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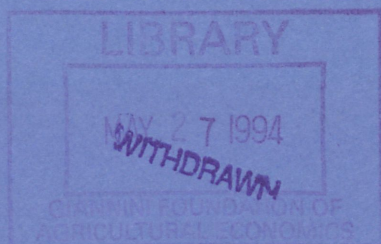
## **A Two-Country Analysis of International Targeting of Nominal GNP**

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Professor of Economics, University of California at  
Berkeley and Research Fellow, Kiel Institute of World  
Economics, Kiel, Germany

April 1994

## Department of Economics

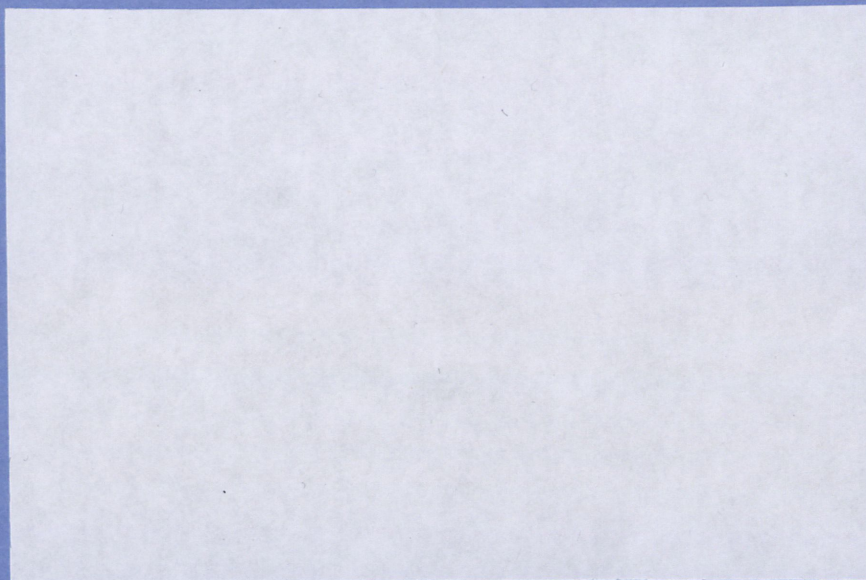


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### Abstract

The paper starts by reviewing three sorts of obstacles to successful coordination: the difficulties of, respectively, compliance, credibility, and certainty. It is argued that nominal-GNP-targeting may have a good chance of overcoming such obstacles. A two-country model is used to evaluate an internationally coordinated version of nominal GNP-targeting in the presence of domestic and/or foreign shocks to supply, money demand, and goods demand. In this simple framework nominal GNP-targeting comes out fairly promising, although it does not dominate alternative regimes (including global monetary targeting, global price rules or discretionary policy) under all circumstances. Simulation results based on the McKibbin-Sachs Global Model are in line with the theoretical findings.



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## 1. INTRODUCTION

The 1980s were the decade when international macroeconomic policy coordination came into its own. To be sure, the subject was not entirely new. In the academic literature, Hamada [1976] had applied game theory to one version of the interdependence question. In the policy world, the Bonn Summit of 1978 was an example of coordination in practice.

In the early 1980s, however, Canzoneri and Gray [1985], Hamada [1985], Oudiz and Sachs [1984], and many others began to develop the analysis more thoroughly. It appeared that theory established a powerful case that setting macroeconomic policies cooperatively would yield higher economic welfare for all countries than setting policies independently. (The area has been surveyed by Cooper [1985] and Fischer [1988].)

Any proposals to put coordination in action were initially rejected out-of-hand by the first Reagan Administration, which believed that each country should be allowed to go its own way. This changed when a new Secretary of the U.S. Treasury took office in 1985, and initiated coordinated intervention in the foreign exchange market at a meeting of finance ministers at the Plaza Hotel in New York in September. At the annual summit meeting of industrialized country leaders in Tokyo the next year, the scope of coordination was broadened from exchange rates to a list of ten economic variables, and the membership of the club was broadened to include all the G-7 countries.<sup>1</sup>

In the 1990s, coordination has lost some of the luster it had a short time ago. The academic literature has discovered a variety of limitations to successful coordination. Meanwhile, the G-7 policy-making process seems stalled. It does not appear to be well-designed to cope with the serious obstacles that any potentially successful coordination faces. The current mechanism of coordination is in particular vulnerable to three sorts of obstacles: compliance, inflation-fighting credibility, and uncertainty. These obstacles are so severe that the institution of international coordination may easily make the world economic worse-off.<sup>2</sup>

This paper will analyze a specific proposal for overcoming those obstacles, a cooperative international version of a nominal GNP rule, which may be called INT, for International Nominal Targeting. Following the introduction, part 2 briefly reviews the main obstacles to policy coordination and suggests that INT may have good chances of overcoming such obstacles. In part three the proposal of an internationally coordinated version of nominal GNP-targeting is evaluated in a two-country model, in the presence of domestic and foreign

---

<sup>1</sup> The story of the management of the dollar in the 1980s is recounted by Funabashi [1988] and Frankel [1990]. The history of the G-7 summits is recounted by Putnam and Bayne [1987].

<sup>2</sup> For skeptical views on international coordination, see e.g. Vaubel [1985], Feldstein [1988] and Frankel [1988].



shocks to supply, money demand, and goods demand. In this simple framework nominal GNP-targeting comes out fairly promising, although it does not dominate alternative regimes, including coordinated monetary targeting, global price rules or discretionary policy under all circumstances. Furthermore, the results reveal that countries that do not participate in the coordination process may be better or worse-off and thus may possibly have an incentive to join the agreement. In part four the McKibbin-Sachs Global model is used to assess the internationally coordinated version of nominal GNP-targeting under somewhat more realistic assumptions. Simulation results are well in line with the theoretical findings in part 2. Finally, part 5 provides some concluding remarks.

## **2. THREE OBSTACLES TO INTERNATIONAL MACROECONOMIC POLICY COORDINATION**

The first obstacle to successful and meaningful coordination is the difficulty of ensuring compliance.<sup>3</sup> Each country, if it takes the other's policy as given, may have an incentive to renege on earlier agreements and leave the burden of the agreed-upon adjustment to the other country in order to raise its own welfare. Of course, cheating only succeeds as long as the other country does not retaliate. Otherwise, we are back in the non-cooperative equilibrium.

Von Furstenberg and Daniels [1991, 1992] have conducted a thorough review of 203 specific commitments made in the annual G-7 Summit declarations between 1975 and 1989. The average scores assigned to these undertakings were so low that the joint null hypothesis of "no summit ambition" and "no summit effect" could barely be rejected.

If the member countries make commitments to attainable macroeconomic targets that can be monitored - which requires that they be explicit, measurable, and preferably public - then they are less likely to cheat on them. The theory of reputations can be used to show why. The current system seems to violate all of these first basic insights. The presence of so many different indicators on the G-7 list, the vagueness as to whether these variables are in fact forecasts, goals or commitments, and the secrecy surrounding the whole procedure, all imply that substantive enforceable agreements are unlikely to emerge from G-7 meetings. Multiple indicators will nearly always permit to find at least one indicator to justify the course action that a country prefers to take. Pressure can hardly be brought to bear on countries that stray from the agreed-upon targets, if the targets are kept secret.

The second danger that threatens the success of coordination efforts is the risk that cooperative agreements will be biased in favor of expansion, with the result that high

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<sup>3</sup> For a more detailed discussion of the main obstacles see Frankel [1989b, 1992].

inflation rates will re-emerge. Rogoff [1985a] has demonstrated that the credibility problem of monetary authorities vis-à-vis the private sector may be increased by central bank coordination. Monetary coordination may lead to systematically higher inflation, because it avoids the negative effects associated with undesired exchange-rate depreciations induced by unilateral expansions. Institutional constraints, e.g. in the form of some degree of commitment to a nominal anchor on a longer term basis may help reduce the time-consistent inflation rate and dominate a pure discretionary policy.

The third danger that threatens the success of coordination efforts is uncertainty: a) with respect to the initial position of the world economy; b) with respect to the effects and transmission effects of a unit change in domestic and foreign macroeconomic policy variables; and c) with respect to the correct weights to be put on the various possible target variables. Uncertainty makes it difficult for each country to know what policy changes are in its best interest. This difficulty arises whether the uncertainty centers on the initial position of the economy (the "baseline forecast"), the desired policy targets (e.g., full employment), or the changes in monetary and fiscal policy necessary to produce desired effects (the multipliers). All three kinds of uncertainty make it difficult for each country in the bargaining process to know even what policy changes it could want its partners to make. A number of pessimistic conclusions emerge. Given differing perceptions, the policy-makers may not be able to agree on a coordination package; and even if they do agree, the effects may be different from what they anticipated.<sup>4</sup>

To review our conclusions so far, the compliance problem suggests that coordination should involve an explicitly-agreed and publicly-announced target. Furthermore, the target should be robust to shocks that occur after the agreement is made. The inflation-fighting credibility problem suggests that the target to which the governments commit should be a nominal variable. The uncertainty problem suggests that governments should commit to a target, where increased knowledge (learning effects) about the true model may be used in future policies. These requirements lead to the suggestion that the nominal target to which the countries should best commit is one that does not even appear on the current G-7 list of indicators at all: nominal GNP.

