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THE MACROECONOMIC EFFECTS OF COMMODITY MARKET DISRUPTIONS IN OPEN ECONOMIES

by

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Abstract

This paper analyzes the macroeconomic effects of two of the principal causes of the commodity price boom in 1973-74: bad harvests and commodity speculation. The analysis uses a dynamic, fixprice-flexprice model of the world economy operating under a regime of flexible exchange rates. Equilibrium in the market for commodities, the flexprice good, is a stock equilibrium like equilibrium in financial markets, so the spot price of commodities and the spot exchange rate are determined simultaneously in asset markets, and bad harvests and commodity speculation initially affect prices through asset markets, broadly defined. Through goods markets, these price changes in turn affect trade flows, capital flows, consumption, and over time, the stocks of real and financial assets.

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I. Introduction

Bad harvests at home and abroad, speculation in commodity markets, and the unprecedented boom in the world economy all contributed to a substantial increase in commodity prices in 1973-74. As Cooper and Lawrence (1975) have documented, the increase in commodity prices was widespread, affecting almost all commodities, and the increases were truly extraordinary, one index of primary commodity prices more than doubling between mid-1972 and mid-1974.

The purpose of this paper is to analyze the macroeconomic effects of two of the principal causes of the commodity price boom: bad harvests and commodity speculation. The analysis uses a two-sector, fixprice-flexprice model of the world economy operating under a regime of flexible exchange rates. The model is dynamic, permitting the analysis of the short-run effects of bad harvests and commodity speculation as well as the process of adjustment to long-run equilibrium.

The commodity market disruptions of the early seventies were so

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large and so broadly based that the repercussions on other financial and goods markets, the focus of this paper, were quite substantial. Commodities other than fuels account for a sufficiently large share of international trade that the changes in commodity prices brought about by bad harvests and commodity speculation may have had significant effects on trade flows, international capital flows, and the dynamics of the exchange rate.[1] A rough calculation suggests that commodity stocks and stocks of assets denominated in foreign currencies are of the same order of magnitude, so if speculators shifted out of foreign exchange into commodities, as Labys (1974), Cooper and Lawrence, and Cline (1976) have suggested, the effects on the foreign exchange market may have been just as important as the effects on commodities markets themselves.[2] If the shift had been out of domestic financial assets instead, which has also been suggested, the effects of the speculation in commodities should have been quite different.

Gordon (1975) and Schlagenhauf and Shupp (1978) both have formal two-sector models for analyzing the effects of the first type of shock, a temporary supply disruption. These papers, however, model closed economies, ignoring the international repercussions of supply disruptions, and assume that commodity prices adjust in the short run to equate flow demand with flow supply, ignoring the important role of commodity stocks in the short run. Findlay and Rodriguez (1977) and Phelps (1978) study the effects of a rise in the price of an intermediate input such as oil, but both papers may be interpreted as modeling permanent, rather than temporary, supply disruptions. Labys (1974) and Cooper and Lawrence analyze the second shock, speculation in commodities, but because they were primarily concerned with identifying the causes of the commodity price boom, not its effects, they did not explore the repercussions of commodity speculation on other markets, foreign or domestic.

In contrast to Gordon and Schlagenhauf and Shupp, it is assumed here that equilibrium in commodity markets, like equilibrium in financial markets, is a stock equilibrium in which prices adjust quickly to make stockholders willing to hold the existing commodity stocks. Hicks (1974) has recently emphasized the stock equilibrium nature of markets for flexprice goods such as commodities, and this approach is consistent with the theoretical and empirical research on commodity markets over the last several decades.[3] The stock rather than flow approach is essential for the analysis in this paper because bad harvests initially affect stocks of agricultural commodities and because commodity speculation is just a shift in asset holders' preferences from stocks of financial assets to stocks of commodities.

The plan of the paper is as follows: section II presents the model and develops the graphical apparatus for analyzing various commodity market disruptions. In section III, this apparatus is used to analyze the macroeconomic effects of bad harvests and portfolio shifts from financial assets to commodities.

