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Ronald G. Wirick

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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

DEPARTMENT OF ECONOMICS
UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2

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RATIONAL EXPECTATIONS AND RATIONAL STABILIZATION POLICY IN AN OPEN ECONOMY

by

Ronald G. Wirick
Department of Economics
University of Western Ontario
London Canada

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ABSTRACT

The open-economy version of the competitive-equilibrium, rational-expectations model does not exhibit short-run neutrality with respect to anticipated changes in monetary and fiscal policy. Such policy shifts, in general, will alter the terms of trade which in turn will create employment and output fluctuations. Furthermore, such open-economy rational-expectations models may have an infinite number of convergent, dynamic solutions. Finally, if an expectations-augmented Phillips curve is substituted for a Lucas supply function, activist "feed-forward" stabilization policy can eliminate the output perturbations caused by anticipated future private-sector shifts in the LM and IS curves.

I. Introduction

Recently Lucas (1972, 1973, 1975), Sargent and Wallace (1975, 1976), Sargent (1976, 1977), and Barro (1976) have developed a competitive-equilibrium, rational-expectations (CERE) theoretical structure to challenge the conventional Keynesian, disequilibrium hypothesis of macroeconomic behavior. The CERE models incorporate a Lucas supply function in which output and employment deviate from their full-information market-clearing levels because unanticipated variations in the aggregate price level cause even "rational" suppliers to misjudge real factor returns. Such models exhibit what is often called the Lucas-Sargent-Wallace (henceforth, LSW) proposition: any systematic (and therefore anticipated) change in monetary policy will have no effect upon output or employment; only monetary surprises affect real variables.

For at least two reasons the CERE model has had a very substantial intellectual impact, even among those who are very skeptical of its competitive market assumptions. First, the policy conclusions are remarkably robust. A wide array of alternate aggregate demand assumptions leaves the LSW proposition intact. In fact, one of the points of the CERE model-builders was that the classical neutrality properties can be derived even with a standard, Keynesian, IS-LM aggregate-demand structure. It can also be demonstrated that the fiscal policy analogue of the LSW proposition is true in a CERE model.[1] In addition, McCallum (1977, 1978) has shown that even if price adjustment is "sticky", a CERE model does not allow anticipated

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[1] See McCallum and Whitaker (1979). Of course the classical non-neutralities of taxation and expenditures still remain. The point is there is no cyclical output effect of fiscal policy.

money supply changes to affect output.[1]

A second, and perhaps even more important factor contributing to the significance attached to the CERE literature is that for closed economies the LSW proposition holds even in non-CERE models. Indeed, the Lucas supply function is imply an "inverted" expectations-augmented, Phillips-curve, so that the acceptance of rational expectations will imply the impotence of monetary policy in the most conventional of disequilibrium, price-adjustment models.

The present paper investigates the robustness of the CERE theoretical properties when the closed-economy assumptions are relaxed.[2] In the open-economy analogue of the Lucas supply function, output depends not only on price surprises, but also on the terms of trade. It is, therefore, possible for output to vary from its stationary equilibrium value even if price (and exchange rate) expectations are not only rational, but held with perfect foresight. Under such circumstances, the two key results of closed-economy rational-expectations models are overturned:

1. In general the LSW proposition is no longer valid in the short run. Only in the special case where domestic prices and the exchange rate affect goods-market equilibrium in a perfectly symmetric fashion will anticipated money supply changes be output neutral. Anticipated fiscal policy (or any private-sector shift in the IS curve) always has an impact on output.

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[1] Buiter (1980, pp. 41-5) has challenged the relevance of this conclusion arguing that it is akin to dressing "a classical market-clearing sheep in non-Walrasian wolf's clothing". Buiter displays a disequilibrium Phillips curve model in which sticky prices do allow a scope for monetary policy. But his resulting equation implies the existence of money illusion even in equilibrium, as the long-run coefficient on expected price is less than one. Such a formulation is counter to both economic theory and empirical evidence.

[2] Considerable effort has been devoted to specifying circumstances under which the LSW proposition is not true. Most analyses have challenged the informational and/or institutional assumptions underlying the Lucas supply function. Clearly if the monetary authority changes its policy rule, then until private agents learn about the new circumstances, systematic policy can influence output (Taylor, 1975; Friedman, 1979; Parkin, 1978). Fischer (1977a), and Phelps and Taylor (1977) have shown that when wage or price precontracting exists, the monetary authority can utilize current information to reduce output fluctuations. Weiss (1980) demonstrated

2. The expectations-augmented Phillips curve (EAPC) is no longer mathematically equivalent to the Lucas supply function. Substituting an EAPC for a Lucas supply function, and retaining perfect foresight expectations, still leaves scope for anticipated monetary and fiscal policy to have output effects. However, the specific dynamic behavior will differ from the CERE model. Finally, in an EAPC open-economy model (short-run) stabilization policy has the same "rational" meaning as that given in textbook formulations: A means of insulating output from the effects of anticipated private-sector shifts in the IS and LM curves.

Although the above results are derived for a small country, it is argued that they can be generalized to any open economy, as long as: (i) The differential between domestic and world interest rates is subject to arbitrage; and (ii) world asset and commodity prices are not dictated solely by domestic economic conditions. Since it is unlikely that even the United States is an independent price-setter in this latter sense, the relevance of the LSW proposition and other closed-economy CERE results is highly questionable.

The explicit, small open-economy model is developed in Section II. Section III examines the dynamic behavior of the model. The response of the model to unanticipated and anticipated monetary and fiscal policy changes is discussed in Section IV. Section V analyses the nature and robustness of the non-neutrality results. Section VI derives an open-economy analogue to the EAPC (as a substitute for the Lucas supply function) and argues that there is a role for "feed-forward" stabilization rules in such a model. Section VIII offers some concluding remarks.

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that differential information among private agents can also invalidate the LSW proposition. Finally, Feige and Pearce (1976) and Howitt (1981) have shown that if information is costly to gather and/or process, then again the LSW proposition may not hold.

II. Derivation of the Model

The model extends the CERE structure as carefully as possible into the framework of a small open economy with mobile capital flows.[1] There are two (composite) goods (which are imperfect substitutes), one produced domestically and one abroad. The price of the foreign good (in terms of foreign currency) is exogenously given to the small country.[2] There are two assets: money and bonds. All money is held by domestic residents; there is no currency substitution. Domestic and foreign bonds are perfect substitutes for each other and can be traded at zero transactions cost. The world interest rate is also exogenous. The model is specified in discrete time, with beginning-of-period asset equilibrium assumed.

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[1]The critical conclusions of the model depend on the way that the output behavior of the CERE model is affected by the interaction between capital mobility and changes in the terms of trade. Both Burton (1980) and Cox (1980) have analyzed open-economy versions of the CERE structure; however neither of these models incorporate the complications and implications of shifting terms of trade. Parkin et al (1979) and Leiderman (1979, 1980) carefully incorporated the appropriate terms-of-trade effects into open-economy CERE models, but neither allowed for capital mobility. The dynamic possibilities of exchange rate overshooting under conditions of (perfect) rational expectations was first explored by Dornbusch (1976) and later extended by Wilson (1979) and Gray and Turnovsky (1979). Also, see Turnovsky and Kingston (1977) for a perfect foresight, open-economy model. None of these analyses incorporated a Lucas supply function. Turnovsky (1981) considers the effects of anticipated monetary policy in a rational-expectations, market-clearing model with capital mobility. However, Turnovsky considers only the special case in which domestic prices and the exchange affects goods-market equilibrium in a symmetric way, and hence he does not obtain the non-neutralities examined here. Also, Turnovsky's supply function is based upon the wage contracting arguments of Gray (1976) and Fischer (1977b), rather than the Lucas framework. Some of his results appear to depend on the differing informational assumptions underlying the former approach as opposed to the latter.

[2]The price of the domestically-produced good is determined within the domestic economy. Implicitly this assumes that exports are not "large" in comparison to domestic consumption of the local good.