### **3. THE PROPOSAL FOR SIMULTANEOUS GNP-TARGETING: A TWO-COUNTRY ANALYSIS**

Here it is argued, that whatever the degree of precommitment to a nominal target, nominal GNP makes a more suitable target than the other nominal variables that have been

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<sup>4</sup> For an analysis of coordination under model uncertainty see Frankel and Rockett [1988], Frankel, Scott and Rockett [1992]. See also Holtham and Hughes Hallet [1987, 1992].



proposed. To consider the problem formally,<sup>5</sup> we use a stochastic symmetric two-country rational expectations model in order to compare alternative policy regimes: discretionary policy, a rigid money supply rule, a rigid nominal GNP rule, and rigid price (inflation) rules - with respect to the consumer price index and the producer price index. We distinguish between world-wide and country-specific shocks. Coordination is characterized by the simultaneous decision of both countries to follow the same policy. Monetary policy can have short-run real effects, because nominal wage contracts for period  $t$  are set at the end of period  $t-1$ . The monetary authorities have perfect information on all current shocks and can reach their targets accurately.

As long as shocks are symmetric, coordinated nominal GNP-targeting is the optimal policy in this simple framework, if the authorities assign equal weight to the real income and inflation objective and the supply elasticity with respect to unexpected inflation is 1. In the event of money demand disturbances, a coordinated version of GNP-targeting isolates the economy; neither real income nor the price level are affected. This is true for symmetric, asymmetric as well as unilateral shocks. Under all other circumstances, however, fixing nominal GNP still comes out fairly well, although it does not give precisely the right answer.

### 3.1. The Two-Country Model

#### 3.1.1. Aggregate Supply

Aggregate supply is given by a Cobb-Douglas production function:<sup>6</sup>

$$(1) \quad y_t = c_0 + a\bar{k} + (1-a)l_t + \mu_t, \quad \mu_t \sim N(0, \sigma_\mu^2),$$

where  $y_t$  is output,  $\bar{k}$  is the fixed capital stock,  $l_t$  is labor,  $c_0$  is a constant term, and  $\mu_t$  is a productivity disturbance (supply shock). Throughout, subscript  $t$  denotes time and lower case letters denote natural logarithms. The demand for labor  $l_t^d$  is obtained by equating the marginal product of labor to the real producer wage  $w_t - p_t$ , where  $w_t$  is the nominal wage rate and  $p_t$  the price of domestic good (producer price).

$$(2) \quad l_t^d = \bar{k} + [c_0 + \log(1-a) + p_t - w_t + \mu_t] / a$$

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<sup>5</sup> Analyses of nominal GNP-targeting in alternative two-country models include Argy [1991], and Leder [1992] Funke [1991, 1992]. Beside alternative rules, Argy considers different wage indexation schemes; Funke [1992] also critically reviews the chances of INT to overcome the main obstacles to policy coordination. These frameworks are extended in particular by the inclusion of price rules, the consumer price index in the authorities' loss-function, as well as discretion from the world perspective.

<sup>6</sup> See for a similar derivation of aggregate supply Currie/Levine [1992] and for the closed economy case Rogoff [1985b].

Labor supply expressed in terms of the real consumption wage is:

$$(3) \quad l_t^s = \bar{l} + \omega(w_t - p_t^c) \quad \omega > 0,$$

The consumer price index  $p_t^c$  is defined as  $p_t^c = gp_t + (1-g)(p_t^* + s_t) = p_t + (1-g)z_t$ , where  $(1-g)$  is the import content of consumers' consumption,  $p_t^*$  the price of the foreign (imported) good, and  $s_t$  the nominal spot exchange rate (the price of the foreign currency measured in terms of the domestic currency). Furthermore,  $z_t$  is referred to as the real exchange rate ( $z_t = p_t^* + s_t - p_t$ ). A rise in  $z_t$  represents a real depreciation of the home currency. We assume  $0.5 < g < 1$ , so residents in both countries have a preference for their own good. To simplify algebra without loss of generality,  $\bar{l}$  is set equal to  $\bar{k} + [c_0 + \log(1-a)]/a$ . Nominal wage contracts are set a period in advance before shocks occur with the intention to achieve full employment.

$$(4) \quad w_t | E_{t-1} l_t^s = E_{t-1} l_t^d$$

Therefore, nominal wage is set at:

$$(5) \quad w_t = E_{t-1} p_t^c - \frac{(1-g)E_{t-1} z_t}{\omega\alpha + 1},$$

where expectations are formed rationally, so that  $E_{t-1} p_t^c$  indicates the consumer price index in period  $t$  expected in  $t-1$ , given the information in  $t-1$ .

Hence, (1), (2) and (5), together with the analytically convenient normalization that  $-c_0 = a\bar{k} + (1-a)\bar{l}$  so that  $\bar{y} = E_{t-1} y_t = 0$ , give an open economy Lucas type of supply function.

$$(6a) \quad y_t = \beta_1(p_t^c - E_{t-1} p_t^c) - \beta_2 z_t + \beta_3 E_{t-1} z_t + (1 + \beta_1)\mu_t,$$

where  $\beta_1 = (1-a)/a$ ,  $\beta_2 = \beta_1(1-g)$ , and  $\beta_3 = \beta_2/(\omega\alpha + 1)$ .

Therefore,  $\beta_3 < \beta_2 < \beta_1$ . A similar supply function holds for the foreign country, where the real exchange rate and the expected real exchange rate enter with opposite sign. An asterisk indicates a foreign variable.

$$(6b) \quad y_t^* = \beta_1(p_t^{c*} - E_{t-1} p_t^{c*}) + \beta_2 z_t - \beta_3 E_{t-1} z_t + (1 + \beta_1)\mu_t^*$$



### 3.1.2. Aggregate Demand

The demand side of the home country and the foreign country is described by standard open economy IS -LM functions. Domestic functions are denoted by (a), foreign equations by (b).

$$(7a) \quad m_t - p_t^c = -\alpha_1 i_t + \alpha_2 y_t + \varepsilon_t$$

$$(7b) \quad m_t^* - p_t^{c*} = -\alpha_1 i_t^* + \alpha_2 y_t^* + \varepsilon_t^*$$

$$(8a) \quad y_t = -\kappa(i_t - E_t p_{t+1}^c + p_t^c) + \varphi z_t + \delta y_t^* + \eta_t \quad 0 < \delta < 1$$

$$(8b) \quad y_t^* = -\kappa(i_t^* - E_t p_{t+1}^{c*} + p_t^{c*}) - \varphi z_t + \delta y_t + \eta_t^*$$

$$(9) \quad i_t - i_t^* = E_t s_{t+1} - s_t$$

where  $m_t$  represents money supply,  $i_t$  the nominal interest rate (not in log). There are two types of demand shocks: a money demand shock ( $\varepsilon_t$ ) and a goods market demand disturbance ( $\eta_t$ ). All disturbances are stochastic and uncorrelated (on a national level) with zero mean and constant variances. Positive and negative correlation between  $\varepsilon_t$  and  $\varepsilon_t^*$ ,  $\eta_t$  and  $\eta_t^*$ , as well as  $\mu_t$  and  $\mu_t^*$  is allowed. All elasticities and semi-elasticities  $\alpha_1, \alpha_2, \kappa, \varphi, \beta$  are assumed to be larger than zero and identical in both countries.

