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Abstract

This paper studies the international coordination of monetary policies in the world economy. It carefully discusses the process of policy competition and the structure of policy cooperation. As to policy competition, the focus is on monetary competition between Europe and America. Similarly, as to policy cooperation, the focus is on monetary cooperation between Europe and America. The spillover effects of monetary policy are negative. The policy targets are price stability and full employment.

Keywords: European Monetary Union, International Policy Coordination, Monetary Policy

JEL classification: E52, F33, F41, F42

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1. Introduction

This paper studies the international coordination of monetary policies in the world economy. It carefully discusses the process of policy competition and the structure of policy cooperation. With respect to policy competition, the focus is on monetary competition between Europe and America. With respect to policy cooperation, the focus is on monetary cooperation between Europe and America. The targets of the European central bank are price stability and full employment in Europe. The targets of the American central bank are price stability and full employment in America. Monetary policy in one of the regions has a large external effect on the other region. For instance, an increase in European money supply lowers American output. The key questions are: Does the process of monetary competition lead to full employment and price stability? Can monetary cooperation achieve full employment and price stability? And is monetary cooperation superior to monetary competition?

The paper is organized as follows: Monetary competition between Europe and America – Monetary cooperation between Europe and America – The anticipation of policy spillovers – Some extensions.

The underlying macroeconomic model is in the tradition of Mundell and Fleming. Some important refercences to international monetary policy coordination are W. H. Buiter, R. C. Marston (1985), M. B. Canzoneri, D. W. Henderson (1991), M. Feldstein (1988), S. Fischer (1988), K. Hamada (1985), K. Hamada, M. Kawai (1997), A. Hughes Hallett, P. Mooslechner, M. Schuerz (2001), R. A. Mundell, A. Clesse (2000), T. Persson, G. Tabellini (2000), and B. van Aaarle, H. Garretsen, F. Huart (2003).

2. Monetary Competition between Europe and America

1) The static model. As a point of reference, consider the static model. The world consists of two monetary regions, say Europe and America. The exchange rate between Europe and America is flexible. There is international trade between Europe and America. There is perfect capital mobility between Europe and America. European goods and American goods are imperfect substitutes for each other. European output is determined by the demand for European goods.

American output is determined by the demand for American goods. European money demand equals European money supply. And American money demand equals American money supply. The monetary regions are the same size and have the same behavioural functions. Nominal wages and prices adjust slowly.

As a result, an increase in European money supply raises European output. On the other hand, it lowers American output. Here the rise in European output exceeds the fall in American output. Correspondingly, an increase in American money supply raises American output. On the other hand, it lowers European output. Here the rise in American output exceeds the fall in European output. In the numerical example, a 1 percent increase in European money supply causes a 0.75 percent increase in European output and a 0.25 percent decline in American output. Similarly, a 1 percent increase in American money supply causes a 0.75 percent increase in American output and a 0.25 percent decline in European output. That is to say, the internal effect of monetary policy is very large, and the external effect of monetary policy is large. Now have a closer look at the process of adjustment. An increase in European money supply causes a depreciation of the euro, an appreciation of the dollar, and a decline in the world interest rate. The depreciation of the euro raises European exports. The appreciation of the dollar lowers American exports. And the decline in the world interest rate raises both European investment and American investment. The net effect is that European output goes up. However, American output goes down. This model is in the tradition of the Mundell-Fleming model, see Carlberg (2000) p. 189.

The static model can be represented by a system of two equations:

$$Y_1 = A_1 + \alpha M_1 - \beta M_2 \quad (1)$$

$$Y_2 = A_2 + \alpha M_2 - \beta M_1 \quad (2)$$

According to equation (1), European output Y_1 is determined by European money supply M_1, American money supply M_2, and some other factors called A_1. According to equation (2), American output Y_2 is determined by American money supply M_2, European money supply M_1, and some other factors called A_2. Here α and β denote the monetary policy multipliers. The internal effect of monetary policy is positive $\alpha > 0$. By contrast, the external effect of monetary policy is negative $\beta > 0$. In absolute values, the internal effect is larger than the

external effect $\alpha > \beta$. The endogenous variables are European output and American output.

2) The dynamic model. At the beginning there is unemployment in both Europe and America. The target of the European central bank is full employment in Europe. The instrument of the European central bank is European money supply. The European central bank raises European money supply so as to close the output gap in Europe:

$$M_1 - M_1^{-1} = \frac{\overline{Y}_1 - Y_1}{\alpha} \tag{3}$$

Here is a list of the new symbols:

Y_1	European output this period
$\overline{Y}_1$	full-employment output in Europe
$\overline{Y}_1 - Y_1$	output gap in Europe this period
M_1^{-1}	European money supply last period
M_1	European money supply this period
$M_1 - M_1^{-1}$	increase in European money supply.

Here the endogenous variable is European money supply this period M_1.