The specific structure of the model is given below:

(1) Import price deflator

$$PI_t = P^* + E_t$$

(2) Consumption price deflator

$$P_t = zPD_t + (1-z)(PI_t); \qquad 0 < z < 1$$

(3) Interest arbitrage condition

$$i_t = i^* + (\hat{E}_{t+1} - E_t)$$

(4) Lucas supply function

$$Y_t = \bar{Y} + a_1[(P_t - \hat{P}_t) + (PD_t - P_t)] \qquad 0 < a_1, \bar{Y}$$

(5) Aggregate expenditure/income equilibrium

$$Y_t = a_2 X_t - b_2(PD_t - PI_t) - c_2(i_t - \hat{PD}_{t+1} + PD_t) + d_2(M_t - PD_t) \quad 0 < a_2, b_2, c_2, d_2$$

(6) Money market equilibrium

$$M_t = PD_t + Y_t - a_3 i_t ; \qquad 0 < a_3$$

The variable definitions are:

PI = price of the foreign good, in terms of domestic currency

P^* = price of the foreign good, in terms of foreign currency

E = the exchange rate defined as the price of foreign currency, in terms of domestic currency

PD_t = the price of the domestically produced good, in terms of domestic currency

P_t = the price of domestic consumption, defined as the weighted geometric mean of domestic and import-good prices

i_t = one plus the domestic (nominal) interest rate

i^*_t = one plus the (nominal) world interest rate

Y = (real) domestic output

X = (real) "autonomous" expenditures

M = (nominal) domestic money supply

All variables are given as natural logarithms. The caret denotes the (assumedly uniform) expectation held by agents regarding the value of that variable. Specifically, $\hat{E}_{t+1}$ and $\hat{PD}_{t+1}$ denote the agent expectations, at time t, of the values that E and PD, respectively, will assume in time t+1. The remaining price expectational variables are discussed below.

Equations (1) and (2) are self-explanatory, while equation (3) simply specifies the interest rate parity condition derived from the assumption of perfect capital mobility.

Equation (4) is the key part of the model, representing the open economy extension of the Lucas supply function used in the rational-expectations literature. It can be justified in a number of ways, but the following explanation is most in keeping with the spirit of Lucas' original (closed economy) arguments.[1] Firms are assumed to operate in a perfectly competitive environment. At each time t they are aware of the price of their own product (say in industry i).[2] To maximize profits the firm hires labour to the point where labour's marginal value product is equal to the nominal wage rate. Assuming a fixed capital stock and summing across all firms yields an aggregate demand for labour function

$$LD_t = F(W_t - PD_t), \qquad F' < o$$

where LD = (the log of) aggregate demand for labour

W = (the log of) the aggregate nominal wage.

Note that the relevant price on the firm side is PD, the price of the (composite) domestic good.

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[1] Lucas and Rapping (1969), Lucas (1972 and 1973).

[2] Lucas (1972, 1973) avoided index number problems by using geographically separated regions to specify different "industries". The present paper uses differentiated products since it seems intuitively more appealing and in an open economy a (consumption) price index cannot be avoided in any case. It is interesting to note that Barro (1976, p. 2) has argued that Lucas' use of physically separated locations "is intended to serve as a proxy for markets in a variety of different goods".

On the labour supply side, individual worker/consumers are assumed to offer their services on the basis of their expected real wage. Following Lucas, it is assumed that at time t workers are aware of the contemporaneous nominal wage offer made by firms, but they do not know the contemporaneous aggregate price index. They therefore must deflate this wage (W_t) by their expectation of the current nominal price of the basket of consumption goods ($\hat{P}_t$). Summing across all worker/consumers, and assuming labour/leisure substitution effects dominate income effects, yields the following aggregate labour supply function:

$$LS_t = G(W_t - \hat{P}_t), \qquad G' > 0$$

where LS = (the log of) the aggregate supply of labour.

Imposing labour market equilibrium and eliminating the nominal wage rate gives a function for actual employment (L),

$$L_t = H(PD_t - \hat{P}_t), \qquad H' > 0$$

Finally, given the fixed capital stock, this employment level can be substituted in the aggregate production function to give aggregate (output) supply.

$$Y_t = J(PD_t - \hat{P}_t), \qquad J' > 0$$

Assuming J is linear implies[1]

$$Y_t = \bar{Y} + a_1(PD_t - \hat{P}_t), \quad \bar{Y}, a_1 > 0$$

This can be rewritten as,

$$(4) \qquad Y_t = \bar{Y} + a_1[(P_t - \hat{P}_t) + (PD_t - P_t)]$$

Aggregate supply behavior as specified in equation (4) is dependent on two asymmetries between firm and worker behavior. First, firms base their decisions on actual prices, while workers must utilize expected price information. If actual prices are higher than expected prices, then actual real

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[1] $\bar{Y}$ is an implicit function of the fixed capital stock. In a closed economy it would be interpreted as full employment (non-cyclical) output. For reasons discussed later, however, full employment output is not policy invariant in a CERE open economy, and hence this interpretation is not valid.

wages are lower than expected real wages. Firms move down their labour demand curve, increasing their employment and output. Workers are willing to supply this labour because they erroneously believe they are receiving higher remuneration than is actually the case. This is essentially the output effect that Lucas originally envisioned and is reflected in the first term of equation (4).[1]

Second, firms react to the price of their output, while consumer behavior is based on the price of their consumption basket. As a result, any increase in the price of the former--relative to the latter--will cause output to increase. To put it another way, any improvement in the terms of trade allows for a simultaneous decrease in real wage costs to firms and an increase in real wage income to workers. This terms-of-trade effect operates even when all prices are correctly anticipated and is reflected in the second term of equation (4).[2]

Finally it should be noted that if workers only consumed the domestic good (i.e., $z = 1$), then the second term of equation (4) would vanish and the supply function would reduce to precisely that given in the standard closed-economy Lucas model,[3]

$$(4a) \qquad Y_t = \bar{Y} + a_1 (PD_t - \hat{PD}_t)$$

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[1]The basic argument can be found in Friedman (1968).

[2]Open economy supply functions essentially the same as equation (4) are derived by Leiderman (1979, 1980) and by Parkin, et al. (1979).

[3]To allow for serially correlated movements in output and employment, even if expectations are formed rationally, the CERE theorists often include a lagged output term on the right-hand side of equation (4a). This extension is justified on the basis of information lags (Lucas, 1975) or costs of output adjustment (Sargent, 1977). The omission of such a term in the present analysis is simply a matter of convenience and does not alter any of the key conclusions.

Equations (5) and (6) specify the aggregate demand side of the model. They are based upon a conventional IS-LM framework. Aggregate expenditures in the IS function are positively dependent on real autonomous expenditures (which include government expenditures and shifts in export demand) and real money balances, and vary inversely with the terms of trade and the real rate of interest.[1] Actual, rather than expected prices, are specified since the terms of trade effect is a composite of numerous individual consumption-substitution decisions, each one of which depends only on observations of specific (nominal) commodity prices. The interest rate is a single economy-wide variable which is contemporaneously observable to all agents. It is assumed that only firms make investment expenditures, and consumption expenditures are independent of the real interest rate.

Asset market equilibrium requires that the supply of and demand for nominal money balances be equal.[2] M_t is assumed to be a policy variable fully controlled by the monetary authorities. Money balances are assumed to be held only by firms. Demand for nominal balances, therefore, is assumed to be inversely related to the interest rate and proportionately dependent on the (nominal) value of the firm's output.[3] This implies that the relevant price

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[1]This excludes effects resulting from changes in the small country's net asset relationship to the rest of the world. Any solution of the model which involves capital account inflows or outflows obviously shifts this asset balance and hence, over time, affects the debt service payments/receipts of the current account. This impact is ignored on the same grounds that the capital/investment relationship is suppressed: The time frame considered is assumed short enough that such stock/flow relationships are of minor importance. If it is assumed that all international debt obligations are calculated in terms of the world currency, then it would be possible to account for changes in the domestic value of the net international asset position (NIA) of the domestic country, by incorporating a term, $e_2(NIA + E_t - PD_t)$, in the IS curve. The behavior of the model, in general, would be robust with respect to such an addition.

[2]The bond market is suppressed by an appeal to Walras' Law.

[3]Once more alternate assumptions would make no difference to the subsequent conclusions.

in the demand function is PD, the price of domestic output. It also implies that actual, rather than expected variables can be used, since each firm is able to observe its own contemporaneous price and real output.