In the money market nominal money supply is deflated by the consumer price index. This reflects that part of the money demand for transactions is used to buy imports. Demand for the good that firms produce is a function of the real interest rate, the real exchange rate, as well as real income in the other country. Uncovered interest rate parity (9) closes the model. To analyze the effects of different monetary policy strategies, alternative policy reaction functions are introduced. We assume that the authorities have an information advantage and can reach their targets accurately:

$$(10a) \quad m_t = -\theta(p_t + y_t) \quad (10a^*) \quad m_t = -\theta p_t^c \quad (10a^{**}) \quad m_t = -\theta p_t$$

$$(10b) \quad m_t^* = -\theta(p_t^* + y_t^*) \quad (10b^*) \quad m_t^* = -\theta p_t^{c*} \quad (10b^{**}) \quad m_t^* = -\theta p_t^*$$

Equations (10a, 10b), (10a\*, 10b\*), and (10a\*\*, 10b\*\*) are the policy-reaction functions for nominal GNP-targeting and price level (inflation rate) rules. We distinguish between inflation rules that try to stabilize the inflation rate as measured by the consumer price index (10a\*, 10b\*) and as measured by the producer price index (10a\*\*, 10b\*\*). If money supply is kept constant in both countries  $\theta = 0$ , whereas in the case of a perfect

nominal income rule  $\theta \rightarrow \infty$  in (10a, 10b). In the case of a perfect price rule  $\theta \rightarrow \infty$  in (10a\*) and (10b\*) and (10a\*\*) and (10b\*\*), respectively.<sup>7</sup>

We follow Rogoff (1985b), who in turn follows Kydland and Prescott (1977) and Barro and Gordon (1983) and assume that the market determined level of real income is below the socially optimal level  $[\hat{y}]$ . Authorities in both countries are tempted to inflate surprisingly in order to raise output beyond the natural rate. The social objective functions in both countries are:

$$(11a) \quad L_t = (y_t - \hat{y})^2 + \chi p_t^{c^2}$$

$$(11b) \quad L_t^* = (y_t^* - \hat{y})^2 + \chi p_t^{c^{*2}},$$

where  $\chi$  is the weight assigned to the inflation objective, since we can normalize the lagged price levels  $p_{t-1}^c$  and  $p_{t-1}^{c^*}$  relative to which  $p_t^c$  and  $p_t^{c^*}$  is measured to zero. We impose  $\hat{y} > 0$ , which builds in an expansionary bias to discretionary policy-making. The bias is assumed to be identical in both countries.

It is analytically convenient to decompose the above system into two independent sub-systems, using the method of Aoki [1981]. The sum of the single-country models can be called the additive or world model and the difference of the two-country models can be called the difference system. Additive variables or disturbances are denoted by a superscript a, differences by a superscript d:

$$x_t^a = x_t + x_t^* \quad x_t^d = x_t - x_t^*,$$

Thus, after solving the system in  $x_t^a$  and  $x_t^d$  we can obtain domestic and foreign variables back by:

$$(12a) \quad x_t = \frac{1}{2}(x_t^a + x_t^d) \quad (12b) \quad x_t^* = \frac{1}{2}(x_t^a - x_t^d)$$

We start by analyzing the additive and difference system separately.

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<sup>7</sup> In fact,  $\theta \rightarrow -\infty$  would also keep nominal income or the price level constant. However, the choice is immaterial, because we do not focus on the transitional mechanism. From an economic perspective it seems more plausible that the authorities increase (decrease) money supply, when nominal income or the price level tend to fall (increase).



### 3.2. The Analysis of the Additive System

By summing the supply, demand, policy reaction, and loss functions of the two countries, we get the world model (6', 7', 8', 10', 11'). Note, for the description of the supply equation (6') and the policy-reaction function (10'\*), that in this symmetrical world economy the additive (average) consumer price index is identical to the additive (average) producer price index ( $p_t^c + p_t^s = p_t + p_t^*$ ).<sup>8</sup> Thus, in the additive system we only have to consider one price rule.

$$(6') \quad y_t^a = \beta_1(p_t^a - E_{t-1}p_t^a) + (1 + \beta_1)\mu_t^a$$

$$(7') \quad m_t^a - p_t^a = -\alpha_1 i_t^a + \alpha_2 y_t^a + \varepsilon_t^a$$

$$(8') \quad y_t^a(1 - \delta) = -\kappa(i_t^a - E_t p_{t+1}^a + p_t^a) + \eta_t^a$$

$$(10') \quad m_t^a = -\theta(p_t^a + y_t^a) \quad (10'*) \quad m_t = -\theta p_t^a$$

$$(11') \quad L_t^a = (y_t^a - \hat{y}^a)^2 + \chi p_t^{a2}$$

Obviously, the world economy is characterized by a standard closed economy IS-LM model along with a closed economy Lucas type of supply function. The average real world output as well as the average world price level are independent of the nominal/real exchange rate in this symmetric two-country world.

Under full discretion, the policy-makers each period choose aggregate demand so as to minimize that period's loss, with aggregate supply including  $E_{t-1}p_t^a$  given. From (11') and (6') we get:<sup>9</sup>

$$(13) \quad dL_t^a / dp_t^a = 2\beta_1[\beta_1(p_t^a - E_{t-1}p_t^a) + (1 + \beta_1)\mu_t^a - \hat{y}^a] + 2\chi p_t^a = 0$$

Therefore

$$(14) \quad p_t^a(\beta_1^2 + \chi) = \beta_1 \hat{y}^a + \beta_1^2 E_{t-1}p_t^a - \beta_1(1 + \beta_1)\mu_t^a$$

By taking expectations on both side we get under rational expectations:

<sup>8</sup> The average real income and price level are  $y_t^{av} = y_t^a / 2$  and  $p_t^{av} = p_t^a / 2$ . As lower case letters denote logarithms, averages refer to the geometric average of the underlying variables ( $Y_t, P_t$ ), which is approximately identical to arithmetic averages for small changes. In order to be meaningful, the price level should always be interpreted as the average price level.

<sup>9</sup> The second order conditions for a minimum are met. The minimum is global, because of the quadratic form of  $L_t^a$ .

$$(15) \quad E_{t-1} p_t^a = \beta_1 \hat{y} / \chi$$

So we can solve (14) for the price level under discretion (DS):

$$(16) \quad p_t^a | DS = \beta_1 \hat{y}^a / \chi - \beta_1 (1 + \beta_1) \mu_t^a / (\beta_1^2 + \chi)$$

From (11') the expected loss under discretion then works out to:

$$(17) \quad EL_t^a | DS = (\chi + \beta_1^2) \hat{y}^{a2} / \chi + (1 + \beta_1)^2 \chi \sigma_{\mu a}^2 / (\beta_1^2 + \chi),$$

where in the following  $\sigma_{\mu a}^2$  is defined as  $E[(\mu_t^a)^2]$  and so forth.

The first term represents the inflationary bias in the system, while the second represents the effect of the supply disturbance after the authorities have chosen the optimal split between inflation and output. The higher  $\beta_1$  and the lower the weight on inflation ( $\chi$ ), the greater the inflationary bias.

To compare the outcome of a discretionary policy with the other regimes, we have to solve the above additive system for a money supply rule (18a,b), a nominal GNP rule (19a,b), and a price level rule (20a,b) [see appendix].

$$(18a) \quad y_t^a | MS = [-\beta_1 \kappa \epsilon_t^a + \beta_1 \alpha_1 \eta_t^a + \kappa(1 + \alpha_1)(1 + \beta_1) \mu_t^a] / N_1$$

$$(18b) \quad p_t^a | MS = \{-\kappa \epsilon_t^a + \alpha_1 \eta_t^a - (1 + \beta_1)[\alpha_1(1 - \delta) + \kappa \alpha_2] \mu_t^a\} / N_1,$$

where  $N_1 = \alpha_1 \beta_1 (1 - \delta) + \kappa(\alpha_1 + \alpha_2 \beta_1 + 1)$

$$(19a) \quad y_t^a | NI = \mu_t^a$$

$$(19b) \quad p_t^a | NI = -\mu_t^a$$

$$(20a) \quad y_t^a | PL = (1 + \beta_1) \mu_t^a$$

$$(20b) \quad p_t^a | PL = 0$$

where MS indicates a money supply rule, NI nominal GNP-targeting and PL price level (inflation rate) targeting.<sup>10</sup>

In the case of a money supply rule, all shocks - money demand, goods market demand disturbances, and supply shocks - influence the world real income and the average world

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<sup>10</sup> The results for nominal GNP-targeting and price level targeting are straight forward from (6'), once it is established that  $E_{t-1} p_t^a = 0$ . In the case of GNP-targeting we can substitute  $y_t^a = -p_t^a$  in (6'), and in the case of price level targeting  $p_t^a = 0$ . Similar considerations hold for the difference system, where the difference of the supply function could also be expressed in terms of the differences in the producer prices.



price level. Trivially, if domestic and foreign shocks are perfectly negatively correlated, world real income and the average world price level remain constant ( $\varepsilon_t^a = \eta_t^a = \mu_t^a = 0$ ).