The target of the American central bank is full employment in America. The instrument of the American central bank is American money supply. The American central bank raises American money supply so as to close the output gap in America:

$$M_2 - M_2^{-1} = \frac{\overline{Y}_2 - Y_2}{\alpha} \tag{4}$$

Here is a list of the new symbols:

Y_2	American output this period
$\overline{Y}_2$	full-employment output in America
$\overline{Y}_2 - Y_2$	output gap in America this period
M_2^{-1}	American money supply last period
M_2	American money supply this period
$M_2 - M_2^{-1}$	increase in American money supply.

Here the endogenous variable is American money supply this period M_2. We assume that the European central bank and the American central bank decide simultaneously and independently.

In addition there is an output lag. European output next period is determined by European money supply this period as well as by American money supply this period:

$$Y_1^{+1} = A_1 + \alpha M_1 - \beta M_2 \tag{5}$$

Here Y_1^{+1} denotes European output next period. In the same way, American output next period is determined by American money supply this period as well as by European money supply this period:

$$Y_2^{+1} = A_2 + \alpha M_2 - \beta M_1 \tag{6}$$

Here Y_2^{+1} denotes American output next period.

On this basis, the dynamic model can be characterized by a system of four equations:

$$M_1 - M_1^{-1} = \frac{\overline{Y}_1 - Y_1}{\alpha} \tag{7}$$

$$M_2 - M_2^{-1} = \frac{\overline{Y}_2 - Y_2}{\alpha} \tag{8}$$

$$Y_1^{+1} = A_1 + \alpha M_1 - \beta M_2 \tag{9}$$

$$Y_2^{+1} = A_2 + \alpha M_2 - \beta M_1 \tag{10}$$

Equation (7) shows the policy response in Europe, (8) shows the policy response in America, (9) shows the output lag in Europe, and (10) shows the output lag in America. The endogenous variables are European money supply this period M_1, American money supply this period M_2, European output next period Y_1^{+1}, and American output next period Y_2^{+1}.

3) The steady state. In the steady state by definition we have:

$$M_1 = M_1^{-1} \tag{11}$$

$$M_2 = M_2^{-1} \tag{12}$$

Equation (11) has it that European money supply does not change any more. Similarly, equation (12) has it that American money supply does not change any more. Therefore the steady state can be captured by a system of four equations:

$$Y_1 = \overline{Y}_1 \tag{13}$$

$$Y_2 = \overline{Y}_2 \tag{14}$$

$$Y_1 = A_1 + \alpha M_1 - \beta M_2 \tag{15}$$

$$Y_2 = A_2 + \alpha M_2 - \beta M_1 \tag{16}$$

Here the endogenous variables are European output Y_1, American output Y_2, European money supply M_1, and American money supply M_2. According to equation (13) there is full employment in Europe, so European output is constant. According to equation (14) there is full employment in America, so American output is constant too. Further, equations (15) and (16) give the steady-state levels of European and American money supply.

The model of the steady state can be compressed to a system of only two equations:

$$\overline{Y}_1 = A_1 + \alpha M_1 - \beta M_2 \tag{17}$$

$$\overline{Y}_2 = A_2 + \alpha M_2 - \beta M_1 \tag{18}$$

Here the endogenous variables are European money supply and American money supply. To simplify notation we introduce:

$$B_1 = \overline{Y}_1 - A_1 \tag{19}$$

$$B_2 = \overline{Y}_2 - A_2 \tag{20}$$

With this, the model of the steady state can be written as follows:

$$B_1 = \alpha M_1 - \beta M_2 \tag{21}$$

$$B_2 = \alpha M_2 - \beta M_1 \tag{22}$$

The endogenous variables are still M_1 and M_2.

Next we solve the model for the endogenous variables:

$$M_1 = \frac{\alpha B_1 + \beta B_2}{\alpha^2 - \beta^2} \tag{23}$$

$$M_2 = \frac{\alpha B_2 + \beta B_1}{\alpha^2 - \beta^2} \tag{24}$$

Equation (23) shows the steady-state level of European money supply, and equation (24) shows the steady-state level of American money supply. As a result, there is a steady state if and only if $\alpha \neq \beta$. Owing to the assumption $\alpha > \beta$, this condition is fulfilled.