Before equations (1)-(6) can be solved to trace policy impacts, it is necessary to specify the mechanism determining expectations. In order to underscore the difference between the open-and closed-economy cases, perfect-foresight expectations, the deterministic special case of rational expectations, is assumed.[1] Specifically, agent expectations about the price and exchange rate variables are assumed to be perfectly accurate: The expected value of a variable is in all cases the value that actually occurs (or will occur in the future). For the closed-economy supply curve of equation (4a), perfect foresight expectations imply that Y_t is always at its full employment level--regardless of the nature of aggregate demand shifts or changes in monetary or fiscal policy. For the open economy the story is different. Imposing perfect foresight expectations on equations (1)-(6) and using equations (1) and (2) to eliminate PI_t and P_t yields the following equation set:

(7) $i_t = i^* + (E_{t+1} - E_t)$

(8) $Y_t = \bar{Y} + a_1(PD_t - E_t - P^*)$

(9) $Y_t = a_2X_t - b_2(PD_t - E_t - P^*) - c_2(i_t - PD_{t+1} + PD_t) + d_2(M_t - PD_t)$

(10) $M_t = PD_t + Y_t - a_3i_t$

For a time-invariant value (M_o, X_o) of (M_t, X_t), the stationary equilibrium solution of equations (7)-(10) is as follows (the tilde over a variable indicates its stationary value):

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[1] Turnovsky (1981) examines the behavior of an open-economy model with stochastic rational expectations.

(11) $\tilde{i} = i^*$

(12) $\tilde{Y} = (\frac{a_1\gamma + \alpha\beta}{\beta\varepsilon})X_o + (\frac{a_1\lambda + b_2\beta}{\beta\varepsilon})\bar{Y} - (\frac{a_1 d_2\tau + a_1 c_2\beta}{\beta\varepsilon})i^*$

(13) $\tilde{PD} = M_o - (\frac{\alpha}{\beta})X_o - (\frac{b_2}{\beta})\bar{Y} + (\frac{\tau}{\beta})i^*$

(14) $\tilde{E} = M_o - (\frac{\alpha\eta + a_2\beta}{\beta\varepsilon})X_o - (\frac{b_2\eta - \beta}{\beta\varepsilon})\bar{Y} + (\frac{\tau\eta - c_2\beta}{\beta\varepsilon})i^* - P^*$

It is also useful to note that the terms of trade (TOT) in stationary equilibrium is given by

(15) $\widetilde{TOT} = (\tilde{PD} - \tilde{E} - P^*) = (\frac{\gamma + a_2\beta}{\beta\varepsilon})X_o + (\frac{\lambda - \beta}{\beta\varepsilon})\bar{Y} - (\frac{d_2\tau - c_2\beta}{\beta\varepsilon})i^*$

where $\alpha = a_1 a_2,\ \beta = (a_1 + b_2 - a_1 d_2),\ \gamma = a_1 a_2 d_2,$

$\varepsilon = (a_1 + b_2),\ \lambda = b_2 d_2,\ \eta = (a_1 + b_2 + d_2),$

$\tau = (a_1 c_2 + a_1 a_3 + b_2 a_3)$

$$\alpha, \gamma, \varepsilon, \lambda, \eta, \tau > 0$$

$$\beta \gtrless 0$$

From equilibrium considitions (11)-(15) it is clear that in the long run a change in M_o merely creates equiproportionate increases in $\tilde{PD}$ and $\tilde{E}$, and has no permanent impact on output. (Such is not the case, however, for a change in X_o. This point will be returned to later.)

III. The Dynamic Behavior of the Model

The dynamics of the model can be ascertained by using repeated substitutions in equations (7)-(14) to eliminate the variables, i_t and Y_t, and to reduce the system to the following simultaneous, first-order difference equations

(16) $c_2 e_{t+1} - (a_1 + b_2 + c_2)e_t - c_2 p_{t+1} + (a_1 + b_2 + c_2 + d_2)p_t = 0$

(17) $a_3 e_{t+1} + (a_1 - a_3)e_t \qquad - (1 + a_1)p_t = 0$

where $e_t = (E_t - \tilde{E})$

$p_t = (PD_t - \tilde{PD})$

With some effort, it is possible to obtain the general solution to (16)-(17):

(18) $e_t = (E_t - \tilde{E}) = A_1\phi_1^t + A_2\phi_2^t$

(19) $p_t = (PD_t - \tilde{PD}) = A_1\mu_1\phi_1^t + A_2\mu_2\phi_2^t$

And therefore it is also true that,

(20) $(TOT_t - \widetilde{TOT}) = A_1\nu_1\phi_1^t + A_2\nu_2\phi_2^t$

where A_1 and A_2 are arbitrary constants and

$$\phi_1 = \frac{(c_2 + a_1a_3 + b_2a_3 + 2c_2a_3 + d_2a_3) + \sqrt{R}}{2c_2a_3} > 1$$

$$\phi_2 = \frac{(c_2 + a_1a_3 + b_2a_3 + 2c_2a_3 + d_2a_3) - \sqrt{R}}{2c_2a_3} \gtrless 1$$

$$\begin{aligned} R = c^2 &- 2a_1c_2a_3 - 2b_2c_2a_3 + 2c_2d_2a_3 \\ &+ a_1^2a_3^2 + 2a_1b_2a_3^2 + 2a_1d_2a_3^2 \\ &+ b_2^2a_3^2 + 2b_2d_2a_3^2 + d_2^2a_3^2 \\ &+ 4c_2a_3a_1d_2 \end{aligned}$$

$$\mu_1 = [\frac{(\phi_1 - 1)a_3 + a_1}{(1 + a_1)}] > 0$$

$$\mu_2 = [\frac{(\phi_2 - 1)a_3 + a_1}{(1 + a_1)}] \gtrless 0 \qquad \text{iff } \phi_2 > 1$$

$$\nu_1 = [\frac{(\phi_1 - 1)a_3 - 1}{(1 + a_1)}] > 0$$

$$\nu_2 = [\frac{(\phi_2 - 1)a_3 - 1}{(1 + a_1)}] \gtrless 0$$

Equations (18)-(19) imply that the model exhibits dynamically unstable behavior. (It is globally unstable if $\phi_2 > 1$ and has saddle point instability if $\phi_2 < 1$.) Specifically, if the system is initially at equilibrium and if, for this original time period, E_t and PD_t are bound to their initial values, then in general an unanticipated rise in M_t (to some $M_1 > M_o$) will cause an explosive <u>appreciation</u> of the exchange rate and an explosive <u>fall</u> in the price level.

Such instability problems are common in perfect foresight models. The common method of overcoming them is to relax the assumption that (E_o, P_o) must be bound to its initial, <u>ex ante</u>, value. Given instantaneous new information (that M_t has shifted), it is argued that it is quite reasonable to expect an instantaneous shift in both E_o and P_o. Of course, every shift in (E_o, P_o) will lead to a different dynamic time path. The set of explosive time paths can be ruled out, however, by the imposition of appropriate requirements upon the terminal values of variables in the model.[1] In the present case it is sufficient to assume that real money balances are strictly positive and finite,[2] i.e.,

$$0 < \lim_{t \to \infty} [\exp(M_t - PD_t)] < \infty$$

An alternative is to assume that agents believe that "too great" a divergence of the exchange rate from its equilibrium value will prompt governmental exchange rate controls.

Either assumption (under the condition of perfect foresight) excludes all explosive solutions to equation (17). However, such terminal conditions are not sufficient to assure that there is a <u>unique</u> convergent solution. Uniqueness will occur only when equations (16)-(17) exhibit global instability--i.e., when both roots, ϕ_1 and ϕ_2, are greater than one. This will always be true for ϕ_1, but for ϕ_2 it is uncertain. Specifically,

$$\phi_2 > 1 \qquad \text{iff} \quad d_2 < \frac{a_1 + b_2}{a_1}$$

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[1] Sargent and Wallace (1973) originally made this argument. Brock (1974, 1975) demonstrated that under certain circumstances these terminal conditions are consistent with optimizing behavior. Kingston (1980) has recently challenged the universality of this latter conclusion.

[2] See Gray and Turnovsky (1979) for a formal proof of this fact in a similar model. In the particular case presently under consideration it is also sufficient to simply assume that real output is strictly positive and finite--although this condition will not be sufficient for all the model variations considered subsequently.