II. The Model

The model by necessity is somewhat complicated, so before presenting it in detail, a brief overview is in order. The model contains two countries of similar size; two goods, one a Hicksian fixprice good called the manufactured good and the other a Hicksian flexprice good called the agricultural commodity; and three assets, termed commodity stocks, domestic money, and foreign exchange. The two financial assets should be liberally interpreted to mean financial assets denominated in the home currency or the foreign currency.

These three assets are imperfect substitutes in asset holders' portfolios because the attributes of each asset and the risks associated with holding each asset differ. Asset holders individually allocate their wealth among the three assets on the basis of expected rates of return, but because aggregate asset stocks are fixed in the short run, the spot exchange rate and the spot price of commodities (and therefore the expected yields on foreign exchange and commodities) quickly adjust so that asset holders in the aggregate willingly hold existing stocks. Hence the spot exchange rate and the spot price of commodities are determined simultaneously in asset markets, and shocks such as bad harvests and portfolio shifts from financial assets to commodity stocks initially affect the exchange rate and the price of commodities through asset markets, broadly defined.[4] Through the goods markets, these price changes in turn affect trade flows, capital flows, consumption of the two goods at home and abroad, and over time, the stocks of real and financial assets.

To simplify the analysis, several specialization assumptions are made. The home country is assumed to specialize in producing agricultural commodities and the foreign country in producing manufactured goods. Residents of both countries consume both goods, so demand for manufactured goods in the home country and demand for agricultural commodities in the foreign country must be satisfied entirely through imports. The agricultural country may be identified as the United States, and while this may appear unduly pastoral, for the purposes of this paper it is quite appropriate. Over the past five years, U.S. exports of agricultural commodities have constituted nearly a quarter of the value of total U.S. exports and more than double the value of agricultural imports. Japan and the EEC, on the other hand, typically show large net imports of food and other primary commodities not including fuels (GATT 1977, pp. 16-17).

In general, one would expect asset preferences at home and abroad to differ, so that the transfer of wealth between countries to finance current account imbalances should bring about changes in asset prices and yields. These effects have been emphasized most recently by Kouri and de Macedo (1978). The asset market model in this paper is specified to capture these effects in the simplest possible way by assuming (a) that asset holders in the home country hold all stocks of commodities and domestic money and (b) that foreign currency is the only asset held by both countries, so it is the asset used to settle current account imbalances. The preferences of risk averse asset holders for financial assets would be biased toward the domestic currency because of the importance of domestically produced goods in aggregate consumption. Asset holders in the agricultural country tend to be the dominant holders of commodity stocks, in part because well-developed domestic futures markets facilitate domestic stockholding by divorcing the functions of stockholding and risk bearing. Hence asset holders in the home country are likely to hold a larger fraction of their wealth in domestic money and in commodities, so a model in which *all* stocks of domestic money and commodities are held in the home country would preserve the expected differences in aggregate portfolio preferences and would capture the expected effects of current account imbalances and the concomitant wealth transfers on asset prices and yields.

II.A Asset Markets

Asset holders in the home country allocate their wealth among domestic money, M, foreign exchange, F, and commodity stocks, C, which are assumed to be gross substitutes in asset holders' portfolios. Because the costs of portfolio adjustment are low, asset markets typically adjust quickly to portfolio imbalance, so it is assumed for convenience that the equilibrium conditions for the three asset markets in the home country are always satisfied:

$$M = m(\overset{-}{r^*}, \overset{-}{r_c}, \overset{+}{Y}; \alpha) \cdot W \tag{1}$$

$$eF = f(\overset{+}{r^*}, \overset{-}{r_c}, \overset{-}{Y}; \alpha) \cdot W \tag{2}$$

$$pC = c(\overset{-}{r^*}, \overset{+}{r_c}, \overset{o}{Y}; \alpha) \cdot W \tag{3}$$

$$Y \equiv p\overline{S} \tag{4}$$

$$W \equiv M + eF + pC \tag{5}$$

where

r^* = expected nominal yield on foreign exchange

r_c = expected nominal yield on commodities

Y = nominal income

α = shift parameter

e = spot exchange rate, expressed as the home currency price of foreign exchange

p = spot price of commodities

$\bar{S}$ = aggregate production of commodities

W = nominal value of net private wealth

m, f, c = fraction of the aggregate portfolio (assumed to be positive) held in each of the three assets.

