Policy Biases When The Monetary and Fiscal Authorities Have Different Objectives*

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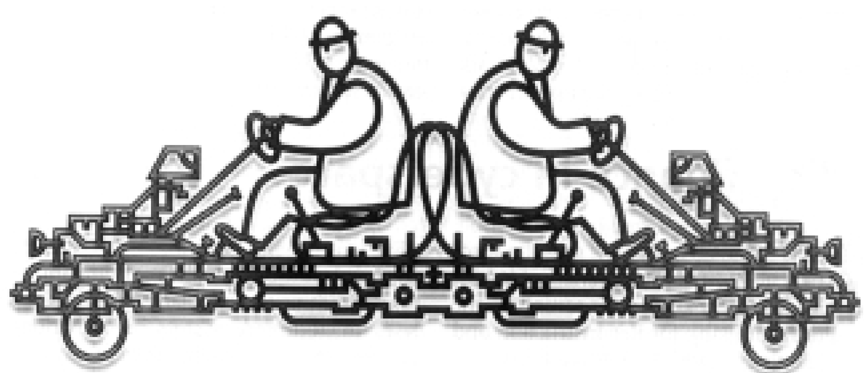
Abstract

Central bank independence has contributed to achieve price stability and fiscal discipline for many countries. The conventional wisdom is that this is a necessary, first-generation reform of fiscal and monetary policy. The question this paper asks is whether a second-generation reform consisting of institutional incentives for domestic policy coordination could be beneficial. The paper presents a game-theoretic model where the fiscal and monetary authorities interact to stabilize the economy, having dissimilar preferences with respect to output and inflation gaps and controlling different policy instruments. Modeled as either Nash or Stackelberg equilibria, the solution under lack of policy coordination implies that an increase in the preference divergence between the monetary and fiscal authorities leads to, *ceteris paribus*, larger public deficits (the fiscal authority's policy instrument) and higher real interest rates (the central bank's instrument). The empirical section of the paper attempts to test this conclusion on a pooled sample of 19 industrial countries with annual information for the period 1970-94 and using a seemingly-unrelated regression estimator that allows for country random effects. Controlling for other shocks and economic conditions, we find that countries and time periods where the central bank places a larger importance on keeping inflation low are associated with both larger primary deficits (as ratio to GDP) and higher domestic real interest rates (as deviations from international rates). The empirical results of the paper should not be taken to imply that in order to reduce these policy biases, the central bank should unilaterally lower its standards for inflation control. Rather, the policy implication favored in the paper is that, without prejudice to the gains from central bank independence, institutional arrangements that allow for coordination both at the level of setting objectives and at the level of policy implementation can alleviate the biases that move the economy to sub-optimally higher fiscal deficits and real interest rates.



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1 Introduction

Until recently, the debate on the relationship between monetary and fiscal authorities has been centered on the inflationary consequences of the monetary financing of the fiscal deficit. The moderate inflation of the 1970s in some industrialized countries and, particularly, the recurring episodes of high inflation in several developing countries justified this focus. The main policy recommendation to avoid high and variable inflation has been the institution of independent monetary authorities whose main mandate would be the control of inflation (see Cukierman 1992, and Walsh 1993). In fact, in recent years several central banks have adopted inflation targeting as the cornerstone of their monetary policy (see Morandé and Schmidt-Hebbel 1999).

On the other hand, fiscal authorities have also come to recognize the harmful effects of inflation and have taken measures to control their deficits. This has been achieved by both rationalizing fiscal expenditures (e.g., eliminating price subsidies and privatizing public enterprises) and raising tax revenues, particularly through the adoption of value-added taxes. Furthermore, fiscal authorities are using domestic and international financial markets to better manage the public debt to avoid the need to collect an inflation tax from outstanding monetary assets.

Thus, in many countries around the world there is a new policy environment, one in which monetary authorities are committed to controlling inflation and fiscal authorities do not rely on the inflationary tax to finance their deficits and debt service. In this new context, a different set of policy issues and questions arise. This paper is devoted to the study of one of the most important of them, namely, the effect of the lack of coordination between monetary and fiscal authorities in achieving the goals of minimizing business cycle fluctuations.

Coordination (or the lack thereof) is a relevant issue because the monetary and fiscal authorities have different policy instruments, different objectives and preferences, and sometimes different perceptions of the how the economy functions. In this paper we concentrate on the effects of having monetary and fiscal authorities with dissimilar objectives and controlling different policy instruments. In this sense, this paper is closely related to Nordhaus (1994) and Loewy (1988). Following these studies, we use a game-theoretic approach to analyze the effects on fiscal deficits and domestic real interest rates in a context where monetary and fiscal authorities are uncoordinated.

In this environment, monetary and fiscal authorities have dissimilar preferences for inflationary and growth gaps with respect to their long-run desired levels, which are assumed to be shared by both authorities.

As an introduction and in order to expose the main issues and results of the paper, we now present a simple fiscal-monetary game modeled after the well-known "prisoner's dilemma." Figure 1 presents the main assumptions and results of this game, in which we analyze the potential response of the monetary and fiscal authorities in the face of a negative shock that rises inflation and lowers employment. The monetary and fiscal authorities have two options each: they can either follow a loose or a tight policy. When both "play" tight, the resulting inflation is low but so is the resulting employment. When both play loose, both inflation and employment are high. And when only one of them plays tight, the result is medium employment and inflation.

The interesting feature of this fiscal/monetary game is that monetary and fiscal authorities have different preferences for inflation and employment (see the payoff schedules in Figure 1). Whereas the monetary authority considers more valuable to achieve low inflation than high employment, the fiscal authority regards obtaining high employment as more important than keeping inflation low. The preference differences between both authorities are chosen to be sufficiently large so as to obtain the result we would like to stress.

The only Nash equilibrium in this game consists of a tight monetary policy and a loose fiscal policy. The other three alternatives present opportunities for one of the players to benefit by unilaterally deviating from the original play. Thus, the equilibrium of this game exposes the paradigmatic conservatism of central banks and liberalism of fiscal authorities. It also illustrates why the response of each of them is optimal given the preference differences between the two. If the monetary authority were to follow a loose policy, thus accepting a fiscal authority's pledge for stricter restraint, then the fiscal authority would find it optimal to renege from its pledge and play a loose policy. By the same token, if the fiscal authority were to conduct a tight policy given a central bank's offer to follow a loose policy, the monetary authority would benefit by deviating from its offer by following a tight policy. Note that in terms of the payoffs to both authorities, the Nash equilibrium is equivalent to the combination of loose monetary and tight fiscal policies. From a long-run perspective, it can be argued that the latter combination of policies is healthier than

Figure 1: A Monetary-Fiscal Game

Fiscal Authority \ Central Bank	Tight Monetary	Loose Monetary
Tight Fiscal	7 4 Low Inflation Low Employment	6 6 Medium Inflation Medium Employment
Loose Fiscal	6 6 Medium Inflation Medium Employment	4 7 High Inflation High Employment

Payoff Schedules

Inflation	Low	Medium	High
Central Bank	6	4	1
Fiscal Authority	3	2	1

Employment	Low	Medium	High
Central Bank	1	2	3
Fiscal Authority	1	4	6

the Nash equilibrium given that it does not compromise fiscal sustainability and does not weaken the investment capacity of the private sector.

Though illustrative of the major themes of the paper, this simple game has obvious shortcomings. One of them is that it requires ad-hoc payoff schedules to obtain the desired result. We may want to clarify the preference conditions under which policy biases occur. The second shortcoming is that the game does not consider the possibility for negotiations between the fiscal and monetary authorities that may result in policy coordination.

In the second section of the paper we present a monetary/fiscal game where the potential advantages of policy coordination can be clearly seen. Through this model we also clarify the conditions under which looser fiscal policy (represented by higher primary fiscal deficits) is accompanied by tighter monetary policy(represented by higher real interest rates), as predicted by the "prisoner's dilemma" game. The basic conclusion of the model is that a rise in the preference divergence for output and inflation gaps between the monetary and fiscal authorities results in an increase of primary fiscal deficits and real interest rates.

Also in the theoretical section, we compare the Nash equilibrium solution with the Stackelberg solution. By allowing one of the authorities to be the leader, the Stackelberg solution introduces dynamic aspects into the game, creating the possibility for the authority leader to act in a way to elicit a mutually beneficial response from the follower. The Stackelberg game also obtains the basic conclusion of the Nash equilibrium; that is, independently of the who the leader is, a widening of the preference divergence leads to an expansion of fiscal deficits and real interest rates. However, by allowing the leader to seek a mutually beneficial response from the follower, the Stackelberg equilibrium comes closer to the coordination solution than the Nash equilibrium does. [1]

The third section of the paper attempts to bring some empirical evidence to bear. We use annual information over the period 1970-94 for a sample of industrialized countries to test the main conclusion of the paper: in a context where fiscal and monetary authorities are independent and do not effectively coordinate their policy responses, countries where the fiscal and monetary authorities are more divergent regarding their preferences for output and inflation gaps will exhibit larger primary deficits and real interest rates. Given the highly simplified nature of our game-theoretic model, this conclusion would apply only after controlling for other factors affecting the level of primary deficits and domestic real interest rates.

We run separate regressions for the primary deficit (as ratio to GDP) and the

[1] We must acknowledge that the coordination solution against which we compare the Nash and Stackelberg equilibria is not derived endogenously in the model. This is because the game we analyze is a "one-shot" game. Endogenous coordination, which is out of the scope of this paper, may arise in the context of a repeated game, where it would be sustained by reputation, commitment and credibility.

real domestic interest rate (as deviation from the international interest rate). Then, we assess whether proxies for the preference divergence between fiscal and monetary authorities are positively related to primary deficits and real domestic interest rates. The proxies we use are indices on how important price stability is for the country's respective central bank. In these regressions we control for a number of effects that may influence (or be influenced by) the dependent variables, such as business cycle effects, international conditions, and Ricardian-equivalence effects.

Using a seemingly-unrelated-regression estimator and accounting for country random effects, we find that, *ceteris paribus*, the larger the importance placed on inflation control by the monetary authority, the larger would be both the primary deficit and the domestic real interest rate.

We conclude that, without prejudice to the gains from central bank independence, there are gains to be made from policy coordination by monetary and fiscal authorities. Central bank independence has helped achieve price stability and has induced fiscal discipline in many countries. As mentioned above, this is a necessary, first-generation reform. A policy implication of this paper is that a second-generation reform consisting of institutional incentives for domestic policy coordination can be beneficial. However, this would be the case only for countries that have already achieved price stability and fiscal discipline.

2 A Game-Theoretic Model

This section presents a one period model of a simple game played by monetary and fiscal authorities. It builds from the trade-off that each authority has to face in the short-run between changes in the inflation rate and the output gap (Phillips Curve). The model emphasizes the effects on the level of fiscal deficits and real interest rates that result from different preferences by the monetary and fiscal authorities with respect to inflation and output deviations from their optimal level.

This game-theoretic approach is based on Frankel (1988), Loewy (1988) and Nordhaus (1994). The main difference between Frankel's model and ours is that Frankel assumes a world where the authorities have the same preference with respect to inflation and output deviations but disagree on the model that best represents the economy [2]. With respect to Nordhaus' model, the main difference is that we assume that the monetary authority dislikes changing the real interest rate from its optimal level. As we show below, in the presence of this assumption it is possible to revert Nordhaus' conclusion that the lack of coordination between monetary and fiscal authorities implies necessarily higher fiscal deficits and higher real interest rates. Also extending Nordhaus' work, we analyze the Stackelberg equilibrium, which allows us to assess whether the main conclusions change if the monetary/fiscal game is played sequentially.

Other two important differences with respect to previous work are that, first, we assume asymmetric preferences and, second, we analyze separately aggregate supply and demand shocks (the latter are studied in the appendix).

2.1 The model

We assume that policy makers seek to maximize an asymmetric utility function. Both fiscal and monetary authorities dislike output falls and inflation hikes; however, they do not mind output rises or inflation drops. In addition, we assume that both authorities dislike changing their respective policy instrument from its equilibrium level.

