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MACROECONOMIC POLICY INTERACTION UNDER FLEXIBLE
EXCHANGE RATES: A TWO-COUNTRY MODEL

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ABSTRACT

This paper analyses macroeconomic policy interaction in a two-country flexible exchange rate model. Each country has a short-run non-vertical Phillips curve, and there is positive transmission of economic expansion through the terms of trade. The product real wage is distinguished from the income real wage, the latter also depending on the terms of trade, and a reduction in the former increasing employment. Inflation brings the actual income real wage below the target real wage. Non-co-operative solutions (Nash and Stackelberg) are shown to have deflationary biases relative to Pareto-efficient outcomes which could be obtained by policy co-ordination. The special properties of the balanced expansion (constant terms of trade) path are explored. An important qualification to the whole analysis, taking into account intertemporal effects, is discussed at the end.

MACROECONOMIC POLICY INTERACTION UNDER FLEXIBLE EXCHANGE RATES: A
TWO-COUNTRY MODEL*

I

INTRODUCTION

This paper is concerned with macroeconomic policy interaction in a two-country flexible exchange rate model with no exchange market intervention. The two key ingredients are (1) a short run non-vertical Phillips curve in each country, and (2) positive transmission of economic expansion through the terms of trade.

With regard to (1) it is assumed that there is nominal wage sluggishness, and that the actual real wage (which determines employment) can diverge from the target real wage, the divergence being brought about by management of nominal demand. With regard to (2), the mechanism is as follows. A rise in output in one country, say the United States, induced by an expansion of nominal demand there, improves the other country's (say Germany's) terms of trade; this shifts outwards the marginal product of labor curve in Germany and then allows Germany to increase employment, the real wage, or both. For the purpose of this model it is nominal demand expansion that is relevant, irrespective of whether it is brought about by

* Work on this paper was begun at the Institute for International Economic Studies, Stockholm in 1982, and carried further in 1983 at the European University Institute, Florence and the Australian National University. It was influenced by discussions with Vijay Joshi in 1982, who queried the main conclusion in Corden (1983), and has benefited from comments by Ben Smith which led to the argument of Section VII.

monetary expansion, fiscal expansion, or some combination of them.

In order to isolate interaction through the effects of changes in aggregate demand on the terms of trade, interaction through the capital market is ruled out. It is simplest to assume that there is zero international capital mobility. Alternatively, if there is capital mobility it might be assumed that a country's change in macroeconomic policy is always so designed as to keep unchanged its net demand for tradeable bonds and equities. A monetary expansion, for example, would always have to be associated with an appropriate degree of fiscal expansion, the two together yielding the desired nominal demand expansion.

The stimulus for this paper was provided by the extensive but unrigorous discussions since 1974 about the need for international co-ordination of macroeconomic policies. Much of this discussion either assumed fixed exchange rates or a regime of managed floating where central banks inevitably intervened by "leaning against the wind" so - in the absence of complete sterilisation - bringing about some inevitable monetary transmission of disturbances. But it can be argued that when governments are free to alter their exchange rates (or allow them to float) they are free to choose their own rates of monetary growth (or nominal demand growth) independent of other countries' policies, so that any transmission to the domestic economy of external disturbances is purely voluntary. In addition, countries - both governments and private agents - can be buyers and sellers of bonds in the world capital market just as they are trading goods and services in the goods and services markets, but such interactions through markets no more call for co-ordination between governments as

interaction in the paradigm free market system calls for explicit co-ordination between households and firms. Markets co-ordinate. This argument was made in Corden (1983). But, as noted there, the standard argument for decentralised decision-making through free markets is subject to qualifications, notably externalities and oligopolistic interactions.

The present paper is concerned with such a qualification, considering a case of bilateral monopoly in the form of two governments managing their aggregate nominal demands and thus - in the short run - their countries' demands for the other's product. It is shown that the likely non-co-ordination solutions will have deflationary biases relative to a co-ordinated set of policies which aims at a Pareto-efficient solution for the world as a whole. The main analysis is strictly short-run, the assumption being that governments are only concerned with unemployment and inflation in the current period, and that any expectational effects operate in later periods. In the last section a significant reservation about the whole approach, taking into account long-run effects, is set out.¹

1. Pioneering work on two-country policy interaction under fixed exchange rates is in Hamada (1974, 1976, 1979), though an early paper by Niehans (1968) and a recent one by Johansen (1982) should also be noted. On the international transmission process through the terms of trade under flexible rates see especially Hamada and Sakurai (1978), Mussa (1979) and Corden and Turnovsky (1983). All the interdependence issues are surveyed in Cooper (1983), which contains many references.