In the case of a nominal-GNP rule or a price level rule, the goods market demand disturbances and money demand disturbances are fully absorbed on the world level.<sup>11</sup> This is true for symmetric, asymmetric as well as unilateral shocks. In the event of disturbances to supply, such as the oil price increases of the 1970s, a nominal-GNP rule divides the effect equi-proportionally between an increase in the price level and a fall in output. The short-run output loss associated with a negative supply shock is, however, under nominal GNP-targeting larger than under a money supply rule, if the absolute value of the price elasticity of aggregate demand under a money supply rule is smaller than one. In the world model this is true if:  $\kappa(1+\alpha_1)/[\alpha_1(1-\delta)+\alpha_2\kappa] < 1$ . Taylor [1985] presents some empirical evidence that aggregate demand is inelastic in the short run. A price level rule has the largest impact on economic activity. To fully compare the alternative regimes, the expected losses are considered:

$$(21) EL_t^a|MS = \hat{y}^{a2} + \{\kappa^2(\beta_1^2 + \chi)\sigma_{\varepsilon a}^2 + \alpha_1^2(\beta_1^2 + \chi)\sigma_{\eta a}^2 + (1+\beta_1)^2\{\kappa^2(1+\alpha_1)^2 + \chi[\alpha_1(1-\delta) + \kappa\alpha_2\kappa]\sigma_{\mu a}^2\} / N_1^2$$

$$(22) EL_t^a|NI = \hat{y}^{a2} + (1+\chi)\sigma_{\mu a}^2$$

$$(23) EL_t^a|PL = \hat{y}^{a2} + (1+\beta_1)^2\sigma_{\mu a}^2$$

From the world perspective, nominal GNP-targeting and price level targeting dominate the money supply as an anchor for monetary policy in the case of money demand shocks and goods market demand shocks. Compared to a discretionary regime, the credible precommitment to a nominal GNP rule or a price level rule avoids the inflationary bias of a discretionary policy regime.<sup>12</sup> Without knowing the parameters of the model it is not possible to determine which rule dominates in the case of supply shocks. However, if the authorities assign equal weights to the real income and inflation target ( $\chi=1$ ), nominal GNP-targeting dominates a price rule if  $\beta_1 > \sqrt{2} - 1 \approx 0.414$ . Estimates of the slope of the supply relationship vary. Some evidence is reviewed in Frankel/Chinn [1991]; most estimates of  $\beta_1$  are greater than this critical value. If  $\chi=1$  and the elasticity of supply with respect to unexpected inflation  $\beta_1=1$ , nominal GNP-targeting unambiguously dominates discretion. In this case, nominal GNP-targeting is the optimal policy.

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<sup>11</sup> Although a nominal GNP rule may fully absorb demand shocks, it may still increase the volatility of velocity. This observation does, however, not effect the existing pros and cons of alternative rules [see Funke, 1993].

<sup>12</sup> It remains crucial that nominal income targets are consistent with the distorted natural rate [Rogoff, 1985b].

As both countries together form a closed economy these results are mostly known.<sup>13</sup> It is more interesting to see how the effects of alternative shocks differ between both countries. As we have shown that the main weakness of discretion may refer to its inflationary bias, we focus in the following on the analysis of rigid rules.

### 3.3. The Analysis of the Difference System

Applying definition (12b) and making use of  $s_t = p_t^{cd} + (2g-1)z_t$  and  $p_t^d = p_t^{cd} - 2(1-g)z_t$ , we get:

$$(6'') \quad y_t^d = \beta_1(p_t^{cd} - E_{t-1}p_t^{cd}) - 2\beta_2z_t + 2\beta_3E_{t-1}z_t + (1+\beta_1)\mu_t^d$$

$$(7'') \quad m_t^d - p_t^{cd} = -\alpha_1i_t^d + \alpha_2y_t^d + \varepsilon_t^d$$

$$(8'') \quad y_t^d = -\kappa(i_t^d - E_t p_{t+1}^{cd} + p_t^{cd}) + 2\varphi z_t - \delta y_t^d + \eta_t^d$$

$$(9'') \quad i_t^d = E_t s_{t+1} - s_t = (2g-1)E_t z_{t+1} + E_t p_{t+1}^{cd} - (2g-1)z_t - p_t^{cd}$$

$$(10'') \quad m_t^d = -\theta(y_t^d + p_t^d) = -\theta[y_t^d + p_t^{cd} - 2(1-g)z_t]$$

$$(10'')^* \quad m_t^d = -\theta p_t^{cd} \quad (10'')^{**} \quad m_t^d = -\theta p_t^d = -\theta[p_t^{cd} - 2(1-g)z_t]$$

The differences between real income and the consumer and producer price level at home and abroad, are in the case of a money supply rule (24a,b,c), a nominal GNP rule (25a,b,c), and price-level rules with respect to the consumer price index (CPI) (26a,b,c) and with respect to the producer price index (PP) (27a,b,c) (see appendix):

$$(24a) \quad y_t^d | MS = \{-\beta_1[\kappa(2g-1)+2\varphi]\varepsilon_t^d + \beta_1[\alpha_1+2(1-g)]\eta_t^d + (1+\beta_1)(1+\alpha_1)[\kappa(2g-1)+2\varphi]\mu_t^d\} / N_2$$

$$\text{where } N_2 = (\alpha_1 + \alpha_2\beta_1 + 1)[\kappa(2g-1)+2\varphi] + \beta_1(1+\delta)[\alpha_1+2(1-g)]$$

$$(24b) \quad p_t^d | MS = \{-[\kappa(2g-1)+2\varphi]\varepsilon_t^d + [\alpha_1+2(1-g)]\eta_t^d - (1+\beta_1)\{\alpha_2[\kappa(2g-1)+2\varphi] + (1+\delta)[2(1-g)+\alpha_1]\}\mu_t^d\} / N_2$$

$$(24c) \quad p_t^{cd} | MS = \{-[\kappa(2g-1)+2\varphi+2\beta_2(1+\delta)]\varepsilon_t^d - [2\alpha_2\beta_2 - \alpha_1(2g-1)]\eta_t^d - (1+\beta_1)\{(2g-1)[\alpha_1(1+\delta)+\alpha_2\kappa]+2\alpha_2\varphi\}\mu_t^d\} / N_2$$

<sup>13</sup> Alternative theoretical analyses include: Bean [1983], Rogoff [1985b], West [1986], Bradley/Jansen [1989], Frankel [1989b], Funke/Mastroberardino [1991] and Asako/Wagner [1992].

$$(25a) \quad y_i^d | NI = \mu_i^d$$

$$(25b) \quad p_i^d | NI = -\mu_i^d$$

$$(25c) \quad p_i^{cd} | NI = \{-2(1-g)\eta_i^d + [2(1+\delta)(1-g) - \kappa(2g-1) - 2\phi]\mu_i^d\} / N_3,$$

$$\text{where } N_3 = \kappa(2g-1) + 2\phi$$

$$(26a) \quad y_i^d | CPI = \{2\beta_2\eta_i^d + (1+\beta_1)[\kappa(2g-1) + 2\phi]\mu_i^d\} / N_4,$$

$$\text{where } N_4 = \kappa(2g-1) + 2\phi + 2\beta_2(1+\delta)$$

$$(26b) \quad p_i^d | CPI = \{2(1-g)\eta_i^d - 2(1+\delta)[\beta_2 + (1-g)]\mu_i^d\} / N_4$$

$$(26c) \quad p_i^{cd} | CPI = 0$$

$$(27a) \quad y_i^d | PP = (1+\beta_1)\mu_i^d$$

$$(27b) \quad p_i^d | PP = 0$$

$$(27c) \quad p_i^{cd} | PP = \{-2(1-g)\eta_i^d + 2(1+\delta)[\beta_2 + (1-g)]\mu_i^d\} / N_3,$$

The above equations reveal the trivial result that both countries are affected in the same way by symmetric shocks ( $\varepsilon_i^d = \eta_i^d = \mu_i^d = 0$ ), since real income and prices are then identical in both countries ( $y_i^d = p_i^{cd} = p_i^d = 0$ ). Furthermore, the difference in real income and the producer price is independent of goods market demand disturbances and money demand disturbances in the case of nominal GNP-targeting, and a producer price rule. The analysis of the additive and the difference system refer to both the world economy as well as the relative effects on both countries. The effects on both the home country and the foreign country can be derived using these results.

### 3.4. The Effects of Shocks on the Home Country and the Foreign Country

Using the definition of (12a) and (12b) we can easily calculate the effects of domestic and foreign shocks on real income and prices at home and abroad. The following example may explain the method. For analyzing the isolated effects of money demand disturbances ( $\eta_i = \eta_i^* = \mu_i = \mu_i^* = 0$ ) under a money supply rule we calculate domestic (28a) and foreign (28b) real income as follows:

$$(28a) \quad y_i = \frac{1}{2}(y_i^a + y_i^d) \quad (28b) \quad y_i^* = \frac{1}{2}(y_i^a - y_i^d)$$

Substituting (18a) and (24a) in (28a) we obtain for the domestic real income:

$$(29a) \quad y_t = \frac{1}{2} \{-\beta_1 \kappa \varepsilon_t^a / N_1 - \beta_1 [\kappa(2g-1) + 2\phi] \varepsilon_t^d / N_2\}$$

Based on (28b) we obtain for the foreign real income:

$$(29b) \quad y_t^* = \frac{1}{2} \{-\beta_1 \kappa \varepsilon_t^a / N_1 + \beta_1 [\kappa(2g-1) + 2\phi] \varepsilon_t^d / N_2\}.$$

From this method we can analyze the effects of symmetric, unilateral, perfectly asymmetric shocks or any other combination. In the case of positive symmetric money demand shocks ( $\varepsilon_t = \varepsilon_t^* > 0$ ) we have  $\varepsilon_t^d = 0$ , but  $\varepsilon_t^a > 0$ . As  $N_1 > 0$  and  $N_2 > 0$  we obtain from (29a) and (29b) that real income drops in both countries. A unilateral positive domestic money demand shock ( $\varepsilon_t > 0$  and  $\varepsilon_t^* = 0$ ) leads to a drop in real income at home. The effect on the foreign country is uncertain without knowing the parameters of the model.<sup>14</sup> In the case of a money demand switch ( $0 < \varepsilon_t = -\varepsilon_t^*$ ) real income in the home country falls, whereas real income abroad increases because  $\varepsilon_t^a = 0$  and  $\varepsilon_t^d > 0$ . A similar analysis can be undertaken for all shocks and all regimes. The direction of change of key macroeconomic variables is summarized in table 1, where a question mark indicates that the direction of change is ambiguous without knowing the parameters.