As an alternative, the steady state can be represented in terms of the initial output gap and the total increase in money supply. Taking differences in equations (1) and (2), the model of the steady state can be written as follows:

$$\Delta Y_1 = \alpha \Delta M_1 - \beta \Delta M_2 \tag{25}$$

$$\Delta Y_2 = \alpha \Delta M_2 - \beta \Delta M_1 \tag{26}$$

Here ΔY_1 is the initial output gap in Europe, ΔY_2 is the initial output gap in America, ΔM_1 is the total increase in European money supply, and ΔM_2 is the total increase in American money supply. The endogenous variables are ΔM_1 and ΔM_2. The solution to the system (25) and (26) is:

$$\Delta M_1 = \frac{\alpha \Delta Y_1 + \beta \Delta Y_2}{\alpha^2 - \beta^2} \tag{27}$$

$$\Delta M_2 = \frac{\alpha \Delta Y_2 + \beta \Delta Y_1}{\alpha^2 - \beta^2} \tag{28}$$

According to equation (27), the total increase in European money supply depends on the initial output gap in Europe, the initial output gap in America, the direct multiplier α, and the cross multiplier β. The larger the initial output gap in Europe, the larger is the total increase in European money supply. Moreover, the larger the initial output gap in America, the larger is the total increase in European money supply. At first glance this comes as a surprise. According to equation (28), the total increase in American money supply depends on the initial output gap in America, the initial output gap in Europe, the direct multiplier α, and the cross multiplier β.

4) Stability. Eliminate Y_1 in equation (7) by means of equation (9) and rearrange terms $\overline{Y}_1 = A_1 + \alpha M_1 - \beta M_2^{-1}$. By analogy, eliminate Y_2 in equation (8) by means of equation (10) to arrive at $\overline{Y}_2 = A_2 + \alpha M_2 - \beta M_1^{-1}$. On this basis, the dynamic model can be described by a system of two equations:

$$\overline{Y}_1 = A_1 + \alpha M_1 - \beta M_2^{-1} \tag{29}$$

$$\overline{Y}_2 = A_2 + \alpha M_2 - \beta M_1^{-1} \tag{30}$$

Here the endogenous variables are European money supply this period M_1 and American money supply this period M_2. To simplify notation we make use of equations (19) and (20). With this, the dynamic model can be written as follows:

$$B_1 = \alpha M_1 - \beta M_2^{-1} \tag{31}$$

$$B_2 = \alpha M_2 - \beta M_1^{-1} \tag{32}$$

The endogenous variables are still M_1 and M_2.

Now substitute equation (32) into equation (31) and solve for:

$$\alpha M_1 = B_1 + \frac{\beta B_2}{\alpha} + \frac{\beta^2 M_1^{-2}}{\alpha} \tag{33}$$

Then differentiate equation (33) for M_1^{-2}:

$$\frac{dM_1}{dM_1^{-2}} = \frac{\beta^2}{\alpha^2} \tag{34}$$

Finally the stability condition is $\beta^2 / \alpha^2 < 1$ or:

$$\alpha > \beta \tag{35}$$

That means, the steady state is stable if and only if the internal effect of monetary policy is larger than the external effect of monetary policy. This condition is satisfied. As a result, there is a stable steady state of monetary competition. In other words, monetary competition between Europe and America leads to full employment in Europe and America.

5) Some numerical examples. An increase in European money supply of 100 causes an increase in European output of 300 and a decline in American output of 100. Correspondingly, an increase in American money supply of 100 causes an increase in American output of 300 and a decline in European output of 100. Further let full-employment output in Europe be 1000, and let full-employment output in America be the same. It proves useful to study four distinct cases:

- unemployment in Europe equals unemployment in America
- unemployment in Europe exceeds unemployment in America
- unemployment in Europe, overemployment in America
- inflation in Europe and America.

First consider the case that unemployment in Europe equals unemployment in America. At the beginning there is unemployment in both Europe and America. More precisely, unemployment in Europe equals unemployment in America. Let initial output in Europe be 940, and let initial output in America be the same. Step 1 refers to the policy response. The output gap in Europe is 60. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 20. The output gap in America is 60. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 20.

Step 2 refers to the output lag. The increase in European money supply of 20 causes an increase in European output of 60. As a side effect, it causes a decline in American output of 20. The increase in American money supply of 20 causes an increase in American output of 60. As a side effect, it causes a decline in European output of 20. The net effect is an increase in European output of 40 and an increase in American output of equally 40. As a consequence, European output goes from 940 to 980, as does American output. Put another way, the output gap in Europe narrows from 60 to 20, as does the output gap in America.

Why does the European central bank not succeed in closing the output gap in Europe? The underlying reason is the negative external effect of the increase in American money supply. And why does the American central bank not succeed in closing the output gap in America? The underlying reason is the negative external effect of the increase in European money supply.

Step 3 refers to the policy response. The output gap in Europe is 20. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 6.7. The output gap in America is 20. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 6.7.

Step 4 refers to the output lag. The increase in European money supply of 6.7 causes an increase in European output of 20. As a side effect, it causes a decline in American output of 6.7. The increase in American money supply of 6.7 causes an increase in American output of 20. As a side effect, it causes a decline in European output of 6.7. The net effect is an increase in European output of 13.3 and an increase in American output of equally 13.3. As a consequence, European output goes from 980 to 993.3, as does American output. And so on. Table 1 presents a synopsis.

What are the dynamic characteristics of this process? There are repeated increases in European money supply, as there are in American money supply. There are repeated increases in European output, as there are in American output. In each round, the output gap declines by 67 percent. There are repeated cuts in the world interest rate. There are repeated increases in European investment, as there are in American investment. There are repeated cuts in budget deficits and

public debts. As a result, monetary competition between Europe and America leads to full employment in Europe and America.