Canzoneri and Gray (1983), Sachs (1983) and Cooper (1983, sec. 5) deals with the flexible exchange rate two-country interaction case along similar lines as the present paper, with somewhat similar results, though the micro-foundations differ. These papers all make the special assumption that the two economies are completely symmetrical, which allows various precise results to be achieved not possible in the present paper. In the present paper an attempt is made to provide firm trade theoretic foundations.

II

THE TERMS OF TRADE AND THE REAL WAGE: A TWO COUNTRY REAL TRADE THEORY MODEL

We begin by setting up a two product two country real trade theory model as a reference point for later analysis. From the point of view of standard real trade theory, the special feature is that the labor supply is variable, and that various explicit assumptions are made about real wage behaviour. As is usual in trade theory, we assume (1) that the product market is always in equilibrium and (2) that the balance of trade is always zero.

The two countries are the USA (U) and Germany (G), each being specialised in a single product X_i ($i = u, g$) while consuming both. The capital stock K_i in each country is fixed. Employment N_i is endogenous, being determined by the production function $X_i = X_i(K_i, N_i)$, which is linear and homogenous, and is assumed given, and by the real product wage R_i . Employment varies so as to equate the marginal product of labor to R_i , an increase in N_i resulting from a fall in R_i . The labor market is not in equilibrium, employment being demand-constrained. It has to be stressed that R_i is the real wage purely in terms of the country's own product, X_i . Finally, in each country there is a demand function for the two goods, X_u and X_g , which is independent of the distribution of income between the two factors, and both goods are superior.

We now move to the two country model and introduce the terms of trade, T , defined as the price of X_g in terms of X_u . Figure 1 is the usual offer curve diagram drawn in x_u, x_g space, where x_i

represents exports. As is usual each offer curve is drawn for a given level of output X_i and thus for a given product real wage R_i . The initial offer curves are OF_u and OF_g , so that the initial trade equilibrium is at L, and the initial terms of trade are represented by the slope of OL. Suppose R_u fell. United States employment and output would then rise, and the United States offer curve would shift outwards to OF'_u . If output in Germany stayed constant (i.e. R_g were fixed) the trade equilibrium would move to K, the volume of trade would have expanded, and T will have risen. But a key aspect of the subsequent analysis is that German output may not stay constant when T rises.

The product real wage R_i must be distinguished from the income real wage, W_i , where $W_i = W_i(R_i, T)$. For a given R_i , an improvement in the terms of trade will raise W_i . If W_i were fixed, an improvement in the terms of trade would have to be compensated by a fall in R_i , which would be brought about by an increase in employment and thus output X_i .

We now turn to Figure 2, referring to Germany and drawn in W_g, N_g space. MM is the marginal product of labor curve, drawn for a constant level of T. A movement downwards results from a fall in R_g , which leads to a fall in W_g . A terms of trade improvement would shift the curve to the right. By contrast, UU is drawn for a constant level of United States output X_u . Associated with it is a given OF_u curve in Figure 1. It tells us that if Germany wished to raise her employment from g_0 to g_1 her income real wage W_g would have to fall from w_0 to w_1 , provided US output did not change. The fall to w_1 results from diminishing returns to labor in the

German production function, and the further fall to w_2 results from lower T as there is a movement along the United States offer curve.

We now show the effects of a rise in United States output. This is represented by a shift of the curve from UU to $U'U'$ and corresponds exactly to the shift of the offer curve in Figure 1 from OF_u to OF' . For given German output (and hence R_g) of g_0 , W_g then rises from w_0 to w_3 , the equilibrium being at K (corresponding to K in Figure 1). The German terms of trade improve, as they must anywhere to the right of MM .²

If German output had simultaneously expanded to g_2 , equilibrium would be at J , the terms of trade would have stayed constant, and W_g would have fallen to w_4 . This German expansion is represented in Figure 1 by a movement of her offer curve to OF'_g , the new equilibrium being at J , with the terms of trade the same as initially at L . This is the special case of a balanced expansion in both countries - i.e. an expansion that leaves the terms of trade unchanged.