Table 1 reveals that all types of shocks - independent to the country of origin - have an impact on real income and prices in both countries under a money supply rule. In this model, with wage rigidities, flexible exchange rates do not isolate the home country from foreign shocks. Obviously, similar results hold for the foreign country, because of the symmetry. The transmission effects of unilateral domestic shocks, however, are mostly uncertain without knowing the parameters of the model.

In contrast, the analysis of coordinated nominal GNP-targeting and coordinated price rules reveal some of the possible advantages of such an agreement. The effects of money demand disturbances on real income, and the price level are fully absorbed, independent of whether shocks are symmetric, completely asymmetric or unilateral. An x percent drop (increase) in money demand is compensated by an x percent reduction (increase) of money

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<sup>14</sup> Negative money demand disturbances have identical effects to unanticipated increases in money supply. Thus, the transmission effects of monetary policy are uncertain in this model. An unexpected increase of money supply in the home country may be associated with positive or negative spill-over effects. This result is compatible with simulation results reported by 12 leading econometric models. Most econometric models, however, suggest that fiscal shocks are transmitted positively [see Bryant et al., 1988].



Table 1 - Direction of change of key macroeconomic variables under alternative monetary policy rules

Type of shock	World Economy		Home country			Foreign country			Real ex- change rate
	$p_t^{av}$	$y_t^a$	$p_t$	$p_t^c$	$y_t$	$p_t^*$	$p_t^{c*}$	$y_t^*$	$z_t$
<b>Money Supply Rules</b>									
Sym. LM-Shock $\varepsilon_t = \varepsilon_t^* > 0$	↓	↓	↓	↓	↓	↓	↓	↓	0
Sym. IS-Shock $\eta_t = \eta_t^* > 0$	↑	↑	↑	↑	↑	↑	↑	↑	0
Sym. Supply-Shock $\mu_t = \mu_t^* > 0$	↓	↑	↓	↓	↑	↓	↓	↑	0
LM-Shock $\varepsilon_t > 0$	↓	↓	↓	↓	↓	?	?	?	↓
IS-Shock $\eta_t > 0$	↑	↑	↑	?	↑	?	↑	?	↓
Supply-Shock $\mu_t > 0$	↓	↑	↓	↓	↑	?	?	?	↑
LM-Switch $0 < \varepsilon_t = -\varepsilon_t^*$	0	0	↓	↓	↓	↑	↑	↑	↓
IS-Switch $0 < \eta_t = -\eta_t^*$	0	0	↑	?	↑	↓	?	↓	↓
Supply-Switch $0 < \mu_t = -\mu_t^*$	0	0	↓	↓	↑	↑	↑	↓	↑
<b>Nominal-GNP Rules</b>									
Sym. LM-Shock $\varepsilon_t = \varepsilon_t^* > 0$	0	0	0	0	0	0	0	0	0
Sym. IS-Shock $\eta_t = \eta_t^* > 0$	0	0	0	0	0	0	0	0	0
Sym. Supply-Shock $\mu_t = \mu_t^* > 0$	↓	↑	↓	↓	↑	↓	↓	↑	0
LM-Shock $\varepsilon_t > 0$	0	0	0	0	0	0	0	0	0
IS-Shock $\eta_t > 0$	0	0	0	↓	0	0	↑	0	↓
Supply-Shock $\mu_t > 0$	↓	↑	↓	?	↑	0	↓	0	↑
LM-Switch $0 < \varepsilon_t = -\varepsilon_t^*$	0	0	0	0	0	0	0	0	0
IS-Switch $0 < \eta_t = -\eta_t^*$	0	0	0	↓	0	0	↑	0	↓
Supply-Switch $0 < \mu_t = -\mu_t^*$	0	0	↓	?	↑	↑	?	↓	↑
<b>Price (CPI)-Rules</b>									
Sym. LM-Shock $\varepsilon_t = \varepsilon_t^* > 0$	0	0	0	0	0	0	0	0	0
Sym. IS-Shock $\eta_t = \eta_t^* > 0$	0	0	0	0	0	0	0	0	0
Sym. Supply-Shock $\mu_t = \mu_t^* > 0$	0	↑	0	0	↑	0	0	↑	0
LM-Shock $\varepsilon_t > 0$	0	0	0	0	0	0	0	0	0
IS-Shock $\eta_t > 0$	0	0	↑	0	↑	↓	0	↓	↓
Supply-Shock $\mu_t > 0$	0	↑	↓	0	↑	↑	0	↑	↑
LM-Switch $0 < \varepsilon_t = -\varepsilon_t^*$	0	0	0	0	0	0	0	0	0
IS-Switch $0 < \eta_t = -\eta_t^*$	0	0	↑	0	↑	↓	0	↓	↓
Supply-Switch $0 < \mu_t = -\mu_t^*$	0	0	↓	0	↑	↑	0	↓	↑
<b>Producer Price Rules</b>									
Sym. LM-Shock $\varepsilon_t = \varepsilon_t^* > 0$	0	0	0	0	0	0	0	0	0
Sym. IS-Shock $\eta_t = \eta_t^* > 0$	0	0	0	0	0	0	0	0	0
Sym. Supply-Shock $\mu_t = \mu_t^* > 0$	0	↑	0	0	↑	0	0	↑	0
LM-Shock $\varepsilon_t > 0$	0	0	0	0	0	0	0	0	0
IS-Shock $\eta_t > 0$	0	0	0	↓	0	0	↑	0	↓
Supply-Shock $\mu_t > 0$	0	↑	0	↑	↑	0	↓	0	↑
LM-Switch $0 < \varepsilon_t = -\varepsilon_t^*$	0	0	0	0	0	0	0	0	0
IS-Switch $0 < \eta_t = -\eta_t^*$	0	0	0	↓	0	0	↑	0	↓
Supply-Switch $0 < \mu_t = -\mu_t^*$	0	0	0	↑	↑	0	↓	↓	↑

supply in the respective country. The effects of symmetric goods market demand shocks are also perfectly neutralized. Furthermore, the effects of unilateral goods demand disturbances or IS-switches are fully absorbed with respect to real income and the producer price index in the case of nominal GNP-targeting or a producer price rule. Price stability measured in terms of the consumer price index is, however, not guaranteed. This occurs, because a change in the nominal exchange rate induces a change of import prices. In general, supply shocks always influence at least one of the macroeconomic target variables. However, domestic (foreign) supply shocks do not have an impact on foreign (domestic) real income and the producer price index in the case of a nominal GNP rule and producer price rule.<sup>15</sup>

Although the analysis of the direction of change of key macroeconomic variables hints at the advantages of feed-back rules, the magnitude of the effects is not visible. Furthermore, it has to be kept in mind that the political goal of real income ( $\hat{y}$ ) exceeds the natural rate in both countries. A symmetric negative money demand shock that increases real income and the inflation rate under a money supply rule, for example, might coincidentally look better than the same shock under the alternative rules that fully absorb the shock. However, a symmetric positive money demand disturbance would definitively reduce welfare under a money supply rule. Keeping these limitations in mind, table 1 nonetheless reveals some of the disadvantages of a fixed money supply rule.

To further compare the remaining strategies<sup>16</sup> we can calculate the expected losses. Because of the symmetry it is sufficient to analyze the expected loss of the home country with respect to domestic and foreign shocks. To simplify the algebra, we assume that all shocks are uncorrelated nationally as well as internationally. The expected losses are calculated by substituting  $y_t$  and  $p_t^f$  in (11a), where  $y_t$  and  $p_t^f$  are derived from the additive and difference system based on (12a).

$$(30) \quad EL|NI = \hat{y}^2 + \sigma_\mu^2 + \chi\{[\kappa(2g-1)+2\varphi-(1+\delta)(1-g)]^2\sigma_\mu^2 + (1+\delta)^2(1-g)^2\sigma_\mu^2 + (1-g)^2(\sigma_\eta^2 + \sigma_{\eta^*}^2)\} / N_3^2$$

$$(31) \quad EL|CPI = \hat{y}^2 + \{(1+\beta_1)^2[\kappa(2g-1)+2\varphi+\beta_2(1+\delta)]^2\sigma_\mu^2 + \beta_2^2(1+\beta_1)^2(1+\delta)^2\sigma_\mu^2 + \beta_2^2(\sigma_\eta^2 + \sigma_{\eta^*}^2)\} / N_4^2$$

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<sup>15</sup> Since in this model all foreign shocks are demand disturbances from the domestic perspective, this implies that a nominal GNP rule and a producer price rule neutralize the effects of all demand disturbances with respect to real income and the producer price level.

