International Finance Discussion Papers

Number 340

January 1989

A NEW INTERPRETATION OF THE COORDINATION PROBLEM AND ITS EMPIRICAL SIGNIFICANCE

Matthew B. Canzoneri and Hali J. Edison

NOTE: International Finance Discussion Papers are preliminary materials circulated to stimulate discussion and critical comment. References in publications to International Finance Discussion Papers (other than an acknowledgment that the writer has had access to unpublished material) should be cleared with the author or authors.

ABSTRACT

In this paper, we discuss a new interpretation of what might be meant by the "coordination" of policies; in this interpretation, the policymakers are selecting a noncooperative solution rather than a cooperative solution. The new interpretation is suggested by the fact that games typically have a large number of Nash solutions, and players are not indifferent as to which occurs. The multiplicity of solutions may be due to information sharing and surveillance, the choice of policy instruments, or the adoption of reputational strategies in repeated versions of the game. The "coordination problem: results from policymakers' desire to coordinate on a good Nash equilibrium.

In section I, we use the simulations of the MCM and the OECD model that were prepared for the May 1988 FRB Monetary Conference to derive reduced forms for inflation and output, and we simulate a one-shot game. We calculate an uncoordinated Nash solution, a Nash solution coordinated on the low deficit assumption, two more Nash solutions coordinated on instruments as well as the low deficit assumption, and finally a cooperative solution. By comparing them, we hope to assess the empirical relevance of the new interpretation of the coordination problem. The Nash solutions based on the low deficit assumptions are to be viewed as approximations to coordinated Nash solutions based on information sharing and surveillance, always overstating their case.

In section II, we provide new simulations from the MCM to illustrate the dynamic paths of four possible outcomes under coordination and to look for indicators. The simulations consider the two scenarios for U.S. government purchases -- low and high. Given these two scenarios, two sets of possible responses are considered. The first set of responses correspond to when the policymakers are correct in predicting the path of the U.S. deficit. The second set of responses occur when the policymakers are wrong. The simulations show how much better off each country is when the policymakers get the shock right; they also suggest which indicator variables might be used as early warnings of mistaken assumptions.

In section III, we study a game that centers on instrument selection instead of information sharing and surveillance. Policymakers in the United States, Germany and Japan inherit inflation problems and full employment. We begin by calculating a Nash solution in which the United States is using the interest rate, while Japan and Germany are using money supply. Then we see how the outcome changes if the United States switches to the money supply or if the policymakers decide to cooperate.

We find, measuring importance by the percentage decrease in losses, that coordination on instruments is about ten times as important as cooperation, and we find that coordination on information and surveillance is about ten times as important as coordination on instruments. The results from our one-shot games are reinforced by the simulation exercise. Furthermore, the simulations suggest that interest rates or exchange rates would be good early warning indicators of mistaken assumptions about the size of the U.S. deficit; the current account would not, since it adjusts very slowly.

A New Interpretation of the Coordination Problem And Its Empirical Significance

Matthew B. Canzoneri and Hali J. Edison*

At the 1986 Economic Summit in Tokyo, the governments of the seven large industrialized nations called for a process of multilateral surveillance to promote "close and continuous coordination of economic policy". The 1986 IMF Interim Committee Communique states that an approach worth exploring is the "formulation of a set of objective indicators related to policy actions and economic performance, having regard to a medium-term framework. Such indicators might help to identify a need for discussions of countries' policies."

It is sometimes difficult to interpret just what is meant by the word "coordination" as used in this and similar contexts. The economists' tendency is to identify coordination with the game theorist's notion of "cooperation". (In a cooperative game, all of the players commit their policy instruments to minimizing a weighted sum of their individual losses. By contrast, in a non-cooperative or Nash game, each player sets instruments to minimize own losses, taking opponents' policies as given.[1/])

However, identifying coordination with cooperation has two difficulties. The first is that the game theorist's notion of cooperation involves the loss of sovereignty. There is a temptation to cheat on any cooperative agreement; cooperation requires the presence of a higher authority that can monitor compliance with the agreement and punish violators.[2/] However, there is nothing in recent summit declarations to suggest that any country is ready to yield sovereignty to a supranational agency like the IMF or the OECD. Furthermore, no committments are even implied by the proposed surveillance: indicators trigger consultations, not automatic policy responses. The second difficulty is that existing empirical studies have not made a strong case for cooperation;

usually the gains from cooperation are small, and often the difference between Nash and cooperative policies is operationally insignificant.[3] Yet policymakers, as evidenced by various communiques, seem to think that there is something to be gained.

In this paper, we discuss a new interpretation of what might be meant by the "coordination" of policies; in this interpretation, the policymakers are selecting a noncooperative, rather than a cooperative, solution.[4] The new interpretation is suggested by the fact that games typically have a large number of Nash solutions, and players are not indifferent as to which occurs. The multiplicity of solutions may be due to information sharing and surveillance, the choice of policy instruments, or the adoption of reputational strategies in repeated versions of the game. The "coordination problem", in this interpretation, results from policymakers' desires to coordinate on a good Nash equilibrium.

This new interpretation avoids the difficulties mentioned above. Since policymakers agree on a noncooperative solution, there will be no temptation to cheat; coordination does not require a world policeman or the loss of national sovereignty. Furthermore, the interpretation is not immediately challenged by existing empirical work; indeed, few studies have tried to quantify the differences between Nash solutions.

Here, we will focus on coordination via information sharing and surveillance or via instrument selection. We take as examples two games that are motivated by current or past policy discussions. In the first, monetary policymakers in the United States, Germany, and Japan have inherited mild inflation and unemployment. In addition, they worry about what will happen to the U.S. fiscal deficit after the coming elections. The monetary policies they

set in place now will have their major impact after the elections, when the new U.S. fiscal policy is in place. If the deficit comes down, then the policymakers will want to have been more expansionary to make up for lower world demand; if on the other hand the deficit gets worse, they will want to have been more contractionary to counter inflationary pressures.

In the absence of coordination, policymakers act on the basis of their expectations about the size of the U.S. deficit. The expected deficit is mildly expansionary, so there is a slight tightening of existing policies in the Nash solution. If the deficit comes down, a mild world recession ensues; if it does not, inflation ensues. The results are not disastrous in either case.

Different outcomes are possible, at least conceptually. Getting the shock right is always important in a stabilization problem. Suppose policymakers meet, share information, and coordinate on one of the two deficit scenarios. If they base policy on what turns out to be the right deficit assumption, the resulting outcome will be much better for all concerned. Of course, these policies are risky. If the policymakers coordinate on the wrong deficit assumption, the result will be much worse: big recessions if the deficit unexpectedly low, and big inflations if it is unexpectedly high.

This is where surveillance and indicators come in. If policymakers have an early warning that they have coordinated on the wrong assumption, they may be able to change policy in time to keep disaster scenarios from being played out. Early deficit figures provide some insight, but they may not reveal the true fiscal stance; additional indicators may also be desirable. Interest rates, exchange rates and current accounts may all be expected to behave one way if the assumed scenario is being played out and in quite another if it is

not. The appropriate indicators can be used to trigger consultations and a change in policy if it is deemed necessary.

Policy coordination based on information sharing and surveillance is however not likely to be as simple as coordinating on one of the two deficit scenarios. In a coordinated Nash solution, policymakers will continue to act in their own self interest, and their actions will continue to be based upon their own priors about the U.S. deficit. One stringent requirement must be met if coordination is to matter: the information sharing and (or) the process of surveillance and consultations must actually change the players' beliefs about game payoffs. If it does not, the coordinated solution will degenerate back to the original uncoordinated Nash.

If information sharing conveyed complete information to all players, then coordinating on the correct deficit scenario, as suggested above, would indeed be a Nash solution. However, in our game the prospects for information sharing seem rather more limited: U.S. monetary authorities may know more than their German and Japanese counterparts, but surely not enough to rule out either deficit scenario entirely. Priors about the deficit may shift, but policy would not be based on one scenario alone. The process of surveillance and consultations, and the consequent possibility of changing course midstream, will change the game's payoff structure; this would result in a new Nash solution even if there were no information to share. Thus, information sharing and the process of surveillance and consultation would be expected to move the coordinated Nash solution in the direction of coordinating on a deficit assumption, but actually basing policy on just one scenario must be a limiting case.

Policy coordination based on instrument selection may also be important, and it is far simpler. Poole (1970) showed that instrument selection matters

to an individual policymaker under uncertainty about private sector supplies or demands. Theoretically, instrument selection will always matter in a (noncooperative) game situation, even if there is no uncertainty about private sector behavior; the choice of a monetary instrument may not affect a policymaker's own inflation-unemployment tradeoff, but it will affect the opponent's.[5/] In addition, in a dynamic setting, pegging an interest rate can have a different effect over the short term than pegging a money supply. (It is this effect, and this effect alone, that is investigated below; clearly, a more systematic study of instrument selection is warranted.) So, policymakers may also wish to coordinate their choices between targetting interest rates and monetary aggregates.

In section I, we use the simulations of the MCM and the OECD model that were prepared for the May 1988 FRB Monetary Conference to derive reduced forms for inflation and output, and we simulate a static (or one-shot) version of the game described above. We calculate an uncoordinated Nash solution, a Nash solution coordinated on the low deficit assumption, two more Nash solutions coordinated on instruments as well as the low deficit assumption, and finally a cooperative solution. By comparing them, we hope to assess the empirical relevance of the new interpretation of the coordination problem. The Nash solutions based on the low deficit assumptions are to be viewed as approximations to coordinated Nash solutions based on information sharing and surveillance, always overstating their case.

In section II, we provide new simulations from the MCM to illustrate the dynamic paths of four possible outcomes under coordination and to look for indicator variables. The simulations consider two scenarios for U.S. government purchases -- low, or Gramm-Rudman path, and high. Given these two

scenarios, two sets of possible responses are considered. The first set of responses correspond to when the policymakers correctly predict the path of the U.S. deficit. The second set of responses occurs when the policymakers are wrong. The simulations show how much better off each country is when the policymakers get the shock right; they also suggest which indicator variables might be used as early warnings of mistaken assumptions.

In section III, we study a game that centers on instrument selection instead of information sharing and surveillance. The game is motivated by the disinflations of the early '80s, though no attempt is made to actually model that period. Policymakers in the U.S., Germany and Japan inherit inflation problems and full employment. We calculate a Nash solution in which the U.S. is using the interest rate, while Germany and Japan are using the money supply. Then, we see how the outcome changes if the U.S. switches to the money supply or if the policymakers decide to cooperate. In this way, we hope to compare the gains (or losses) from coordination on instruments with the gains from cooperation.

Measuring importance by the percentage decrease in losses, we find that coordination on instruments is about ten times as important as cooperation, and we find that coordination on information and surveillance (or more accurately, getting the shock right) is about ten times as important as coordination on instruments. The results from our one-shot games are reinforced by the simulation exercise. Furthermore, the simulations suggest that interest rates or exchange rates would be good early warning indicators of mistaken assumptions about the size of the U.S. deficit; the current account would not, since it adjusts very slowly.

I. The U.S. Deficit Game

First, we describe the structure of the game and the reduced forms for inflation and output coming from the MCM and the OECD model. Then, we calculate the uncoordinated Nash solution and a Nash solution coordinated on the low deficit scenario. Finally, we consider two further refinements: coordination on instruments and cooperation.