Taking the sum over all periods, the increase in European money supply is 30, as is the increase in American money supply, see equations (27) and (28). That means, the total increase in European money supply is large, as compared to the initial output gap in Europe of 60. And the same applies to the total increase in American money supply, as compared to the initial output gap in America of 60. The effective multiplier in Europe is $60 / 30 = 2$, as is the effective multiplier in America. In other words, the effective multiplier in Europe is small. And the same holds for the effective multiplier in America.

Second consider the case that unemployment in Europe exceeds unemployment in America. Let initial output in Europe be 940, and let initial output in America be 970. Step 1 refers to the policy response. The output gap in Europe is 60. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 20. The output gap in America is 30. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 10.

Step 2 refers to the output lag. The increase in European money supply of 20 causes an increase in European output of 60. As a side effect, it causes a decline in American output of 20. The increase in American money supply of 10 causes an increase in American output of 30. As a side effect, it causes a decline in European output of 10. The net effect is an increase in European output of 50 and an increase in American output of 10. As a consequence, European output goes from 940 to 990, and American output goes from 970 to 980.

Step 3 refers to the policy response. The output gap in Europe is 10. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 3.3. The output gap in America is 20. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 6.7.

Step 4 refers to the output lag. The increase in European money supply of 3.3 causes an increase in European output of 10. As a side effect, it causes a decline in American output of 3.3. The increase in American money supply of 6.7 causes

an increase in American output of 20. As a side effect, it causes a decline in European output of 6.7. The net effect is an increase in European output of 3.3 and an increase in American output of 16.7. As a consequence, European output goes from 990 to 993.3, and American output goes from 980 to 996.7. And so on. Table 2 gives an overview.

What are the dynamic characteristics of this process? There are repeated increases in European money supply, as there are in American money supply. There are repeated increases in European output, as there are in American output. As a result, the process of monetary competition leads to full employment.

Taking the sum over all periods, the increase in European money supply is 26.25, and the increase in American money supply is 18.75, see equations (27) and (28). The total increase in European money supply is large, as compared to the initial output gap in Europe of 60. And the total increase in American money supply is even larger, as compared to the initial output gap in America of 30. The effective multiplier in Europe is $60 / 26.25 = 2.3$, and the effective multiplier in America is $30 / 18.75 = 1.6$. That is to say, the effective multiplier in Europe is small, and the effective multiplier in America is even smaller.

Third consider unemployment in Europe and overemployment in America. At the beginning there is unemployment in Europe but overemployment in America. Thus there is inflation in America. Let initial output in Europe be 940, and let initial output in America be 1030. Step 1 refers to the policy response. The output gap in Europe is 60. The target of the European central bank is full employment in Europe. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 20. The inflationary gap in America is 30. The target of the American central bank is price stability in America. The monetary policy multiplier in America is 3. So what is needed in America is a reduction in American money supply of 10.

Step 2 refers to the output lag. The increase in European money supply of 20 causes an increase in European output of 60. As a side effect, it causes a decline in American output of 20. The reduction in American money supply of 10 causes a decline in American output of 30. As a side effect, it causes an increase in European output of 10. The total effect is an increase in European output of 70

and a decline in American output of 50. As a consequence, European output goes from 940 to 1010, and American output goes from 1030 to 980.

Step 3 refers to the policy response. The inflationary gap in Europe is 10. The monetary policy multiplier in Europe is 3. So what is needed in Europe is a reduction in European money supply of 3.3. The output gap in America is 20. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 6.7.

Step 4 refers to the output lag. The reduction in European money supply of 3.3 causes a decline in European output of 10. As a side effect, it causes an increase in American output of 3.3. The increase in American money supply of 6.7 causes an increase in American output of 20. As a side effect, it causes a decline in European output of 6.7. The total effect is a decline in European output of 16.7 and an increase in American output of 23.3. As a consequence, European output goes from 1010 to 993.3, and American output goes from 980 to 1003.3. And so on. For an overview see Table 3.

What are the dynamic characteristics of this process? There are damped oscillations in European money supply, as there are in American money supply. There are damped oscillations in European output, as there are in American output. The European economy oscillates between unemployment and overemployment, and the same holds for the American economy. As a result, the process of monetary competition leads to both price stability and full employment. The total increase in European money supply is 18.75, and the total reduction in American money supply is 3.75. The effective multiplier in Europe is 3.2, and the effective multiplier in America is 8. That means, the effective multiplier in Europe is large, and the effective multiplier in America is even larger.