Signs over the arguments indicate the signs of the partial derivatives. Units are chosen so all prices initially equal 1.

At any moment in time, asset holders in the aggregate are constrained by net private wealth, so the sum over all assets of the responses to changes in r^*, r_c, Y, or α must be zero:

$$m_i + f_i + c_i = 0, \qquad i = 1,..,4 \tag{6}$$

where m_1 is the partial derivative of m with respect to the first argument, r^*, and so forth. The balance sheet constraint also requires that the fractions of net wealth held in each of the three assets sum to 1:

$$m + f + c = 1 \tag{7}$$

The nominal own currency yields on domestic money and foreign exchange and the cost of storing commodity stocks are all assumed to be zero, so the nominal yield on foreign exchange is just the expected rate of depreciation of the home currency, and the nominal yield on commodities is the expected rate of change in the spot price of commodities:

$$r^* = \dot{e}^e \tag{8}$$

$$r_c = \dot{p}^e \tag{9}$$

where $\dot{e}^e$ and $\dot{p}^e$ are the expected rates of change in the two prices.

Because participants in the markets for foreign exchange and commodities are generally knowledgeable, they are assumed to possess long-run perfect foresight.[5] Under this assumption, asset holders correctly calculate the long-run equilibrium values of the two prices, $\bar{p}$ and $\bar{e}$, and expect that spot prices will adjust at rates that are proportional to the discrepancies between spot and long-run equilibrium prices:

$$r^* = \dot{e}^e = -\theta(e - \bar{e}), \qquad \theta > 0 \tag{10}$$

$$r_c = \dot{p}^e = -\delta(p - \bar{p}), \qquad \delta > 0 \tag{11}$$

where θ and δ are the rates at which asset holders expect the two spot prices to adjust.[6] Although asset holders correctly calculate $\bar{p}$ and $\bar{e}$, their expectations about the rates at which p and e adjust are, in general, incorrect. In the limiting case where $\theta = \delta = 0$, asset holders have static expectations.

II.B Momentary Equilibrium in Asset Markets

The short-run effects of small changes in stocks of F and C on the exchange rate and the spot price of commodities can be obtained by substituting equations (4), (5), (10), and (11) in equations (2) and (3), totally differentiating the resulting equations holding M and α constant, and rearranging terms:

$$D \begin{bmatrix} de \\ dp \end{bmatrix} = B \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{12}$$

where

$$D = W \begin{bmatrix} f_1\theta + f(1-f) & f_2\delta - f_3\bar{S} - fc \\ c_1\theta - fc & c_2\delta + c(1-c) \end{bmatrix}$$

$$B = \begin{bmatrix} f-1 & f \\ c & c-1 \end{bmatrix}$$

The terms de, dp, dF, and dC should be interpreted as deviations from prices and stocks that will obtain in long-run equilibrium.

The solutions for de and dp are:

$$\begin{bmatrix} de \\ dp \end{bmatrix} = D^{-1} B \begin{bmatrix} dF \\ dC \end{bmatrix} = A \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{13}$$

where

$$A = D^{-1} B = \frac{W}{\Delta} \begin{bmatrix} \delta(cm_2 - mc_2) - \bar{S}cm_3 - cm & \delta(mf_2 - fm_2) + \bar{S}(1-c)m_3 \\ \theta(mc_1 - cm_1) & \theta(fm_1 - mf_1) - mf \end{bmatrix}$$

The determinant of the D matrix, Δ, is positive if the three assets are gross substitutes.

The signs of the elements of the A matrix, a_{ij}, give the qualitative effects of changes in asset stocks on prices. Each term in a_{11} and a_{22} is negative, so the diagonal elements are unambiguously negative. Hence a decline in stocks of foreign exchange held by asset holders in the home country depreciates the exchange rate above its long-run equilibrium value, and a decline in commodity stocks raises the price of commodities above the long-run equilibrium price.