Ia. The Maintained Hypotheses

We think of a game being played by the monetary authorities in the U.S., Germany and Japan. Fiscal policies and the policies of other countries are fixed. Policymakers in the United States, Germany, and Japan worry about unemployment (or output) and inflation; their losses are given by

$$(1)\quad L_{US} = z_{US}^T \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} z_{US}, \quad L_G = z_G^T \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} z_G \quad \text{and} \quad L_J = z_J^T \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} z_J.$$

The z's are 2x1 vectors measuring deviations in output and inflation from their optimal values; the first element in the vector is output and the second is inflation. Deviations are calculated as averages over a four year period. U.S. and Japanese policymakers put equal weight on output and inflation; the Germans put twice as much weight on inflation.

The reduced forms for the z vectors are given by

$$(2)\quad z_{US} = R_{US}x + \varepsilon_{US}, \quad z_G = R_G x + \varepsilon_G \quad \text{and} \quad z_J = R_J x + \varepsilon_J.$$

x is a 3x1 vector of changes in U.S., German, and Japanese policy; policy

changes are viewed as a percentage change in a money supply or an interest rate that is sustained over a four year period. The R's are 2x3 matrices of policy multipliers. The multipliers give the effect on output or inflation of a change in policy; the effect is averaged over a four year period. The R matrices reported in Table 1 come from the simulations of the MCM and OECD models prepared for this conference.

Policymakers use interest rates in some of our Nash solutions and money supplies in others. If for example the U.S. is using the interest rate while Germany and Japan are using the money supply, then we would take the first column in the R matrices from the interest rate multipliers reported in Table 1 and the second and third columns from the money supply multipliers.

The ε vectors in equation (2) are the "shocks" that cause the game; they give the deviations (from optimal values) in output and inflation that would occur if there were no changes in policy. The shocks reflect the effects of the U.S. fiscal deficit and other underlying conditions. More specifically,

$$(3) \quad \varepsilon_{US} = \delta_{US} + \begin{bmatrix} 0 \\ 4 \end{bmatrix}, \quad \varepsilon_{G} = \delta_{G} + \begin{bmatrix} -1 \\ 2 \end{bmatrix} \quad \text{and} \quad \varepsilon_{J} = \delta_{J} + \begin{bmatrix} -1 \\ 2 \end{bmatrix}.$$

The δ vectors give the effects of the U.S. fiscal deficit; they are random vectors from the point of view of the policymakers. The second vectors represent underlying problems in output and inflation. The U.S. is seen as having no employment problem, but an underlying inflation rate of 4%. The Germans and the Japanese have mild output and inflation problems.

We assume that there are two basic scenarios for the U.S. deficit: it will either come down, or it will get worse. The low deficit δ vectors reported in Table 2 give the effect on output and inflation in each country of a decrease

in US government purchases equal to one percent of U.S. GNP; the effect is averaged over a four year horizon. The high deficit δ vectors represent the other scenario; they are fifty percent larger than the low deficit vectors. If we had actually modeled the low deficit scenario as Gramm-Rudman, then we would have had to double the low deficit δ vectors, and the outcome in the uncoordinated Nash solution would be much less sanguine.

The maintained hypotheses in this exercise are certainly heroic. We simply postulated the parameters in the policymakers' loss functions; however, our basic results seem to be robust for reasonable changes in them. The importance of other maintained hypotheses is more difficult to check; in most cases, we have not even tried. Our use of simple four year averages for evaluating losses is probably not innocent. Some may wish that we had used a shorter horizon, or some sort of weighted averages, or a dynamic game specification. We eschewed dynamic games on the grounds that policymakers do not seem to trust existing policy models enough to behave in way dynamic games imply. Other decisions were more arbitrary, but they had to be made.

II. The Policy Multipliers Implied by the MCM and OECD Models

The multipliers in Table 1 describe the responses of output and inflation to a change in policy at home or abroad. The differences between these matrices are worth noting; they help explain the results that follow.

First, consider the own effects of policy, that is, the direct effects on the home country. The ratio of the inflation multiplier to the output multiplier is the inflation - output tradeoff. The OECD model implies a steeper tradeoff than the MCM, and dramatically so for the U.S. Policymakers will therefore respond more to an inflationary situation in the OECD model than in the MCM; there is more inflation abatement in the OECD model for a given

reduction in output.

Next, consider the size of the spillover effects of policy on other countries. The size of these effects varies greatly. In the OECD model they average only about 5% of the size of the own effects, for both output and inflation. The spillover effects are much larger in the MCM. When money supplies are the instruments, spillover effects on output are about 5% the size of own effects, but the spillover effects on inflation are about 15% the size of own effects. When interest rates are the instruments, spillover effects on output are about 10% the size of own effects, and spillover effects on inflation are about 25% the size of own effects. Thus, one would expect strategic considerations to matter more in the MCM than in the OECD model, especially when interest rates are the instruments.

It should be noted that we simply made up one of the multipliers reported in Table 1. The OECD simulations imply a multiplier of -.004 for the effect of a one percent increase in German Central Bank Money on German inflation. (In the simulation, the inflationary consequences of an increase in money are small and die out very quickly; the multipliers we calculate give average inflation over a four year period.) This multiplier would give unbelievable results in a game situation. So, we raised it to +.080. This implies a German inflation - output tradeoff of one third, the same as is implied by the OECD interest rate multipliers; it is also in line with the tradeoff implied by the MCM.

Ic. The Uncoordinated Nash Solution

Suppose policymakers think that the two U.S. deficit scenarios are equally likely. Expected deviations in output and inflation (from optimal values) are given in Table 3; the high and low δ vectors have been averaged, and then added to the vectors of inherited output and inflation problems. The expected

deficit is mildly expansionary; so, policymakers find themselves in a moderately inflationary situation, especially in the U.S.

The Nash solution to this game is given in Table 4. In a Nash solution, each policymaker minimizes his own (expected) loss taking the policies of his opponents as given. In this benchmark case, we assume that the U.S. and the Japanese use an interest rate as the instrument of monetary policy, while Germany uses Central Bank Money. All three countries respond to this inflationary situation by contracting. They do so more aggressively in the OECD model than in the MCM; inflation - output tradeoffs are steeper in the OECD model, and output reductions but more inflation relief.

Of course, the actual outcome depends upon which deficit scenario proves to be correct. If the low deficit occurs, then recessions result; the U.S. recession is worst because it is hardest hit by the low deficit and because it was the most contractionary. If the high deficit occurs, then inflations result; inflation occurs during the four year period and in some cases later, because outputs are too high. (This is one interpretation of the losses due to positive deviations in output.) Note that in either outcome the U.S. fares much better in the OECD model than in the MCM; its problem is inflation, and the OECD model implies a much steeper inflation - output tradeoff for the U.S.

Id. The Gain from Coordinating on a Deficit Assumption

Suppose the policymakers coordinate on the low deficit scenario; that is, they make policy on the assumption that the low deficit will prevail. As explained in the introduction, coordination on a deficit assumption may be viewed as the limiting case of coordination based on information sharing and a process of surveillance and consultation. Strictly speaking, the gains reported here are the gains from getting the shock right; they overstate the gains to be had

by information sharing and the process of surveillance and consultation.

Table 5 gives the Nash solution that results from coordination on the low deficit assumption. If the deficit does indeed come down, the outcome is much better than in the uncoordinated Nash. Recessions are milder, especially in the U.S. and Japan where policymakers settle for more inflation. Reductions in loss range from 25 to 30 percent in the in the MCM; they are much lower in the OECD model, but still quite important. Getting the shock right is of major importance.

Of course the outcome is much worse for the U.S. and Japan if it turns out that the deficit goes up. (Curiously, Germany may be better off.) This is of course where surveillance comes in. The policymakers need an early warning if they have coordinated on the wrong assumption, so that they can change policy and keep this scenario from being played out.

Ie. Two Extensions: Coordination on Instruments and Cooperation

There are two further steps the policymakers could take. Having coordinated on the low deficit scenario, they might also coordinate the instruments they use to implement their policies. Or, they might move to the cooperative solution. We now ask what additional gain might accrue from either of these refinements, always assuming that the low deficit does actually occur.

Instrument selection may matter in a game like this for three different reasons. First, Poole (1970) has noted that the effect of a given shock (that is, the size of our δ vectors) may depend upon the choice of instruments. Second, Turnovsky and d'Orey (1986) and Canzoneri and Henderson (1987) have noted that instrument selection may be an important strategic consideration, since it affects other countries' inflation - output tradeoffs. And finally, while a (permanent) increase in the interest rate should have the same long run

effect as a decrease in the rate of growth of money, their effects over the intermediate run may well differ.

In this study, we can not pick up the Poole effect. We have government spending simulations for one specification of the instruments, so the size of our δ vectors in Table 2 will not be affected by a change of instruments. For similar reasons, we can not pick up the strategic effect; inflation - output tradeoffs will not be affected by a change of instruments.[5/] If, for example, the U.S. is targetting the money supply in the MCM, then its inflation - output tradeoff is .088/.367 no matter what instruments Germany and Japan are using. We can only pick up the third effect. The conclusions we reach must be understood in this context. Clearly, instrument selection deserves a more careful study than we are able to provide here.

In the Nash solution described by Table 5, the U.S. and Japan used the interest rate while Germany set central bank money. Suppose Germany switches to the interest rate. Table 6a gives the Nash solution in which policymakers coordinate on both the low deficit assumption and interest rates. In the MCM, Germany is worse off while the U.S. and Japan are only marginally affected. Germany is worse off because its recession is deeper. In switching from money to the interest rate, Germany's inflation - output tradeoff rises from .285 to .371; it would have to accept a greater amount of inflation to get the same increase in output. In the OECD model, there is very little change. It will be recalled that we had to construct the German money - inflation multiplier; we chose a value that made the inflation - output tradeoff for money the same as the tradeoff for the interest rate. Here, we see an unfortunate implication of that assumption.

Suppose instead that the U.S. and Japan switch to targetting money, while

Germany continues to target money. Table 6b gives the Nash solution in which policymakers coordinate on both the low deficit assumption and money supplies. Here, the results for Germany and Japan differ dramatically as we go from the MCM to the OECD model.

In the MCM, Germany's recession is halved, and it is much better off. This cannot be due to a change in Germany's inflation - output tradeoff since its instrument was not changed; instead, Germany's increase in output seems to be the result of smaller negative spillovers from Japan. The U.S. is worse off while Japan is only marginally affected. Germany would presumably have to offer the U.S. some compensation to get it to coordinate on this solution.

In the OECD model, Germany is only marginally affected while Japan is better off. Japan's higher output may be explained in part by its lower inflation - output tradeoff. But once again, spillover effects must also play a role in these results; they can not be attributed to changes in inflation - output tradeoffs alone: the U.S. is worse off in both models, but in the MCM its inflation - output tradeoff went up while in the OECD model it went down.

There are five more instrument combinations that we could investigate, but the basic message seems to be clear. There are significant gains and losses to be had through instrument selection, but these gains and losses are on average a tenth of the size of the gain from getting the shock right.

Suppose now that the policymakers decide to cooperate with each other; that is, they commit their instruments to minimizing a weighted sum of their losses. The policymakers always have an incentive to cheat on a cooperative agrement. Therefore, as noted above, cooperation requires the loss of sovereignty if it is to be credible; some higher authority must monitor compliance with the agreement and punish transgressors.[7/] One might ask whether the gains

from cooperation are worth the political costs.