Fourth consider inflation in Europe and America. At the start there is overemployment in both Europe and America. For that reason there is inflation in both Europe and America. Let overemployment in Europe exceed overemployment in America. Let initial output in Europe be 1060, and let initial output in America be 1030. Step 1 refers to the policy response. The inflationary gap in Europe is 60. The target of the European central bank is price stability in Europe. The monetary policy multiplier in Europe is 3. So what is needed in

Europe is a reduction in European money supply of 20. The inflationary gap in America is 30. The target of the American central bank is price stability in America. The monetary policy multiplier in America is 3. So what is needed in America is a reduction in American money supply of 10.

Step 2 refers to the output lag. The reduction in European money supply of 20 causes a decline in European output of 60. As a side effect, it causes an increase in American output of 20. The reduction in American money supply of 10 causes a decline in American output of 30. As a side effect, it causes an increase in European output of 10. The net effect is a decline in European output of 50 and a decline in American output of 10. As a consequence, European output goes from 1060 to 1010, and American output goes from 1030 to 1020.

Step 3 refers to the policy response. The inflationary gap in Europe is 10. The monetary policy multiplier in Europe is 3. So what is needed in Europe is a reduction in European money supply of 3.3. The inflationary gap in America is 20. The monetary policy multiplier in America is 3. So what is needed in America is a reduction in American money supply of 6.7.

Step 4 refers to the output lag. The reduction in European money supply of 3.3 causes a decline in European output of 10. As a side effect, it causes an increase in American output of 3.3. The reduction in American money supply of 6.7 causes a decline in American output of 20. As a side effect, it causes an increase in European output of 6.7. The net effect is a decline in European output of 3.3 and a decline in American output of 16.7. As a consequence, European output goes from 1010 to 1006.7, and American output goes from 1020 to 1003.3. And so on. For a synopsis see Table 4.

What are the dynamic characteristics of this process? There are repeated cuts in European money supply, as there are in American money supply. There are repeated cuts in European output, as there are in American output. As a result, the process of monetary competition leads to both price stability and full employment.

Taking the sum over all periods, the reduction in European money supply is 26.25, and the reduction in American money supply is 18.75. The total reduction in European money supply is large, as compared to the initial inflationary gap in

Europe of 60. And the total reduction in American money supply is even larger, as compared to the initial inflationary gap in America of 30. The effective multiplier in Europe is 2.3, and the effective multiplier in America is 1.6. That is to say, the effective multiplier in Europe is small, and the effective multiplier in America is even smaller.

3. Monetary Cooperation between Europe and America

1) Introduction. As a starting point, take the output model. It can be represented by a system of two equations:

$$Y_1 = A_1 + \alpha M_1 - \beta M_2 \tag{1}$$

$$Y_2 = A_2 + \alpha M_2 - \beta M_1 \tag{2}$$

Here Y_1 denotes European output, Y_2 is American output, M_1 is European money supply, and M_2 is American money supply. The endogenous variables are European output and American output. At the beginning there is unemployment in both Europe and America. The targets of monetary cooperation are full employment in Europe and full employment in America. The instruments of monetary cooperation are European money supply and American money supply. So there are two targets and two instruments.

2) The policy model. On this basis, the policy model can be characterized by a system of two equations:

$$\overline{Y}_1 = A_1 + \alpha M_1 - \beta M_2 \tag{3}$$

$$\overline{Y}_2 = A_2 + \alpha M_2 - \beta M_1 \tag{4}$$

Here $\overline{Y}_1$ denotes full-employment output in Europe, and $\overline{Y}_2$ denotes full-employment output in America. The endogenous variables are European money supply and American money supply.

To simplify notation, we introduce $B_1 = \overline{Y}_1 - A_1$ and $B_2 = \overline{Y}_2 - A_2$. Then we solve the model for the endogenous variables:

$$M_1 = \frac{\alpha B_1 + \beta B_2}{\alpha^2 - \beta^2} \tag{5}$$

$$M_2 = \frac{\alpha B_2 + \beta B_1}{\alpha^2 - \beta^2} \tag{6}$$

Equation (5) shows the required level of European money supply, and equation (6) shows the required level of American money supply. There is a solution if and only if $\alpha \neq \beta$. Due to the assumption $\alpha > \beta$, this condition is met. As a result, monetary cooperation between Europe and America can achieve full employment in Europe and America. It is worth pointing out here that the solution to monetary cooperation is identical to the steady state of monetary competition.

