in which both fiscal and monetary policies are coordinated internationally is the welfare benchmark in our analysis. With equal bargaining powers, the first-order conditions to be solved are $\frac{\partial(L_i^S)}{\partial g_i} + \frac{\partial(L_j^S)}{\partial g_i} = 0$ for fiscal policy and $\frac{\partial(L_i^S)}{\partial m_i} + \frac{\partial(L_j^S)}{\partial m_i} = 0$ for monetary policy ($i, j = A, B$ and $i \neq j$).

In the equilibrium, we have:

$$g^C = \frac{(\beta_0 + \beta_1) p \bar{y}}{(\alpha_0 + \alpha_1)^2 d + (\beta_0 + \beta_1)^2 p + dp} \quad (\text{C.1})$$

$$m^C = \frac{(\alpha_0 + \alpha_1) d \bar{y}}{(\alpha_0 + \alpha_1)^2 d + (\beta_0 + \beta_1)^2 p + dp} \quad (\text{C.2})$$

$$y^C - \bar{y} = -\frac{dp \bar{y}}{(\alpha_0 + \alpha_1)^2 d + (\beta_0 + \beta_1)^2 p + dp} \quad (\text{C.3})$$

$$(L^S)^C = \frac{dp \bar{y}^2}{(\alpha_0 + \alpha_1)^2 d + (\beta_0 + \beta_1)^2 p + dp} \quad (\text{C.4})$$

Welfare losses are lower in the cooperative regime when compared with the Nash equilibrium because all externalities are internalized (compare (B.4) with (C.4): $(L^s)^N > (L^s)^C$).

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