Table 7 gives the cooperative solution corresponding to the Nash solution in Table 5; that is, policymakers continue to coordinate on the low deficit scenario, and we return to the original instrument specification. Here. the MCM and the OECD model tell similar stories. Policies are more expansionary than in the Nash, and outputs and inflations are correspondingly higher. Gains from cooperation are larger in the MCM than in the OECD model; it will be recalled that the spillover effects are larger in the MCM. However, even in the MCM the gains from cooperation are rather small; the gains and losses from instrument selection can be ten times the size.

II. MCM Simulations: The Deficit Game

This section presents the results of a series of simulations under alternative government spending scenarios for the United States. The simulations were performed using the MCM over the period 1987 Q1 to 1992 Q4.[8/] These simulations correspond roughly to those considered in the deficit game in section I. The purpose of this exercise is to assess the path of the important variables over the entire horizon, which was not possible in the one shot-game in section I. To evaluate the different simulations we will present and analyze the empirical results using charts. In addition, we will consider the usefulness of indicators as a early warning device in letting policymakers know that they have backed the wrong assumption about the deficit.

These simulations differ somewhat from those used in section I. First, Japan and Germany are assumed to have two instruments -- monetary and fiscal policy -- and two targets -- GNP growth and inflation -- in the low U.S. deficit scenario. (In the high U.S. deficit it is assumed that Japan and Germany only have one instrument monetary policy and the same two targets.[9/]) Second, we assume that the United States has one policy instrument -- monetary policy. U.S. fiscal policy in this exercise is treated as exogenous. The United States is also assumed to have two targets -- GNP growth and inflation. Third, the size of the shocks differ between the two experiments. The low deficit path in section I corresponds to 1 percent of GNP decline in government purchases, while the low deficit path in this section is designed to actually follow the Gramm-Rudman deficit path, which requires a much larger and variable change in government purchases.

IIa. Experimental Design

Two scenarios for the U.S. government spending are considered: (1) a low or Gramm-Rudman path and (2) a high or unfixed U.S. government deficit.[10/] Given these two scenarios, six simulations are run. The first two simulations capture the effects of the change in U.S. government purchases. The second two simulations consider the joint response of the U.S. monetary authorities along with the German and Japanese monetary and fiscal authorities. The selection of the response was geared towards maintaining the original baseline GNP and inflation levels without achieving them exactly.

Once we have calculated these simulations we ask what if the authorities have misinformation about the actual path U.S. fiscal authorities will follow. Therefore, the last two simulations capture the effects of 'policy uncertainty'. The authorities are assumed to miscalculate the path of U.S. government purchases and apply the wrong policy mix. In particular, we assume that the authorities think that the U.S. deficit is going to be high and therefore apply a contractionary policy to compensate for this policy. However, they apply this contractionary 'high deficit' package when the U.S. actually follows a low deficit path. This simulation is labelled in the next part as LOW/WRONG. Similarly we assume that the authorities think that the U.S. deficit is going to be low and apply an expansionary policy to compensate for this policy. Once again the authorities act incorrectly; the U.S. actually follows a high deficit path (these simulations are labelled HIGH/WRONG).

In presenting these simulations we describe the low deficit scenarios first. In particular, we report the initial effects of a cut in U.S. government purchases, then we consider the joint policymakers response assuming that they correctly predict the shock and when they incorrectly predict the shock.

We repeat this exercise for the high deficit scenario.

IIb. Low U.S. Government Deficit

1. Initial Effects:

Chart 1 displays the effects the Gramm-Rudman law has on the U.S., Germany, and Japan. This simulation (labelled LOW) is run when no policy response is allowed in any of the countries; furthermore it is assumed that the monetary authorities keep their money supplies unchanged from the baseline. To approximate the Gramm-Rudman deficit path -- a zero federal budget deficit in 1992 -- it was necessary to cut U.S. government spending by roughly 1.1 percent of baseline GNP in 1987 and to increase steadily the amount out to 3.1 percent of baseline GNP in 1992. The reduction in U.S. government purchases leads to a reduction in real income in the United States; crowding-in effects are not visible because the shock continues to increase over time. With a fixed path of money supply, interest rates tend to fall in the U.S., which precipitates a depreciation of the dollar exchange rate. Both the fall in income and the depreciation of the dollar leads to a considerable improvement in current account. Prices tend to fall as output falls because of excess capacity in the economy.

The initial impact of the change in government purchases is to lower real GNP by roughly 1.8 percent at the end of the first year and by about 3.9 percent at the end of the sixth year. Inflation changes are slow to manifest themselves. At the end of the first year, inflation falls by only .02 percent, while at the end of 6 years inflation has dropped by over 1.7 percent. Interest rates, on the other hand, fall almost monotonically through the simulation horizon dropping at first 160 basis points to more than 600 basis

points at the end. This fall in interest rates leads to a depreciation of 7.5 percent of the dollar trade - weighted exchange rate at the end of the horizon.[11/] The U.S. current account improves continuously throughout the simulation.

The impact on Japan and Germany is felt directly on the reduction of demand for their exports. This effect is larger for Japan than for Germany. Initially, the fall in income is much smaller abroad than in the United States, but over time the effects of the dollar depreciation reduces exports sharply and hence income abroad. The loss of income in Japan is nearly as large as that in the United States by the end of the period.

2. Joint Policy Response -- Low Deficit

Chart 2 shows the results from a second simulation in which the U.S. monetary authorities and foreign countries respond to the U.S. fiscal contraction using expansionary policies in an attempt to maintain the level of output and inflation. It is not possible to use just monetary policy to hold real GNP constant in the face of a shock because of the nature of lagged response of demand to interest rate changes. It is possible to use government purchases in Japan and Germany in such a way to hold real their GNP exactly at its baseline level. This method seemed uninteresting. Instead, we have selected a path for monetary growth in each country combined with some fiscal expansion in Germany and Japan which reduces considerably the decline in income in each country.

In this simulation, Germany and Japan increase fiscal policy by roughly 1/2 percent of baseline GNP. Monetary expansion is phased in slowly for each country at varying speeds. The monetary expansion in the U.S. starts by increasing the money supply at 2.5 percent over baseline rising to 7.5 percent increase over baseline in 1992. The increases in money supply are much smaller

in Germany and Japan. In Japan money supply is increased by 2 percent in the first year and by 3.8 percent in the fourth year and then brought back to the baseline level for the rest of the simulation. In Germany money supply is steadily increased from .5 percent in 1987 to 3.2 percent over baseline in 1992.

The effect of this expansionary joint response to a contractionary U.S. fiscal is to lower the decline in U.S. income at the end of the second year by 50 percent and lower the decline by 66 percent at the end of the six year horizon. Initially there is a very rapid decline in U.S. interest rates which leads to a large depreciation of the dollar exchange rate. The U.S. current account improves dramatically; after five years it improves so much that it eradicates the deficit completely moving into a slight surplus. The expansionary monetary policy does not erode away the improvements made on the U.S. federal government. In fact, the lower interest rates reduces debt repayments; higher income levels raises revenue consequently the federal deficit tends to go into surplus.

The expansionary policy in Germany and Japan raises output slightly above the baseline levels. Interest rates fall but not as much as the U.S. therefore their bilateral exchange rates appreciate. This appreciation along with higher income causes a deterioration of both German and Japanese current accounts. The inflationary price paid for these gains is very modest, which reflects in part the 'stickiness' of the price determination mechanism in the MCM.

3. Joint Policy Response -- Wrong Policy Mix

Chart 3 report the simulations where the monetary authorities in all three countries and the fiscal authorities in Germany and Japan all think that the U.S. fiscal authorities are going to follow the low deficit path, thus they

each decide that it is in each of their best interest to use an expansionary policy mix. However, in this simulation the U.S. does not follow a low deficit path, but follows a high deficit path. The expansionary policy mix, which is the same used in the joint policy response when the authorities thought the U.S. was going to follow the low deficit path, tends to lead to overexpansion and heats up inflation.

This simulation, labelled high/wrong, shows that not knowing the policy that is going to be adopted by one country or by the fiscal authorities in one country can lead to disastrous policy mixes for all countries involved. In this instance we see that there is rapid increases in GNP and inflation rises steadily. Furthermore the policies as they have been implemented lead to rather volatile exchange market conditions.

IIc. High U.S. Government Deficit

1. Initial Effects

Chart 4 displays the possible effects of not containing the U.S. government deficit.[12/] Once again this simulation is run when no policy response is allowed in any of the countries and the relevant monetary aggregate is kept constant at the baseline level. In this simulation it is assumed that U.S. government purchases rise slowly over the six year period. In 1987, government purchases remain at the baseline level increasing to 1/4 of a percent of baseline GNP in 1988 to 1.2 percent of baseline GNP in 1992.[13/]

Income in the U.S. rises continuously. We do not see crowding - out effects in this simulation because the increase in government purchases is phased in over the 6 year horizon. Interest rates rise along with the increase in government spending which leads to an appreciation of the dollar. Both the rise in the exchange rate and the rise in income contribute to the further

deterioration of the current account. As expected the government deficit grows throughout the simulation. Prices rise, but only sluggishly.

The effect of the expansionary fiscal policy abroad is transmitted mainly through increases in exports and through depreciations of the exchange rate. These effects stimulate both economies; income in both Japan and Germany rises, somewhat more in Japan.

2. Joint Policy Response -- High Deficit:

Chart 5 exhibits the effects of a high U.S. deficit with a joint contractionary monetary policy reaction. The authorities choose a contractionary monetary policy stance to compensate for the anticipated U.S. expansionary fiscal policy. The U.S. decreases money supply initially by 1 percent of baseline money supply and steadily decreases this amount to 6.5 percent in 1992. The Japanese and Germans cut their money supply by smaller amounts (from .5 percent to 4.5 percent in Japan and 0 percent to 3 percent in Germany). In the U.S., the consequences of reducing money supply raises interest rates, which tends to choke off the increase in income which accompanied the higher U.S. deficit. In fact, income returns back almost to the baseline level. Interest rates which are elevated lead to an appreciation of the dollar; the current accoubt slowly deteriorates. In both Germany and Japan, the contractionary policy offsets most of the spillover effects. Income remains almost at the baseline; their current accounts tend to improve due to the depreciation of their currencies.

3. Joint Policy Response -- Wrong Policy Mix:

Chart 6 illustrates a simulation in which we assume that policymakers think that the U.S. is going to follow a high deficit path, but actually follows a low deficit path. The authorities choose a contractionary monetary

policy stance to compensate for the anticipated U.S. fiscal expansion. The policy package used is exactly the same as when the policymakers got the deficit path correct. This simulation is labeled low/wrong.

The effect of this 'wrong' policy mix is striking. The decline in U.S. income at the end of six years is greater than 6 percent of baseline GNP, which is almost double the initial impact effect with no policy response. Inflation in the U.S. also drops off significantly; it is about 2.5 percent lower than the original simulation.

Following a contractionary policy in Japan and Germany also leads to a very recessionary condition in these countries. It is obvious that all countries are worse off with this policy mix.

IId. Good Indicators of Bad Deficit Assumptions

The foregoing reinforces the finding in section I that large benefits are to be had by coordinating on the right deficit assumption, while big problems follow from coordinating on the wrong assumption. This is where surveillance and indicators can play a role.