<sup>16</sup> We omit the expected loss of a money supply rule, which results from tedious calculations and remains difficult to interpret.

$$(32) \quad EL|PP = \hat{y}^2 + (1 + \beta_1)^2 \sigma_\mu^2 + \chi \{ (1 + \delta)^2 (\beta_2 + 1 - g)^2 (\sigma_\mu^2 + \sigma_{\mu^*}^2) + (1 - g)^2 (\sigma_\eta^2 + \sigma_{\eta^*}^2) \} / N_3^2$$

where  $\sigma_\mu^2$  is defined as  $E[(\mu_t)^2]$  and  $\sigma_{\mu^*}^2$  as  $E[(\mu_t^*)^2]$  and so forth.

Obviously, none of these rules is able to avoid the expected losses associated <sup>with</sup> the political goal of raising real income above the natural rate. Furthermore, it is interesting to note that under all three regimes, the expected loss of goods demand disturbances is independent of the country of origin in this symmetrical world. The expected loss is furthermore identical under a nominal income rule and a producer price rule. In contrast, the expected loss associated <sup>with</sup> supply shocks is generally higher with respect to domestic supply shocks than with respect to foreign supply shocks. Nominal income targeting remains definitively superior to a producer price rule in the case of domestic supply shocks.

Although the above analysis reveals that the superiority of a rule depends on the structural parameter of the model, the type of shocks, the country of origin as well as the weights in the social objective function, nominal GNP-targeting is never clearly inferior, as e.g. money supply targeting. Thus, nominal GNP-targeting remains a fairly promising candidate for future monetary policy.

### 3.5. Asymmetric Rules

Up to now, we assumed that both countries agreed on following the same rule. In the following part, it will be analyzed how these results may change, if both countries follow for whatever reason different rules. Starting from a situation where both countries follow a constant money supply rule, we assume that the home country changes its regime.<sup>17</sup> We are thus interested in answering the following type of questions. Under which type of shocks does the home country clearly benefit from its regime shift? Is the foreign country better or worse off from the fact that the home country follows a flexible rule?

In the case of a positive money demand shock in the home country, the domestic central bank increases money supply in such a way that the demand disturbance is fully offset under a nominal GNP rule and under both price rules. The home country clearly benefits from the regime shift, as a needless recession is avoided. The foreign country would also be clearly advantaged by the home country's strategy, if the government's objective would be to obtain price stability and to stabilize real income at the natural rate. However, results are less clear-cut if the political goal of real income exceeds the natural rate. Under a constant money

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<sup>17</sup> Argy [1991] presents a similar analysis. His results, however, differ mainly because in his model the government's real income objective is the natural rate and not a higher level ( $\hat{y}$ ).

supply rule the transmission effects of a unilateral money demand shock is uncertain without knowing the parameters of the model. Thus, if the spill-over effects of a negative unilateral money demand shock were positive with respect to foreign real income, it might coincidentally improve welfare in the foreign country, because the welfare gain of a rising real income may overcompensate for the loss associated <sup>with</sup> less price stability.

If the money demand disturbance occurs in the foreign country, the impact on the home country's prices or nominal GNP is ambiguous. Therefore, the necessary direction of change of the home country's monetary policy to accommodate the effects of the shock is again uncertain. Since the spill-over effects of monetary policy are ambiguous, the foreign country may be better or worse off.

The analysis of foreign goods demand disturbances or supply shocks leads to similar vague conclusions. In the case of a coordinated money supply rule the spill-over effects of both types of shocks are ambiguous. If nominal income or the corresponding price level tend to increase (decrease) in the home country the authorities will follow a restrictive (expansionary) monetary policy under a nominal income or a price-level rule respectively. The effects of monetary policy are again ambiguous with respect to the foreign policy objectives. The unilateral implementation of a nominal GNP rule or a price level rule may again improve or worsen the situation abroad.

In contrast, the effects of all types of foreign shocks are neutralized with respect to real domestic income and the domestic producer price under a producer price rule or nominal GNP-targeting. The same holds for domestic money demand disturbances and for domestic goods demand disturbances.<sup>18</sup> Although it remains difficult to reach conclusions about the concrete welfare effects, the analysis suggests that a single large country that commits to a nominal GNP rule may still benefit to some extent from the demand-shock-absorbing capacity of this rule.

The above results are derived from a simplified symmetrical two-country model. The gap between the theoretical approach and the real world is still large. Countries are not symmetric, shocks may be permanent and it remains difficult to identify the nature and source of shocks. To further compare the effects of alternative policy regimes, a full model simulation is needed.

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<sup>18</sup> This can be easily seen when the supply functions are expressed in terms of the producer price index.



#### 4. SIMULATION RESULTS OF SIMULTANEOUS NOMINAL GNP-TARGETING

Warwick McKibbin and Frankel have started to use the McKibbin-Sachs Global (MSG) model<sup>19</sup> of the world economy to assess the effects of alternative shocks, including a doubling of the world price of oil, a 5 percent unilateral US money demand shock as well as a 1 percent unilateral US real demand shock under alternative policy regimes. The MSG model takes into account country specific characteristics and covers altogether seven regions: the USA, Japan, Germany, the rest of the European Monetary System, the rest of the Organization for Economic Cooperation and Development (OECD), non-oil developing countries and the Organization of Petroleum countries. In the simulation analysis it is assumed that the USA, Japan and Germany adopt the same policy regime. The rest of the OECD countries, which are reported as a unit, are assumed to keep their money supplies fixed. Table 2 reports some of the simulation results.

Table 2 reports the effects of the three types of shocks under four alternative regimes, a constant money supply rule in both countries, nominal GNP-targeting, non-cooperative discretion as well as cooperative discretionary policy. The latter assumes a G-3 central planner who maximizes a world objective function in which the individual objective functions enter with their shares of GNP. Both discretionary regimes reported here, however, have to be interpreted as being ideal, because they do not yet incorporate any temptation of the government to inflate <sup>by</sup> surprise. Both regimes would lose some of their advantages in the presence of an "inflationary-bias" [for a detailed description and results see Frankel, 1991]. The first year effects on output and inflation are reported as percentage deviations from baseline in each first column. The second column of each regime conveys the overall magnitude of effect over 5 years; it is the square root of the sum of the yearly squared effects.

Simulation results are in line with the results of the symmetric two-country analysis. A nominal GNP rule fully neutralizes the effects of money demand shocks and substantially reduces the effects associated to a 1 percent US real demand shock in the G-3 countries. A doubling of the world price of oil would lead to a greater short-run loss under nominal GNP-targeting than under money supply targeting or the discretionary regimes. Furthermore, table 2 reveals that the rest of the OECD countries does not necessarily benefit from the introduction of nominal GNP-targeting in the G-3 countries, depending on the weights assigned to the output and inflation objective. Countries that do not participate in the coordination process may possibly have an incentive to join the club or to switch their regimes independently. These results are compatible with those of the two-country model with asymmetric rules, where the foreign country does not necessarily benefit from the

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<sup>19</sup> For a detailed description of the framework see McKibbin and Sachs [1986, 1989a,b].