The interesting case is where the income real wage in Germany is rigid. The United States expansion would then lead to a rise in German output to g_1 , bringing equilibrium to H , causing W_g to stay at w_0 and T to rise, but less than if German output had not changed. (In Figure 1, equilibrium would also be at H). The reaction of German

2. In this paper each country is specialised in producing one good, and the two goods are both superior, so that there must be positive transmission. In a non-specialisation model there could be negative transmission through the terms of trade, as shown in Corden and Turnovsky (1983): US expansion could worsen Germany's terms of trade (the US offer curve moving inwards), this shifting Germany's marginal product (UU) curve in Figure 2 to the left; or an improvement in the German terms of trade could even have such an adverse effect on the marginal product curve. The present paper could be extended to incorporate these cases. The effects of negative transmission in the two-country interaction model are considered in Canzoneri and Gray (1983).

employment to changes in United States employment and output can thus be regarded as depending on the behaviour of the German income real wage, one special case being a rigid real wage and another a real wage that adjusts to maintain employment constant.

Figure 3 is drawn in N_g, N_u space and shows the reaction curves $G'G'$ and $U'U'$ for the two countries, each drawn on the assumption that the relevant income real wage is rigid. Starting at A, the balanced expansion path, along which T stays constant, is AQ . If German employment were to rise from g_0 to g_1 , T would have to rise to compensate for the fall in R_g , so constant W_g requires an equilibrium above AQ , at a point such as C; on the other hand, constant W_u requires a fall in T , so that equilibrium would have to be at a point such as D. If W_g were not rigid but were flexible so as to keep German employment constant at g_0 , the German reaction curve would be vertical through A.

Rather than considering an exogenous rise in United States employment, say from u_0 to u_1 , it might be more realistic to suppose that the exogenous shock is a fall in W_u . Let us assume that this shifts the US reaction curve to $U''U''$. Equilibrium will then be at C. The rise in US employment has then two components: first the rise from A to B without any change in German output, and then the rise from B to C resulting from the positive German reaction.

III

MACROECONOMICS INTRODUCED: THE PHILLIPS CURVE AND THE TRADE-OFF

The next step is to derive what is essentially a short-term non-vertical Phillips curve consistent with our various assumptions. In particular, we assume that the product market is always in equilibrium, even though the labor market is not. In Figure 5 UU is drawn in $\hat{p}_g, N_g$ space for constant United States output, where $\hat{p}_g$ is the German rate of price inflation - which is a weighted average of the rate of inflation of the price of X_g and of the price of X_u in terms of German currency.³ Initially German inflation is $\hat{p}_0$ and employment g_0 , while (with US output constant) a rise in employment to g_1 would lead to price inflation $\hat{p}_1$. The task now is to relate this curve to the underlying real story represented in Figure 4 and to the underlying monetary mechanism.

Suppose we start at a real equilibrium L in Figure 4. Let us assume that this results from a steady state monetary situation where both prices and the nominal wage are growing at the same rate. Thus if $\hat{n}$ is the rate of growth of German nominal demand (equal to the rate of money supply growth when the velocity of circulation is constant) and $\hat{w}$ is the rate of German nominal wage increase, we assume that, to

3. It is usual to draw the Phillips curve in unemployment, not employment, space. Hence this is not an orthodox Phillips curve, though it expresses the same basic idea. While the original Phillips curve related the rate of nominal wage increase to unemployment the term has been expanded to include one that has the rate of price inflation on the vertical axis. It will be clear that the analysis here is strictly short-term, so the curve is not expectations-augmented.

start with, $\hat{n} = \hat{p} = \hat{w}$. If the rate of inflation of the price of X_u is also constant, then there will be steady depreciation or appreciation of the Germany currency depending on whether inflation in the United States is lower (requiring German depreciation) or higher (appreciation).