The setup of these simulations allows us to evaluate the usefulness of indicators as an early warning device to policymakers. The paths of the key variables in the graphs on charts 2 and 3 and charts 5 and 6 show this feature. In Chart 2, for example, the fall in income and inflation has been moderated from the initial impact of the low deficit; on the other hand, in chart 3, which represents the scenario where policymakers think the United States is going to follow the low deficit path but does not, income and inflation tend to take off. The paths of interest rates, exchange rates and government deficits are all very different.

In general, indicators should show that the policies that are being

employed are not consistent with the policymakers objectives. Following Crockett (1987) we classify indicators into two categories: (1) indicators of economic performance and (2) intermediate indicators. Potential indicators of economic performance includes the rate of economic growth and the rate of inflation. In addition, we include unemployment; unemployment is another way of evaluating the state of the economy, and is possibly a substitute for economic growth. Exchange rates, interests rates and current accounts are potential intermediate indicators. (When interest rates are the instruments, then monetary aggregates become intermediate indicators.) Interest rates, exchange rates and current accounts tend to influence economic performance.

Tables 8 and 9 report the movement of key variables that might be good indicators of the changing status of the economy. We are limited in the conclusions we can draw about the merits of any variable as an indicator because we observe and evaluate only one disturbance. Keeping this limitation in mind, table 8 shows the results of the initial impacts of a change in U.S. fiscal policy without any policy response. The first column gives the average baseline values for these variables after 2 years and its standard deviation. Column 2 refers to the low deficit scenario; column 3 refers to the high deficit scenario. Because the source of the shock comes from the United States, it is not surprising to find that the effects after 2 years are stronger in the U.S. than in Japan and Germany. Movements in GNP growth, exchange rates and interest rates, even after the first two years, are quite large. For example, U.S. GNP growth falls on average by about 50 percent (relative to the baseline) and U.S. interest rates drop by nearly 250 basis points. These results indicate a recessionary trend in the economy, at least vis a vis the baseline. The responses in Japan and Germany are large, but

about half that in the United States. Inflation and current account tend to react somewhat slower to these changes. Inflation is 5 percent lower; the U.S. current account shows only a 19 billion dollar improvement.

Table 9 contains a similar set of statistics for the other four simulations. The interesting comparison in this table is comparing the simulation where the policymakers choose their policies based on one scenario, in one instance they are right about the U.S. fiscal deficit path (e.g. the low deficit path labelled Low/Resp) and in the other instance they are wrong (High/Wrong). In the United States, using an expansionary policy mix when the high deficit path occurs instead of the low leads to a GNP growth that is twice as high and interest rates that are 160 basis points higher than expected. The means of the exchange rates are not very different, but from charts 2 and 3 we can see that the path and pattern are affected from the policy package. These effects are exhibited in Germany and Japan but somewhat less.

The difference in outcomes is perhaps illustrated more clearly when comparing the outcome for the high deficit -- when it was expected (High/Resp) and when it was expected and it did not occur (Low/Wrong). In the case where the high deficit was expected, every one applies a contractionary policy. However, because the deficit is low the U.S. and the other countries go into a recession. In the U.S. GNP growth is a third of what it would have been if the policymakers got the deficit path correct. In Germany GNP growth is down by 23 percent and in Japan it is down by about 30 percent. Interest rates move rapidly to reflect the difference in policy mix; the U.S. interest rate would be down by 175 basis points while in Germany and Japan interest rates move by 80 and 30 basis points. Exchange rate movements as shown in chart 5 and 6 show differences in movements which the simple statistics do not pick up. Inflation

once again appears to react slowly, as does the current account.

III. The Disinflation Game

This game is motivated by the disinflations of the early '80s. In October of 1979, the U.S. made a well publicised shift from pegging an interest rate to controlling a monetary aggregate; we will evaluate some of the consequences of that decision, for the U.S. and for Germany and Japan. (We fully recognize that some benefits of the decision may not be captured here.) This game is played in complete certainty; we want to focus on instrument selection rather than information sharing.

Most of the game structure described in section I can be retained. We use the loss functions (1), the reduced forms (2), and the policy matrices given in Table 1. We just change the ε vectors that start the game: let

$$(3)' \quad \varepsilon_{US} = \begin{bmatrix} 0 \\ 8 \end{bmatrix}, \quad \varepsilon_{G} = \begin{bmatrix} 0 \\ 8 \end{bmatrix} \quad \text{and} \quad \varepsilon_{J} = \begin{bmatrix} 0 \\ 8 \end{bmatrix}.$$

The policymakers have no employment problem, but inflation is running 8% higher than desired.

Suppose the U.S. is using the interest rate while Germany and Japan are using the money supply. The Nash solution to this disinflation game is given in Table 10. All countries contract; Germany is the most contractionary since it is the most inflation conscious. All countries are more contractionary in the OECD model than in the MCM; inflation - output tradeoffs are steeper in the OECD model, and a marginal reduction in output buys more inflation relief.

Suppose the U.S. switches to the money supply. The new Nash solution is given in Table 11. Once again, the MCM and the OECD model tell very different stories. Going from interest rates to the money supply in the MCM, the U.S.

inflation - output tradeoff rises from .20 to .24; a marginal reduction in U.S. output buys more inflation relief. The U.S. exploits this fact and is about 2% better off; Germany is also better off, and Japan is only marginally affected. In the OECD model, the U.S. inflation - output tradeoff falls from 1.51 to 1.45; inflation relief is more expensive. The U.S. is worse off, while both Germany and Japan benefit from the spillover effects.

Suppose instead that the countries decide to cooperate. The cooperative solution is given in Table 12. For the U.S. and Japan, the outcome is quite similar to the Nash outcome. Germany is more agressive about fighting inflation in the MCM, and gains from cooperation are again somewhat larger because of the larger spillover effects. However, the gain from cooperation is quite modest, for all countries and in both models.

Once again, the gains and losses to be had through instrument selection are about ten times the gains from cooperation.

FOOTNOTES:

* We wish to thank Dale Henderson, Karen Johnson, Jaime Marquez, Flint Brayton, Larry Promisel, Andrew Crockett and James Boughton for helpful discussions. Michael Mabry and Stephen Scott provided valuable assistance.

This paper was prepared for the conference on Monetary Aggregates and Financial Sector Behavior in Interdependent Economies sponsored by the Board of Governors of the Federal Reserve System and held May 26 - 27, 1988. It will appear in Hooper et al (forthcoming), the conference volume.

Matthew B. Canzoneri is a Professor of Economics at Georgetown University and Hali J. Edison is a staff economist in the Division of International Finance. The opinions expressed here are our own; they should not be interpreted as reflecting those of the Board of Governors of the Federal Reserve System or other members of its staff. Canzoneri's contribution to this work benefited from a stint as Visiting Scholar at the Federal Reserve Board, for which he is grateful.

1. There seems to be a systematic difference between the way policymakers and game theorists use the words "cooperation" and "coordination". In government circles, "coordination" is often synonymous with the game theorist's notion of cooperation while "cooperation" is a broader (and weaker) concept; the words "convergence" and "harmonization" also have rather precise meanings in government circles. See Horne and Masson (1987) for the policymaker's definition of these concepts; see also Bryant (1987) and definitions attributed to Henry Wallich in Rowan (1988). Friedman (1986) provides a game theorist's definition of "cooperation" in his first chapter. "Coordination" does not appear to have any standard meaning in game theory, but our definition is consistent with Canzoneri and Henderson's (1988).

2. Friedman (1986) describes the distinction between cooperative and noncooperative games as follows:

> The presence or absence of binding agreements is the definitive element for cooperative versus noncooperative games. If binding agreements are possible, then the game (structure) is cooperative, otherwise it is noncooperative. ... In motivating the notion of a binding agreement, it is usual to note that the game requires an outside authority that enforces any such agreements. ... The authority can monitor the agreement at no cost ... and can, like an avenging angel, impose on violators sanctions so severe that cheating is absolutely out of the question.

3. Actually, the jury is still out on this. There have not been many studies, and most of the existing studies have limitations that may bias their results. First, the games postulated are responses to macroeconomic shocks; ongoing conflicts over trade policy, etc., are generally ignored. Second, policymaker response to model uncertainty is ignored. Ghosh and Masson (1988) have recently shown that when policymaker uncertainty is added the gains from cooperation may be significant.

Studies of the gains from cooperation include Oudiz and Sachs (1984), Taylor (1985), Edison and Tryon (1986), Frankel and Rockett (1986), McKibbin and Sachs (1987), Currie, Levine and Vidalis (1987), Holtham and Hughes Hallett (1987), Frankel (1988), and Canzoneri and Minford (1988a, 1988b). Fischer (1987) and Horne and Masson (1987) discuss some of these studies.

4. This interpretation was first introduced by Canzoneri and Henderson (1988).

5. If we could pick up both the Poole effect and the strategic effect, the multiplicity of solutions might evaporate and coordination on instruments would not be an option. See Canzoneri and Henderson's (1987) discussion of the work of Klemperer and Meyer.

6. Canzoneri and Henderson (1988) discuss this in some detail.

7. The same efficient outcomes might supportable by reputational effects or by tit for tat punishment mechanisms, but then we have a new Nash solution rather than cooperation; see Canzoneri and Henderson (1988).

8. For detailed description of the MCM see Edison, Marquez, and Tryon (1987). The baseline used for the simulations in this section is that designed for this conference with one minor adjustment to the path of U.S. government purchases. For details about the design of the baseline and the conference simulations see Brayton and Marquez (1988) and Marquez and Brayton (1987).

9. We make this assumption because we can achieve our targets using the one instrument. This is partly due to the fact that inflation is so sluggish in the model and partly due to the size of shock that is imposed on the model.

10. The low deficit path starting in 1987 is as follows: 108, 89, 78, 39, 0, 39. The high deficit path that is assumed is as follows: 108, 115, 122, 129, -136, 146. Note that these numbers refer not to the deficit of the federal government but to the general government as a whole. The general government includes the federal deficit as well as the state and local deficit. The category for state and local governments tend to be in a surplus because state retirement funds are included in the deficit numbers and they run large surpluses.

11. Note that the two bilateral exchange rates displayed are reported as \$/DM and \$/Yen exchange rates. Therefore, a rise in either of these rates implies a depreciation of the dollar. On the other hand, the trade-weighted dollar exchange rate, the trade-weighted average of the DM, Yen, British Pound and the Canadian dollar the four MCM countries is calculated as FX_i/ \$. Thus, a rise in the trade-weighted dollar implies an appreciation of the dollar.

12. Flint Brayton suggested that this path for the U.S. government deficit was a realistic scenario if Gramm - Rudman was not enforced.

13. The actual path of the U.S. government deficit is as follows: 123, 130, 127, 132, 138, 150. This is slightly higher than the target path.

REFERENCES:

Brayton, F. and J. Marquez, "The Behavior of Monetary Sectors and Monetary Policy: Evidence from Multicountry Models", May 1988.

Bryant, R. "Intergovernmental Coordination of Economic Policies: an Interim Stocktaking", in International Monetary Cooperation: Essays in Honor of Henry C. Wallich, Princeton Essays in International Finance, # 169, Dec. 1987.

Canzoneri, M. and D. Henderson, "Is Sovereign Policymaking Bad?", Carnegie - Rochester Conference Series on Public Policy, forthcoming, 1988.

Canzoneri, M. and D. Henderson, "Optimal Choice of Monetary Policy Instruments in a Simple Two Country Game", mimeo, Dec. 1987.