Table 2 - Macroeconomic effects in the McKibbin-Sachs Global Model<sup>a</sup>

	Money Rule		Nominal Income Targeting		Non-Cooperative Discretion		Cooperative Discretion	
	1 year	s.e	1 year	s.e	1 year	s.e	1 year	s.e
<i>Oil price shock (100%)</i>								
US Economy								
Output, %y	-1.79	3.05	-2.92	3.81	-2.47	2.79	-2.31	2.62
Inflation	3.57	4.52	2.94	3.88	3.09	3.45	3.19	3.58
Japanese Economy								
Output, % y	-1.07	1.12	-2.14	2.16	-0.61	0.62	-0.52	0.53
Inflation	2.84	3.64	2.16	2.93	3.30	3.31	3.35	3.51
German Economy								
Output, % y	-0.29	3.63	-1.47	2.86	-0.10	0.20	0.00	0.07
Inflation	2.46	3.03	1.50	1.95	2.44	3.17	2.52	3.33
Rest of OECD Economies								
Output, % y	-1.35	2.34	-0.98	2.39	-1.15	2.10	-1.20	2.08
Inflation	3.38	4.18	4.15	5.14	3.57	4.61	3.48	4.49
<i>US money demand shock (5%)</i>								
US Economy								
Output, %y	-1.21	1.26	0.00	0.01	0.01	0.01	0.01	0.01
Inflation	-0.92	1.09	-0.01	0.01	-0.01	0.01	-0.01	0.01
Japanese Economy								
Output, % y	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Inflation	0.18	0.25	0.00	0.00	0.00	0.00	0.00	0.01
German Economy								
Output, % y	0.36	0.49	0.00	0.01	0.00	0.00	0.00	0.00
Inflation	0.25	0.33	0.00	0.01	0.00	0.01	0.00	0.01
Rest of OECD Economies								
Output, % y	0.26	0.29	0.03	0.03	0.03	0.03	0.03	0.03
Inflation	0.30	0.39	0.03	0.04	0.03	0.04	0.03	0.04
<i>US-real demand shock (1%)</i>								
US Economy								
Output, %y	1.33	1.36	0.15	0.33	0.19	0.27	0.19	0.27
Inflation	0.52	0.58	-0.24	0.35	-0.22	0.32	-0.22	0.33
Japanese Economy								
Output, % y	0.42	0.43	-0.05	0.06	-0.02	0.03	-0.02	0.03
Inflation	0.33	0.39	0.11	0.15	0.13	0.16	0.13	0.27
German Economy								
Output, % y	0.54	0.73	0.02	0.19	0.01	0.01	0.00	0.00
Inflation	0.36	0.43	-0.12	0.19	-0.13	0.22	-0.14	0.23
Rest of OECD Economies								
Output, % y	0.51	0.53	0.85	0.92	0.84	0.91	0.84	0.92
Inflation	0.40	0.46	0.97	1.21	0.96	1.19	0.96	1.20

<sup>a</sup> Selected results from Frankel [1991].

domestic regime shift. In the two-country case, both countries may already be interpreted as a bloc of countries that follows different rules.

## 5. CONCLUDING REMARKS

A fundamental precondition for any successful international coordination scheme is its ability to overcome three obstacles: compliance, credibility, and certainty.

The incentive to deviate from the international agreement largely depends on the robustness of the coordination scheme with respect to disturbances that occur after the agreement is made. In a two-country model different monetary policy arrangements were compared, including simultaneous nominal GNP rule, a simultaneous money supply rule, simultaneous price-level (inflation) rules as well as discretionary policy from the world perspective. As long as shocks are symmetric, nominal income targeting dominates all other regimes, if the authorities assign equal weights to the real income and inflation objective and the supply elasticity with respect to unexpected inflation is 1. The first condition may represent roughly the split that a discretionary policy would favor anyway, while the second condition is close to some empirical estimates. In the event of money demand disturbances, a coordinated version of nominal GNP-targeting as well as price rules insulate the economy, neither real income nor the price level are affected. This is true for symmetric, asymmetric as well as unilateral shocks. Under all other circumstances, however, fixing nominal GNP still comes out fairly well, although it does not give precisely the right answer. In particular in the case of supply shocks, an absolute commitment to a nominal GNP rule is unwisely constraining. Simulation results based on the McKibbin-Sachs Global model are in line with these findings. All these results, however, are still derived under simplified assumptions and the version of nominal GNP-targeting that is evaluated is a restricted one. It is assumed that both countries eternally fix their rate of nominal growth and are able to hit their targets accurately.<sup>20</sup>

Frankel [1989a] has proposed a cooperative international version of a nominal GNP rule, where the G-7 participants would (a) loosely commit themselves to broad target ranges for their collective and individual rates of growth of nominal demand,<sup>21</sup> for five years into the future, and (b) commit themselves to somewhat narrower targets for the coming year. A minimum requirement for the credibility of the authorities' commitment vis-à-vis <sup>their</sup> partners

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<sup>20</sup> Asako [1991] analyzes nominal GNP-targeting under money supply and multiplier uncertainties.

<sup>21</sup> There is a reason for choosing nominal demand (defined as GNP minus the trade balance) as the target variable, in place of nominal GNP, even though the latter is a more familiar concept. In the event of a recession, countries need to be discouraged from the temptation to accomplish their expansion of output through net foreign demand - for example, through protectionist measures - as opposed to domestic demand.

and the private sector is that the agreement should be explicit. The targets would be publicly announced, in the manner that the Chairman of the Federal Reserve Board announced to the US Congress target ranges for M1 money supply until recently or the German Bundesbank still does at the end of each year. A significant deviation of the rate of growth of nominal demand from the target value would be noted disapprovingly at the next G-7 meeting. The threat of losing reputation should create the right incentives to stick to the agreement. Nonetheless, for each cooperator the challenge remains to control its own nominal demand target in line with the agreement. Thus, it should best be up to each country how to attain the target, though the tools of monetary policy must presumably take precedence over the tools of fiscal policy for purposes of short-run adjustment.

As long as the coordination process remains stalled, a single country may well start introducing nominal GNP-targeting in a first step, if the preferences of this country are such. The theoretical analysis of asymmetric regimes suggests that this country may still be able to reap at least some of the benefits. If competition about the appropriate monetary strategy leads then to an assimilation of targets, the fundamental basis for INT would be created.

## APPENDIX

### Additive System

#### Nominal GNP-Targeting and Money Supply Targeting:

From (6'), (7'), (8') and (10') we get the difference equation of the sum of prices (A1) by substituting for  $i_t^a$  and  $m_t^a$  in equation (7') using (8') and (10') and subsequently substituting  $y_t^a$  using equation (6').

$$(A1) \quad -\alpha_1 \kappa E_t p_{t+1}^a + [\theta \kappa (1 + \beta_1) + \kappa (\alpha_1 + \alpha_2 \beta_1 + 1) + \alpha_1 \beta_1 (1 - \delta)] p_t^a - \beta_1 [\alpha_1 (1 - \delta) + \kappa (\alpha_2 + \theta)] E_{t-1} p_t^a = u_t^a$$

where  $u_t^a = -\kappa \varepsilon_t^a + \alpha_1 \eta_t^a - (1 + \beta_1) [\alpha_1 (1 - \delta) + \kappa (\alpha_2 + \theta)] \mu_t^a$ ,

Forwarding (A1)  $j$  periods ahead and taking expectations in  $t-1$ , we obtain:

$$(A1') \quad -\alpha_1 \kappa E_{t-1} p_{t+1+j}^a + \kappa (\theta + \alpha_1 + 1) E_{t-1} p_{t+j}^a = 0$$

The characteristic root of (A1') is  $\lambda = 1 + (1 + \theta) / \alpha_1$ . Excluding the possibility of an exploding price path for  $|\lambda| > 1$ , which we get if  $\theta < -2\alpha_1 - 1$  or  $\theta > -1$ , it is conventionally imposed that  $E_t p_{t+1}^a = E_{t-1} p_t^a = 0$  in this case. Under these circumstances we obtain (A2) for  $p_t^a$

$$(A2) \quad p_t^a = \frac{u_t^a}{\theta \kappa (1 + \beta_1) + \kappa (\alpha_1 + \alpha_2 \beta_1 + 1) + \alpha_1 \beta_1 (1 - \delta)}$$

In the case of a money supply rule in both countries  $\theta = 0$ . (A3) is identical to (18b) in the text.

$$(A3) \quad p_t^a | MS = \{-\kappa \varepsilon_t^a + \alpha_1 \eta_t^a - (1 + \beta_1) [\alpha_1 (1 - \delta) + \kappa \alpha_2] \mu_t^a\} / N_1,$$

where  $N_1 = \kappa (\alpha_1 + \alpha_2 \beta_1 + 1) + \alpha_1 \beta_1 (1 - \delta)$

In the case of nominal income targeting  $\theta \rightarrow \infty$ .

$$(A4) \quad p_t^a | NI = \lim_{\theta \rightarrow \infty} p_t^a = \lim_{\theta \rightarrow \infty} \frac{-\kappa \varepsilon_t^a \theta^{-1} + \alpha_1 \eta_t^a \theta^{-1} - (1 + \beta_1) [\alpha_1 (1 - \delta) + \kappa (\alpha_2 + \theta)] \mu_t^a \theta^{-1}}{\kappa (1 + \beta_1) + \kappa (\alpha_1 + \alpha_2 \beta_1 + 1) \theta^{-1} + \alpha_1 \beta_1 (1 - \delta) \theta^{-1}} = -\mu_t^a$$

Real income is obtained by substituting the above results for the price level in (6') with  $E_{t-1} p_t^a = 0$ .