The (income) real wage w_0 is the target real wage at the level of employment g_0 , so that the labor market is in equilibrium at L in the special sense that the unions (or others who determine wages) are satisfied with the real wage at that level of employment, even though there are potential workers involuntarily unemployed. The curve VV traces out the target real wage at various levels of employment. It could be thought of, alternatively, as a trade union supply curve.⁴

We now make the following simple assumption. The actual real wage (which determines employment) can be brought below the target real wage during the period concerned by continuous price inflation above the initial level. Price inflation can bring about this gap between the actual and the higher target real wage because of sluggishness of nominal wage adjustment. The greater the required gap, the greater price inflation needs to be. In turn, increased inflation is brought about by an increase in the rate of growth of nominal demand (rate of money supply growth when velocity is constant). Obviously this is a short-term analysis, subject to all

4. Instead of letting the target real wage vary directly with employment we could let it be determined by trade unions trading-off real wage gains against employment increases. In Figure 4 a union indifference curve could then be tangential to UU at L, yielding the real wage target w_0 . Given UU, this target stays unchanged even though the actual real wage can be brought below it by inflation. Thus at employment g_1 the wage gap is HE, not EF, as before, and the required $\hat{p}$ is thus less than before. It follows that, in Figure 5, UU will be flatter.

the limitations of drawing a fixed non-vertical Phillips curve.⁵ We thus derive the curve UU in Figure 5. The increase from p_0 to p_1 is required to sustain the actual-target real wage gap FE in Figure 4.

Consider now the effects of an increase in US output that shifts the UU curve in Figure 4 to $U'U'$. In this particular case, if employment were again to rise to g_1 the actual real wage would need to stay constant at w_0 . But since the target real wage has risen there is still a real wage gap FH. With the lower wage gap, the required increase in the German rate of inflation is less, as shown in Figure 5 by the point H. Thus the increase in US output shifts the German Phillips curve in Figure 5 downwards, any given level of employment in Germany requiring less inflation than before.⁶

The next step is to introduce the usual social welfare contours allowing for the selection of the optimal points on the two Phillips curves. We assume that the original point L in Figure 5 represented the optimal point (a contour being tangential to UU at L), while the new optimal point will be southeast of L, say at Z, expressing the simple idea that the gains from US expansion will be taken out by Germany partly in less inflation and partly in more employment. The point Z is also shown in Figure 4. It involves not only a rise in the

5. The idea is that a rise in $\hat{p}$ sustained over the short-run period under consideration here leads to a temporary rise of $\hat{p}$ over $\hat{w}$, so that W_g falls by a given amount over the period; this implies that by the end of the period $\hat{w}$ has caught up with $\hat{p}$. If $\hat{p}$ stayed ahead of $\hat{w}$, W_g would be continuously falling.
6. If it were assumed (see footnote 4) that the real wage target was determined by a trade union trade-off (rather than varying directly with employment) then VV in Figure 4 could be thought of as tracing out the trade union optimal points as UU rises, a rise in US output thus raising the German target real wage irrespective of the actual level of German employment attained by macroeconomic policy. This approach assumes that the unions take as given the level of US output and is thus subject to the same myopia on which the government reaction curve GG in Figure 6 is based.

actual real wage but also a negative real wage gap (target real wage below actual real wage). In addition the point Z is shown in Figure 1. It involves a greater terms of trade improvement relative to the initial position than at H (where W_g stayed constant) but less than at K (when German employment did not increase).

It is then possible to derive a new German reaction curve GG in Figure 3 which is steeper than G'G' (along which W_g is constant). For any given rise in N_u , there will be a lesser rise in N_g than when W_g is rigid because some of the gains from US expansion will be taken out by Germany in a higher real wage rather than all in higher employment. Moving upwards along GG there is a steady rise in W_g . Similarly, of course, there will be a new (flatter) US reaction curve (not drawn).

Before making use of these reaction curves to analyse the two countries' policy interactions we might note that there are three distinct reasons why the German curve is steeper than the United States one - three factors that ensure (each factor on its own) stability and uniqueness of the Nash equilibrium to be discussed below: (1) diminishing physical returns to extra employment in each country owing to the fixity of the capital stock, (2) an increase in the target real wage as employment increases, and (3) a reduction in the rate of price inflation as employment increases. In the absence of all three factors in both countries the two reaction curves would coincide with AQ, one country's expansion eliciting expansion by the other country along the balanced expansion (constant terms of trade)

path.⁷ The presence of at least one of these factors in at least one country is sufficient for the analysis to follow.

The assumption of diminishing returns to extra employment (so that the real product wage R_i must fall as N_i rises) is thus not essential for the model, even though it seems a natural assumption in a neo-classical framework. This is an important point since some might regard the assumption as inappropriate in a short-run model.