Canzoneri, M. and P. Minford, "Policy Interdependence: Does Strategic Behaviour Pay?" in Hodgeman and Wood, eds. Macroeconomic Policy and Economic Interdependence, Macmillan Press, forthcoming, 1988a.

Canzoneri, M. and P. Minford, "When International Policy Coordination Matters: An Empirical Analysis", Applied Economics, forthcoming, 1988b.

Crockett, A. "Strengthening International Economic Cooperation: The Role of Indicators in Multilateral Surveillance", IMF Working Paper, Nov. 1987.

Currie, D., P. Levine and N. Vidalis, "International Cooperation and Reputation in an Empirical Towo-Block Model", in R. Bryant and R. Portes, eds., Global Macroeconomics: Policy Conflict and Cooperation, London, MacMillan, 1987.

Edison, H. and R. Tryon, "An Empirical Analysis of Policy Coordination in the United States, Japan and Europe", I.F.D.P. # 286, 1986.

Edison, H., J. Marquez and R. Tryon, "The Structure and Properties of the Federal Reserve Board Multicountry Model", Economic Modelling, Vol. 4, No. 2, 1987.

Frankel, J. "The Implications of Conflicting Models for Coordination between Monetary and Fiscal Policymakers", in R. Bryant, D. Henderson, G. Holtham, P. Hooper, S. Symansky, eds. Empirical Macroeconomic for Interdependent Economies, Brookings, 1988.

Frankel, J. and K. Rockett, "International Macroeconomic Policy Coordination when Policy-Makers Disagree on the Model", NBER Working Paper # 2059, Oct. 1986.

Friedman, J. Game Theory with Applications to Economics, Oxford University Press, New York, 1986.

Fischer, S. "International Macroeconomic Policy Coordination", NBER Working Paper # 2224, May 1987.

Ghosh, A. and P. Masson, "International Policy Coordination in a World with Model Uncertainty", IMF Working Paper, Dec. 1987.

Holtham, G. and A. Hughes Hallett, "International Policy Coordination and Model Uncertainty", in R. Bryant and R. Portes, eds., Global Macroeconomics: Policy Conflict and Cooperation, London, MacMillan, 1987.

Horne, J. and P. Masson, "Scope and Limits of International Economic Cooperation and Policy Coordination", IMF Working Paper, April 1987.

McKibbin, W. and J. Sachs, "Coordination of Monetary and Fiscal Policies in the OECD", in J. Frenkel, ed. International Aspects of Fiscal Policy, University of Chicago Press, Chicago, 1987.

Marquez, J. and F. Brayton "Experimental Design for the Fed 1988 Conference", FRB mimeo, 1987.

Oudiz, G. and J. Sachs, "Macroeconomic Policy Coordination Among the Industrial Countries", Brookings Papers on Economic Activity, I, 1984, 1 - 64.

Rowen, H. "Reflections on World Cooperation", The Washington Post, February 21, 1988.

Taylor, J. "International Coordination in the Design of Macroeconomic Policy Rules", European Economic Review, 28, 1985, 53 - 81.

Turnovsky, S. and V. d'Orey, "A Strategic Analysis of the Choice of Monetary Instrument in Two Interdependent Economies", mimeo, 1986.

TABLE 1: The Policy Matrices*

MCM Money Supply Multipliers

$$R_{US}=\begin{bmatrix} .367 & -.021 & .027 \\ .088 & -.011 & .004 \end{bmatrix} \quad R_{G}=\begin{bmatrix} .003 & .347 & -.023 \\ -.032 & .099 & -.011 \end{bmatrix} \quad R_{J}=\begin{bmatrix} -.130 & -.046 & .631 \\ -.027 & -.011 & .096 \end{bmatrix}$$

MCM Interest Rate Multipliers

$$R_{US}=\begin{bmatrix} -.999 & .044 & -.052 \\ -.202 & .025 & .044 \end{bmatrix} \quad R_{G}=\begin{bmatrix} -.047 & -.665 & .152 \\ .139 & -.247 & .050 \end{bmatrix} \quad R_{J}=\begin{bmatrix} .428 & .112 & -1.721 \\ .097 & .028 & -.256 \end{bmatrix}$$

OECD Money Multipliers**

$$R_{US}=\begin{bmatrix} .185 & -.010 & .007 \\ .268 & -.008 & .003 \end{bmatrix} \quad R_{G}=\begin{bmatrix} .019 & .241 & .006 \\ -.005 & .080 & .001 \end{bmatrix} \quad R_{J}=\begin{bmatrix} -.022 & -.007 & .367 \\ .016 & .006 & .137 \end{bmatrix}$$

OECD Interest Rate Multipliers

$$R_{US}=\begin{bmatrix} -.619 & .020 & -.003 \\ -.934 & .039 & .027 \end{bmatrix} \quad R_{G}=\begin{bmatrix} -.043 & -.516 & -.023 \\ .036 & -.172 & .029 \end{bmatrix} \quad R_{J}=\begin{bmatrix} -.069 & .005 & -.709 \\ -.017 & .009 & -.284 \end{bmatrix}$$

*These multipliers give the average effect over a four year period (1987 - 1990) of a permanent, one percent increase in a money supply or an interest rate. The first row gives the effect on output, the second on inflation; the first column is for a change in US policy, the second is for German policy, and the third is for Japanese policy. The money supplies are M2 for the US, Central Bank Money for Germany, and M2 for Japan. The interest rates are short-term rates.

**The effect of German money on German inflation has been raised from -.004 to +.080.

TABLE 2: The Effect of the US Deficit on Output and Inflation.*

MCM low deficit scenario:

$$\delta_{US} = \begin{bmatrix} -1.580 \\ -.340 \end{bmatrix} \qquad \delta_{G} = \begin{bmatrix} -.520 \\ -.258 \end{bmatrix} \qquad \delta_{J} = \begin{bmatrix} -1.017 \\ -.149 \end{bmatrix}$$

MCM high deficit scenario:

$$\delta_{US} = \begin{bmatrix} 2.370 \\ .510 \end{bmatrix} \qquad \delta_{G} = \begin{bmatrix} .780 \\ .387 \end{bmatrix} \qquad \delta_{J} = \begin{bmatrix} 1.526 \\ .224 \end{bmatrix}$$

OECD low deficit scenario:

$$\delta_{US} = \begin{bmatrix} -.744 \\ -.657 \end{bmatrix} \qquad \delta_{G} = \begin{bmatrix} -.325 \\ -.132 \end{bmatrix} \qquad \delta_{J} = \begin{bmatrix} -.466 \\ -.126 \end{bmatrix}$$

OECD high deficit scenario:

$$\delta_{US} = \begin{bmatrix} 1.116 \\ .986 \end{bmatrix} \qquad \delta_{G} = \begin{bmatrix} .488 \\ .198 \end{bmatrix} \qquad \delta_{J} = \begin{bmatrix} .699 \\ .189 \end{bmatrix}$$

* The low deficit scenario represents a decrease in government purchases by 1 percent of U.S. GNP. The high deficits are 1.5 times the absolute value of the low deficit multipliers.

TABLE 3: Expected Deviations of Output and Inflation from Optimal Values

MCM multipliers:

$$E\varepsilon_{US} = \begin{bmatrix} 0.395 \\ 4.085 \end{bmatrix} \qquad E\varepsilon_{G} = \begin{bmatrix} -0.870 \\ 2.065 \end{bmatrix} \qquad E\varepsilon_{J} = \begin{bmatrix} -0.746 \\ 2.037 \end{bmatrix}$$

OECD multipliers:

$$E\varepsilon_{US} = \begin{bmatrix} 0.186 \\ 4.164 \end{bmatrix} \qquad E\varepsilon_{G} = \begin{bmatrix} -0.919 \\ 2.033 \end{bmatrix} \qquad E\varepsilon_{J} = \begin{bmatrix} -0.884 \\ 2.032 \end{bmatrix}$$

TABLE 4: The Uncoordinated Nash Solution

Using MCM multipliers:

	US	Germany	Japan
Nash policies	$\Delta i = 1.191$	$\Delta m = -0.891$	$\Delta i = 0.072$
Nash outcome, low deficit			
output	-2.755	-1.874	-1.590
inflation	3.432	1.823	1.958
loss	9.685	5.080	3.181
Nash outcome, high deficit			
output	1.195	-0.574	0.952
inflation	4.282	2.468	2.330
loss	9.883	6.256	3.169

Using OECD multipliers:

	US	Germany	Japan
Nash policies	$\Delta i = 3.196$	$\Delta m = -1.262$	$\Delta i = -0.372$
Nash outcome, low deficit			
output	-2.709	-1.758	-1.414
inflation	0.358	1.871	1.918
loss	3.733	5.047	2.838
Nash outcome, high deficit			
output	-0.849	-0.946	-0.249
inflation	2.000	2.201	2.233
loss	2.361	5.293	2.524

TABLE 5: Coordinating on the Low Deficit Scenario

Using MCM multipliers:

	US	Germany	Japan
Nash policies	$\Delta i = -0.799$	$\Delta m = 1.924$	$\Delta i = -1.243$
Nash outcome, low deficit			
output	-0.757	-1.004	-0.308
inflation	3.746	1.759	2.071
loss	7.301	3.599	2.191
Gain from coordination*	24.6 %	29.2 %	31.1 %
Nash outcome, high deficit			
output	3.193	0.296	2.235
inflation	4.596	2.404	2.443
loss	15.656	5.824	5.481

Using OECD Multipliers:

	US	Germany	Japan
Nash policies	$\Delta i = 2.096$	$\Delta m = 0.411$	$\Delta i = -1.065$
Nash outcome, low deficit			
output	-2.042	-1.292	-0.859
inflation	1.353	1.945	2.143
loss	3.001	4.619	2.665
Gain from coordination*	19.6 %	8.5 %	6.1 %
Nash outcome, high deficit			
output	-0.182	-0.479	0.306
inflation	2.996	2.275	2.458
loss	4.504	5.292	3.068

*Gains are measured by percent decreases in loss from the Uncoordinated Nash solution in Table 4.

TABLE 6a: Coordinating on the Low Deficit Scenario and Instruments

Using MCM multipliers:

	US	Germany	Japan
Nash policies	$\Delta i = -0.785$	$\Delta i = -0.592$	$\Delta i = -1.227$
Nash outcome, low deficit			
output	-0.758	-1.276	-0.308
inflation	3.750	1.718	2.072
loss	7.318	3.765	2.195
Gain from Coordination*	-0.2 %	-4.6 %	-0.2 %

Using OECD multipliers:

	US	Germany	Japan
Nash policies	$\Delta i = 2.093$	$\Delta i = -0.183$	$\Delta i = -1.064$
Nash outcome, low deficit			
output	-2.040	-1.296	-0.857
inflation	1.352	1.944	2.139
loss	2.995	4.619	2.655
Gain from Coordination*	0.2 %	0.0 %	0.4 %

*Gains are measured by percent decreases in loss from the Coordinated Nash solution in Table 5.

TABLE 6b: Coordinating on the Low Deficit Scenario and Instruments

Using MCM multipliers:

	US	Germany	Japan
Nash policies	$\Delta m = 1.756$	$\Delta m = 2.983$	$\Delta m = 3.273$
Nash outcome, low deficit			
output	-0.910	-0.555	-0.317
inflation	3.795	1.945	2.085
loss	7.614	2.046	2.224
Gain from Coordination*	-4.3 %	43.2 %	-1.5 %

Using OECD Multipliers:

	US	Germany	Japan
Nash policies	$\Delta m = -7.173$	$\Delta m = 0.618$	$\Delta m = 2.320$
Nash outcome, low deficit			
output	-2.061	-1.298	-0.777
inflation	1.423	1.956	2.081
loss	3.136	4.667	2.466
Gain from Coordination*	-4.5 %	-1.0 %	7.5 %

*Gains are measured by percent decreases in loss from the Coordinated Nash solution in Table 5.