The utility level for the fiscal authority is denoted by U^F and its relative preference between objectives is given by the coefficients α^F, β^F and δ. They measure respectively the cost associated to output falling below a certain threshold $(y - y^*)$, to inflation rising beyond a desired level $(\pi - \pi^*)$ and to deficit deviations from a socially optimal level $(D - D^*)$. Note that $\alpha^F, \beta^F, \delta \geq 0$.[3]

$$U^F = V^F\{(y - y^*), (\pi - \pi^*), (D - D^*)\}$$
$$U^F = -\alpha^F\{\min(y - y^*, 0)\}^2 - \beta^F\{\max(\pi - \pi^*, 0)\}^2 - \delta(D - D^*)^2 \tag{1}$$

The monetary reaction function is modeled with the same structure, but instead of the deficit deviation it has an intrinsic preference over its instrument, the real

[2]Frankel concludes that policy coordination may not be welfare improving if it means a departure from the "true" model. However, coordination would be more likely to be welfare improving if this means sharing information and agreeing on a common model for the economy.

[3]More precisely, D represents the overall deficit minus interest payments (primary deficit).

interest rate (r). As in equation (1), U^M represents the monetary authority utility level and α^M, β^M and τ measure respectively the cost associated to output falling below a certain threshold $(y - y^*)$, to inflation rising beyond a desired level $(\pi - \pi^*)$ and to real interest rate deviations from its socially optimal level $(r - r^*)$. Note that $\alpha^M, \beta^M, \tau \geq 0$.

$$U^M = V^M\{(y - y^*), (\pi - \pi^*), (r - r^*)\}$$

$$U^M = -\alpha^M\{\min(y - y^*, 0)\}^2 - \beta^M\{\max(\pi - \pi^*, 0)\}^2 - \tau(r - r^*)^2 \qquad (2)$$

The assumptions that $\delta, \tau \neq 0$ can be justified as reflecting: i) a political cost faced by the monetary and fiscal authorities of changing their respective instruments, and ii) a real cost over the economy in the long run coming from policy induced deviations from the optimal levels (e.g. high cost of capital may have effects over the long-run rate of growth).

We assume that the monetary authority cares more for inflation hikes than the fiscal authority does. Conversely, the fiscal authority is more concerned about output drops than its monetary counterpart is. That is , $\beta^M > \beta^F$ and $\alpha^F > \alpha^M$. Thus, the divergent authorities' preferences reflect both the Central Bank's mission to contain inflation and the voters' aversion to unemployment that the fiscal authority has to deal with. We assume that the socially optimal levels y^*, r^*, D^*, and r^* are perceived to be the same by both authorities.

The forces that rule the economy are modeled as follows:

$$y - y^* = \gamma_D(D - D^*) - \gamma_r(r - r^*) + \gamma_0 \qquad (3)$$

$$\pi - \pi^* = \lambda_y(y - y^*) - \lambda_0 \qquad (4)$$

Equation (3) gives the aggregate demand function and (4) gives aggregate supply (or Phillips Curve). The term $(y - y^*)$ represents the output gap, $(\pi - \pi^*)$ represents the inflation level deviation from the optimal rate, γ_D and γ_r represent respectively the output gap elasticity to fiscal deficits and to real interest rate, and λ_y represents the inflation elasticity to output gap. Aggregate demand and supply shocks are represented respectively by γ_0 and λ_0. For simplicity, we set $D^*, r^* = 0$.[4]

[4]In modern macroeconomics, the Phillips Curve is given by the relation between unexpected changes in the inflation rate and the output gap. However, in our one-period model, unexpected changes in the inflation rate can be represented by $\pi - \pi^*$.

In what follows we concentrate on aggregate supply shocks, which in our model create a trade-off between output and inflation for both authorities. In the appendix we study the fiscal and monetary response to aggregate demand shocks; we show that the central hypothesis of the model, tested in the empirical section, holds for this type of shock as well.

The solution for the case of a positive aggregate supply shock ($\lambda_0 > 0$) is trivial. This results from the type of asymmetric loss functions that we have assumed. A positive supply shock leaves inflation lower than π^* and output higher than y^*, in which case neither authority suffer a loss and thus their is no policy response. On the other hand, a negative supply shock lowers output and increases inflation, thus inducing a policy reaction by both authorities. It is this case which we study in detail in the following sections

Given a negative supply shock, the loss functions (equations 1 and 2) can be written as follows:

$$U^F = -\alpha^F (y - y^*)^2 - \beta^F (\pi - \pi^*)^2 - \delta (D - D^*)^2 \tag{5}$$

$$U^M = -\alpha^M (y - y^*)^2 - \beta^M (\pi - \pi^*)^2 - \tau (r - r^*)^2 \tag{6}$$

This simplification is correct because, as we show below, the resulting equilibrium level of output is lower than y^* and inflation is higher than π^*. In other words, the solution is interior to the range $y < y^*$ and $\pi > \pi^*$.

2.2 Single economic authority

First we determine the optimal levels of D and r in the case that each authority is able to determine both instruments (single economic authority). This will give us their respective "bliss points." We can then compare the situation when each authority determines its own instrument under lack of coordination with alternative scenarios such as first, a single economic authority managing both monetary and fiscal policies, and, second, the two authorities working under policy coordination.[5]

[5] By coordination we understand the process through which two independent authorities negotiate their strategies in order to improve results for both.

When the fiscal authority also determines the interest rate, the first order conditions (F.O.C.s) are:

$$\frac{\partial U^F}{\partial D} = -2\alpha^F(y-y^*)\gamma_D - 2\beta^F(\pi-\pi^*)\lambda_y\gamma_D - 2\delta D = 0 \tag{7}$$

$$\frac{\partial U^F}{\partial r} = 2\alpha^F(y-y^*)\gamma_r + 2\beta^F(\pi-\pi^*)\lambda_y\gamma_r = 0 \tag{8}$$

From (7), and substituting (3) and (4), we obtain the fiscal reaction function (FRnFn):

$$\text{FRnFn:} \quad D = \left[\frac{1}{1+\frac{\delta}{\gamma_D^2(\alpha^F+\beta^F\lambda_y^2)}}\right]\frac{\gamma_r}{\gamma_D}r + \left[\frac{\lambda_y\lambda_0}{\frac{\delta}{\beta^F\gamma_D}+\gamma_D(\alpha^F/\beta^F+\lambda_y^2)}\right] \tag{9}$$

From (8) we obtain what we call the fiscal cross maximization function (FCrMx) because it results from the fiscal authority optimization over the "cross" instrument (i.e. the real interest rate).

$$\text{FCrMx:} \quad D = \frac{\gamma_r}{\gamma_D}r + \left[\frac{\lambda_y\lambda_0}{\gamma_D(\alpha^F/\beta^F+\lambda_y^2)}\right] \tag{10}$$

Figure 2 shows equations (9) and (10), FRnFn (Fiscal Reaction Function) and FCrMx (Fiscal Cross Maximization) respectively. The intersection of these two equations results in the optimal pair (D^F, r^F), the fiscal authority's bliss point. The maximization is achieved at the fiscal's optimal level of aggregate demand with $D^F = 0$. This result is to be expected given the fiscal authority's dislike of deviating the public deficit from its optimal level. From the fiscal authority utility function (5) we can see that it is costless to obtain the optimal aggregate demand level using r instead of D as the policy instrument.

The dotted lines in Figure 2 and the ones that follow, represent iso-aggregate demand levels (iso-AD). The slope of the aggregate demand function is γ_r/γ_D. From equation (10), the slope of FCrMx is γ_r/γ_D, so this line also represents an aggregate demand level, which in this case is the optimal fiscal activity level.

Analogously, we can obtain the monetary authority's bliss point. When the central bank determines both D and r, the F.O.C.s are derived from the maximization of the central bank's utility function (6) with respect to both instruments. The Monetary Reaction Function (MRnFn) is given by:

$$\begin{aligned}\frac{\partial U^M}{\partial r} &= 0 \Longrightarrow \\ \text{MRnFn:} \quad D &= \left[1 + \frac{\tau}{\gamma_r^2(\alpha^M + \beta^M \lambda_y^2)}\right] \frac{\gamma_r}{\gamma_D} r + \left[\frac{\lambda_y \lambda_0}{\gamma_D(\alpha^M/\beta^M + \lambda_y^2)}\right] \end{aligned} \qquad (11)$$

and the Monetary Cross Maximization (MCrMx) is given by:

$$\begin{aligned}\frac{\partial U^M}{\partial D} &= 0 \Longrightarrow \\ \text{MCrMx:} \quad D &= \frac{\gamma_r}{\gamma_D} r + \left[\frac{\lambda_y \lambda_0}{\gamma_D(\alpha^M/\beta^M + \lambda_y^2)}\right] \end{aligned} \qquad (12)$$

The monetary authority's bliss point, pair (D^M, r^M), is obtained in the same way as for the fiscal authority. Its optimal aggregate demand level is reached with its instrument unchanged, $r = 0$. Figure 2 shows that the level of aggregate demand obtained at the monetary bliss point is lower than the one reached at the fiscal bliss point. This comes from the relationship between α^F/β^F and α^M/β^M, the authorities' relative preferences for inflation and output $(\alpha^F/\beta^F > \alpha^M/\beta^M)$.[6]

What happens if the monetary authority presents a higher preference loss related to inflation? (higher β^M). The central bank's optimal aggregate demand will decreases in other to reach lower inflation. As discussed in the paragraph above, this change in the bliss point represents a downward movement along the D axe.

Summarizing, the simple scenarios of non-independence (single economic authority) shows: i) the effects over activity caused by different preference in the authority's utility function, and ii) the desire of each authority to use the other's instrument to adjust the output and inflation gaps and thus optimize its utility function.

In addition to the cases of non-independence, it is interesting to study the case where there is coordination between independent powers. The contract curve shown in Figure 2 describes the possible solutions for this scenario. It is the group of points where there is no possibility to improve the situation of one player without diminishing

[6]Remember that the dotted lines represent iso-AD. In this case, the MCrMx (12) gives the bliss aggregate demand level for the monetary authority.

the utility level of the other. In other words, the contract curve is the line that contains the tangents points between the two sets of iso-utility curves.[7]

Even though with independent authorities, points on the contract curve seem to be the best solution to both players, this coordinated equilibrium may not be enforceable and thus unlikely to be achieved. In the real world, the existence of independence plus i) the obstacles to enforce all commitments, ii) the transaction costs that hinder the coordination process and iii) the practical inability to discern outcomes due to policies from those due to shocks suggest that actual policy actions may be more realistically modeled as Nash or Stackelberg games.

2.3 The Nash equilibrium

The Nash equilibrium applies when both players decide simultaneously and without coordination their respective strategies. In the monetary-fiscal game, this means that each authority has to decide the level of its instrument knowing that its counterpart is rational and has certain preference over inflation and output gaps. Then, the Nash equilibrium will result in a pair (D^N, r^N) in which no player can reach a higher utility level by unilaterally deviating from it.