The off-diagonal elements, a_{12} and a_{21}, can be either positive or negative, so the effects of changes in commodity stocks on the exchange rate and the effects of changes in stocks of foreign exchange on the spot price of commodities are ambiguous. Fortunately, however, the effects of changes in asset stocks on the terms of trade are not ambiguous. Recalling that prices are initially normalized to 1, it can be shown that:

$$\frac{d(p/e)}{dF} = \frac{dp}{dF} - \frac{de}{dF} = a_{21} - a_{11} > 0$$
$$\frac{d(p/e)}{dC} = \frac{dp}{dC} - \frac{de}{dC} = a_{22} - a_{12} < 0 \tag{14}$$

The terms of trade vary directly with changes in foreign exchange holdings and move inversely with changes in commodity stocks.[7] These results will prove useful for analyzing the model's stability in section II.D and in the appendix.

II.C The Goods Markets

The real side of the model differs from the standard two-sector model primarily in that spot prices do not adjust in the short run to clear flow markets. Instead, the goods market equations take prices as given and determine changes in the stocks of financial assets and commodities, which in turn feed back through the asset markets to affect prices and commodity flows in the future.

Two of the three independent nominal prices in the model -- the exchange rate and the spot price of commodities -- are determined in asset markets. The third price, the foreign currency price of manufactured goods, is assumed to be fixed. The home currency price of imports of manufactured goods therefore varies directly with the exchange rate:

$$p_m = p_m^* \cdot e \tag{15}$$

where p_m is the home currency price of manufactured goods and p_m^* is the fixed foreign currency price.[8] If units are chosen so that $p_m^* = 1$, then:

$$p_m = e \quad . \tag{16}$$

Production of each good is fixed, because each country specializes in producing one good and labor is assumed to be fully employed. Hence price changes affect only flow demands, not flow supplies. Assume that the demand for each good in the home country is a function homogeneous of degree zero in nominal prices, nominal income, and nominal wealth, and that foreign demands for the two goods are homogeneous of degree zero in the two prices.[9] For the home country:

$$\dot{C} = \overline{S} - D^c(\overset{-}{p},\overset{+}{e},\overset{+}{Y},\overset{+}{W}) - X(\overset{-}{p},\overset{+}{e}) \tag{17}$$

$$\dot{F} = \frac{p}{e} X - X^* \tag{18}$$

$$eX^* = D^m(\overset{+}{p},\overset{-}{e},\overset{+}{Y},\overset{+}{W}) \tag{19}$$

where D^c and D^m are domestic demand for commodities and manufactured goods, X is exports, and X^* is imports.

Equation (17) says that the rate at which commodity stocks are being accumulated equals the flow excess supply of commodities, given world prices and income and wealth in the home country.[10] Equation (18) states that any current account surplus or deficit, here expressed in units of foreign currency, is financed by increasing or decreasing stocks of foreign exchange. The third equation simply states that the value of imports of manufactured goods equals domestic demand because the home country produces only agricultural commodities.[11] Note that the inclusion of wealth as an argument in the home country's demand functions implicitly defines an aggregate savings function. If wealth falls, *ceteris paribus*, domestic consumption of both goods falls, increasing the rates at which commodities and foreign exchange are being accumulated.

Dynamic adjustment towards long-run equilibrium in goods markets can be analyzed using equations (17) and (18). Substitute the definitions of income and wealth, take a Taylor's series expansion of the resulting equations in the neighborhood of long-run equilibrium (where $\dot{C}$ and $\dot{F}$ equal zero), and rearrange terms:

$$\begin{bmatrix} \dot{F} \\ \dot{C} \end{bmatrix} = G \begin{bmatrix} de \\ dp \\ dF \\ dC \end{bmatrix} \tag{20}$$

where

$$G = \begin{array}{c} \begin{array}{cc} \qquad\qquad\qquad P \qquad\qquad\qquad & \qquad\qquad W \end{array} \\ \left[\begin{array}{cc|cc} (X_2-D_2^m-X-F\cdot D_4^m) & (X_1-D_1^m+X-\bar{S}\cdot D_3^m-C\cdot D_4^m) & -D_4^m & -D_4^m \\ -(D_2^c+X_2+F\cdot D_4^c) & -(D_1^c+X_1+\bar{S}\cdot D_3^c+C\cdot D_4^c) & -D_4^c & -D_4^c \end{array}\right] \end{array}$$

The matrix G contains parameters for all the effects of deviations in prices and deviations in the home country's asset stocks on the rates at which these asset stocks are changing.