Therefore, a sufficient condition to assure these inequalities is that d_2, the elasticity of aggregate expenditures with respect to real balances, is less than one. Empirically, this would seem to be quite likely; however, theoretically there is obviously no requirement that it be true.

To the best of the author's knowledge, there are no previous examples of an open-economy, rational-expectations model which exhibits multiple solutions. Indeed outside of the capital accumulation and growth literature there have been few examples of any standard macro model with such a disturbing theoretical property.[1] Therefore, before continuing with the mainline analysis, it is useful to examine somewhat more closely the nature of the multiple-solution possibility.

Therefore, assume for the moment that $Q_2 < 1$. In this case equations (18)-(19) describe a saddle-point solution. The stable arm occurs when A_1 equals zero, and its slope can be found by dividing (19) by (18).

$$\frac{p_t}{e_t} = [\frac{(\phi_2 - 1)a_3 + a_1}{1 + a_1}] < 1$$

The slope can be positive or negative, but it will always be less than one (since by assumption $\phi_2 < 1$). This situation is portrayed in the phase diagram of Figure 1, where QQ is the stable saddle branch.

The system is initially in static equilibrium at point O. Now assume there is an unanticipated increase in the money supply. PD_o and E_o will then fall short of their new stationary equilibrium values by equal amounts. Therefore, the system will be perturbed to a point such as J, along the 45 degree line SS. If both PD_t and E_t were <u>predetermined</u> variables, in the sense that neither could adjust instantaneously (i.e., in the contemporary time period)

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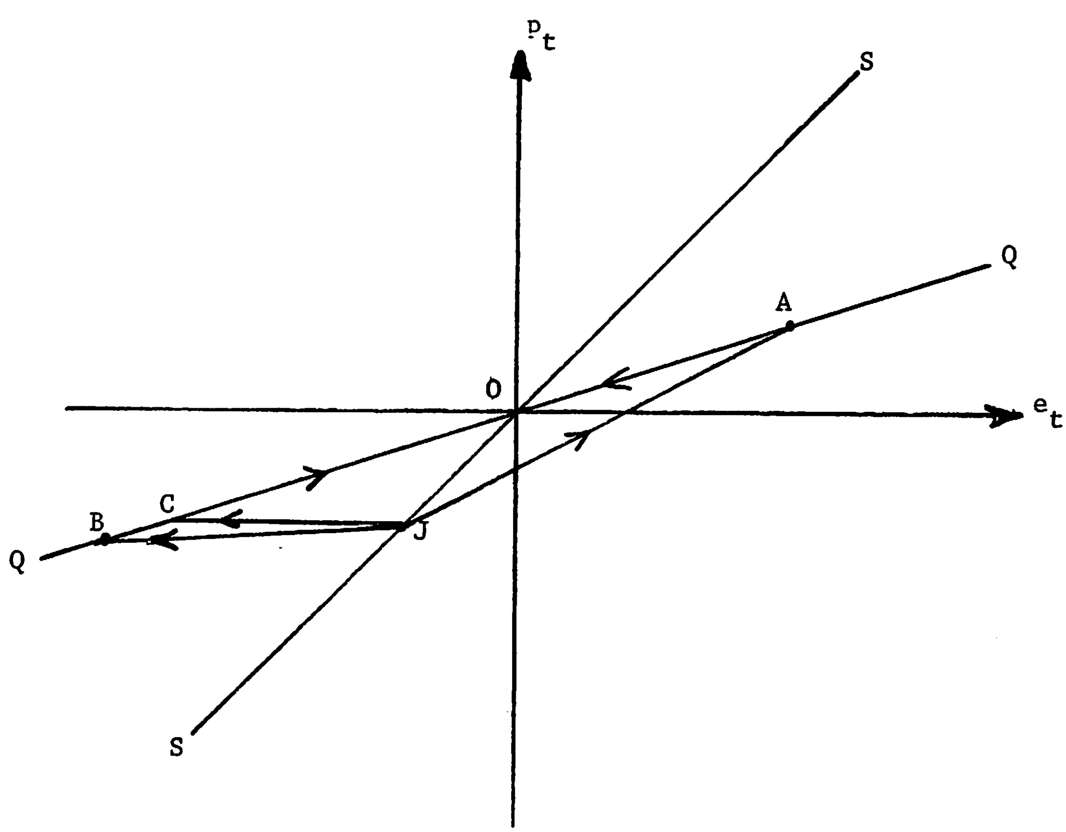
[1] Taylor (1977) develops a multiple-solution, rational-expectations, macro model, but the indeterminancy of this dynamic path depends on real balances being included in the aggregate supply function. While this is a defensible proposition it is certainly "non-standard".

to the money supply shift, then each would explosively diverge to negative infinity. However, as argued previously, the exchange rate and the price level in the CERE model are both perfectly flexible and therefore capable of instantaneous shifts. The multiple-solution problem occurs because convergence back to stationary equilibrium at point 0 will be assured by any shift which places (p_t, e_t) somewhere on the stable saddle branch, QQ--and there are an infinite number of such possibilities.

Figure 1



This makes an economic interpretation of the behavior of the model virtually impossible. The money supply increase could cause "overshooting" increases in both the price and the exchange rate, followed by a gradual asymptotic decline in both variables toward their new equilibrium values (such as dynamic path JAO). Or the exact opposite could occur--immediate declines in PD_o and E_o followed by converging increases (along path JBO). It is also possible to have (p_t, e_t) shift back immediately to stationary equilibrium at point O.[1]

The explanation of this frustrating situation is that, with $\phi_2 < 1$, the model has too much flexibility in it. In the analogous saddle point model considered by Dornbusch (1976), the use of a simple Phillips curve as the aggregate supply function caused the price level to be a predetermined variable; no instantaneous shifts in prices were possible. Imposition of the same restriction in the present case would eliminate the multiple solution problem and result in the unique convergent dynamic path JCO. Of course, there is no economic justification for such a restriction. Similarly, in the money and growth model considered by Sargent and Wallace (1973) there are, like the present model, no predetermined variables. But the Sargent and Wallace model is <u>globally</u> unstable, so the convergent time path is again uniquely determined (as the instantaneous shift to the new equilibrium).

In general uniqueness will be assured if, and only if, the number of non-predetermined variables in the first-order difference equation system is equal to the number of unstable solution roots. In the present model if $\phi_2 < 1$, there are two non-predetermined variables and only one unstable root. Therefore there are an infinite number of convergent paths.[2]

Fortunately all these problems can be avoided if $\phi_2 > 1$. As this is a very reasonable empirical assumption, its validity will be assumed

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[1] Paralleling Taylor (1977) it is possible to argue that a "collective rationality" will assure that since no real variable has changed the direct leap to point 0 is indeed the "correct" solution. Though tempting, such a resolution seems both contrived and unconvincing. Also, it does not eliminate the multiple solution possibility in the case of a future anticipated money supply increase.

[2] This would appear to be an example of the uniqueness criteria derived by Blanchard and Kahn (1980). However, their definition of predetermined and non-predetermined variables differs somewhat from the one used here.

henceforth.[1]

IV. Monetary and Fiscal Policy in the Open-Economy CERE Model

Assuming $\phi_2 > 1$, the impact of an unanticipated increase in the money supply (from M_o to M_1) is very simple. (PD_t, E_t) takes an instantaneous and proportionate jump from its original (equilibrium) value, $(\widetilde{PD}_o, \tilde{E}_o)$, to its new value $(\widetilde{PD}_1, \tilde{E}_1)$. There is an equivalent increase in all other nominal values, while the terms of trade, output, and the interest rate remain unchanged. In short an unanticipated money supply increase has no effect on real variables.[2]

This is not the case, however, for an <u>anticipated</u> <u>future</u> change in the money supply.[3] Specifically, assume that at time $t = 0$ an announcement is made that a future time $(t = T)$ the money supply will be increased to M_1. Money neutrality is achieved for unanticipated changes because it is possible to have a concurrent, instantaneous shift in prices and the exchange rate. However, there can be no such instantaneous movements in (anticipated) future price and exchange rate values, since any such discontinuities would be eliminated by arbitrage in the forward-exchange and/or money markets. Hence any jumps in E_t or PD_t must occur contemporaneous with the money supply announcement. Specifically at time $t = 0$, E_t and PD_t must jump by the precise amounts necessary to assure that at time $t = T$ (when the money supply actually increases to M_1) they have reached their new equilibrium values, $\tilde{E}_1$ and $\widetilde{PD}_1$. This implies that A_1 and A_2 must satisfy the equations

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[1] If $\phi_2 > 1$, then β (the "unsigned" parameter of equations (11)-(15)) must be greater than zero. This condition assures that the model will have reasonable comparative static properties--e.g., an increase in the capital stock (raising Y) will then have an unambiguously positive effect on $\tilde{Y}$.