The Nash solution is obtained when each authority maximizes its utility function with respect to its own instrument, taken the other policy instrument as given. Equations (7) and (11) represent the F.O.C.s of the Nash solution. Thus, the reaction function of the fiscal authority (FRnFn) is given by equation (9):

$$\text{FRnFn:} \quad D = \left[\frac{1}{1+\frac{\delta}{\gamma_D^2(\alpha^F+\beta^F\lambda_y^2)}}\right]\frac{\gamma_r}{\gamma_D}r + \left[\frac{\lambda_y\lambda_0}{\frac{\delta}{\beta^F\gamma_D}+\gamma_D(\alpha^F/\beta^F+\lambda_y^2)}\right] \quad (9)$$

and the monetary authority's reaction function (MRnFn) by equation (11):

$$\text{MRnFn:} \quad D = \left[1+\frac{\tau}{\gamma_r^2(\alpha^M+\beta^M\lambda_y^2)}\right]\frac{\gamma_r}{\gamma_D}r + \left[\frac{\lambda_y\lambda_0}{\gamma_D(\alpha^M/\beta^M+\lambda_y^2)}\right] \quad (11)$$

Comparing these two equations we can see that: i) the slope of MRnFn is higher than γ_r/γ_D and the slope of FRnFn is lower than γ_r/γ_D, which reflects the loss

[7] The shape of the iso-utilities shown in Figure 2 depends on the authorities' utility function parameters: i) the relative preference for inflation and output gaps and ii) the relative cost associated with deviations of the respective instrument.

associated to deviating their respective policy instrument from its optimal level, and ii) the intercept of MRnFn is more negative than that of FRnFn, which results from the monetary authority's lower loss from output gaps (and higher loss from inflation gaps) than the fiscal authority (see Figure 3)

The intersection of MRnFn and FRnFn gives the Nash solution. After a fair amount of algebra, the solution of the Nash equilibrium is given by,

$$D^N = \frac{-\gamma_r^2 \lambda_y (\alpha^F \beta^M - \alpha^M \beta^F)\lambda_0 + \tau \beta^F \lambda_y \lambda_0}{\gamma_r^2 \delta / \gamma_D (\alpha^M + \beta^M \lambda_y^2) + \tau \delta / \gamma_D + \gamma_D \tau (\alpha^F + \beta^F \lambda_y^2)} \tag{13}$$

$$r^N = \frac{-\gamma_D^2 \lambda_y (\alpha^F \beta^M - \alpha^M \beta^F)\lambda_0 - \delta \beta^M \lambda_y \lambda_0}{\gamma_r \delta (\alpha^M + \beta^M \lambda_y^2) + \tau \delta / \gamma_r + \gamma_D^2 \tau / \gamma_r (\alpha^F + \beta^F \lambda_y^2)} \tag{14}$$

From equation (13) note that the sign of D^N doesn't have to be strictively positive. In fact D^N will be negative if the preference difference between monetary and fiscal authorities is small with respect to the utility loss of changing the interest rate from its optimal long-run level. This case, however, is of little practical importance. This is so because in the presence of a negative supply shock, central bank independence would result in a higher inflation rate with respect to the fiscal bliss point (see Figure 5). Therefore, in what follows we assume that the condition given in equation (15) holds, so that the Nash equilibrium always implies higher deficits and real interest rates than the solution under a single economic authority. Intuitively, this condition requires that the central bank values low inflation sufficiently more than the fiscal authority and sufficiently more than keeping the interest rate at its long-run level.

$$\alpha^F \beta^M - \alpha^M \beta^F > \tau \frac{\beta^F}{\gamma_r^2} \tag{15}$$

The Nash equilibrium portrayed in Figure 3 represents the conclusion given in Loewy (1988) and Nordhaus (1994): the levels of the real interest rate and the fiscal deficit in the Nash equilibrium are higher than those given in either bliss point. In fact, the aggregate demand level obtained at the Nash equilibrium can be achieved by a large number of combinations of lower deficits and interest rates. The Nash equilibrium (D^N, r^N) is Pareto inferior to a large set of points, particularly the contract curve between the two bliss points.

Why does this "inefficiency" occur? The following example, presented in the Box of Figure 3, may clarify the intuition behind this result. Starting from the fiscal bliss point (D^F, r^F), suppose that the central bank is granted independence and no coordination is possible. The monetary authority could react to the initial aggregate demand level by increasing r to a new level, through which it can maximize its utility function for the fiscal deficit $D = 0$ (point 1). A rational fiscal authority knows this possible reaction and the aggregate demand level that it implies, and thus it could react with a D level that maximizes its own utility function given the new real interest rate level (point 2). Analogously, the monetary authority could reset its instrument to a new optimal level given the latest fiscal reaction (point 3). As we can see from the figure, both authorities will continue to adjust their respective policy instrument until no player can improve its utility given the rational reaction of the other player. This equilibrium is represented by the optimal pair (D^N, r^N).

What happens if the difference in preferences between the two authorities becomes wider (the difference between α^F/β^F and α^M/β^M gets higher)? Modeled as higher β^M ($\widehat{\beta}^M > \beta^M$), from Figure 4 we can see that the new equilibrium $(D^{\widehat{N}}, r^{\widehat{N}})$ will necessarily be located to the north-east of (D^N, r^N), which means higher levels of both instruments and lower inflation and aggregate demand. Both the intercept and the slope of MRnFn will be lower if β^M increases to $\widehat{\beta}^M$, reflecting the lower desired aggregate demand level that results from the stronger central bank's anti-inflation preference. [8]

Summarizing, modeled as a Nash game, the uncoordinated policy reaction of fiscal and monetary authorities to a negative supply shock results in higher fiscal deficits and higher real interest rates than those obtained if either authority determine both instruments. Moreover, when the authorities become more divergent on their preferences for output and inflation gaps, the resulting fiscal deficit and real interest rate become larger.

Finally, substituting the resulting D^N and r^N in the output gap equation (3) and in the inflation equation (4), it can clearly be seen that the equilibrium output is lower than y^* and inflation higher than π^*. In other words, the solution is interior to

[8]This result is maintained if we modeled the increase in preference's difference as a higher α^F, lower α^M or lower β^F. The last two results can easily be derived from the resulting values of D^N and r^N.

the range $y < y^*$ and $\pi > \pi^*$. Thus, it is valid to assume that given a negative supply shock the authorities' utility function can be modeled as the simple quadratic form of equations (5) and (6).

2.4 The Stackelberg equilibrium

Whereas the Nash equilibrium is obtained when both players move simultaneously, a sequential play of the game leads to the Stackelberg equilibrium. For the monetary-fiscal game this means that one authorities decides first the magnitude of its instrument and the other one follows it. Assume first that the monetary authority is the leader. The opposite case is analyzed at the end of this section.

In the Stackelberg game, when the central bank is the leader, it knows that the fiscal reaction to its move will be ruled by equation (9), the optimal response of the fiscal authority to a given real interest rate. Thus, the follower's (fiscal) reaction function is given by:

$$\text{FRnFn:} \quad D = \left[\frac{1}{1+\frac{\delta}{\gamma_D^2(\alpha^F+\beta^F\lambda_y^2)}}\right]\frac{\gamma_r}{\gamma_D}r + \left[\frac{\lambda_y\lambda_0}{\frac{\delta}{\beta^F\gamma_D}+\gamma_D(\alpha^F/\beta^F+\lambda_y^2)}\right] \tag{9}$$

The central bank's F.O.C. as the leader of the Stackelberg game is obtained by maximizing U^M with respect to r, taking into account that the central bank is now able to affect D according to the fiscal authority's reaction function (9). We can then express the monetary authority's "action" function (MAnFn) as follows:

$$\text{MAnFn:} \quad D = \left[1+\frac{\tau}{\Phi\gamma_r^2(\alpha^M+\beta^M\lambda_y^2)}\right]\frac{\gamma_r}{\gamma_D}r + \left[\frac{\lambda_y\lambda_0}{\gamma_D(\alpha^M/\beta^M+\lambda_y^2)}\right] \tag{16}$$

where

$$\Phi = \frac{1}{1+\frac{\gamma_D^2(1+\beta^F\lambda_y^2)}{\delta}} < 1 \tag{17}$$

Substituting (9) into (16), we can determine the central bank's optimal magnitude for the real interest rate. Then, given r the fiscal authority decides its deficit according to (9). The Stackelberg solution is given by:

$$D^S = \frac{-\Phi\gamma_r^2\lambda_y(\alpha^F\beta^M-\alpha^M\beta^F)\lambda_0+\tau\beta^F\lambda_y\lambda_0}{\Phi\gamma_r^2\delta/\gamma_D(\alpha^M+\beta^M\lambda_y^2)+\tau\delta/\gamma_D+\gamma_D\tau(\alpha^F+\beta^F\lambda_y^2)} \tag{18}$$

$$r^S = \frac{-\Phi\gamma_D^2\lambda_y(\alpha^F\beta^M - \alpha^M\beta^F)\lambda_0 - \Phi\delta\beta^M\lambda_y\lambda_0}{\Phi\gamma_r\delta(\alpha^M + \beta^M\lambda_y^2) + \tau\delta/\gamma_r + \gamma_D^2\tau/\gamma_r(\alpha^F + \beta^F\lambda_y^2)} \tag{19}$$

As in the Nash equilibrium, the resulting fiscal deficit, equation (18), doesn't have to be strictively positive. As the authorities' preferences get more similar, the positive first term in the numerator gets smaller; and as τ, the relative cost of central bank's deviation of its instrument gets higher, the sum of the last two term becomes more negative. As previously, the case of a negative equilibrium deficit has little practical importance for it implies that central bank independence would result in a higher inflation rate with respect to the fiscal bliss point. Therefore, in what follows we assume that the condition given in equation (20) holds, so that the Stackelberg equilibrium always implies higher deficits and real interest rates than the solutions under a single economic authority.

$$\alpha^F\beta^M - \alpha^M\beta^F > \frac{\beta^F}{\gamma_r^2\Phi} \tag{20}$$

Figure 6 shows the Stackelberg equilibrium, which is the intersection between equation (16), MAnFn (Stackelberg), and equation (9), FRnFn. Similarly to the Nash solution the lack of policy coordination modeled as a Stackelberg game results in higher fiscal deficits and higher real interest rates than those obtained when either authority controls both policy instruments

In this case, what happens if the difference in preferences between the two authorities becomes wider (the difference between α^F/β^F and α^M/β^M gets higher)? As in the Nash game, modeled as higher β^M ($\widehat{\beta}^M > \beta^M$), the new equilibrium $(D^{\widehat{S}}, r^{\widehat{S}})$ will necessarily be located to the north-east of (D^S, r^S), which means higher levels of both instruments and lower inflation and aggregate demand. [9]

Relative to the Nash solution, the Stackelberg equilibrium produces lower deficits and interest rates. When the monetary authority is the leader it also implies a higher level of activity (and inflation) and allow both authorities to reach a higher iso-utility curve than in the Nash equilibrium. The Box in Figure 6 shows the case in which the fiscal authority is the leader. In this scenario the conclusions are similar except that the resulting aggregate demand level is lower with respect to the Nash solution.

[9] As in the Nash game, this result is maintained if we modeled the increase in preference's difference as a higher α^F, lower α^M or lower β^F. The last two results can easily be derived from the resulting values of D^S and r^S.

Finally, with the same procedure used in the Nash game, it can clearly be seen that the Stackelberg solution is interior to the range $y < y^*$ and $\pi > \pi^*$. Thus, it is valid to assume that given a negative supply shock the authorities' utility function can be modeled as the simple quadratic form of equations (5) and (6).

2.5 Main conclusions

We have modeled the lack coordination between fiscal and monetary authorities as, alternatively, Nash or Stackelberg games. Under the assumptions that i) the monetary authority loses more from inflation than output gaps than the fiscal authority does, and ii) the monetary authority is sufficiently willing to modify its instrument, we find three main conclusions.

First, in the presence of a negative supply shock the lack of coordination results in higher fiscal deficits and interest rate than those obtained when either authority controls both instruments. Second, when the preference divergence between the monetary and fiscal authorities increases, so do the equilibrium fiscal deficits and interest rate. As we show in the appendix, the latter result holds not only for negative supply shocks, but also in the presence of aggregate demand shocks. This is the main conclusion tested in the empirical section of the paper.

Third, when the relationship between the fiscal and monetary authorities can be represented as a leader-follower relationship, the Stackelberg solution applies. In this case, the previous two conclusions are also valid, but in a milder form: the Stackelberg solution produces levels of fiscal deficits and interest rates that are in between the policy-coordination solution and the Nash equilibrium.

3 Empirical Evidence

The main conclusion of the theoretical section can be summarized as follows. In a context where fiscal and monetary authorities are independent and do not effectively coordinate their policy responses, countries and time periods where the fiscal and monetary authorities are more divergent regarding their preferences for output and inflation gaps will exhibit larger primary deficits and real interest rates. Given the highly simplified nature of our game-theoretic model, this conclusion would apply only after controlling for other factors affecting the level of primary deficits and domestic real interest rates.

In this section, we bring to bear some empirical evidence concerning our main conclusion. We base this evidence on regressions using both cross-country and time-series data. This choice is justified by the nature of our conclusion, which compares different policy regimes within and between countries.

3.1 The empirical model

Let d be the primary deficit (properly normalized to be comparable across countries and over time) and r the real domestic interest rate (specifically, its portion subject to changes in policy.) Then, consider the following two regression equations:

$$d_{i,t} = \beta_d X_{i,j} + \theta_d m f_{i,t} + \varepsilon_{i,t} \tag{21}$$

$$r_{i,t} = \beta_r X_{i,j} + \theta_r m f_{i,t} + \mu_{i,t} \tag{22}$$

where *mf* is an indicator of the preference difference between monetary and fiscal authorities regarding inflation and output gaps, X is a set of control variables, and the subscripts i and t denote country and time, respectively. We assume that there is cross-country homogeneity in the response of primary deficits and real interest rates to changes in *mf* and X, thus the coefficients β and θ are the same across countries and over time.