This matrix can be partitioned into two matrices called P and W as indicated above, the first containing the price effects, the second containing what will be called the direct wealth effects of changes in asset stocks. Note that hereafter W refers to the W matrix, not to nominal wealth. Therefore:

$$\begin{bmatrix} \dot{F} \\ \dot{C} \end{bmatrix} = P \begin{bmatrix} de \\ dp \end{bmatrix} + W \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{21}$$

Substituting for de and dp from equations (13) and collecting terms yields the final system of differential equations:

$$\begin{bmatrix} \dot{F} \\ \dot{C} \end{bmatrix} = [PA+W] \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{22}$$

Although the [PA+W] matrix is complicated, equations (22) have a simple, intuitive interpretation. Displacements of asset stocks from their equilibrium values have two sets of effects on the rates of accumulation: First, displacements affect nominal prices through asset market adjustments, and these changes in nominal prices generate substitution, income, and wealth effects in goods markets that lead to flow excess demands or flow excess supplies of commodities and foreign exchange. These effects are contained in the matrix [PA]. Second, these stock displacements generate direct wealth effects that further influence flow excess demands or excess supplies. The sum of the two sets of effects, the matrix [PA+W], gives the total effects of displacements on the two rates of accumulation.

II.D Stability and the Path of Adjustment to Long-Run Equilibrium

The stability of the system and the path of adjustment to long-run equilibrium both depend on the properties of the [PA+W] matrix. As shown in the appendix the following five conditions are sufficient for stability:

1) The terms of trade must vary inversely with the level of

commodity stocks.

2) The commodity market must possess Marshallian stability: a rise in the relative price of commodities (p/e) must increase flow excess supply.

3) The terms of trade must vary directly with the home country's stocks of foreign exchange.

4) The markets for traded goods must satisfy a variant of the Marshall-Lerner condition: an improvement in the terms of trade must increase the home country's current account deficit.

5) An increase in wealth must increase consumption of both goods, lowering the rates at which stocks are accumulated.

Conditions 1 and 3 were demonstrated in section II.B above. Conditions 2 and 4 are standard stability conditions for goods and foreign exchange markets.

The path of adjustment to long-run equilibrium can be analyzed using a phase diagram, but to draw the phase diagram it is necessary to determine the signs of the four elements of the [PA+W] matrix, z_{ij}. Consider first the sign of z_{22}. Stability conditions 1, 2, and 5 imply that a fall in commodity stocks improves the terms of trade and reduces real wealth, both of which generate a flow excess supply of commodities that gradually restores commodity stocks. Therefore, z_{22} is negative. Similarly, conditions 3, 4, and 5 ensure that z_{11} is negative as well.

The signs of z_{12} and z_{21}, however, are ambiguous because the price effects are positive but the direct wealth effects are negative. A fall in commodity stocks, for example, improves the terms of trade, creating a current account *deficit* and an outflow of foreign exchange, but the reduction in wealth induces a current account *surplus* and an inflow of foreign exchange. The direct wealth effects are probably small, though, and commodity market disruptions are important economic and political problems precisely because their effects on prices are large, so it will be assumed that the price effects dominate and z_{12} and z_{21} are in fact positive.