[2] This is also true for the perfect-foresight version of the closed-economy CERE model.

[3] Wilson (1979), and Gray and Turnovsky (1979) were the first to consider the impact of an anticipated monetary policy change in a perfect-foresight, open-economy model.

$$(20) \quad E_T = \tilde{E}_1 = \tilde{E}_o + A_1\phi_1^T + A_2\phi_2^T$$

$$(21) \quad PD_t = \tilde{PD}_1 = \tilde{PD}_o + A_1\mu_1\phi_1^T + A_2\mu_2\phi_2^T$$

Therefore,

$$(22) \quad A_1 = \frac{(\tilde{PD}_1 - \tilde{PD}_o) - \mu_2(\tilde{E}_1 - \tilde{E}_o)}{\phi_1^T(\mu_1 - \mu_2)}$$

$$(23) \quad A_2 = \frac{(\tilde{PD}_1 - \tilde{PD}_o) - \mu_1(\tilde{E}_1 - \tilde{E}_o)}{\phi_1^T(\mu_2 - \mu_1)}$$

Noting that

$$(\tilde{PD}_1 - \tilde{PD}_o) = (\tilde{E}_1 - \tilde{E}_o) = M_1 - M_o$$

and

$$0 < \mu_2 < 1 < \mu_1$$

yields

$$(24) \quad A_1 = \frac{(M_1 - M_o)(1 - \mu_2)}{\phi_1^T(\mu_1 - \mu_2)} > 0$$

$$(25) \quad A_2 = \frac{(M_1 - M_o)(1 - \mu_1)}{\phi_2^T(\mu_2 - \mu_1)} > 0$$

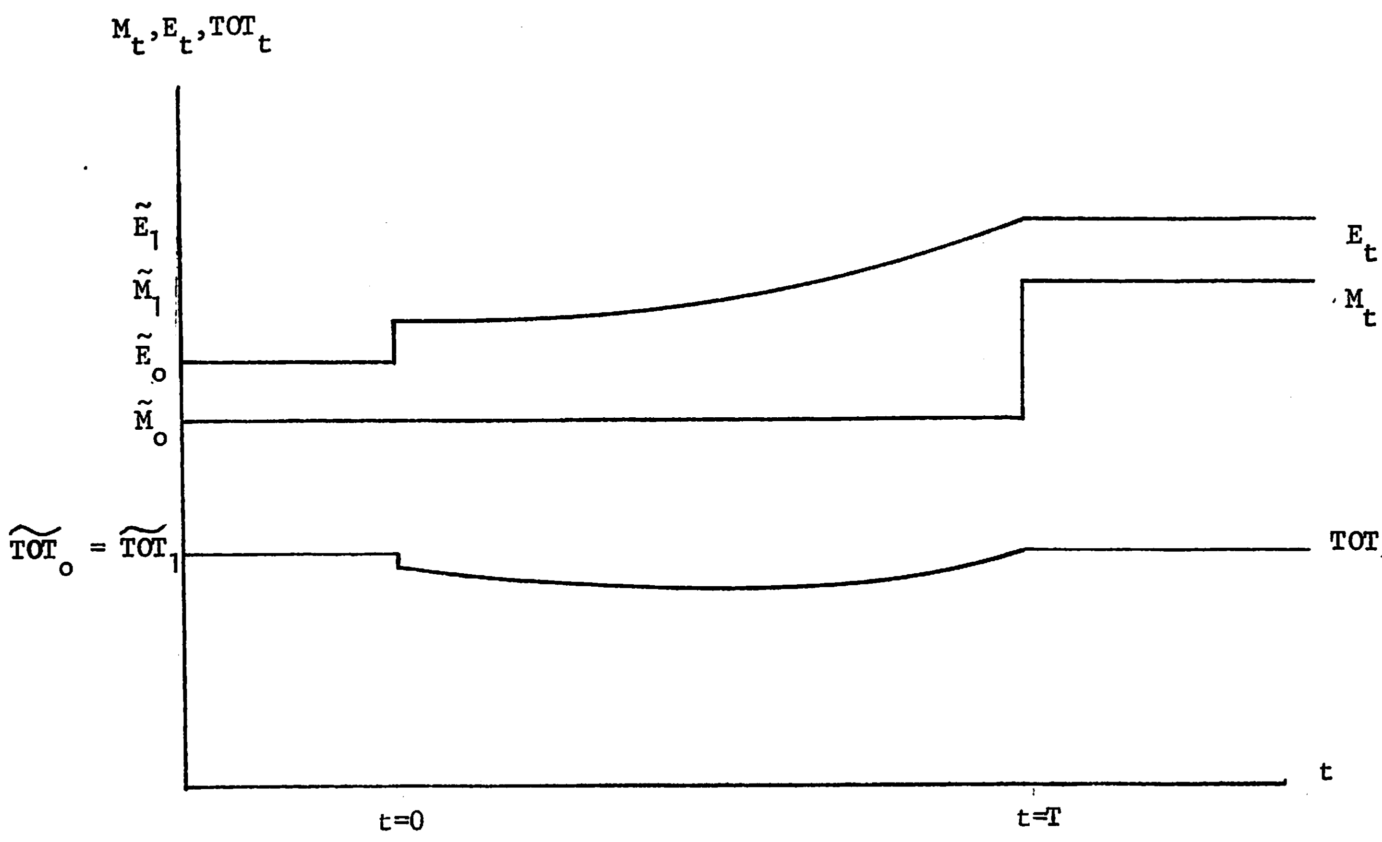
Equations (18)-(19) and (24)-(25) indicate that the effect of the anticipated money supply increase is to cause instantaneous (though unequal) rises in both PD_t and E_t, with further price inflation and exchange rate depreciation to occur until the new stationary equilibrium is reached at time T. Furthermore, since the exchange rate and price movements always occur at differential rates, the terms of trade must also shift during the anticipation period. In particular by substituting expressions (24)-(25) into the dynamic solution for the terms of trade it is possible to derive the impact effect on the terms of trade.

$$(26) \quad TOT_o - \widetilde{TOT}_o = \frac{(\mu_1 - 1)(1 - \mu_2)(\phi_2^T - \phi_1^T)(M_1 - M_o)}{\phi_1^T\phi_2^T(\mu_1 - \mu_2)} < 0$$

Therefore, the immediate effect of the announced monetary policy change is to cause an instantaneous deterioration in the terms of trade. (The rise in domestic prices is exceeded by the exchange rate depreciation.) The terms of trade may fall further but eventually will rise back to the (unchanged) stationary equilibrium value. An illustrative adjustment time path of the exchange rate and terms of trade is given in Figure 2.