Hypothesis test. The test of our main hypothesis is based on the sign and significance of both θ_d and θ_r. If both are significantly positive, we conclude that an increase in the preference divergence between monetary and fiscal authorities rises, *ceteris paribus*, the primary deficit and the real interest rate, thus supporting our main hypothesis.

Sample. We use a pooled data set of annual observations for the period 1970-94 covering most industrialized countries. Since the paper focuses on the interaction of fiscal and monetary policies towards stabilization, we cannot use countries where the fiscal-monetary relationship has been dominated by the inflationary finance of the fiscal deficit. We recognize that in that case, the issues analyzed in this paper are of second order importance. That is the reason why in the empirical section we do not work with developing countries or with OECD countries that have experienced relatively high inflation over the last three decades; this is the case of Greece (average inflation: 14%), Iceland (24%), and Portugal (14%.) For the remaining industrial countries the average inflation rate for the period has been below 10%. In the 1990s many developing countries have pursued stabilization policies that brought their inflation rate down to single digits (notably, Argentina, Bolivia, Peru, and Poland.) In so far as these countries do not revert to using the inflation tax as a means to finance their fiscal deficit, the issues and policy biases put forward in this paper are relevant for them. However, given that their period of stability is too recent, we cannot include them in the paper's empirical analysis. The industrialized countries in the sample are Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, the United Kingdom, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Sweden, and the United States.

Structure of the error terms and method of estimation. Regarding the characteristics of the error terms in the deficit and interest-rate regressions, we work under the following two alternative sets of assumptions:

a) Joint endogeneity of d and r and no country random effects: We allow for the joint endogeneity of d and r by admitting a contemporaneous correlation between their respective error terms. However, we assume that each error term is uncorrelated both serially and across countries. In this case the method of estimation is the seemingly unrelated regression estimator ($SURE$) applied to pooled data.

$$E\left[\varepsilon_{i,t}\mu_{j,s}\right] = \sigma_{\varepsilon\mu} \text{ for } i = j,\ t = s \text{ and } 0 \text{ otherwise} \tag{23}$$

$$E\left[\varepsilon_{i,t}\varepsilon_{j,s}\right] = \sigma_{\varepsilon\varepsilon} \text{ for } i = j,\ t = s \text{ and } 0 \text{ otherwise} \tag{24}$$

$$E\left[\mu_{i,t}\mu_{j,s}\right] = \sigma_{\mu\mu} \text{ for } i = j,\ t = s \text{ and } 0 \text{ otherwise} \tag{25}$$

b) Joint endogeneity of d and r and country random effects: As in the previous case, we allow for the joint endogeneity of d and r by admitting a contemporaneous correlation between their respective error terms. Additionally, in this case we allow the error terms corresponding to the same country to be correlated. However, we keep the assumption that the error terms of different countries be uncorrelated. In this case the method of estimation is the seemingly unrelated regression estimator

($SURE$) joint with the random effects estimator applied to pooled data.

$$E\left[\varepsilon_{i,t}\mu_{j,s}\right] = \sigma_{\varepsilon\mu} \text{ for } i = j,\ t = s \text{ and } 0 \text{ otherwise} \tag{26}$$

$$E\left[\varepsilon_{i,t}\varepsilon_{i,t}\right] = \sigma_{\varepsilon\varepsilon},\ E\left[\varepsilon_{i,t}\varepsilon_{i,s}\right] = \sigma_{R\varepsilon} \text{ for } t \neq s \text{ and } E\left[\varepsilon_{i,t}\varepsilon_{j,s}\right] = 0 \text{ for } i \neq j \tag{27}$$

$$E\left[\mu_{i,t}\mu_{i,t}\right] = \sigma_{\mu\mu},\ E\left[\mu_{i,t}\mu_{i,s}\right] = \sigma_{R\mu} \text{ for } t \neq s \text{ and } E\left[\mu_{i,t}\mu_{j,s}\right] = 0 \text{ for } i \neq j \tag{28}$$

Dependent variables. For the deficit regression, the dependent variable is the ratio of the central government's primary deficit (total deficit minus interest payments) to GDP. Dividing by GDP makes the scale (or metric) of primary deficits such that it can be used for regressions across countries and over time. For the interest-rate regression, the dependent variable is the domestic real interest rate minus the international rate. We use the deviations from the international rate to account for the fact that domestic rates are heavily influenced by parity conditions in countries with open capital accounts.[10]

Control variables. Our main hypothesis deals with only one of the many potential determinants of primary fiscal deficits and domestic real interest rates. Therefore, in order to test it we must control for other variables that influence or are influenced by primary deficits or domestic real interest rates. We use the same control variables for both regressions. To account for the real effects of the business cycle, we use both the current GDP growth rate (G) and the growth rate deviation from its previous five-year average (GD). We include the current inflation rate (π) to control for seignorage-related factors and its deviation from the previous five-year average (πD) to control for the price effects of the business cycle. In order to account for international conditions and shocks, we incorporate the terms of trade (TOT) and the average growth rate of all industrialized countries ($GOECD$). Finally, to control for Ricardian-equivalence effects, we use the private saving rate (sp).

Proxies for the variable of interest. The variable whose effect on fiscal primary deficits and domestic interest rates we want to assess is the preference difference between monetary and fiscal authorities regarding inflation and output gaps. We proxy for this variable with measures of the central bank's commitment to control inflation,

[10]Nominal domestic rates are deflated by an average of current and next-year inflation rates. The international real interest rate is the nominal Eurodollar London rate adjusted with the CPI percentage change for industrial countries.

as expressed in its charter. This is an appropriate proxy under the maintained assumption that the fiscal authorities' relative preference for output and inflation gaps does not vary much over time and across countries.

The first two proxies are based on the 1992 paper by Cukierman, Webb and Neyapti (CWN, for short). The first one (πobj) is their index for the importance of price stability as a central bank objective. [11] This proxy covers most industrialized countries and many developing countries over the period 1970-89. The second proxy (πobj-a) results from updating the CWN's index up to 1994. The update is done assuming that the central banks of the sample countries have not changed their stance about inflation *except* when they explicitly adopted an inflation-targeting regime.

The third proxy ($\pi targ$) is a dummy variable for whether the Central Bank has an explicit inflation-targeting regime. Except for the case of Germany, explicit inflation-targeting regimes have been adopted rather recently: Australia (1993), Canada (1991), Finland (1993), New Zealand (1990), and Sweden (1993). In addition, we use CWN's index of central bank independence (*cbi*), exclusive of the price-stability objective, in order to compare the effects of central bank independence with those of central bank preference for price stability.

3.2 Discussion of results

Tables 1, 2 and 3 present the estimation results. The first two tables use the proxies based on how important the inflation objective is for the central bank (πobj, πobj-a, and $\pi targ$). The third table presents the results using the index of central bank independence (*cbi*) as the explanatory variable of interest. In each table, we present the regression results by pairs of the primary deficit and the real interest rate as dependent variables in each SURE system. Whereas the estimation presented in Table 1 is performed under the assumption of homoskedasticity and independence

[11] CWN's index for the inflation objective of the central bank is based on explicit information contained in its charter. The index goes from 0 to 1. The specific values are assigned according to the following criteria: 1 if *price stability is mentioned as the only or major goal, and in case of conflict with government CB has final authority to pursue policies aimed at achieving this goal*; 0.8 if *price stability is mentioned as the only goal*; 0.6 if *price stability is mentioned along with other objectives that do not seem to conflict with price stability (e.g., stable banking)*; 0.4 if *price stability is mentioned with a number of potentially conflicting goals (e.g., full employment)*; 0.2 if *central bank charter does not contain any objectives for the central bank* and 0 if *some goals appear in the charter but stability is not one of them.*

across countries and over time, the estimation results in Table 2 are obtained through a country random-effects model. Table 3 presents both estimation methods for the case of *cbi* as explanatory variable.

The estimation results presented in Tables 1 and 2 broadly support our main hypothesis. Controlling for shocks and economic conditions that influence primary deficits and the real interest rate, countries and time periods where the central bank places a larger importance on keeping inflation down are associated with both larger primary deficits and real interest rates. In the case of π*obj-a*, the proxy with largest coverage and signal variance, its effect on both the primary deficit (as ratio to GDP) and the real interest rate (as deviation from the international rate) is positive and significant at the 5% level. The sign, significance and even size of the corresponding coefficients are virtually the same both ignoring and controlling for country random effects. The estimated coefficients with the random-effects model imply that a 1 standard deviation increase in π*obj-a* is associated with both a primary deficit increase of 0.56% of GDP and a rise of the domestic real interest rate by 0.46 percentage points over the international rate.

The results obtained with the other two proxies based on the central bank's concern for price stability, π*obj* and π*targ*, are fairly similar. The estimated coefficients are always positive. In most cases they are statistically significant at conventional levels (5% or 10% significance), and in the rest they are at least marginally significant (the largest p-value is 17%).

In Table 3, we study whether measures of central bank independence would render the same results as the measures of central bank's concern for price stability. We find no significant effects of central bank independence on primary deficits under either estimation method. Central bank independence does have a positive and significant effect on real interest rates when homoskedasticity and independence of the error term is assumed. However, the statistically significance of this result vanishes when country random effects are allowed for. Comparing the results of Table 3 with those of Tables 1 and 2, we conclude that having an independent central bank is not by itself conducive to the policy biases that result from the lack of policy coordination. The key issue is the divergence of objectives (revealing different preferences) between fiscal and monetary authorities.

Finally, we give a note of caution. In the empirical exercises presented in the paper, we have proxied the preference divergence between fiscal and monetary authorities with measures of the central bank's concern with price stability. However, policy implications should be derived with respect to the variable of interest (difference in preferences) and not with respect to its proxy. We worked under the assumption that fiscal authorities' preferences are relatively constant across countries and over time. We adopted this empirical approach for convenience given that it is easier to find empirical measures for central bank's objectives than for those of fiscal authorities. Thus, the note of caution is that the empirical results of the paper should not be taken to imply that in order to reduce the described policy biases, the central bank should unilaterally lower its standards for inflation control. Rather, the policy implication we favor is that coordination both at the level of setting objectives and at the level of policy implementation can alleviate the biases that move the economy to sub-optimally higher fiscal deficits and real interest rates.

Table 1: The Effects of Different Preferences Between Fiscal and Monetary Authorities on Deficits and Real Interest Rates

Sample: 19 Industrial Countries, 1970 – 1994

Estimation: SURE, independence and homoskedasticity

		SURE 1		SURE 2		SURE 3	
Dependent Variable		D/GDP	r-r^{int}	D/GDP	r-r^{int}	D/GDP	r-r^{int}
Preference for	**πobj**	.010	.011				
inflation control		(2.5)	(2.29)				
	πobj-a			.012	.013		
				(2.85)	(3.06)		
	πtarg					.008	.013
						(1.56)	(2.52)
Growth		-.114	-.002	-.350	-.162	-.315	-.110
		(-.99)	(-.02)	(-3.12)	(-1.38)	(-2.77)	(-.93)
Growth deviation		.197	-.192	.353	-.126	.335	-.163
		(1.52)	(-1.25)	(2.81)	(-.96)	(2.62)	(-1.22)
Inflation		.366	-.204	.374	-.336	.377	-.323
		(9.46)	(-4.48)	(9.77)	(-8.36)	(9.47)	(7.78)
Inflation deviation		-.324	-.393	-.313	-.33	-.328	-.354
		(-4.88)	(-5.02)	(-4.47)	(4.44)	(-4.58)	(-4.72)
Terms of trade		-.05	.026	-.039	.048	-.04	.047
		(-3.77)	(1.68)	(-2.72)	(3.21)	(-2.8)	(3.11)
Growth OECD		-2.067	-.386	-.129	-.59	-.151	-.612
		(-2.2)	(-3.49)	(-1.31)	(-5.7)	(-1.52)	(-5.91)
Private saving		-.351	-.036	.34	-.013	.311	-.043
		(9.8)	(-.86)	(9.42)	(-.34)	(8.99)	(-1.2)
C		-.042	-.014	-.048	-.017	-.037	-.007
		(-2.59)	(-.73)	(-2.75)	(-.92)	(-2.18)	(-.36)
R^2		0.41	0.28	0.32	0.42	0.31	0.41
# Countries / Obs.		19/348	19/348	19/438	19/438	19/438	19/438

t-Statistics in parenthesis.