7. To elaborate, in Figure 3 there are three reasons why a rise in German employment from g_0 to g_1 requires a US expansion that improves the German terms of trade (i.e. that brings equilibrium above AQ, to a point such as D):

(1) The terms of trade must improve just to keep the income real wage W constant (to reach C), since higher employment involves a fall^g in the German product real wage R . (2) W must actually rise if the real wage gap is not^g to increase, because higher employment leads to a rise in the target real wage. (3) Because a lower rate of inflation will be chosen when employment increases, W must rise further to reduce the real wage gap (make it negative if it were zero initially) so as to lower the rate of price inflation.

IV

NON-CO-OPERATIVE EQUILIBRIA

Figure 6, like Figure 3, shows the two reaction curves drawn in N_g , N_u space. Each reaction curve is drawn on the assumption that a country takes as given the other's level of employment, and then adjusts its level of nominal demand so as to obtain the optimal point on its Phillips curve. Since the given production functions link output and employment in each country the diagram might, alternatively, have been drawn in X_g , X_u space, but this would not alter the substance of any of the following argument.

If there were indeed non-co-operative behaviour based on the myopic assumption that the other country's output stayed fixed, the Nash equilibrium at A would be attained. The USA would always move vertically towards UU and Germany would move horizontally towards GG. Each country would have its proximate instrument, N_u and N_g - in turn determined by adjusting nominal demand via monetary and fiscal policy - and its target UU and GG, and the assignment of instrument to target is stable.

The levels of social welfare attained are indicated by the two indifference curves through A, uu tracing out equal social welfare for the USA (any curve to the right representing an improvement), and gg tracing out equal social welfare for Germany, (higher curves representing an improvement). It is apparent that a move to any point on these curves up to C, or within the area enclosed by uu and gg,

Fig. 6

would be a Pareto-improvement. Thus, while the Nash equilibrium is stable, it is not Pareto efficient. The Nash equilibrium has a contractionary bias, in the sense that both countries could be better off if, within limits, they both expanded beyond that equilibrium.

Alternatively, a non-co-operative equilibrium might be attained through policy leadership by one country. Germany might react to US policy by taking US output as given, so staying on GG, while the United States adjusts its policy so as to attain the optimal point for it on GG. This would yield the Stackelberg equilibrium at B, which is Pareto-superior to A, but still has some contractionary bias.

Special note might be taken of the balanced expansion path AQ along which the terms of trade stay constant. Moving upwards along it from A, as employment rises the product real wages of both countries must steadily fall owing to diminishing returns. Neither country can be compensated by a terms of trade improvement for the adverse movement in its product real wage, so the two income real wages must also fall. Price inflation will steadily increase in both countries, since the target real wage of each must be rising with higher employment, while the actual income real wage is falling. Since the rate of price inflation need not be the same in the two countries at any point, the nominal exchange rate could be moving either way. The balanced expansion path might be described as a path where the real exchange rate (equivalent in this model to the terms of trade) but not the nominal exchange rate, is constant.⁸

8. The balanced expansion path AQ assumes that the Nash equilibrium is the starting point. In principle each starting point has a balanced expansion path along which joint expansion keeps the terms of trade constant.

There can be excessive mutual expansion along this balanced path: beyond D (which could be either side of C) a point on the path is no longer Pareto-superior to A, since at least one country will be worse off, and beyond E both will be worse off. Thus there can be excessive mutual expansion along this balanced path.

A non-co-operative equilibrium might be attained through policy leadership where the reactive country, Germany, aims to keep the terms of trade constant, while the USA chooses an optimal point given this reaction. This is equivalent to a constant-market-shares equilibrium in duopoly, with one firm taking the initiative. AQ then becomes the German reaction curve and the USA chooses the point F. For the United States this is superior both to the Nash and to the Stackelberg equilibrium. But this may not be so for Germany. The optimal point on AQ for Germany could be either above or below F, so that US leadership could yield either over- or under-expansion for Germany, and if F were between D and E Germany would be worse off than at A.

It cannot, of course, be assumed that non-co-operative behaviour would lead to any of the results just discussed. In particular, the Nash equilibrium implies myopia. The question then is whether there are any general rules to constrain non-co-operative behaviour that are likely to have favorable results. One rule has, in effect, already been discussed, namely to compel one of the parties to ensure by its macroeconomic policy that the terms of trade are kept constant. Another might be called the unilateral expansion rule and seems, at first sight, plausible. Wherever countries find themselves initially, they may expand, but may not contract. The point is that one country's contraction always has an adverse effect on the other,

so this rule ensures that any voluntary change is a Pareto improvement. A country will expand only if this would benefit itself, and such expansion must also benefit the other country. This rule would limit equilibria to somewhere on or within the cone GAU (above A). Of course, this includes areas that are inferior to A for one or both countries. Such a rule might need to be supplemented by an agreement for co-ordinated contraction when both desire this.