3) Another version of the policy model. As an alternative, the policy model can be stated in terms of the initial output gap and the required increase in money supply. Taking differences in equations (1) and (2), the policy model can be written as follows:

$$\Delta Y_1 = \alpha \Delta M_1 - \beta \Delta M_2 \tag{7}$$

$$\Delta Y_2 = \alpha \Delta M_2 - \beta \Delta M_1 \tag{8}$$

Here ΔY_1 denotes the initial output gap in Europe, ΔY_2 is the initial output gap in America, ΔM_1 is the required increase in European money supply, and ΔM_2 is the required increase in American money supply. The endogenous variables are ΔM_1 and ΔM_2. The solution to the system (7) and (8) is:

$$\Delta M_1 = \frac{\alpha \Delta Y_1 + \beta \Delta Y_2}{\alpha^2 - \beta^2} \tag{9}$$

$$\Delta M_2 = \frac{\alpha \Delta Y_2 + \beta \Delta Y_1}{\alpha^2 - \beta^2} \tag{10}$$

According to equation (9), the required increase in European money supply depends on the initial output gap in Europe, the initial output gap in America, the

direct multiplier α, and the cross multiplier β. The larger the initial output gap in Europe, the larger is the required increase in European money supply. Moreover, the larger the initial output gap in America, the larger is the required increase in European money supply. At first glance this comes as a surprise. According to equation (10), the required increase in American money supply depends on the initial output gap in America, the initial output gap in Europe, the direct multiplier α, and the cross multiplier β.

4) Some numerical examples. An increase in European money supply of 100 causes an increase in European output of 300 and a decline in American output of 100. Further let full-employment output in Europe be 1000, and let full-employment output in America be the same. It proves useful to consider four distinct cases:

- unemployment in Europe equals unemployment in America
- unemployment in Europe exceeds unemployment in America
- unemployment in Europe, overemployment in America
- inflation in Europe and America.

First consider the case that unemployment in Europe equals unemployment in America. Let initial output in Europe be 940, and let initial output in America be the same. The output gap in Europe is 60, as is the output gap in America. So what is needed, according to equations (9) and (10), is an increase in European money supply of 30 and an increase in American money supply of equally 30. The increase in European money supply of 30 raises European output by 90 and lowers American output by 30. The increase in American money supply of 30 raises American output by 90 and lowers European output by 30. The net effect is an increase in European output of 60 and an increase in American output of equally 60. As a consequence, European output goes from 940 to 1000, as does American output. In Europe there is now full employment, and the same holds for America. As a result, monetary cooperation can achieve full employment.

The required increase in European money supply is large, as compared to the initial output gap in Europe. And the same applies to the required increase in American money supply, as compared to the initial output gap in America. The effective multiplier in Europe is $60/30 = 2$, as is the effective multiplier in America. That is to say, the effective multiplier in Europe is small. And the same is true of the effective multiplier in America. Table 5 presents a synopsis.

Second consider the case that unemployment in Europe exceeds unemployment in America. Let initial output in Europe be 940, and let initial output in America be 970. The output gap in Europe is 60, and the output gap in America is 30. So what is needed, according to equations (9) and (10), is an increase in European money supply of 26.25 and an increase in American money supply of 18.75. The increase in European money supply of 26.25 raises European output by 78.75 and lowers American output by 26.25. The increase in American money supply of 18.75 raises American output by 56.25 and lowers European output by 18.75. The net effect is an increase in European output of 60 and an increase in American output of 30. As a consequence, European output goes from 940 to 1000, and American output goes from 970 to 1000. In Europe there is now full employment, and the same holds for America. As a result, monetary cooperation can achieve full employment.

The required increase in European money supply is large, as compared to the initial output gap in Europe. And the required increase in American money supply is even larger, as compared to the initial output gap in America. The effective multiplier in Europe is 60/26.25 = 2.3, and the effective multiplier in America is 30/18.75 = 1.6. That means, the effective multiplier in Europe is small, and the effective multiplier in America is even smaller. Table 6 gives an overview.

Third consider unemployment in Europe but overemployment in America. Let initial output in Europe be 940, and let initial output in America be 1060. The output gap in Europe is 60, and the output gap in America is −60. What is needed, then, is an increase in European money supply of 15 and a reduction in American money supply of equally 15. The increase in European money supply of 15 raises European output by 45 and lowers American output by 15. The reduction in American money supply of 15 lowers American output by 45 and raises European output by 15. The total effect is an increase in European output of 60 and a decline in American output of equally 60.

The required increase in European money supply is small, as compared to the initial output gap in Europe. Correspondingly, the required cut in American money supply is small, as compared to the initial inflationary gap in America. The effective multiplier in Europe is 60/15 = 4, and the effective multiplier in

America is equally 60/15 = 4. That is to say, the effective multiplier in Europe is large. And the same is true of the effective multiplier in America. Table 7 presents a synopsis.

Fourth consider inflation in Europe and America. At the start there is overemployment in both Europe and America. For that reason there is inflation in both Europe and America. Let overemployment in Europe exceed overemployment in America. Let initial output in Europe be 1060, and let initial output in America be 1030. The inflationary gap in Europe is 60, and the inflationary gap in America is 30. The targets of monetary cooperation are price stability in Europe and price stability in America. What is needed, then, is a reduction in European money supply of 26.25 and a reduction in American money supply of 18.75. The reduction in European money supply of 26.25 lowers European output by 78.75 and raises American output by 26.25. The reduction in American money supply of 18.75 lowers American output by 56.25 and raises European output by 18.75. The net effect is a decline in European output of 60 and a decline in American output of 30. As a consequence, European output goes from 1060 to 1000, and American output goes from 1030 to 1000. There is now full employment in both Europe and America. For that reason there is now price stability in both Europe and America. As a result, monetary cooperation can achieve full employment and price stability.