Table 2: The Effects of Different Preferences Between Fiscal and Monetary Authorities on Deficits and Real Interest Rates

Sample: 19 Industrial Countries, 1970 – 1994

Estimation: SURE, random effects

		SURE 1		SURE 2		SURE 3	
Dependent Variable		D/GDP	r-r^{int}	D/GDP	r-r^{int}	D/GDP	r-r^{int}
Preference for	**πobj**	.011	.014				
inflation control		(1.39)	(1.9)				
	πobj-a			.017	.014		
				(2.52)	(2.37)		
	πtarg					.012	.009
						(1.85)	(1.46)
Growth		-.189	.184	-.518	-.016	-.51	.001
		(-1.62)	(1.37)	(-4.44)	(-.13)	(-4.24)	(.01)
Growth deviation		.246	-.371	.504	-.303	.500	-.309
		(1.92)	(-2.5)	(3.92)	(-2.31)	(3.83)	(-2.30)
Inflation		.377	-.155	.382	-.374	.388	-.372
		(8.18)	(-3.02)	(9.19)	(-8.89)	(9.05)	(-8.54)
Inflation deviation		-.323	-.469	-.282	-.321	-.297	-.333
		(-4.80)	(-6.05)	(-4.04)	(-4.47)	(-4.17)	(-4.54)
Terms of trade		-.05	.003	-.04	.027	-.04	.026
		(-3.51)	(.16)	(-2.74)	(1.78)	(-2.72)	(1.72)
Growth OECD		-.177	-.352	-.079	-.556	-.095	-.571
		(-2.02)	(-3.43)	(-.84)	(-5.68)	(-1.01)	(-5.85)
Private saving		.3	-.108	.341	-.044	.319	-.068
		(5.99)	(-2.04)	(6.90)	(6.60)	(8.99)	(-1.46)
C		-.03	.014	-.046	.008	-.036	.018
		(-1.68)	(.69)	(-2.48)	(.41)	(-1.99)	(1.01)
R^2		0.51	0.41	0.42	0.51	0.42	0.50
# Countries / Obs.		19/348	19/348	19/438	19/438	19/438	19/438

t-Statistics in parenthesis.

Table 3: The Effects of Different Preferences Between Fiscal and Monetary Authorities on Deficits and Real Interest Rates

Sample: 19 Industrial Countries, 1970 – 1989

Estimation: SURE

		Independence and homoskedasticity		Random effects	
Dependent Variable		D/GDP	r-r^{int}	D/GDP	r-r^{int}
Preference for	**cbi**	-.004	.025	.0003	.014
inflation control		(-0.44)	(2.31)	(0.02)	(1.11)
Growth		-.11	.082	-.193	.231
		(-.95)	(.59)	(-1.64)	(1.7)
Growth deviation		.204	-.25	.257	-.4
		(1.53)	(-1.61)	(1.99)	(-2.66)
Inflation		.35	-.16	.378	-.122
		(8.15)	(-3.18)	(7.87)	(-2.23)
Inflation deviation		-.317	-.455	-.327	-.51
		(-4.49)	(-5.53)	(-4.73)	(-6.38)
Terms of trade		-.052	.025	-.051	-.001
		(-3.93)	(1.63)	(-3.54)	(-.1)
Growth OECD		-.214	-.403	-.181	-.35
		(-2.26)	(-3.64)	(-2.07)	(-3.48)
Private saving		.326	-.069	.286	-.153
		(9.41)	(-1.7)	(5.83)	(-2.78)
C		-.028	-.016	-.023	.023
		(-1.67)	(-.83)	(-1.22)	(1.06)
R^2		0.39	0.28	0.51	0.42
# Countries / Obs.		19/348	19/348	19/348	19/348

t-Statistics in parenthesis.

4 Conclusions

Central bank independence has contributed to achieve price stability and fiscal discipline for many countries. The conventional wisdom is that this is a necessary, first-generation reform of fiscal and monetary policy. The question this paper asks is whether a second-generation reform consisting of institutional incentives for domestic policy coordination could be beneficial. The paper presents a game-theoretic model where the fiscal and monetary authorities interact to stabilize the economy, having dissimilar preferences with respect to output and inflation gaps and controlling different policy instruments. It is assumed, realistically, that the monetary authority has a larger utility loss from inflation than output gaps than the fiscal authority does.

Modeled as either Nash or Stackelberg equilibria, the solution under lack of policy coordination implies that in the face of a negative supply shock the fiscal authority acts more liberally and the monetary authority more conservatively than if either controlled all policy instruments. Moreover, we find that an increase in the preference divergence between the monetary and fiscal authorities leads to, *ceteris paribus*, larger public deficits (the fiscal authority's policy instrument) and real interest rates (the central bank's instrument). This conclusion holds true in the presence of both negative demand and supply shocks.

The empirical section of the paper attempts to test the latter conclusion on a pooled sample of 19 industrial countries with annual information for the period 1970-94 and using a seemingly-unrelated regression estimator that allows for country random effects. Working under the assumption that the fiscal authorities' relative preference for output and inflation gaps do not vary much over time and across countries, we proxy for the preference divergence between monetary and fiscal authorities with measures of the central bank's commitment to control inflation. Controlling for other shocks and economic conditions, we find that countries and time periods where the central bank places a larger importance on keeping inflation low are associated with both larger primary deficits (as ratio to GDP) and domestic real interest rates (as deviations from international rates).

The empirical results of the paper should not be taken to imply that in order to reduce these policy biases, the central bank should unilaterally lower its standards for inflation control. Rather, the policy implication favored in the paper is that, without prejudice to the gains from central bank independence, coordination both at the level of setting objectives and at the level of policy implementation can alleviate the biases that move the economy to sub-optimally higher fiscal deficits and real interest rates. This goal must be achieved with "second generation reforms". These must deal with the issues that hinder the process of coordination, such as contract enforceability, transaction costs, and the practical inability to discern outcomes due to policies from those due to shocks.

References

[1] Cukierman, A. (1992). *Central Bank Strategy, Credibility, and Independence: Theory and Evidence*. MIT Press.

[2] Cukierman, A., S. B. Webb and B. Neyapti (1992). "Measuring the Independence of Central Banks and Its Effect on Policy Outcomes." *The World Bank Economic Review* 6(3): 353-398.

[3] Frankel, J. A. (1988). "The Implications of Conflicting Models for Coordination between Monetary and Fiscal Policymakers." In *Empirical Macroeconomics for Interdependent Economies*, edited by Bryant, R.C. *et al.*. Washington, Brooking Institution.

[4] Loewy, M. (1988). "Reganomics and Reputation Revisited." *Economic Inquiry*. Vol. XXVI (April): 253-263.

[5] Morandé, F. and K. Schmidt-Hebbel (1999). "The Scope for Inflation Targeting in Emerging Market Economies." *Mimeo*, Central Bank of Chile.

[6] Nordhaus, W. (1994). "Policy Games: Coordination and Independence in Monetary and Fiscal Policies." *Brooking Papers on Economic Activity* 2: 139-215.

[7] Perry, G. and D. Lederman (1997). "The Importance of Macroeconomic Policy Coordination: A Note". *Mimeo*, Office of the Chief Economist, Latin America and the Caribbean, The World Bank.

[8] Walsh, C. E. (1993). "Central Bank Strategies, Credibility and Independence: A Review Essay." *Journal of Monetary Economics* 32: 287-302.

Appendix: Response to aggregate demand shocks

In contrast to supply shocks, aggregate demand shocks ($\gamma_0 \neq 0$) move output and inflation in the same direction. Therefore, both positive and negative demand shocks bring forth a policy reaction by fiscal and monetary authorities. Neither solution is trivial, as was the case for positive supply shocks (given that the authorities do not care for inflation falls or output increases). In this appendix, we briefly analyze the fiscal and monetary response to aggregate demand shocks. We do it separately for positive and negative shocks.

In order to isolate the response to demand shocks, we set the aggregate supply shock equal to zero. Therefore, the economy's aggregate demand and supply functions are given by

$$y - y^* = \gamma_D (D - D^*) - \gamma_r (r - r^*) + \gamma_0 \quad \text{(A.1)}$$

$$\pi - \pi^* = \lambda_y (y - y)^* \quad \text{(A.2)}$$

A.1 Positive aggregate demand shocks ($\gamma_0 > 0$)

A positive demand shock induces a rise in output and inflation. Considering the type of asymmetric loss functions that we have assumed, only the inflation hike is of concern to fiscal and monetary authorities. In this case, the loss functions can be written as,

$$U^F = -\beta^F (\pi - \pi^*)^2 - \delta (D - D^*)^2 \quad \text{(A.3)}$$

$$U^M = -\beta^M (\pi - \pi^*)^2 - \tau (r - r^*)^2 \quad \text{(A.4)}$$

It is straightforward to show that the simplified loss functions above follows from the general loss functions in equations (1) and (2) in the presence of a positive demand shock. The key issue to realize is that the outcome for inflation and output is interior to the range $\pi > \pi^*$ and $y > y^*$.

Nash equilibrium. The reaction functions in the Nash game are given by,

$$\text{FRnFn:} \quad D = \left[\frac{1}{1 + \frac{\delta}{\gamma_D^2 \lambda_y^2 \beta^F}} \right] \frac{\gamma_r}{\gamma_D} r - \frac{\gamma_o}{\gamma_D + \frac{\delta}{\gamma_D^2 \lambda_y^2 \beta^F}} \quad \text{(A.5)}$$

$$\text{MRnFn:} \quad D = \left[1 + \frac{\tau}{\gamma_r^2 \lambda_y^2 \beta^M}\right] \frac{\gamma_r}{\gamma_D} r - \frac{\gamma_0}{\gamma_D} \tag{A.6}$$

Drawing from the previous sections, we note that the bliss points for the monetary and fiscal authorities are obtained by setting $D = 0$ (monetary bliss point) or $r = 0$ (fiscal bliss point) in the corresponding reaction function.

The Nash equilibrium is obtained by the intersection of the two reaction functions. The closed-form solutions are given in the following expressions. In addition, Figure A1 presents graphically the reaction functions and the Nash equilibrium.

$$D_{AD+}^N = \frac{-\tau\gamma_0}{\tau\gamma_D + \frac{\tau\delta}{\gamma_D^2 \lambda_y^2 \beta^F} + \frac{\gamma_r^2 \delta \beta^M}{\gamma_D \beta^F}} \tag{A.7}$$

$$\gamma_{AD+}^N = \frac{\delta\gamma_0}{\delta\gamma_r + \frac{\tau\delta}{\gamma_r \lambda_y^2 \beta^M} + \frac{\gamma_0^2 \tau \beta^F}{\gamma_r \beta^F}} \tag{A.8}$$

Note that in the case of positive aggregate demand shocks, the resulting deficit is below D^* and the equilibrium interest rate is above r^*. Taking derivatives of the Nash solutions with respect to the preference parameters, we find that an increase in β^M or a decrease in β^F lead to an increase in both the equilibrium deficit and interest rate. In other words, a widening of the preference divergence between monetary and fiscal authorities with respect to inflation results in larger deficits and interest rates. This is the conclusion tested in the empirical section of the paper.

Stackelberg equilibrium. Let us assume that the monetary authority is the leader. (The results when the fiscal authority is the leader are qualitatively the same and are explained at the end of this section.)

When the monetary authority is the leader, the fiscal reaction function is the same that under the Nash game. However, the monetary "action" function (MAnFn) becomes,

$$\text{MAnFn:} \quad D \left[1 + \frac{\tau}{\Psi\gamma_r^2 \lambda_y^2 \beta^M}\right] \frac{\gamma_r}{\gamma_D} r - \frac{\gamma_0}{\gamma_D} \tag{A.9}$$

$$\Psi = \frac{\delta}{\delta + \gamma_D^2 \beta^F \lambda_y^2} < 1$$

The intercept of the monetary action function (Stackelberg) is the same as that of its reaction function (Nash). However, the slope is larger in the Stackelberg case. The closed-form solutions of the Stackelberg equilibrium are presented in the following expressions (see also Figure A2).

$$D^s_{AD+} = \frac{-\tau\gamma_0}{\tau\gamma_D + \frac{\tau\delta}{\gamma_r\lambda_y^2\beta^F} + \Psi\frac{\gamma_r^2\delta\beta^M}{\gamma_D\beta^F}} \tag{A.10}$$

$$r^S_{AD+} = \frac{\delta\gamma_0}{\delta\gamma_r + \frac{\tau\delta}{\Psi\gamma_r\lambda_y^2\beta^M} + \frac{\tau\gamma_D^2\beta^F}{\Psi\gamma_r\beta^M}} \tag{A.11}$$

Similarly to the Nash game, an increase in the preference divergence in the Stackelberg game (higher β^M or lower β^F) results in higher D and r.