TABLE 7: The Cooperative Solution with the Low Deficit Scenario

Using MCM multipliers:

	US	Germany	Japan
Cooperative weights**	0.500	0.120	0.380
Cooperative policies	$\Delta i = -1.050$	$\Delta m = 3.307$	$\Delta i = -1.438$
Cooperative outcome, low deficit			
output	-0.526	-0.542	-0.143
inflation	3.772	1.852	2.081
loss	7.254	3.575	2.176
Gain from Cooperation*	0.6 %	0.7 %	0.7 %

Using OECD multipliers:

	US	Germany	Japan
Cooperative weights**	0.400	0.175	0.425
Cooperative policies	$\Delta i = 2.022$	$\Delta m = -0.494$	$\Delta i = -1.225$
Cooperative outcome, low deficit			
output	-1.987	-1.503	-0.733
inflation	1.425	1.866	2.185
loss	2.990	4.610	2.655
Gain from Cooperation*	0.4 %	0.2 %	0.4 %

*Gains are measured by percent decreases in loss from the Coordinated Nash solution in Table 5.

**Weights were chosen to make the gains from cooperation approximately equal.

TABLE 8: Evaluation of Indicators by Comparing Initial Effects

Indicators of Economic Performance

	Baseline	Low	High
UNITED STATES			
GNP Growth.....	3.000	1.527	3.449
	(0.000)	(0.243)	(0.167)
Unemployment.....	6.667	7.679	6.513
	(0.177)	(0.357)	(0.317)
Inflation.....	4.250	4.030	4.231
	(0.198)	(0.034)	(0.202)
Current Account...	136.954	117.995	139.714
	(10.587)	(21.025)	(8.182)
GERMANY			
GNP Growth.....	1.749	1.361	1.823
	(0.198)	(0.164)	(0.235)
Unemployment.....	8.111	8.208	8.100
	(0.132)	(0.201)	(0.121)
Inflation.....	1.124	0.647	1.203
	(0.296)	(0.233)	(0.340)
Current Account...	33.311	32.883	33.349
	(4.108)	(4.601)	(4.066)
JAPAN			
GNP Growth.....	3.499	2.496	3.691
	(0.000)	(0.094)	(0.095)
Unemployment.....	2.978	3.055	2.970
	(0.067)	(0.115)	(0.064)
Inflation.....	0.873	0.612	0.918
	(0.692)	(0.650)	(0.714)
Current Account...	73.376	68.181	73.966
	(6.068)	(10.217)	(5.567)
	INTERMEDIATE INDICATORS		
UNITED STATES			
Interest Rate.....	6.400	4.900	6.606
	(0.381)	(0.557)	(0.575)
GERMANY			
Interest Rate.....	3.667	3.079	3.751
	(0.381)	(0.678)	(0.330)
Exchange Rate.....	0.476	0.488	0.474
	(0.010)	(0.018)	(0.008)
JAPAN			
Interest Rate.....	3.467	3.215	3.496
	(0.539)	(0.691)	(0.519)
Exchange Rate.....	0.006	0.006	0.006
	(0.000)	(0.000)	(0.000)

Note to table:
First number indicates the mean of the variable after 2 years. The second number in parenthesis represents the standard deviation.

TABLE 9: Evaluation Of Indicators by Comparing Policy Responses

Indicators of Economic Performance

	Baseline	Low/Resp	Low/Wrong	High/Resp	High/Wrong
UNITED STATES					
GNP Growth.....	3.000	2.483	1.105	3.035	4.370
	(0.000)	(0.376)	(0.153)	(0.097)	(0.290)
Unemployment.....	6.667	7.222	7.86	6.690	6.072
	(0.177)	(0.112)	(0.496)	(0.189)	(0.630)
Inflation.....	4.250	4.193	3.978	4.204	4.318
	(0.198)	(0.186)	(0.020)	(0.185)	(0.315)
Current Account...	136.954	113.611	118.669	140.536	135.290
	(10.587)	(23.336)	(20.437)	(7.762)	(10.621)
GERMANY					
GNP Growth.....	1.749	1.784	1.280	1.742	2.243
	(0.198)	(0.121)	(0.103)	(0.172)	(0.125)
Unemployment.....	8.111	8.003	8.220	8.112	7.896
	(0.132)	(0.116)	(0.210)	(0.130)	(0.075)
Inflation.....	1.124	0.595	0.610	1.166	1.140
	(0.296)	(0.342)	(0.279)	(0.372)	(0.436)
Current Account...	33.311	32.040	32.628	33.105	32.525
	(4.108)	(5.135)	(4.444)	(3.930)	(4.551)
JAPAN					
GNP Growth.....	3.499	3.389	2.242	3.424	4.570
	(0.000)	(0.155)	(0.259)	(0.087)	(0.059)
Unemployment.....	2.978	2.982	3.059	2.974	2.897
	(0.067)	(0.069)	(0.122)	(0.065)	(0.076)
Inflation.....	0.873	0.674	0.627	0.930	0.978
	(0.692)	(0.748)	(0.631)	(0.700)	(0.806)
Current Account...	73.37	66.522	68.383	74.140	72.375
	(6.068)	(13.503)	(10.245)	(6.052)	(9.320)
	INTERMEDIATE INDICATORS				
UNITED STATES					
Interest Rate.....	6.400	3.591	5.587	7.314	5.231
	(0.381)	(1.681)	(0.782)	(1.057)	(1.530)
GERMANY					
Interest Rate.....	3.667	2.179	3.571	4.256	2.825
	(0.381)	(1.322)	(0.682)	(0.611)	(1.149)
Exchange Rate.....	0.476	0.495	0.485	0.471	0.481
	(0.010)	(0.023)	(0.018)	(0.009)	(0.014)
JAPAN					
Interest Rate.....	3.467	2.371	3.785	4.087	2.622
	(0.539)	(0.970)	(0.555)	(0.428)	(0.916)
Exchange Rate.....	0.006	0.006	0.006	0.006	0.006
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note to table:
First number indicates the mean of the variable after 2 years. The second number in parenthesis represents the standard deviation.

TABLE 10: The Uncoordinated Nash Solution to the Disinflation Game

Using MCM multipliers

	US	Germany	Japan
Nash policies	$\Delta i = 1.713$	$\Delta m = -11.735$	$\Delta m = -3.926$
Nash outcome			
output	-1.571	-4.062	-1.205
inflation	7.767	7.119	7.918
loss	31.400	58.938	32.075

Using OECD multipliers

	US	Germany	Japan
Nash policies	$\Delta i = 6.107$	$\Delta m = -17.520$	$\Delta m = -6.241$
Nash outcome, low deficit			
output	-3.648	-4.522	-2.589
inflation	2.418	6.812	6.936
loss	9.579	56.629	27.406

TABLE 11: Coordinating on the Instruments in the Disinflation Game

Using MCM multipliers:

	US	Germany	Japan
Nash policies	$\Delta m = -5.382$	$\Delta m = -11.798$	$\Delta m = -3.874$
Nash outcome			
output	-1.832	-4.021	-1.202
inflation	7.641	7.047	7.903
loss	30.868	57.742	31.953
Gain from Coordination*	1.7 %	2.0 %	0.4 %

Using OECD multipliers:

	US	Germany	Japan
Nash policies	$\Delta m = -20.733$	$\Delta m = -16.818$	$\Delta m = -5.947$
Nash outcome			
output	-3.709	-4.483	-2.521
inflation	2.560	6.752	6.753
loss	10.156	55.641	25.977
Gain from Coordination*	-6.1 %	1.7 %	5.2 %

*Gains are measured by percent decreases in loss from the Uncoordinated Nash solution in Table 8.

TABLE 12: A Cooperative Solution to the Disinflation Game

Using MCM multipliers:

	US	Germany	Japan
Cooperative weights**	0.680	0.100	0.220
Cooperative policies	$\Delta i = 1.252$	$\Delta m = -8.111$	$\Delta m = -3.231$
Cooperative outcome			
output	-1.168	-2.799	-1.130
inflation	7.823	7.407	7.900
loss	31.284	58.775	31.847
Gain from Cooperation*	0.4 %	0.3 %	0.7 %

Using OECD multipliers:

	US	Germany	Japan
Cooperative weights**	0.650	0.220	0.130
Cooperative policies	$\Delta i = 5.930$	$\Delta m = -18.638$	$\Delta m = -5.567$
Cooperative outcome			
output	-3.523	-4.780	-2.322
inflation	2.594	6.717	7.025
loss	9.570	56.541	27.368
Gain from Cooperation*	0.1 %	0.2 %	0.2 %

*Gains are measured by percent decreases in loss from the Uncoordinated Nash solution in Table 8.

**Weights were chosen to make the gains from cooperation approximately equal.

CHART 1
Low U.S. Government Deficit: Initial Effects
(deviation from baseline path)

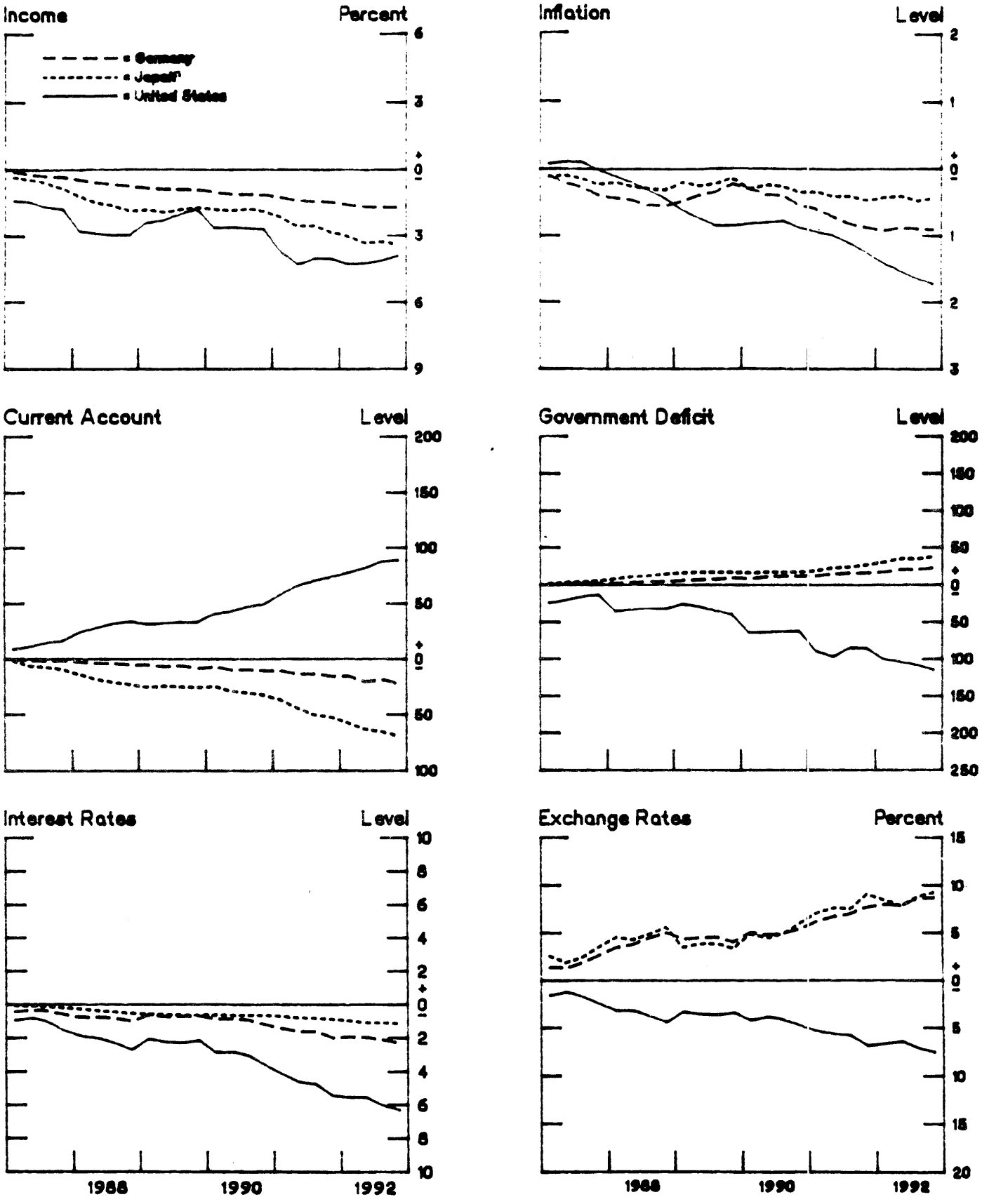


CHART 2
Low U.S. Government Deficit: Joint Response
(deviation from baseline path)