V

POLICY CO-ORDINATION

In Figure 6, JJ' traces out points of tangency of the indifference curves. This is the Pareto-efficiency locus. It divides the cone GAU referred to above into an upper and a lower part. If the countries are not on this locus they can, by mutual arrangement, always achieve a Pareto-improvement. This could be brought about by both expanding (if they start in the lower part of the cone), both contracting (starting in the upper part), or one expanding and the other contracting (possibly required if starting outside the cone). Let us consider the first two cases in more detail.

(1) Starting at A it is apparent that there is much scope for joint expansion that yields a Pareto improvement. Concentrating on the balanced expansion path, a movement to K (where this path intersects the locus) would make both countries better off in the case drawn. Furthermore, there is some movement along the path (up to where it first hits uu or gg) which must be a Pareto improvement. But, starting on the path above A, it may be necessary to go off the path to obtain a further Pareto-improvement. The possible need to go off the path can be made with regard to the starting point at F. A move from F to K would make the USA worse off because the favorable effects on her of German expansion would be outweighed by the unfavorable effects on her of her own expansion. Thus there must be somewhat less US and more German expansion, with the net effect of

improving the US terms of trade to get on or within the range $F'F''$, so yielding a Pareto-improvement. As is well-known, attainment of the maximum Pareto improvement requires not attainment of any point on a Pareto-efficiency locus but some point within a particular range, depending on the starting point.

(2) We might start at F^* , a case of mutual over-expansion. A move to the same $F'F''$ range will again yield a Pareto improvement. Contraction by one country will always have an adverse effect on the other country (as is evident by moving horizontally or vertically from F^* .), but the losses for the other country are in this case outweighed by the gains from its own contraction.

The point made in the introduction and implied in popular arguments for co-ordination that non-co-ordination is likely to lead to a contractionary bias - so that co-ordination calls for mutual expansion - assumes that in the absence of co-ordination the Nash or Stackelberg equilibria would be reached. Thus the starting point is assumed to be in the lower part of the cone. But once this assumption is removed, co-ordination to attain a Pareto improvement may require contraction by one or both countries.

Finally, Figure 6 makes the idea of policy co-ordination look very attractive. It is hard to see why two rational governments should not welcome the opportunity that co-ordination would give to improve the social welfare of both of them. But there are at least two problems.

(1) If one country expands to attain its share of the joint target and the other is slow to follow then the first may incur a temporary loss; thus there has to be not just co-ordination of ultimate targets but also of timing of expansion. Presumably there is both an enforcement and an information problem.

(2) There may be a difference of perception as to where the starting point is. Thus the US may believe it to be at A and favor joint expansion to F, which would benefit both countries, while Germany believes the starting point is at D, say, where a balanced expansion would lower the welfare of both.⁹

9. This appeared to have been the problem in 1978 when the United States urged mutual expansion on Germany on the basis of the "locomotive theory" (which is formalised in our model).

VI

A WORLD OF MANY COUNTRIES

Is the model applicable to a world of many countries?

At the limit all countries are sufficiently small that none can affect its terms of trade; so countries are perfectly competitive, can disregard the effects of their own macroeconomic policy decisions on others, and decentralised decision-making is Pareto-efficient. Oligopolistic issues do not arise, and the simple argument against the need for co-ordination in Corden (1983) applies.

Then there is the small number case presented in this paper. While one can describe certain non-co-ordination solutions - e.g. Nash and Stackelberg - these imply myopic behaviour by governments, and the actual solution must be regarded as indeterminate until further considerations from game theory are introduced.

In between is the situation where countries know that economic expansion would lead to deterioration of their terms of trade but do not expect reactions from other countries. This would then lead to a multi-country Nash equilibrium with its contractionary bias. The Nash equilibrium is thus an interesting case because it may well come close to describing the non-co-ordination outcome in a world of many countries. Alternatively, all countries other than the United States might be regarded as ignoring reactions, even though many of them would worsen their terms of trade with economic expansion. In this

case the Stackelberg equilibrium is a reasonable representation of the non-co-ordination outcome.