When the fiscal authority is the leader (see lower panel of Figure A2), an increase in the preference divergence also leads to higher D and r. The difference between the monetary-leader solution and the fiscal-leader solution is that in the former case both D and r are lower than in the Nash game, whereas in the latter case the opposite result holds.

A.2 Negative aggregate demand shocks ($\gamma_0 < 0$)

A negative demand shock induces a drop in output and inflation. Given the type of asymmetric loss function that we have assumed, only the output drop is of policy concern. In this case, the loss functions can be written as,

$$U^F = -\alpha^F(y - y^*)^2 - \delta\left(D - D^*\right)^2 \tag{A.12}$$

$$U^M = -\alpha^M(y - y^*)^2 - \tau\left(r - r^*\right)^2 \tag{A.13}$$

It is straightforward to show that the simplified loss functions above follows from the general loss functions in equations (1) and (2) in the presence of a negative demand shock. The key issue to realize is that the outcome for inflation and output is interior to the range $\pi < \pi^*$ and $y < y^*$.

Nash equilibrium. The reaction functions in the Nash game are given by,

$$\text{FRnFn:} \quad D = \left[\frac{1}{1 + \frac{\delta}{\gamma_D^2\alpha^F}}\right]\frac{\gamma_r}{\gamma_D}r - \frac{\gamma_0}{\gamma_{D+\frac{\delta}{\gamma_D\alpha^F}}} \tag{A.14}$$

$$\text{MRnFn:} \quad D = \left[1 + \frac{\tau}{\gamma_r^2\alpha^M}\right]\frac{\gamma_r}{\gamma_D}r - \frac{\gamma_0}{\gamma_D} \tag{A.15}$$

The bliss points for the monetary and fiscal authorities are obtained by setting $D = 0$ (monetary bliss point) or $r = 0$ (fiscal bliss point) in the corresponding reaction function.

The Nash equilibrium is obtained by the intersection of the two reaction functions. The closed-form solutions are given in the following expressions. In addition, Figure A3 presents graphically the reaction functions and the Nash equilibrium.

$$D^N_{AD-} = \frac{-\tau\gamma_0}{\tau\gamma_D + \frac{\tau\delta}{\gamma_D\alpha^F} + \frac{\gamma_r^2\delta\alpha^M}{\gamma_D\alpha^F}} \tag{A.16}$$

$$r^N_{AD-} = \frac{\delta\gamma_0}{\delta\gamma_r + \frac{\tau\delta}{\gamma_r\alpha^M} + \frac{\gamma_0^2\tau\alpha^F}{\gamma_r\alpha^M}} \tag{A.17}$$

Note that in the case of negative aggregate demand shocks, the resulting deficit is above D^* but the equilibrium interest rate is below r^*. Taking derivatives of the Nash solutions with respect to the preference parameters, we find that an increase in α^F or a decrease in α^M lead to an increase in both the equilibrium deficit and interest rate. In other words, a widening of the preference divergence between monetary and fiscal authorities with respect to output results in larger deficits and interest rates. This is the conclusion tested in the empirical section of the paper.

Stackelberg equilibrium. Let us assume that the monetary authority is the leader. (The results when the fiscal authority is the leader are qualitatively the same and are explained at the end of this section.)

When the monetary authority is the leader, the fiscal reaction function is the same that under the Nash game. However, the monetary "action" function (MAnFn) becomes,

$$\text{MAnFn:} \quad D = \left[1 + \frac{\tau}{\Psi\gamma_r^2\alpha^M}\right]\frac{\gamma_r}{\gamma_D}r - \frac{\gamma_o}{\gamma_D} \tag{A.18}$$

$$\Psi = \frac{1}{1 + \frac{\delta}{\gamma_D^2\alpha^F}} < 1$$

The intercept of the monetary action function (Stackelberg) is the same as that of its reaction function (Nash). However, the slope is larger in the Stackelberg case. The closed-form solutions of the Stackelberg equilibrium are presented in the following expressions (see also Figure A4).

$$D^S_{AD-} = \frac{-\tau\gamma_0}{\tau\gamma_D + \frac{\tau\delta}{\gamma_D\alpha^F} + \frac{\gamma_r^2\delta\alpha^M}{\gamma_D\alpha^F}\Psi} \tag{A.19}$$

$$\gamma^S_{AD-} = \frac{\delta\gamma_0}{\delta\gamma_r + \frac{\tau\delta}{\gamma_r\alpha^M\Psi} + \frac{\tau\gamma_D^2\alpha^F}{\gamma_r\alpha^M\Psi}} \tag{A.20}$$

Similarly to the Nash game, in the Stackelberg equilibrium an increase in the preference divergence (higher α^F or lower α^M) generates higher D and r.

When the fiscal authority is the leader (see lower panel of Figure A4), an increase in the preference divergence also leads to higher D and r. The difference between the monetary-leader solution and the fiscal-leader solution is that in the former case both D and r are higher than in the Nash game, whereas in the latter case the opposite result holds.

A.3 Conclusion

An increase in the preference divergence between monetary and fiscal authorities leads to a rise in deficits and interest rates in the face of positive or negative aggregate demand shocks. As discussed in the text, this is also one of the main conclusions regarding the policy response to negative aggregate supply shocks.

Figure 2. Bliss points and the contract curve

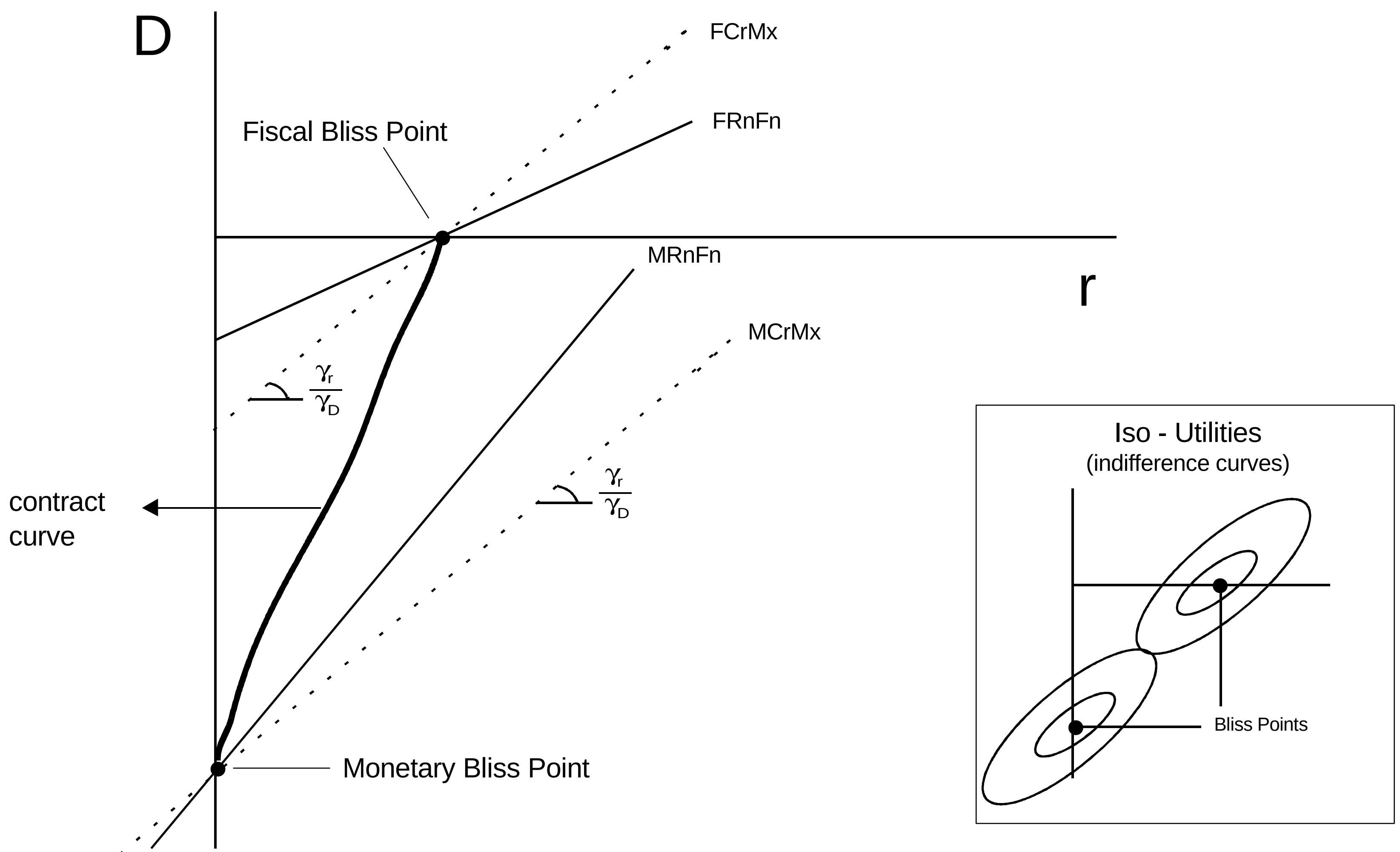

Figure 3. The Nash equilibrium

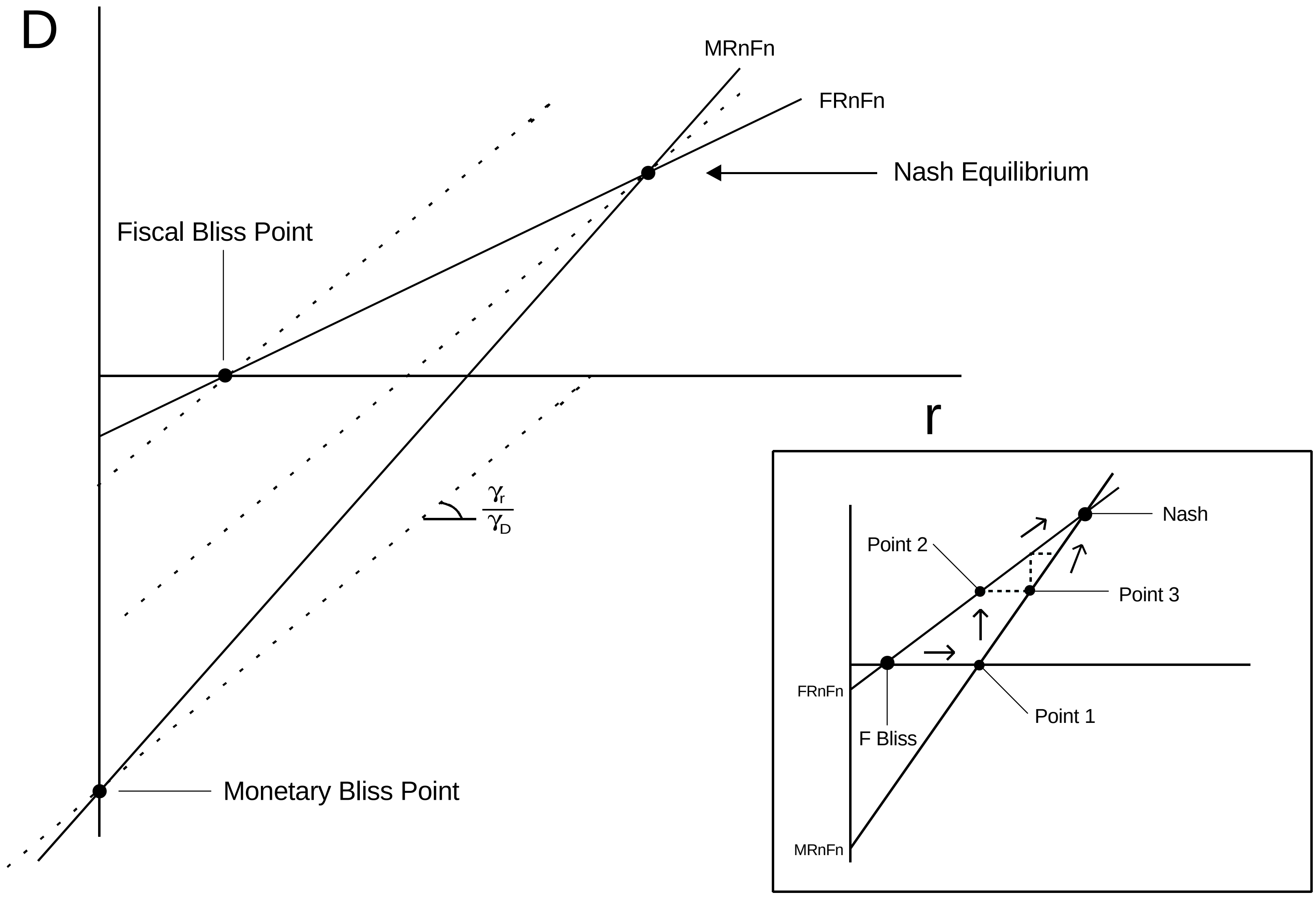

Figure 4. An increase in central bank's anti-inflation preference (Nash equilibrium)