The impact on real output follows immediately from these arguments as aggregate supply is solely dependent on the terms of trade. Hence, an anticipated <u>increase</u> in the future value of the money supply will cause an immediate <u>fall</u>

<u>Figure 2</u>



in real output. As time passes this decline will be gradually reversed, until at the exact time of the implementation of the monetary increase, the original output level will be restored. Therefore, although the anticipated money supply increase is neutral in the long run, there are very definite interim output effects: the LSW proposition does not hold.[1]

An anticipated change in fiscal policy also will have effects upon real output, although the exact nature of this impact differs in two key aspects from its monetary policy analogue. To demonstrate this assume there is an announcement that (bond-financed) government expenditures will rise at time T. This will cause X_t to rise from X_o to X_2 at time T, and (from equations 13-14) will create a fall in the long-run equilibrium price level from $\widetilde{PD}_o$ to $\widetilde{PD}_2$ and a decrease (i.e., appreciation) of the equilibrium exchange rate from $\tilde{E}_o$ to $\tilde{E}_2$.[2] Arguing as before, equations (18)-(19) can be combined with expressions (22)-(23) and stationary solutions (13)-(14) to prove that convergence requires an immediate fall in both E_o and PD_o followed by further exchange-rate appreciation and price deflation until the new equilibrium value $(\widetilde{PD}_2, \tilde{E}_2)$, is just reached at time T (see Figure 3). Similarly it can be demonstrated that the terms of trade (and hence output) will take an initial upward jump and continue to rise until at time T it assumes its new, permanently higher, value of $\widetilde{TOT}_2$. In short an anticipated fiscal stimulus, in contrast to monetary policy, will cause output to rise permanently, rather than to fall temporarily.[3]

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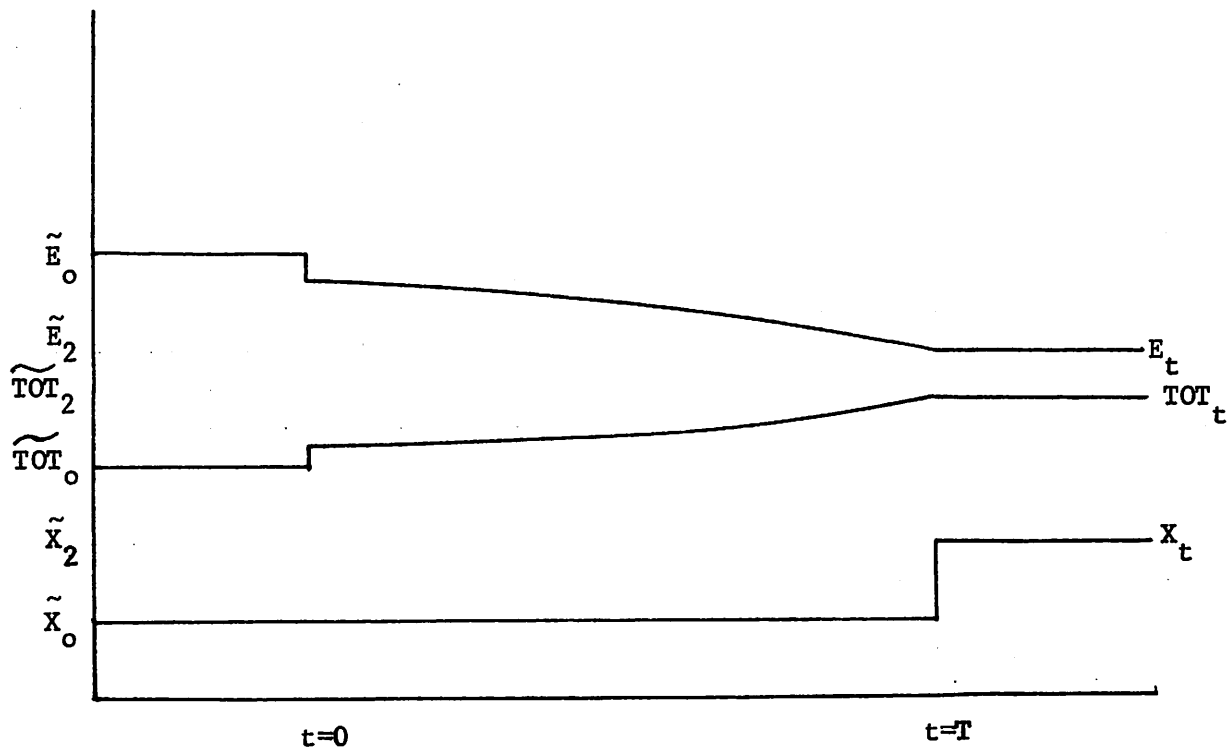
[1] There are two interesting points to note here. First, the LSW proposition also fails in the multiple-solution case when $\beta < 0$. In this situation output will vary in all possible dynamic responses to an anticipated money-supply increase. Second, a Granger (1969) causality test, as usually constituted, would conclude that exchange-rate and/or price movements cause money supply changes, rather than vice versa.

[2] The condition assuring a unique convergent dynamic solution ($\beta > 0$) is also that condition which dictates that a rise in X_t will cause the stationary equilibrium values of $\tilde{E}$ and $\widetilde{PD}$ to fall.

[3] It is possible to eliminate the permanent effect of fiscal policy on output by modifying the specification of the open-economy labour-supply function. A plausible alternative extension of Lucas and Rapping (1969) would require that labour supply have a totally inelastic response to long-run changes in the real wage but will be sensitive to intertemporal substitution effects. This yields a labour supply function dependent on the difference between the expected current and the expected stationary equilibrium real wage rate. In this case anticipated policy still will cause short-run output fluctuations and both short- and long-run shifts in the terms of trade. But stationary equilibrium requires the actual wages to assume their long-run value, so there will be no permanent changes in either labour supply or output.

Figure 3



V. The Nature and Robustness of the Non-Neutrality Results

The (short-run) non-neutrality of monetary policy derives from the interaction of two factors. First, given the equilibrium conditions in the international capital and money markets, anticipations of a future rise in the money supply require an immediate increase in both domestic prices and the exchange rate. This increase will be larger the closer in time is the money supply change. Second, the presence of a real balance effect in the IS function prevents the dynamic paths of PD_t and E_t from being identical--therefore the terms of trade, and real output, must alter. These facts can be perceived by a closer examination of the goods-market equilibrium condition. Specifically, if equation (7) is substituted into equation (9), IS equilibrium requires,

$$Y_t = a_2X_o - b_2(PD_t - E_t - P^*) - c_2(i^* + E_{t+1} - E_t - PD_{t+1} + PD_t) + d_2(M_D - PD_t) \quad (27)$$

As the domestic price level rises, real balances fall. To maintain goods-market equilibrium (while keeping real output and therefore the terms of trade constant), the real interest rate must fall. But from equation (27) it is clear that the real interest rate can change only if the growth rate of PD_t differs from that of E_t. In other words the terms of trade and real output must alter.

The non-neutrality would be eliminated if there was no direct effect of real balances upon aggregate expenditures. In that case E_t and PD_t would follow identical dynamic paths in response to an anticipated future money supply increase. The real interest rate, the terms of trade, and real output would remain unchanged, and the LSW proposition apparently is resuscitated.

However, this revival is fragile and largely illusory. For the non-neutrality will occur for any goods-market specification in which the exchange rate and domestic prices enter asymmetrically. Only in the case of perfect symmetry will it be possible for PD_t and E_t to have the same adjustment paths, and hence for the terms of trade and real output to remain unchanged. Even if the real balance effect is suppressed, other alterations in the aggregate demand structure can easily create a wedge between the dynamics of exchange-rate and price adjustments--and therefore cause money to be non-neutral in the short run. For example, consider the following two disparate specification changes:

(1) the addition of an expected inflation variable affecting both the demand for money and the financial-savings/expenditure-on-real-assets decision, or

(2) the allowance for an income tax structure which taxes nominal interest income.

If the model is altered in either of these (or undoubtedly a number of other ways), the monetary policy will affect real output in the short run.[1]

[1]These facts are easily established through proof by contradiction--see the Appendix.

One of the strengths of the LSW proposition in the closed-economy model is its robustness with respect to varying aggregate demand assumptions. (Neither a real balance effect, nor either of the above changes, alters the short-run neutrality of money in a closed economy.) The point of the present argument is that this is simply not true for anticipated future money supply changes in the more general open-economy case. Only under very restrictive circumstances will the LSW proposition hold; under all alternative conditions it will fail. Also it should be noted that because it creates permanent changes in the equilibrium terms-of-trade, anticipated fiscal policy <u>always</u> will have output effects in an open economy.[1]

Three additional points can be made about the robustness of these conclusions. First, in the "asymmetric" model variations considered so far money is non-superneutral. For example, in the original real-balance specification, an increase in the permanent money supply growth rate will create a proportionate rise in steady-state inflation, but it also will cause a fall in the terms of trade and real output. It is important to realize that the invalidity of the LSW proposition does not result from the existence of non-superneutralities, output is affected because an anticipated rise in the <u>future level</u> of the nominal money supply causes a decline in the <u>current level</u> of the real money supply. This distinction can be easily demonstrated by altering the IS specification so that aggregate expenditures are dependent not on current real balances, but on the ratio of real balances to (steady-state) equilibrium real balances. With this change, the model will be superneutral; however, an anticipated change in the money supply from M_o to M_1 still will depress output in the short run. Therefore, the LSW proposition can be invalid even in cases where money is superneutral.