The adjustment process can now be analyzed diagrammatically, using the phase diagram in figure 1a on p. 38. The FF curve, derived by setting $\dot{F} = 0$ in the first equation of (22), plots all the combinations of the stocks of the two assets that balance the current account. Its slope, $-z_{11}/z_{12}$, is positive. The CC curve shows stock levels that leave commodity stocks unchanged over time. Its slope, $-z_{21}/z_{22}$, is also positive but less than that of the FF curve. The intersection of the two curves determines the long-run equilibrium levels of the two stocks. The paths of adjustment, indicated by the arrows in each of the four regions of the figure, follow from the stability conditions, and the approach to long-run equilibrium is noncyclical.[12]

The behavior of nominal prices during the adjustment process can be analyzed in the price space of figure 1b. Two sets of equations will be helpful for analyzing price behavior. Because asset markets are always in equilibrium, the exchange rate and the spot price of commodities that obtain at each point in time during the adjustment process can be determined from equations (13) and plotted in price space. A second set of equations, giving the rates at which the two prices are changing, can be derived easily from equations (13):

$$\begin{bmatrix} \dot{e} \\ \dot{p} \end{bmatrix} = A \begin{bmatrix} \dot{F} \\ \dot{C} \end{bmatrix} = A\ [PA+W] \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{23}$$

One striking implication of equations (23) is that one cannot infer from the current account the direction in which the exchange rate is moving. In much of the literature on the asset market approach to the exchange rate (see, e.g., Kouri (1976)), a current account surplus and the concomitant inflow of foreign exchange, for example, imply an unambiguous appreciation of the exchange rate. Here, as long as $a_{12} \neq 0$ it is possible to have a current account *surplus* and a *depreciating* exchange rate or a current account *deficit* and an *appreciating* exchange rate, depending on the signs of a_{12} and $\dot{C}$.

The price space of figure 1b can also be used to decompose the changes in nominal GNP that are brought about by commodity market disruptions into changes in real income and changes in the domestic price level. First, note that nominal GNP is the sum of consumption of the two goods, inventory investment, and net exports:

$$Y \equiv (pD^{c} + eD^{m}) + p\dot{C} + (pX - eX^{*}) \quad . \tag{24}$$

Totally differentiating equation (24) in the neighborhood of long-run equilibrium and rearranging terms yields:

$$\frac{dY}{Y} = [(1 - \sigma)\ dp + \sigma\ de] + \sigma d(p/e) \tag{25}$$

where $\sigma = eX^{*}/Y$, the share of imports in domestic consumption. The expression in brackets gives the change in the domestic price level; the second term gives the change in real income, which varies only with the terms of trade because output and employment are fixed. The slope of the line along which the domestic price level is constant is $-(1 - \sigma)/\sigma$ and is plotted as the PP curve in figure 1b. Above and to the right of the PP line the domestic price level is higher than in the initial equilibrium. Real income is constant along the YY line, which has a slope of 1 and passes through the origin. Pairs of prices above and to the left of the YY line indicate improved terms of trade for the home country and hence greater real income.

III. The Macroeconomic Effects of Disturbances in Commodity Markets

This section uses the model developed above to analyze two different disturbances in commodity markets: bad harvests and shifts in asset holders' preferences among the three assets in the model. In each case, the disturbance is modeled as a shock that initially affects asset markets, bringing about instantaneous changes in the spot exchange rate and the spot price of commodities, followed by dynamic adjustments back to long-run equilibrium.

III.A A Bad Harvest in the Home Country

Bad weather in the United States in 1974 inflicted on U.S. agriculture the worst production setback in almost 40 years.[13] Moreover, stocks carried into 1974 were low because of bad weather abroad and the mysterious disappearance of Peruvian anchovies in 1972-73. The combined effect of tight stocks and the bad harvest was to further reduce stocks and to increase sharply the dollar price of grain, as indicated in chart 1 on p. 37.