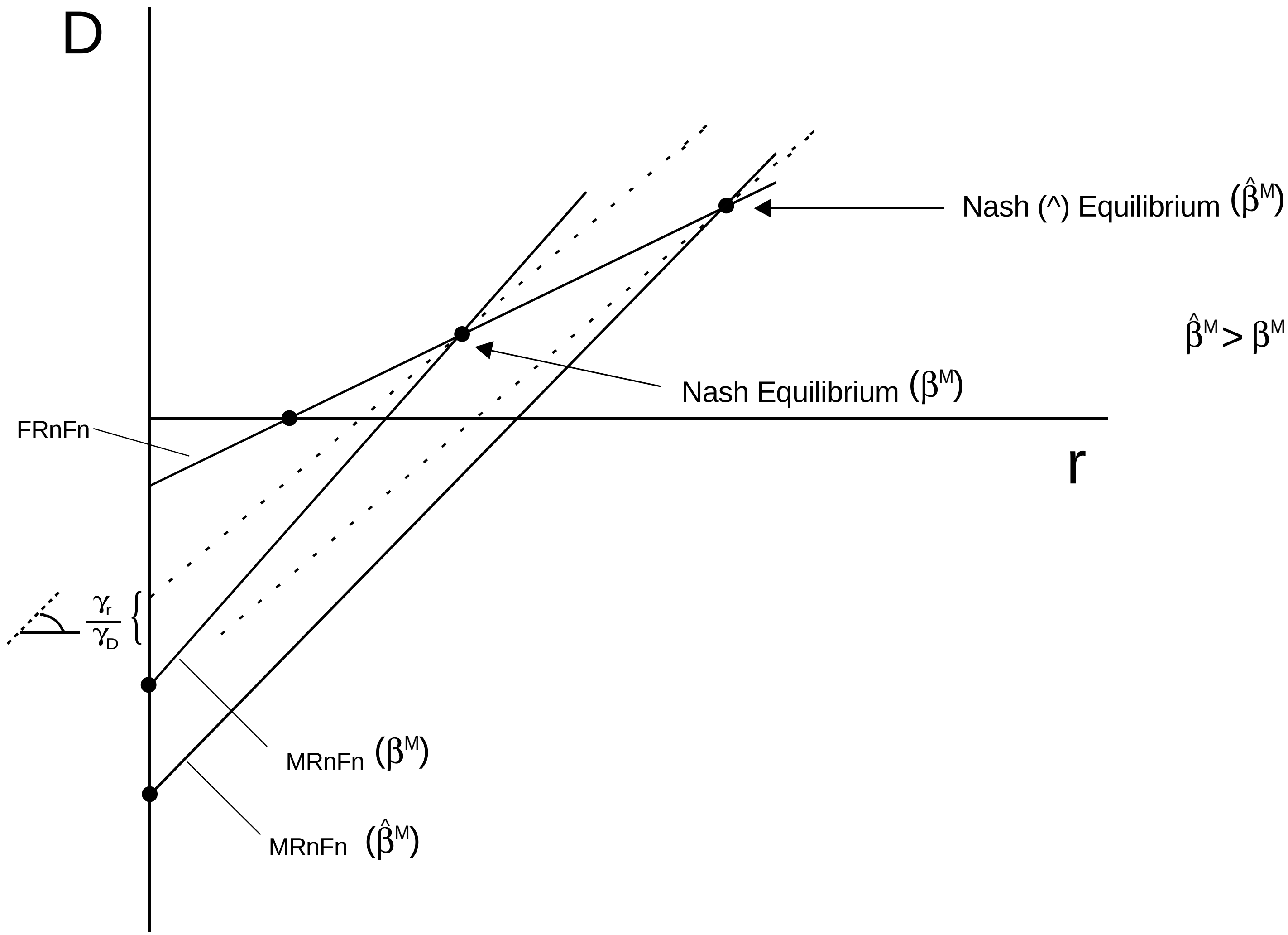

Figure 5. Nash equilibrium when the central bank sufficiently dislikes changing the interest rate

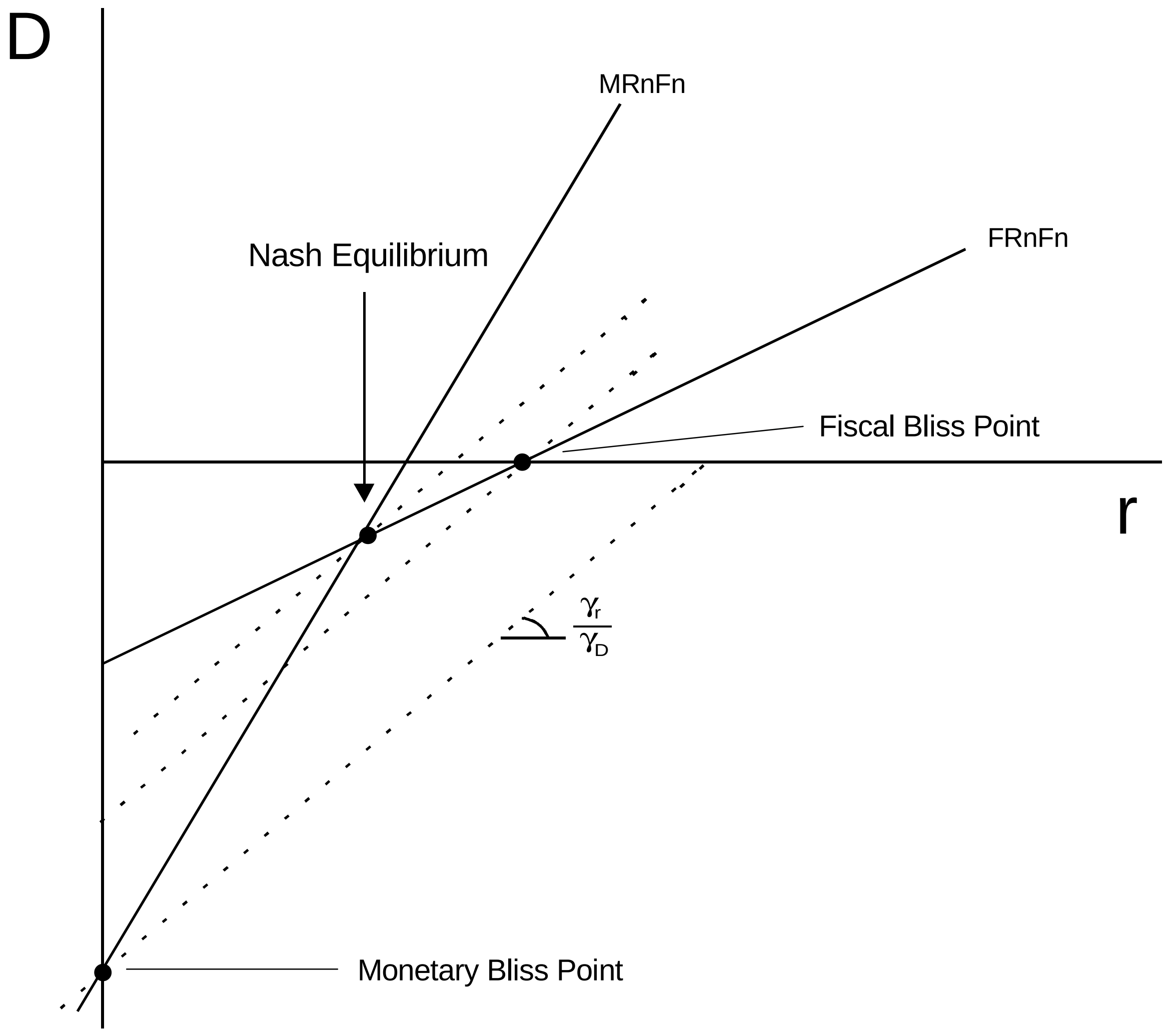

Figure 6. The Stackelberg equilibrium (leader: central bank)