### Price level rule:

The results for a price level rule are obtained similarly by solving the difference equation (A5), which is derived from (6', 7', 8', 10'\*):

$$(A5) \quad -\alpha_1 \kappa E_t p_{t+1}^a + [\kappa(\theta + 1 + \alpha_1) + \alpha_1 \beta_1 (1 - \delta) + \alpha_2 \beta_1 \kappa] p_t^a - \beta_1 [\alpha_1 (1 - \delta) + \alpha_2 \kappa] E_{t-1} p_t^a \\ = -\kappa \varepsilon_t^a + \alpha_1 \eta_t^a - (1 + \beta_1) [\alpha_1 (1 - \delta) + \alpha_2 \kappa] \mu_t^a$$

### **Difference System**

#### Nominal GNP-Targeting and Money Supply Targeting

From (6'', 8'', 9'') and from (6'', 7'', 9'', 10'') we obtain the following pair of (dynamic) equations (A6) and (A7):

$$(A6) \quad \beta_1 (1 + \delta) p_t^{cd} - \beta_1 (1 + \delta) E_{t-1} p_t^{cd} + \kappa (2g - 1) E_t z_{t+1} - [\kappa (2g - 1) + 2\varphi + 2\beta_2 (1 + \delta)] z_t \\ + 2\beta_3 (1 + \delta) E_{t-1} z_t = -(1 + \delta) (1 + \beta_1) \mu_t^d + \eta_t^d$$

$$(A7) \quad \alpha_1 E_t p_{t+1}^{cd} - [\theta (1 + \beta_1) + \beta_1 \alpha_2 + 1 + \alpha_1] p_t^{cd} + \beta_1 (\alpha_2 + \theta) E_{t-1} p_t^{cd} + \alpha_1 (2g - 1) E_t z_{t+1} \\ + [2\theta (1 - g + \beta_2) + 2\alpha_2 \beta_2 - \alpha_1 (2g - 1)] z_t - 2\beta_3 [\alpha_2 + \theta] E_{t-1} z_t = \varepsilon_t^d + (1 + \beta_1) (\theta + \alpha_2) \mu_t^d$$

After taking expectations in  $t-1$  and forwarding  $j$  periods ahead the two characteristic roots are:

$$\lambda_1 = 1 + 2[\varphi + (1 + \delta)(\beta_2 - \beta_3)] / \kappa (2g - 1) \text{ and } \lambda_2 = 1 + (1 + \theta) / \alpha_1.$$

As all elasticities and semi-elasticities are assumed to be positive and  $g > 0.5$ , and since  $\beta_2$  is larger than  $\beta_3$  we always get  $\lambda_1 > 1$ . Furthermore, we get  $|\lambda_2| > 1$  if  $\theta < -2\alpha_1 - 1$  or  $\theta > -1$ .

To exclude explosive paths, it is conventionally imposed under these conditions that:  $E_{t-1} z_t = E_{t-1} p_t^{cd} = E_t p_{t+1}^{cd} = E_t z_{t+1} = 0$ . Solving (A6) for  $z_t$  results then in:

$$(A8) \quad z_t = \{(1 + \delta)(1 + \beta_1) \mu_t^d - \eta_t^d + \beta_1 (1 + \delta) p_t^{cd}\} [\kappa (2g - 1) + 2\varphi + 2\beta_2 (1 + \delta)]^{-1}$$

Substituting (A8) in (A7), and making use of  $\beta_2 = \beta_1 (1 - g)$  in the denominator results in:

$$(A9) \quad p_t^{cd} = \frac{-[\kappa(2g-1)+2\varphi+2\beta_2(1+\delta)]\varepsilon_t^d - [2\theta(1+\beta_2-g)+2\alpha_2\beta_2-\alpha_1(2g-1)]\eta_t^d}{[\theta(1+\beta_1)+\alpha_2\beta_1+1+\alpha_1][\kappa(2g-1)+2\varphi]+\beta_1(1+\delta)[\alpha_1+2(1-g)]} \\ + \frac{+(1+\beta_1)\{(1+\delta)[2\theta(1-g)-\alpha_1(2g-1)]-(\theta+\alpha_2)[\kappa(2g-1)+2\varphi]\}\mu_t^d}{[\theta(1+\beta_1)+\alpha_2\beta_1+1+\alpha_1][\kappa(2g-1)+2\varphi]+\beta_1(1+\delta)[\alpha_1+2(1-g)]}$$

In the case of a money supply rule  $\theta = 0$  in (A9). Therefore we get (24c). In the case of nominal GNP-targeting  $\theta \rightarrow \infty$  results in (25c). To calculate  $p_t^d$  we use the fact that:  $p_t^d = p_t^{cd} - 2(1-g)z_t$  together with (A8). Real Income can then easily be calculated by using the supply function  $y_t^d = \beta_1(\bar{p}_t^d - E_{t-1}p_t^d) - 2(\beta_2 - \beta_3)E_{t-1}z_t + (1+\beta_1)\mu_t^d$ , which is the difference of the supply functions in terms of the difference of the producer prices.

#### Price Level (Inflation-Rate) Targeting: CPI

The calculation follows the same procedure. From (6''), (7''), (9'') and (10'\*) we obtain:

$$(A10) \quad \alpha_1 E_t p_{t+1}^{cd} - [\theta + \beta_1 \alpha_2 + 1 + \alpha_1] p_t^{cd} + \alpha_2 \beta_1 E_{t-1} p_t^{cd} + \alpha_1 (2g-1) E_t z_{t+1} + [2\alpha_2 \beta_2 - \alpha_1 (2g-1)] z_t \\ - 2\alpha_2 \beta_3 E_{t-1} z_t = \varepsilon_t^d + \alpha_2 (1 + \beta_1) \mu_t^d$$

Substituting  $z_t$  from (A8) in (A10) along with  $E_{t-1} p_t^{cd} = E_{t-1} p_t^{cd} = E_{t-1} z_t = E_t z_{t+1} = 0$  results in (A11), where we use again  $\beta_2 = \beta_1(1-g)$  in the denominator:

$$(A11) \quad p_t^{cd}|_{CPI} = \frac{-[\kappa(2g-1)+2\varphi+2\beta_2(1+\delta)]\varepsilon_t^d - [2\alpha_2\beta_2-\alpha_1(2g-1)]\eta_t^d}{(\theta+\alpha_2\beta_1+1+\alpha_1)[\kappa(2g-1)+2\varphi]+\beta_1(1+\delta)[2\theta(1-g)+\alpha_1+2(1-g)]} \\ + \frac{+(1+\beta_1)\{\alpha_1(1+\delta)(2g-1)-\alpha_2[\kappa(2g-1)+2\varphi]\}\mu_t^d}{(\theta+\alpha_2\beta_1+1+\alpha_1)[\kappa(2g-1)+2\varphi]+\beta_1(1+\delta)[2\theta(1-g)+\alpha_1+2(1-g)]}$$

Taking limit  $\theta \rightarrow \infty$  in (A11) results in (26c). From  $p_t^d = p_t^{cd} - 2(1-g)z_t$  we calculate (26b). Substituting the results in the supply equation gives (26a).

The calculation follows again the same procedure. From (6''), (7''), (9''), and (10'\*) we get:

$$(A12) \quad \alpha_1 E_t p_{t+1}^{cd} - [\theta + \beta_1 \alpha_2 + 1 + \alpha_1] p_t^{cd} + \alpha_2 \beta_1 E_{t-1} p_t^{cd} + \alpha_1 (2g-1) E_t z_{t+1} \\ + [2\theta(1-g) + 2\alpha_2 \beta_2 - \alpha_1 (2g-1)] z_t - 2\alpha_2 \beta_3 E_{t-1} z_t = \varepsilon_t^d + \alpha_2 (1 + \beta_1) \mu_t^d$$

Substituting (A8) in (A12) and using  $\beta_2 = \beta_1(1-g)$  in the denominator along with  $E_{t-1} p_t^{cd} = E_{t-1} p_t^{cd} = E_{t-1} z_t = E_t z_{t+1} = 0$  results in:

$$(A13) \quad p_t^{cd} = \frac{-[\kappa(2g-1) + 2\varphi + 2\beta_2(1+\delta)]\varepsilon_t^d - [2\theta(1-g) + 2\alpha_2 \beta_2 - \alpha_1(2g-1)]\eta_t^d}{(\theta + \alpha_2 \beta_1 + 1 + \alpha_1)[\kappa(2g-1) + 2\varphi] + \beta_1(1+\delta)[\alpha_1 + 2(1-g)]} \\ + \frac{+(1 + \beta_1)\{(1+\delta)[2\theta(1-g) - \alpha_1(2g-1)] - \alpha_2[\kappa(2g-1) + 2\varphi]\}\mu_t^d}{(\theta + \alpha_2 \beta_1 + 1 + \alpha_1)[\kappa(2g-1) + 2\varphi] + \beta_1(1+\delta)[\alpha_1 + 2(1-g)]}$$

Taking limit in (A13) results in (27c), where we again make use of  $\beta_2 = \beta_1(1-g)$  in the numerator. (27a) and (27b) are obtained as above.

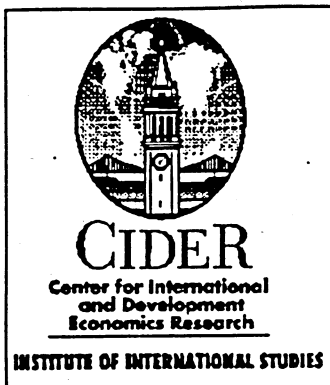
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