The required cut in European money supply is large, as compared to the initial inflationary gap in Europe. And the required cut in American money supply is even larger, as compared to the initial inflationary gap in America. The effective multiplier in Europe is 60/26.25 = 2.3, and the effective multiplier in America is 30/18.75 = 1.6. That means, the effective multiplier in Europe is small, and the effective multiplier in America is even smaller. Table 8 gives an overview.

5) Comparing monetary cooperation with monetary competition. Monetary competition can achieve full employment. The same applies to monetary cooperation. Monetary competition is a slow process. By contrast, monetary cooperation is a fast process. Judging from these points of view, monetary cooperation seems to be superior to monetary competition.

4. The Anticipation of Policy Spillovers

The focus here is on monetary competition between Europe and America. The European central bank closely observes the measures taken by the American central bank. And what is more, the European central bank can respond immediately to the measures taken by the American central bank. The other way round, the American central bank closely observes the measures taken by the European central bank. And what is more, the American central bank can respond immediately to the measures taken by the European central bank. That means, the inside lag of monetary policy is short. On the other hand, the outside lag of monetary policy is long and variable.

In the current section we assume that the European central bank anticipates the spillovers from monetary policy in America. Likewise we assume that the American central bank anticipates the spillovers from monetary policy in Europe. To illustrate this, have a look at a numerical example. An increase in European money supply of 100 causes an increase in European output of 300 and a decline in American output of 100. Further let full-employment output in Europe be 1000, and let full-employment output in America be the same.

Let initial output in Europe be 940, and let initial output in America be 970. Steps 1, 2 and 3 refer to a series of policy responses. Then step 4 refers to the output lag. Let us begin with step 1. The output gap in Europe is 60. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 20. The output gap in America is 30. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 10.

In step 2, the European central bank anticipates the effect of the increase in American money supply. And the American central bank anticipates the effect of the increase in European money supply. The European central bank expects that, due to the increase in American money supply of 10, European output will only rise to 990. And the American central bank expects that, due to the increase in European money supply of 20, American output will only rise to 980. The expected output gap in Europe is 10. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 3.3. The expected output gap in America is 20. The monetary policy multiplier in

America is 3. So what is needed in America is an increase in American money supply of 6.7.

We now come to step 3. The European central bank expects that, due to the increase in American money supply of 6.7, European output will only rise to 993.3. And the American central bank expects that, due to the increase in European money supply of 3.3, American output will only rise to 996.7. The expected output gap in Europe is 6.7. The monetary policy multiplier in Europe is 3. So what is needed in Europe is an increase in European money supply of 2.2. The expected output gap in America is 3.3. The monetary policy multiplier in America is 3. So what is needed in America is an increase in American money supply of 1.1.

Step 4 refers to the output lag. The accumulated increase in European money supply of 25.6 causes an increase in European output of 76.7. As a side effect, it causes a decline in American output of 25.6. The accumulated increase in American money supply of 17.8 causes an increase in American output of 53.3. As a side effect, it causes a decline in European output of 17.8. The net effect is an increase in European output of 58.9 and an increase in American output of 27.8. As a consequence, European output goes from 940 to 998.9, and American output goes from 970 to 997.8. Table 9 gives an overview. As a result, the anticipation of policy spillovers speeds up the process of monetary competition. Thus there seems to be no need for monetary cooperation.

5. Some Extensions

1) Compare low capital mobility with high capital mobility. Under high capital mobility, monetary competition is a slow process. Conversely, under low capital mobility, monetary competition is a fast process.

2) Compare gradualist policies with cold-turkey policies. A gradualist strategy can slow down or speed up the process of monetary competition, depending upon initial conditions. Further, a gradualist strategy can prevent output from oscillating.

3) Monetary competition between Europe, America and Asia. The world consists of three monetary regions, say Europe, America and Asia. The monetary regions are the same size and have the same behavioural functions. At the beginning there is unemployment in each of the regions. As a result, the steady state is stable if and only if the internal effect of monetary policy is larger than the external effect of monetary policy. This condition is fulfilled. In other words, the process of monetary competition leads to full employment in each of the regions. Now compare the world of three regions with the world of two regions. In the world of two regions, monetary competition is a relatively fast process. By contrast, in the world of three regions, monetary competition is a relatively slow process.

4) Monetary cooperation between Europe, America and Asia. As a result, there is a solution to monetary cooperation. That is to say, monetary cooperation can achieve full employment in each of the regions.

5) Rational policy expectations. The focus here is on monetary competition between Europe and America. At the beginning there is unemployment in both Europe and America. The target of the European central bank is full employment in Europe. The instrument of the European central bank is European money supply. The target of the American central bank is full employment in America. The instrument of the American central bank is American money supply. We assume that the European central bank and the American central bank decide simultaneously and independently.