The effects of a bad harvest on asset stocks, the price of commodities, and the exchange rate are summarized in figures 2a and 2b on p. 38. Suppose that just before the harvest in the home country, bad weather destroys part of the crop. The initial effect is to reduce commodity stocks from C_0 to C_1, where $\overline{C_0 C_1}$ is the size of the production shortfall.[14] The sharp decline in commodity stocks is assumed to have no effect on asset holders' expectations about long-run equilibrium prices, but it does quickly push up the spot price of commodities, not to equate flow demand with reduced flow supply, but to reduce stock demand *pari passu* with commodity inventories. The rise in the spot price of commodities restores stock equilibrium both by raising the nominal value of commodity stocks and by lowering the expected yield, reducing demand.[15]

The short-run effect on the exchange rate, however, is ambiguous (see equations (13)). The increase in the spot price of commodities increases nominal income and the transactions demand for domestic money, but it also makes the nominal yield on commodities negative, increasing the demand for *both* financial assets through substitution effects. If the increase in demand for domestic money is greater than the increase in demand for foreign exchange, the exchange rate must initially appreciate to restore asset market equilibrium. But if the income effects are small and if commodities and foreign exchange are close substitutes, then the exchange rate might well depreciate initially instead. The net effects of these price changes in the home country are to improve the terms of trade but increase the domestic price level, as shown in figure 2b.

These initial effects on the exchange rate and the price level are surprising. In a quantity theory world with a fixed nominal money stock, one would expect an unambiguous appreciation of the exchange rate, keeping the domestic price level down so that the demand for nominal money balances would not exceed the fixed nominal money stock. But if such an appreciation occurred in this model, there would be substantial excess demand for foreign exchange due to both the negative expected yield on commodities and the positive expected yield to foreign exchange. This incipient excess demand for foreign exchange limits (or even reverses) the initial appreciation of the exchange rate.

The initial improvement in the home country's terms of trade reduces the foreign country's demand for imports of agricultural commodities and stimulates the home country's demand for imports of manufactured goods. The resulting trade deficit is financed by running down the home country's stocks of foreign exchange, gradually depreciating the exchange rate.[16] The improved terms of trade also creates a flow excess supply of commodities that begins rebuilding commodity stocks depleted by the bad harvest, at the same time gradually lowering the spot price. The initial current account deficit is not inconsistent with the commonly held view that, because export demand is inelastic, bad harvests increase export earnings from agriculture. As long as the Marshall-Lerner condition is satisfied, the value of imports increases by more than the value of exports, resulting in a current account deficit. Eventually, the trade deficit turns to surplus (where the adjustment path crosses the FF curve in figure 2a), asset holders begin rebuilding their stocks of foreign exchange as well as commodities, and the exchange rate starts appreciating back to its long-run equilibrium value.

One interesting implication of the stock approach to commodity market equilibrium is that the high spot price of commodities persists long after agricultural production is restored, returning to its long-run equilibrium value only when commodity stocks have been replenished. Gordon's (1975) model simulations, in contrast, show prices falling immediately after farm output is restored. The data plotted in chart 1 are consistent with the stock, rather than the flow approach: the world grain harvest in 1976 was a record harvest, sufficient to add over 40 million metric tons to world stocks, but grain prices remained well above normal because stocks were still low. This persistence of high commodity prices is an important characteristic of the model and of the real world, because it implies the persistence of current account imbalances, changes in asset stocks, and changes in exchange rates, all of which a flow analysis would miss.

A number of conclusions can be drawn from the analysis above. First, there is a natural tendency for commodity stocks to be restored to initial levels and for the initial long-run equilibrium to be regained, even though the shock to the model was a real shock. In effect, the world economy restores commodity stocks by saving out of current consumption, with the adjustment process complicated by the effects of high commodity prices on other markets.

Second, the exchange rate, the current account, and international capital flows do respond during the adjustment period, even though they all ultimately return to their initial levels. These markets are necessarily linked because the response of the home country's commodity exports to changes in the terms of trade affects the rates at which stocks of both commodities and foreign exchange are altered. One interesting implication of the interaction of these markets is that the increase in the price level initially brought about by the bad harvest may be prolonged by the depreciation of the exchange rate during the initial stage of adjustment. The hangover price effect from the bad harvest could create long-term inflation or unemployment problems if ultimately reflected in nominal wages.

Third, the real burden of restoring commodity stocks is shared by the two countries, the foreign country's share being imposed from abroad by the worsening of its terms of trade throughout the adjustment period.[18] Note that flexible exchange rates do not insulate the foreign country from bearing its share of the real burden. Furthermore, not only may changes in the exchange rate exacerbate the effects of the bad harvest on commodity prices in the foreign country, but freely flexible exchange rates may fail to prevent significant swings in the current and capital accounts.