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[1]The only way in which the fiscal and monetary policy situations can be made symmetrical is to impose the modified open-economy Lucas supply function discussed in footnote 3, p. 20. In this case if the equilibrium terms of trade is defined to be the equilibrium value that will prevail in the long run (i.e., $\lim_{t\to\infty} \widetilde{TOT}_t$), then anticipated fiscal policy will be output neutral in the same special cases as monetary policy.

The second point has to do with the nature of the hypothetical policy experiment being conducted. Up until time $t = 0$ all agents believe "with perfect foresight" that the money supply will remain at M_o. Then through an announcement effect, or some other means, agents adjust their expectations and (correctly) anticipated that the money supply will increase to M_1 at time $t = T$ and remain at this new level indefinitely. It is possible to argue, therefore, that the money supply change was not fully anticipated--since prior to the announcement, agents were operating under erroneous information. Indeed, the argument could continue that it is the previously <u>unanticipated change</u> in policy that gives rise to the non-neutralities, and that therefore the LSW proposition is supported, rather than refuted.

There are two responses to such a position. First, the argument implies that the correct reading of the LSW proposition is that changes in monetary policy which are currently perceived and which have been correctly anticipated forever in the past will have no impact on output. In this form the LSW proposition seems like a relatively frail assertion. Far more interesting is the question of whether a change in monetary policy direction, if it is instantly perceived by private agents, will have any effect on output. It is almost certain that the competitive-equilibrium theorists meant to include this latter situation under the neutrality assertion. And using this interpretation the modelling approach of the present paper is a valid test of the LSW proposition.

All of this interpretive argument, however, is somewhat beside the point, for the short-run non-neutrality of money does <u>not</u> depend upon even the limited "surprise" effect of a (fully perceived) change in policy. Even if the money supply change has been anticipated from the beginning of time, interim non-neutrality effects can occur. For example assume that at time T_1 the money supply increases from M_o to M_1, and at time T_2 it further rises to M_2 where it stays indefinitely into the future. Furthermore assume that all agents have always known that these changes would occur. In this case, prior to T_2 both PD_t and E_t will be rising (with a "kinked" deceleration in their rates of growth at T_1). Output and the terms of trade will be below their stationary equilibrium values--first falling, then gradually rising to reach stationarity at T_2. In short the LSW proposition, even in its weak form, will be invalid.

The third point regarding the robustness of the results is that while the non-neutrality of fiscal and monetary policy has been derived explicitly for a small economy, it should be intuitively clear that, unless the domestic economy is so large as to be immune from the feedback effects of shifting exchange rates, similar arguments apply to any open economy.[1] Since it is doubtful that even the United States is a price-maker on world commodity and capital markets, it must be concluded that in general the LSW proposition is invalid, even for a model containing competitive-equilibrium, rational-expectations assumptions.

V. The Augmented Phillips Curve and Stabilization Policy

In a closed economy the LSF supply function is mathematically identical to an expectations-augmented Phillips curve (supplemented by a price mark-up equation). In the open economy case this equivalence no longer holds, and therefore the economic behavior of the two models will differ.

The EAPC posits an essentially *ad hoc* (Walrasian) disequilibrium wage adjustment process. Specifically, the rate of change of *expected* real wages is assumed to be

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[1]The Appendix demonstrates that the LSW proposition does not hold in a simple two-country model.

directly dependent on the level of excess demand. In extending the EAPC to an open economy it is necessary to establish whether nominal wages are deflated by expected consumer or producer price increases. The assumption made here is that a weighted average of the two is used--although it turns out that, as long as consumer prices exert some influence, the ultimate functional form is independent of the weighting used.[1] Specifically, it is assumed that wage changes are determined by

$$(28)\qquad \Delta W_t - \Delta W_{t-1} - \theta \Delta \hat{P}_t - (1-\theta)\Delta \widehat{PD}_t = \rho(Y_t - \bar{Y})$$

where Δ is the backward difference operator and $0 < \theta \leq 1$, $0 < \rho$. Domestic producer prices are assumed to be established as a proportionate mark-up over wage costs. Therefore

$$(29)\qquad PD_t - PD_{t-1} = W_t - W_{t-1}.$$

Combining the two equations and substituting the definition of $\hat{P}_t$, yields,

$$(30)\qquad PD_t - PD_{t-1} = [1 - (\theta - \theta z)](\Delta \widehat{PD}_t) + (\theta - \theta z)(\Delta \widehat{PI}_t) + \rho(Y_t - \bar{Y})$$

The proportionate change in producer prices, therefore, is equal to a weighted average of the expected producer price increase and the expected import price change, plus an excess demand factor. It should be noted that in a closed economy ($\theta = 0$), equation (30) is perfectly equivalent to the closed-economy version of the LSW supply function given in equation (4a). Such is not the case, however, for an open economy.

Imposing perfect foresight expectations on equation (30) and solving for Y_t gives

$$(8a)\qquad Y_t = \bar{Y} + a_1'(PD_t - PD_{t-1} - E_t + E_{t-1}) = \bar{Y} + a_1'(\Delta TOT_t)$$

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[1] Empirical work on the Phillips curve usually has not distinguished between the two concepts. Recently, however, Fortin and Newton (1981) have argued that, at least in the Canadian case, such differentiation is important.

where $a_1' = \frac{\theta(1-z)}{\rho} > 0$.

In the EAPC supply function of equation (8a) output depends on the change in terms of trade, whereas in the LSW supply function of equation (8) output varies as the level of the terms of trade. When the former function is substituted for the latter, the behavior of the open-economy model (equations (7), (8a), (9), (10)) alters in two ways. First, and rather obviously, the dynamic time path of adjustment changes. (The LSW proposition, however, remains invalid.) Second, anticipated fiscal policy changes, while still creating short-run output effects, no longer alter output in the long run. Indeed in the EAPC open-economy model (as with its closed-economy analogue) stationary equilibrium requires Y to be equal to $\bar{Y}$, regardless of what happens to the remaining exogenous variables.

This latter property has a useful implication. In the CERE open-economy model (using the LSW supply function) it is not easy to talk in a sensible manner about stabilization policy. Since any IS shock creates a permanent change in "full-employment" output, it is difficult to define an optimizing criterion toward which monetary and fiscal policy should be directed. The problem is complicated still further since even short-run variations in output are assumedly the result of individual optimizing decisions based on full information. Without backing up quite a bit, and being explicit about both individual utility functions and aggregation procedures, specifying an appropriate role for stabilization policy is next to impossible.

THE EAPC formulation, however, encounters neither of these problems. Full employment output is uniquely defined to be $\bar{Y}$, and since the EAPC is supposed to reflect a disequilibrium adjustment process, there is a presumption that deviations from $\bar{Y}$ are undesirable. Stabilization policy can then be defined in standard textbook fashion as monetary and fiscal policy interventions designed to minimize some loss function related to the deviations of Y_t from $\bar{Y}$. Such a justification, of course, remains *ad hoc*, but it is certainly plausible. The important point is that a perfect foresight, EAPC open-economy has both a need for and a (simplistic) strategy to implement an activist stabilization policy. Any anticipated future private sector shifts in the IS or LM functions can be neutralized by corresponding offsetting changes in monetary and fiscal policy. In essence although no *feedback* stabilization rule exists, this simple procedure represents a *feed-forward* rule (in which *current* policy is based upon anticipated *future* behavioral changes) that is both feasible and desirable.

VI. Conclusions

A central point of the literature applying rational expectations to macroeconomics is that the economic impact of a change in the money supply depends critically on whether or not the shift is correctly perceived by private agents. Errors in perceptions provide a basis for output and employment fluctuations even in a competitive economy. It is maintained, however, that perceived money supply shifts should have no effect on real output.