The European central bank sets European money supply, forming rational expectations of American money supply. And the American central bank sets American money supply, forming rational expectations of European money supply. That is to say, the European central bank sets European money supply, predicting American money supply by means of the model. And the American central bank sets American money supply, predicting European money supply by means of the model. As a result, there is an immediate equilibrium of monetary competition. In other words, monetary competition leads to full employment immediately. It is worth pointing out here that the equilibrium under rational expectations is identical to the steady state under adaptive expectations.

Here a comment is in place. The European central bank closely observes the measures taken by the American central bank. And what is more, the European central bank can respond immediately to the measures taken by the American central bank. The other way round, the American central bank closely observes the measures taken by the European central bank. And what is more, the American central bank can respond immediately to the measures taken by the European central bank. Therefore rational policy expectations do not seem to be very important.

6. Conclusion

1) Monetary competition between Europe and America. The world consists of two monetary regions, say Europe and America. Now let there be unemployment in Europe and America. Then the process of monetary competition leads to full employment in Europe and America. There are repeated increases in European money supply, as there are in American money supply. There are repeated increases in European output, as there are in American output. Instead let there be overemployment and hence inflation. Then the process of monetary competition leads to full employment and price stability. There are repeated cuts in European money supply, as there are in American money supply. There are repeated cuts in European output, as there are in American output. Monetary competition is a slow process. The reason is the negative external effect of monetary policy.

2) Monetary cooperation between Europe and America. Now let there be unemployment in Europe and America. Then monetary cooperation can achieve full employment in Europe and America. What is needed is an increase in European and American money supply. Instead let there be overemployment and inflation. Then monetary cooperation can achieve full employment and price stability. What is needed is a cut in European and American money supply. Monetary cooperation is a fast process, as compared to monetary competition. The reason is that the negative external effect of monetary policy can be internalized by cooperation. From this perspective, monetary cooperation seems to be superior to monetary competition.

3) The anticipation of policy spillovers. The focus here is on monetary competition between Europe and America. The European central bank anticipates the spillovers from monetary policy in America. And the American central bank anticipates the spillovers from monetary policy in Europe. As a result, the anticipation of policy spillovers speeds up the process of monetary competition. Thus there seems to be no need for monetary cooperation.

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Table 1

Monetary Competition between Europe and America

Unemployment in Europe Equals Unemployment in America

	Europe	America
Initial Output	940	940
Change in Money Supply	20	20
Output	980	980
Change in Money Supply	6.7	6.7
Output	993.3	993.3
and so on	…	…

Table 2

Monetary Competition between Europe and America

Unemployment in Europe Exceeds Unemployment in America

	Europe	America
Initial Output	940	970
Change in Money Supply	20	10
Output	990	980
Change in Money Supply	3.3	6.7
Output	993.3	996.7
Change in Money Supply	2.2	1.1
Output	998.9	997.8
and so on	…	…

Table 3

Monetary Competition between Europe and America

Unemployment in Europe Exceeds Overemployment in America

	Europe	America
Initial Output	940	1030
Change in Money Supply	20	– 10
Output	1010	980
Change in Money Supply	– 3.3	6.7
Output	993.3	1003.3
Change in Money Supply	2.2	– 1.1
Output	1001.1	997.8
and so on	…	…

Table 4

Monetary Competition between Europe and America

Inflation in Europe Exceeds Inflation in America

	Europe	America
Initial Output	1060	1030
Change in Money Supply	– 20	– 10
Output	1010	1020
Change in Money Supply	– 3.3	– 6.7
Output	1006.7	1003.3
Change in Money Supply	– 2.2	– 1.1
Output	1001.1	1002.2
and so on	…	…

Table 5
Monetary Cooperation between Europe and America
Unemployment in Europe Equals Unemployment in America

	Europe	America
Initial Output	940	940
Change in Money Supply	30	30
Output	1000	1000

Table 6
Monetary Cooperation between Europe and America
Unemployment in Europe Exceeds Unemployment in America

	Europe	America
Initial Output	940	970
Change in Money Supply	26.25	18.75
Output	1000	1000

Table 7
Monetary Cooperation between Europe and America
Unemployment in Europe Equals Overemployment in America

	Europe	America
Initial Output	940	1060
Change in Money Supply	15	– 15
Output	1000	1000

Table 8

Monetary Cooperation between Europe and America

Inflation in Europe Exceeds Inflation in America

	Europe	America
Initial Output	1060	1030
Change in Money Supply	– 26.25	– 18.75
Output	1000	1000

Table 9

Monetary Competition between Europe and America

The Anticipation of Policy Spillovers

	Europe	America
Initial Output	940	970
Change in Money Supply	20	10
Change in Money Supply	3.3	6.7
Change in Money Supply	2.2	1.1
Output	998.9	997.8

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