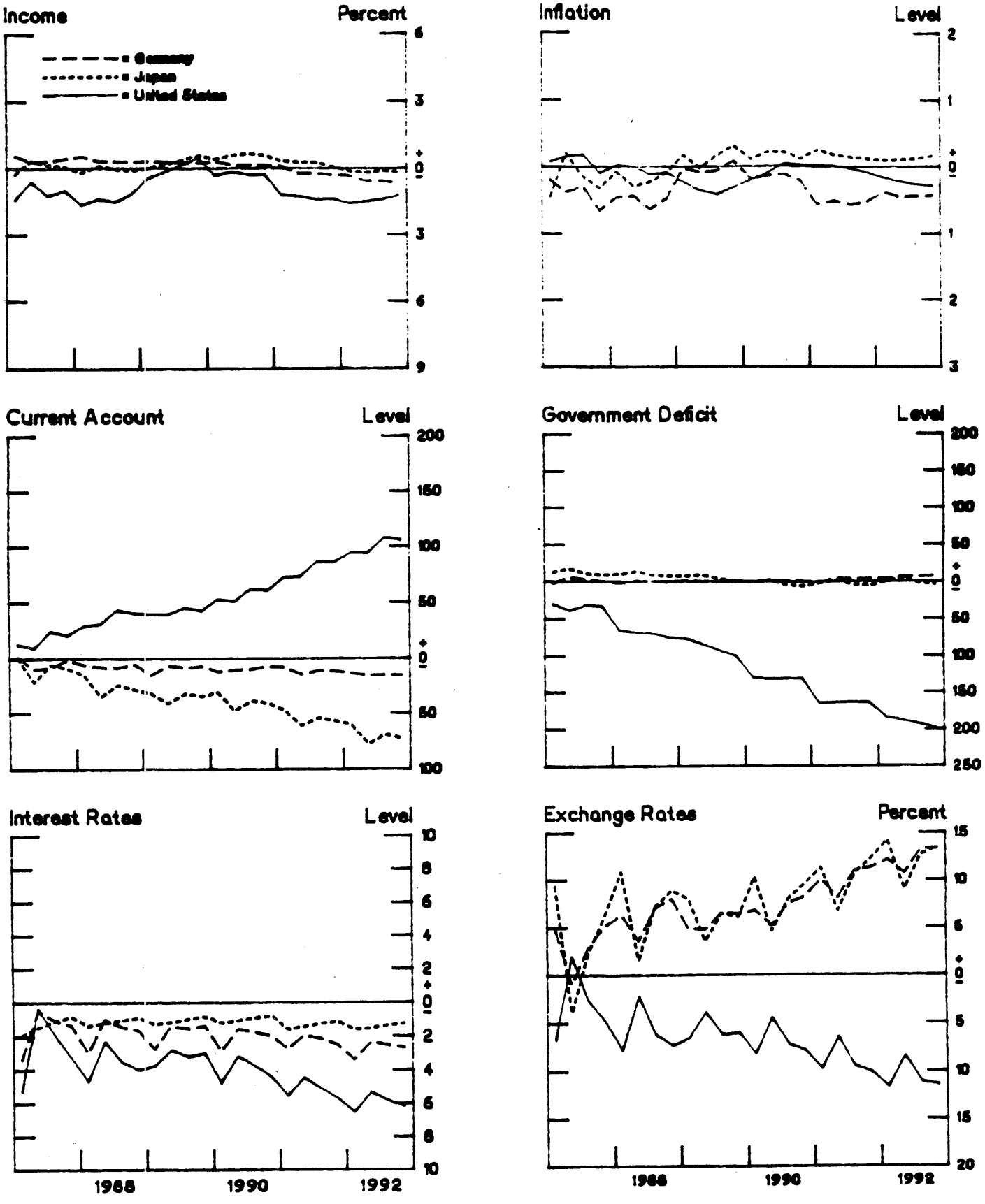


CHART 3
High U.S. Government Deficit: 'Wrong' Joint Response
(deviation from baseline path)

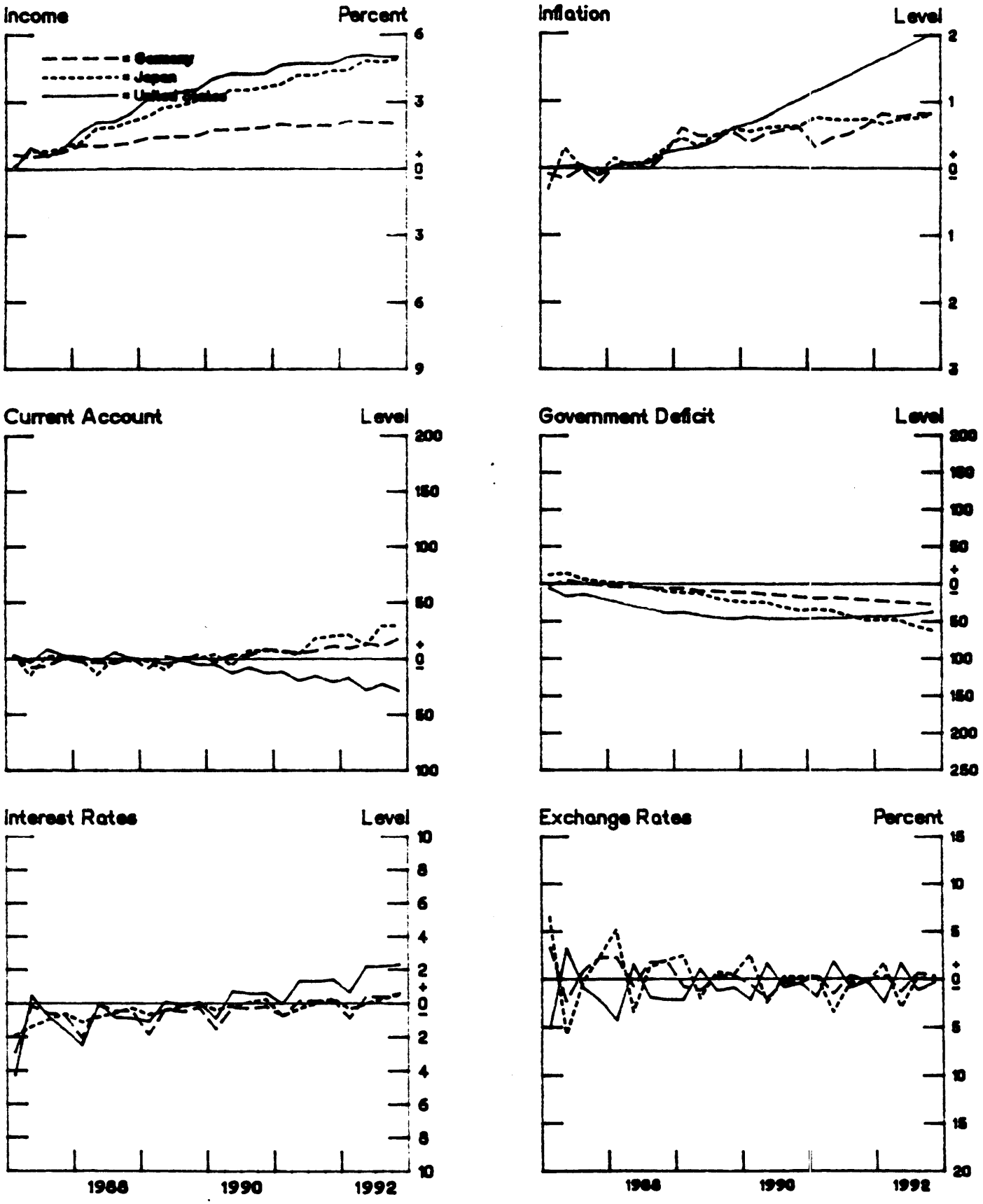


CHART 4
High U.S. Government Deficit: Initial Effects
(deviation from baseline path)