One way of interpreting the present paper is as a statement that perceptual *timing* is as important as perceptual *accuracy*. Anticipations of future policy changes can cause shifts in current and interim asset prices, and in general there is no reason to believe that such shifts can occur without real consequences. Even in a closed economy framework Fischer (1979) has shown that the anticipation of a future money supply increase can trigger a Tobin-effect causing a decline in the real interest rate and a rise in both the capital stock and real output.

The analysis of this paper demonstrates that in an open economy even the use of a "pure" Lucas supply function (with the capital stock fixed) is no guarantee of short-run money neutrality. Indeed anticipation of a future increase in the money supply in the interim will depress the terms of trade and real output unless the goods-market equilibrium condition is symmetrically dependent on the exchange rate and domestic prices.[1]

What is true of public-sector policy changes is equally true of private-sector behavioral shifts. Any anticipated shift in the IS or LM curves will cause real output effects. If price and wage movements follow a disequilibrium, expectations-augmented Phillips curve process, then there is plausible reason for believing that such perturbations should be eliminated. Compensatory <u>feed-forward</u> rules for fiscal and monetary policy will accomplish this goal.[2]

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[1] If the capital stock is allowed to vary, output could rise or fall depending on whether the real-interest-rate or the terms-of-trade effect is more powerful.

[2] In a stochastic rational expectations world some portion of such shifts will occur as unanticipated shocks, and hence full compensatory policy is not possible. However, if such shocks are serially correlated, compensatory action would be of help in all but the initial time period.

Appendix

The short run non-neutrality of anticipated changes in the money supply can be easily demonstrated for a variety of alternative model specifications through proof by contradiction. Specifically, if the LSW supply function of equation (8) is assumed to hold, then for output to be invariant with respect to anticipated money-supply shifts, the terms of trade must be constant,

$$\text{(i)} \quad TOT_t = \widetilde{TOT}_o \qquad \text{for all } t$$

Condition (i) implies

$$\text{(ii)} \quad PD_{t+1} - PD_t = E_{t+1} - E_t \qquad \text{for all } t$$

Any violation of either (i) or (ii) implies that the LSW proposition is not correct.

Case I : Expected inflation influences both money demand and aggregate expenditures

Under these circumstances the IS function becomes

$$\text{(9c)} \quad Y_t = a_2\bar{X} - b_2(TOT_t) - c_2(i - PD_{t+1} + PD_t) + d_2(PD_{t+1} - PD_t)$$

Conditions (i) and (ii) imply

$$Y_t = \bar{Y} + a_1(\widetilde{TOT}_o) = \tilde{Y}$$

Therefore

$$\tilde{Y}_o = a_2\bar{X}_o - b_2(\widetilde{TOT}_o) - c_2 i^* + d_2(PD_{t+1} - PD_t)$$

Which means that

$$\text{(iii)} \quad PD_{t+1} - PD_t = E_{t+1} - E_t = 0$$

This, in turn, can only be true if PD and E jump immediately to their respective values consistent with stationary equilibrium at time $t = T$ (when M_t increases to M_1). Therefore

$$\text{(iv)}\quad PD_t = \widetilde{PD}_1 \quad \text{and} \quad E_t = \widetilde{E}_1, \text{ for all } t$$

The LM function is

$$\text{(10c)}\qquad M_t = PD_t + Y_t - a_3 i_t - b_3(PD_{t+1} - PD_t)$$

Imposing conditions (i), (ii), and (iii) yields

$$\widetilde{M}_o = PD_t + \widetilde{Y}_o - a_3 i^*$$

And again there is a contradiction since condition (iv) requires PD_t to be $\widetilde{PD}_1$, while money market equilibrium requires PD_t to be $\widetilde{PD}_o$. Hence, the LSW proposition must be invalid.

Case II: <u>An income tax is levied on nominal interest receipts</u>.

The existence of the tax means that the user cost of capital is no longer the (before tax) real interest rate. To trace the effects of the tax it is necessary to distinguish explicitly between the natural logarithms and the levels of the key variables. Specifically, let

I^* = the nominal foreign interest rate
I = the nominal domestic interest rate
p = the level of domestic producer prices
U = the (after-tax) user cost of capital
$u = \log(1+U)$
e = the level of the exchange rate
r = the marginal tax rate on nominal interest income

$\Pi_{t+1} = \dfrac{p_{t+1} - p_t}{p_t}$ = the (fully-anticipated) inflation rate between time period $\underline{t}$ and $\underline{t+1}$.

The user cost of capital is given by

$$U_t = (1-r)I_t - \Pi_{t+1}$$

Furthermore, note that for small values of Π, I, C

$$U_t \doteq u_t$$

$$I_t \doteq i_t$$

$$\Pi_{t+1} \doteq (PD_{t+1} - PD_t)$$

Therefore

$$u_t \doteq (1-r)(i^* + E_{t+1} - E_t) - PD_{t+1} + PD_t$$

Now the IS function is assumed to be

$$Y_t = a_2\overline{X} - b_2(TOT_t) - c_2(u_t) \tag{9d}$$

Imposing conditions (i) and (ii), and substituting the derived expression for u_t implies

$$\tilde{Y}_o \doteq a_2\overline{X}_o - b_2(\widetilde{TOT}) - c_2(1-r)i^* - r(PD_{t+1} - PD_t)$$

This again implies that

$$(PD_{t+1} - PD_t) = (E_{t+1} - E_t) = 0$$

which will lead to the same contradiction as in case I. Once more, therefore, the LSW proposition does not hold.

Case III: The Two-Country World.

The simple two-country analogue to equations (7)-(10) is given below (note that all starred variables refer to the foreign country):

$$\text{AS:}\quad Y_t = \overline{Y} + a_1(PD_t - PD_t^* - E_t)$$

$$\text{IS:}\quad Y_t = a_2\overline{X}_t - b_2(PD_t - PD_t^* - E_t) - c_2(i_t - PD_{t+1} + PD_t) + d_2(M_t - PD_t)$$

$$\text{LM:}\quad M_t = PD_t + Y_t - a_3 i_t$$

$$\text{IRP:}\quad i_t = i_t^* + (E_{t+1} - E_t)$$

$$\text{AS*:}\quad Y_t^* = \overline{Y}^* - a_1^*(PD_t - PD_t^* - E_t)$$

$$\text{IS*:}\quad Y_t^* = a_2^*\overline{X}_t^* + b_2^*(PD_t - PD_t^* - E_t) - c_2^*(i_t^* - PD_{t+1}^* + PD_t^*) + d_2^*(M_t^* - PD_t^*)$$

$$\text{LM*:}\quad M_t^* = PD_t^* + Y_t^* - a_3^* i_t^*$$

In the two-country case it is still true that for the LSW proposition to hold, the terms of trade must be constant, specifically, (i)′ $TOT_t = PD_t - PD_t^* - E_t = \widetilde{TOT}_o$, for all t

(ii)′ $PD_{t+1} - PD_t = PD_{t+1}^* - PD_t^* + E_{t+1} - E_t$, for all t

Imposing conditions (i)′ and (ii)′ on the two AS and IS functions yields

$$\tilde{Y}_o = a_2\bar{X}_o - b_2(\widetilde{TOT}_o) - c_2 i_t^* + c_2(PD_{t+1}^* - PD_t^*)$$
$$\tilde{Y}_o^* = a_2^*\bar{X}_o^* - b_2^*(\widetilde{TOT}_o^*) - c_2^* i_t^*$$

Together these equations imply

(iii)′ $i_t^* = \tilde{i}_o^*$, $i_t = \tilde{i}_o$

(iv)′ $PD_{t+1}^* = PD_t^*$, $PD_{t+1} = PD_t$

(v)′ $E_{t+1} = E_t$

Equation (v)′ can only be true if E has an instantaneous jump to $\tilde{E}_1$ at the time of the policy announcement. Therefore,

(vi)′ $E_t = \tilde{E}_1$, for all t

Substituting (vi)′ into (i)′ yields

(vii)′ $PD_t - PD_t^* - \tilde{E}_1 = \widetilde{TDT}_o$

This can only be true if

either $PD_o > \tilde{PD}_o$ or $PD_o^* < \tilde{PD}_o^*$

But both of these latter situations are impossible since each would prevent money market equilibrium (along the lines of the argument in case I). Therefore the LSW proposition also fails in the case of a two-country world.

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