It is because these two solutions appear to be applicable to an extended model quite close to the "real world" that it has seemed appropriate to explore the Nash and Stackelberg cases, especially the former, in some detail in this paper.

VII

INTERTEMPORAL EFFECTS

It has been assumed that one country, say the USA, balances the favorable current output effects of an expansion against the unfavorable inflation effects. But the transmission to the other country, Germany, is purely through the output effect, which, if the transmission is positive, is favorable for Germany. US inflation has no effect on Germany, which can insulate itself from foreign inflation with a flexible exchange rate. Put another way, a US expansion has a favorable real and an unfavorable nominal effect, and only the real effect is transmitted to Germany. Thus it is in the interests of each country that the other country expands as much as possible irrespective of the inflationary effects in the other country, and, from a world point of view, each should expand more than if it considered only its own interest. This sums up the "locomotive argument" for co-ordination, which has been formalised in this paper and in the papers by Canzoneri and Gray (1983) and by Sachs (1983).¹⁰

The difficulty about this approach is as follows. There is no reason why a country should regard an increase in its rate of inflation as adverse if this is never expected to have any real effects. Presumably the reason why an increase in current inflation

10. The inflation effect might be either current, as in this paper, or future, in the form of inflationary expectations generated by current monetary expansion, without necessarily any rise in current inflation, as in Canzoneri and Gray (1983).

(or in future inflation stimulated perhaps by an increase in inflationary expectations now) is thought adverse is because it is expected to have adverse real effects of some kind. But the future real effects in the USA of a rise in current US inflation would spill over to Germany in the usual way through the terms of trade. Hence, Germany should expect to lose later from US expansion currently. The Phillips curve trade-off decision should really be regarded as part of a government's social savings and investment decisions. The foreign country will incidentally be affected by these decisions. The special feature of the model in this paper, and of all similar models or arguments which these models seek to formalise, is that the foreign country is assumed not to expect to lose from the adverse real effects expected for the future in the home country from a rise in the latter's rate of inflation.

This qualification does not make the present paper and the papers by Canzoneri and Gray (1981) and Sachs (1983) irrelevant because they elucidate the implications of the widely accepted locomotive argument. It is useful to be clear about the key assumptions that are implied. Furthermore, a basis is provided for further analysis, the general outlines of which will now be sketched out.¹¹

Let us suppose, then, that a US expansion today will have a favorable effect on US output and hence the German terms of trade today, and an unfavorable effect on both later. Thus we continue to

11. Sachs (1983, pp.11-20) presents a Dynamic Model which seems to get close to this issue. It is not clear to me whether it actually rests on the same, simple, point. Possibly it rests, rather, on the implication from the main model that any inflation and term of trade changes resulting from expansion or contraction must be temporary, as the analysis is short-run. In the first period we have a non-vertical Phillips curve and in later periods the curve is again vertical, so that any first-period effects are reversed.

assume positive transmission in each separate period. The question is whether the expected effect on Germany in both periods combined would be regarded as favorable or not. Does it improve or worsen the total (two-period) trade-off available to Germany? Two factors appear to be relevant.

First, there is the relative magnitude of the first period favorable terms of trade effect on Germany as against the second period unfavorable terms of trade effect. In the formal model the second period effect has been implicitly assumed zero. This relative magnitude, in turn, depends on (a) the relative magnitudes of the two output effects in the USA, and (b) the two positive transmission effects which convert US output changes into terms of trade changes.

Secondly, there are all the considerations in Germany which determine whether German welfare is likely to be raised or lowered by a terms of trade improvement in the first period balanced by an equal terms of trade loss in the later period. If Germany discounts the future then, presumably an equal change like this would represent a net gain, and even if the latter terms of trade deterioration were greater than the earlier improvement, the net result might still be, in terms of Germany's social welfare function, a net gain. In that case we could say that - in the complete total (two-period) sense - there has been positive transmission to Germany of current US expansion. It would then be in the interests of Germany that the USA expanded more than if the latter only considered her own interests.

If such positive total transmission also applied to expansion by Germany, then the whole of our earlier analysis would essentially still be applicable. World Pareto-efficiency would require more

expansion by both than would result from the Nash equilibrium. The main idea of the locomotive theory would be endorsed. On the other hand, there could be negative total transmission, so that Germany would prefer the USA to expand less than the latter would choose from the point of view of her own interests. The conclusions of the model must then be put appropriately into reverse.

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