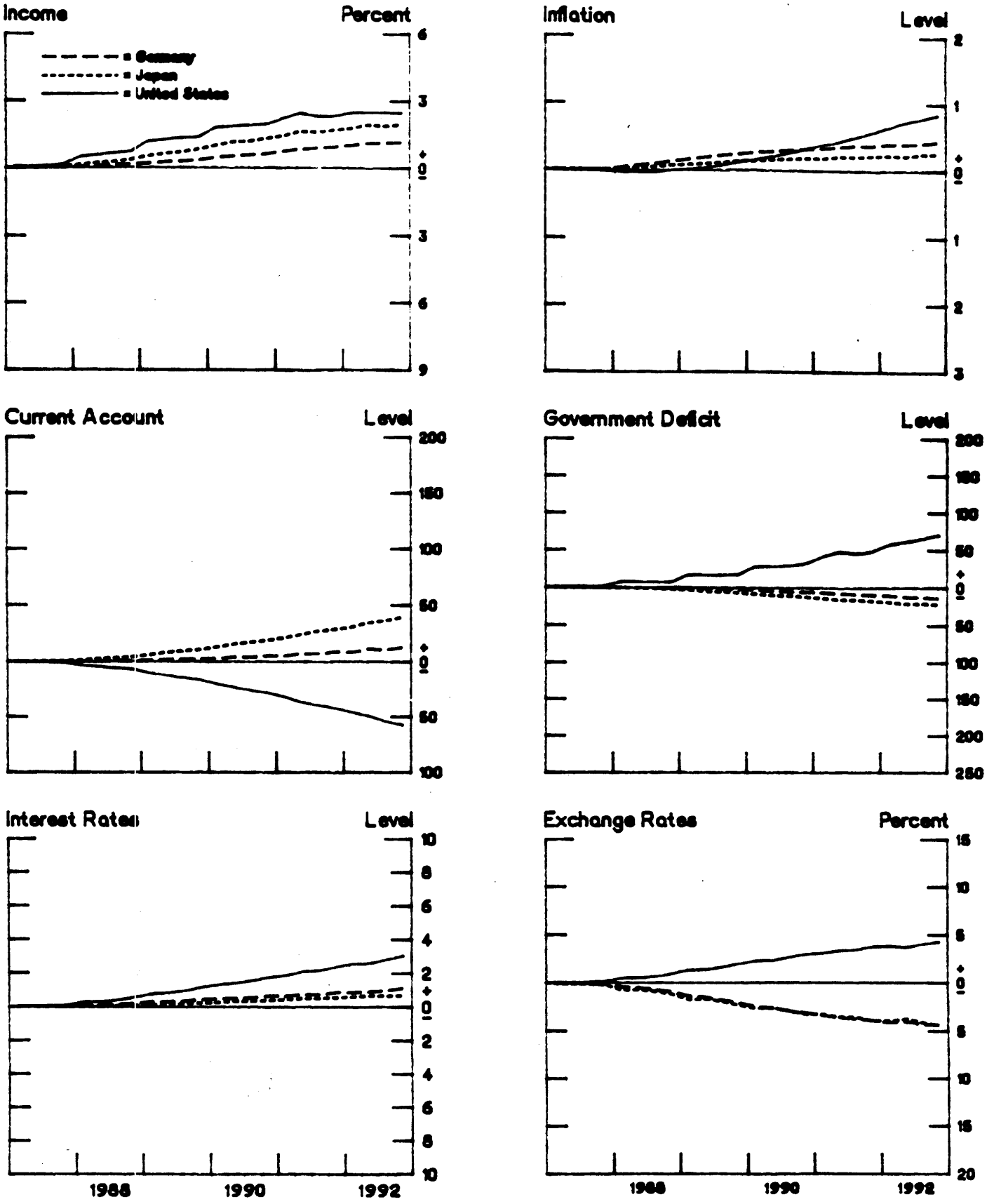


CHART 5
High U.S. Government Deficit: Joint Response
(deviation from baseline path)

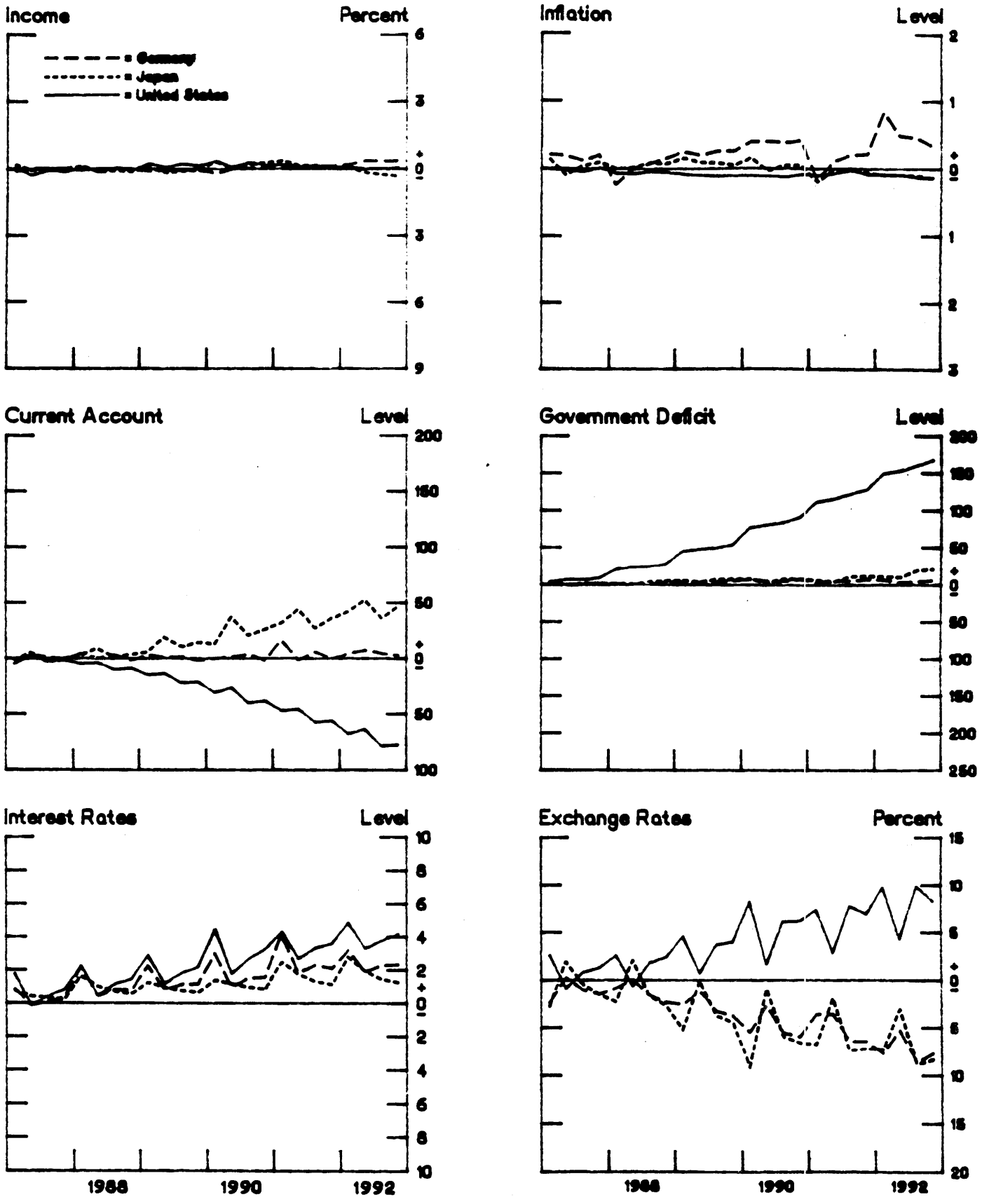
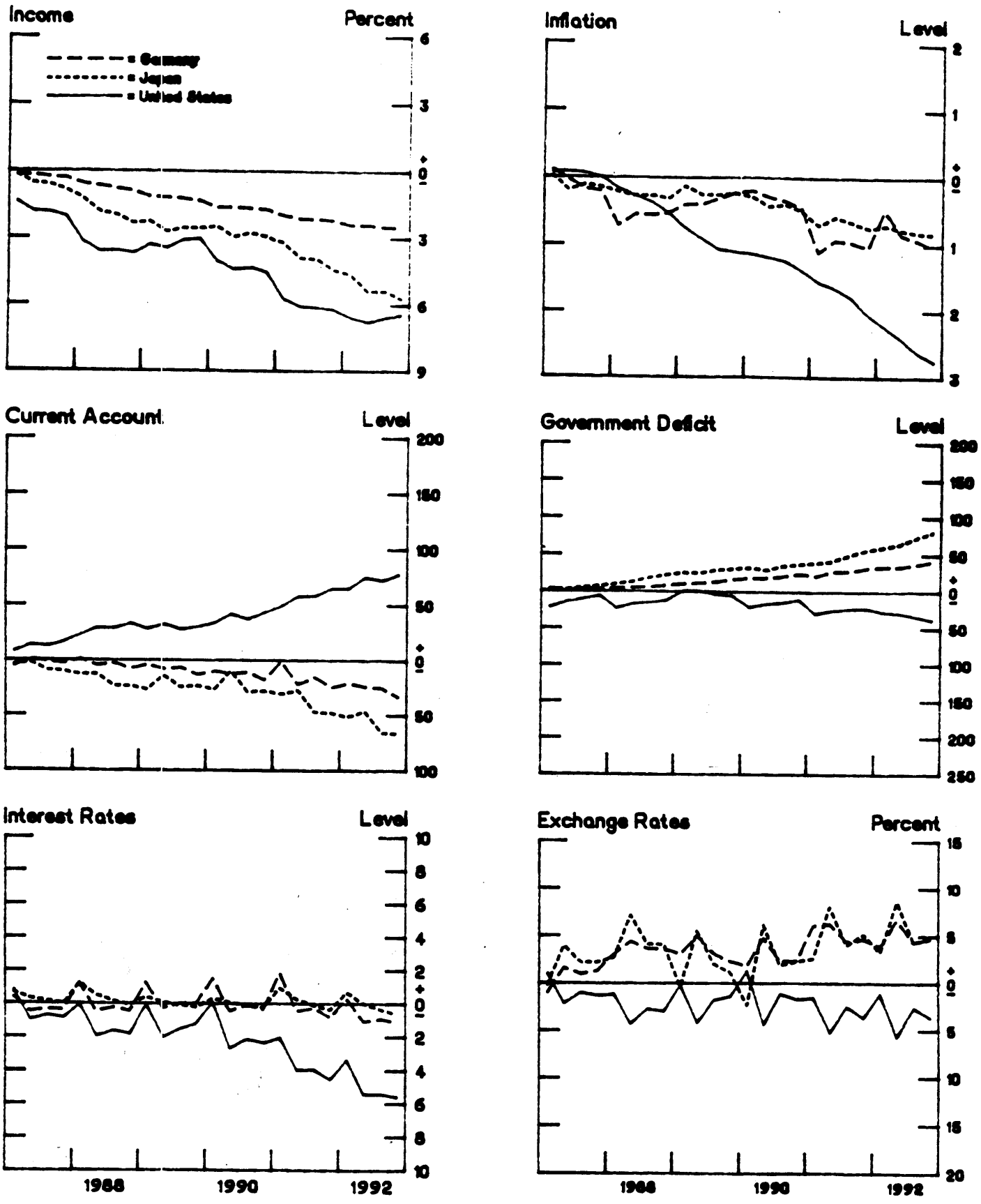


CHART 6
Low U.S. Government Deficit: 'Wrong' Joint Response
(deviation from baseline path)



International Finance Discussion Papers

IFDP NUMBER	TITLES	AUTHOR(s)
	1989	
340	A New Interpretation of the Coordination Problem and its Empirical Significance	Matthew B. Canzoneri Hali J. Edison
339	A Long-Run View of the European Monetary System	Hali J. Edison Eric Fisher
	1988	
338	The Forward Exchange Rate Bias: A New Explanation	Ross Levine
337	Adequacy of International Transactions and Position Data for Policy Coordination	Lois Stekler
336	Nominal Interest Rate Pegging Under Alternative Expectations Hypotheses	Joseph E. Gagnon Dale W. Henderson
335	The Dynamics of Uncertainty or The Uncertainty of Dynamics: Stochastic J-Curves	Jaime Marquez
334	Devaluation, Exchange Controls, and Black Markets for Foreign Exchange in Developing Countries	Steven B. Kamin
333	International Banking Facilities	Sydney J. Key Henry S. Terrell
332	Panic, Liquidity and the Lender of Last Resort: A Strategic Analysis	R. Glen Donaldson
331	Real Interest Rates During the Disinflation Process in Developing Countries	Steven B. Kamin David F. Spigelman
330	International Comparisons of Labor Costs in Manufacturing	Peter Hooper Kathryn A. Larin
329	Interactions Between Domestic and Foreign Investment	Guy V.G. Stevens Robert E. Lipsey
328	The Timing of Consumer Arrivals in Edgeworth's Duopoly Model	Marc Dudey
327	Competition by Choice	Marc Dudey

Please address requests for copies to International Finance Discussion Papers, Division of International Finance, Stop 24, Board of Governors of the Federal Reserve System, Washington, D.C. 20551.