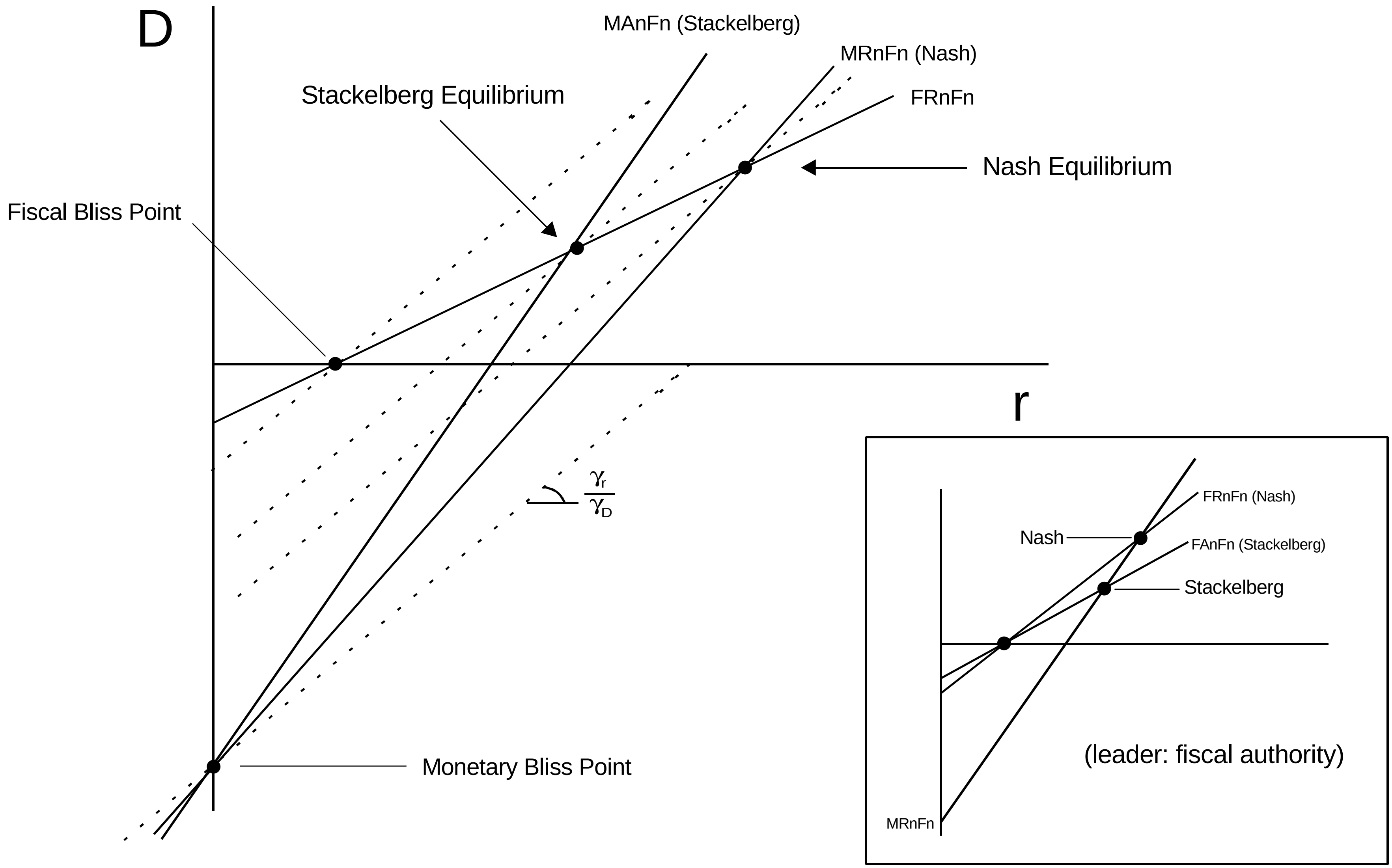

Figure A1. Nash equilibrium

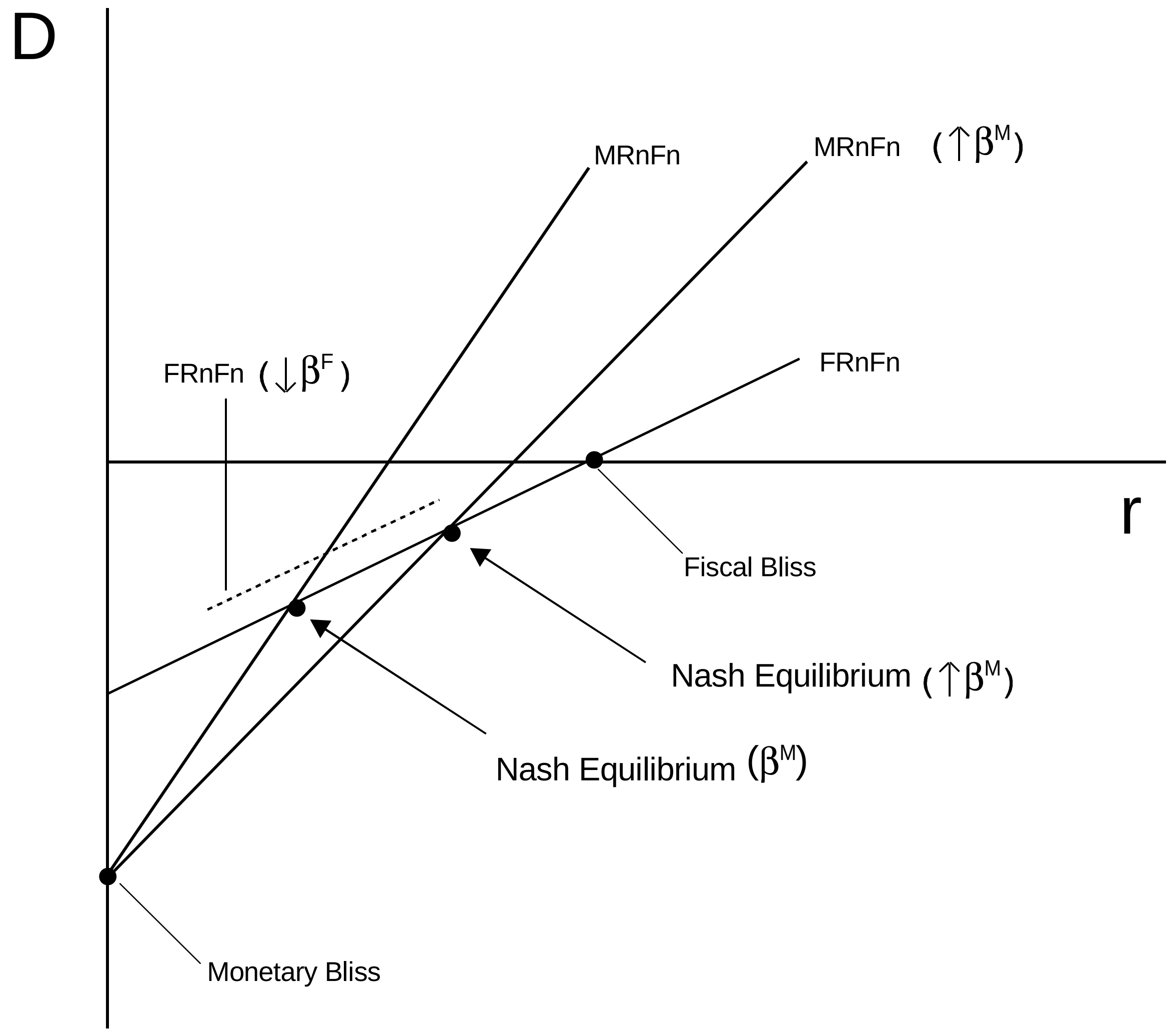

Figure A2. Stackelberg equilibrium

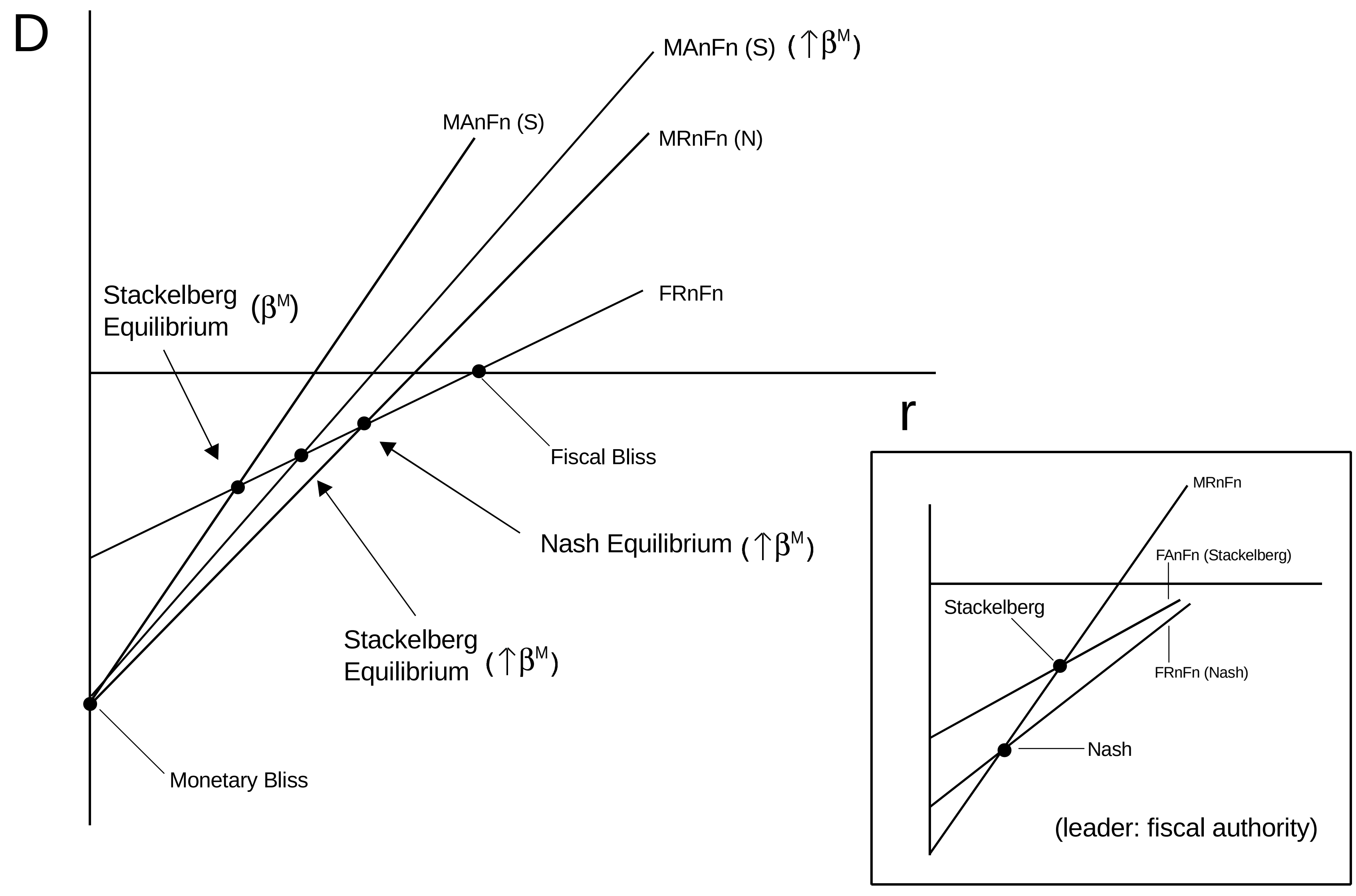

Figure A3. Nash equilibrium

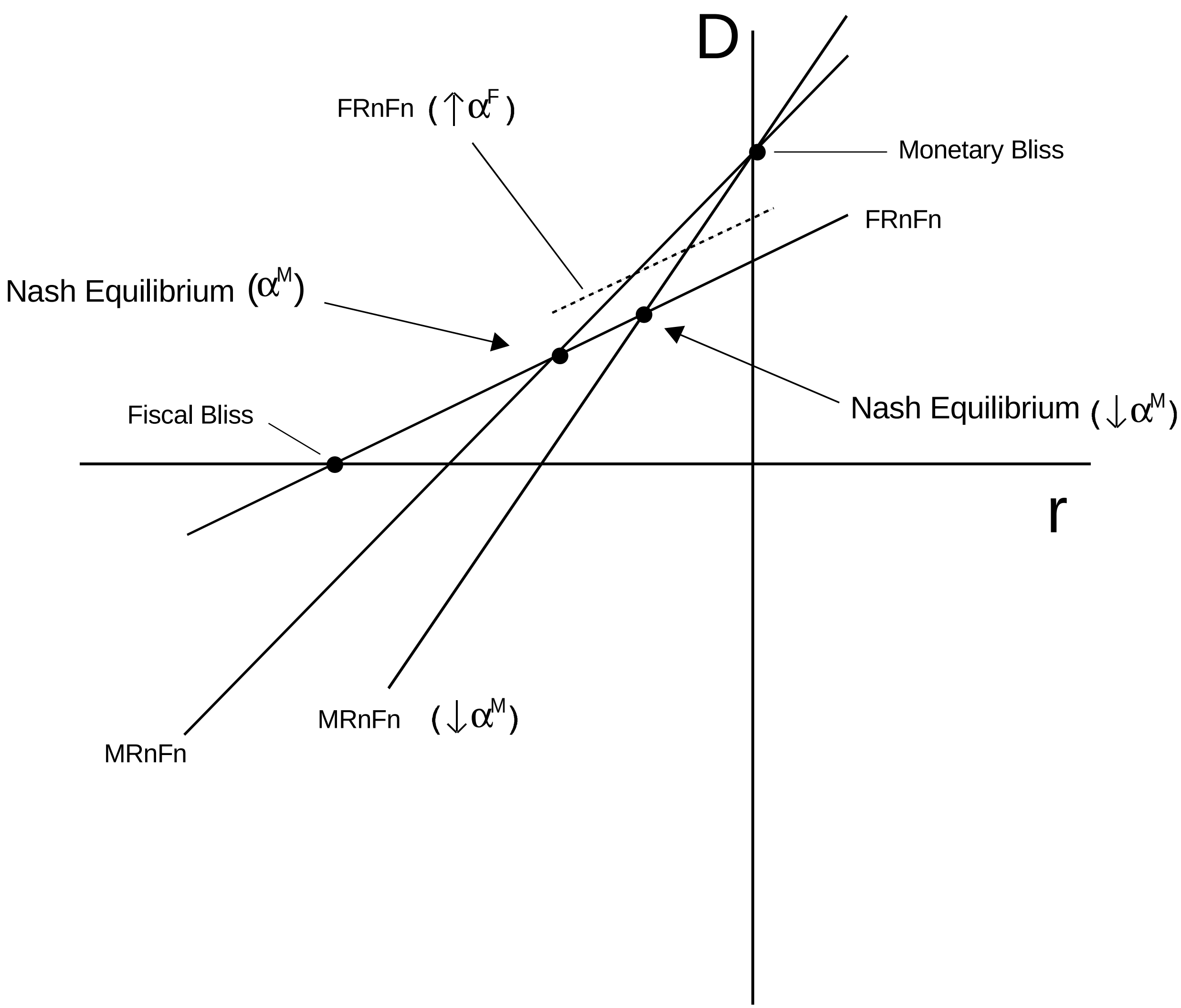

Figure A4. Stackelberg equilibrium