III.B Portfolio Shifts Between Financial Assets and Commodities

Commodity speculation, or a shift in asset holders' portfolio preferences from financial assets to commodities, has been identified by several authors as an important cause of the commodity price boom in the early seventies. Labys (1974), Cooper and Lawrence, and Cline have proposed several rationales for this shift. First, the move to more flexible exchange rates in the early seventies may have increased the perceived risk of holding foreign currencies and led to portfolio diversification away from currencies into commodities. An increase in before the current account swings to surplus and the exchange rate, having overshot its long-run equilibrium value, finally begins to appreciate towards $\bar{e}'$.

A comparison of these two cases is instructive. Looking first at asset stocks, it is clear that in long-run equilibrium the mix of asset stocks differs in the two cases: in both cases, the stock of commodities is larger, but in the case of foreign exchange risk, the stock of foreign exchange falls while the stock of money balances remains unchanged, and in the other case, the stock of real money balances falls while the stock of foreign exchange remains unchanged. The adjustment paths differ also, as can be seen by comparing figures 3a and 4a.

The most striking differences between the two cases occur in the behavior of prices and the price level. If asset holders in the home country are fleeing foreign exchange risk, the appreciation of the exchange rate offsets much if not all of the effect of higher commodity prices on the price level. If asset holders are hedging against domestic inflation expected in the future, however, the immediate effects on the price level could be substantial. The increase in the prices expected to obtain in long-run equilibrium induces an immediate bidding up of the two spot prices. The excess demand for commodities further bids up the spot price of commodities above its new long run equilibrium value, with little offset likely from an appreciating exchange rate. Furthermore, these temporary effects of excess demand for commodities on the domestic price level may be sustained for a considerable part of the adjustment period, because the gradual depreciation of the exchange rate raises the price of imports as the price of commodities falls.

the expected rate of inflation also may have induced a shift out of nominal assets into real assets, including commodities. A third hypothesis, popular in the early seventies, is that increased uncertainty of commodity supplies raised the nonmonetary or convenience yield provided by commodity stocks, increasing the demand for commodities by individuals, firms, and governments.

This section will analyze the *foreign exchange risk* rationale, modeled as a shift in demand from F into C, and the *inflation hedge* rationale, modeled as a shift from M into C.[19] These distinctions are not clearcut if asset holders in different countries all hold diversified portfolios of financial assets denominated in different currencies. A general shift out of dollars into commodities, for example, might be viewed as hedging against inflation by asset holders in the United States and, at the same time, as avoiding foreign exchange risk by European or Japanese asset holders. These distinctions are useful, though, for organizing the analysis and for emphasizing the primary conclusions of the section: namely that the short-run and long-run effects of commodity speculation, as well as the dynamic adjustment process set in motion by such speculation, all depend crucially on which financial assets are sold by asset holders in their attempts to increase their holdings of commodities.

<u>Foreign exchange risk</u> - The effects of a shift in portfolio preferences from F into C are shown in figures 3a and 3b on p. 39. In figure 3a, the point (F_0, C_0) is the mix of stocks consistent with long-run equilibrium before the shift in portfolio preferences. After the shift, asset holders in the aggregate would prefer to hold the mix (F_1, C_1), which

contains more C and less F. Any other combination of assets, now including (F_0,C_0), results in a dynamic adjustment of asset stocks, as indicated by the new positions of the FF and CC curves, until the new long-run equilibrium is obtained.

The reason for the dynamic adjustment should be clear from figure 3b. Although the pair of prices that yields long-run equilibrium is unchanged, both spot prices adjust immediately to restore asset market equilibrium. The spot price of commodities is bid up until the expected capital loss offsets the increase in demand due to the portfolio shift. The exchange rate appreciates until the expected capital gain on holding foreign exchange offsets the shift in demand for F. The initial effect on prices is represented in figure 3b by the movement from point $(\overline{e},\overline{p})$ to point (e_1,p_1). The effect on the domestic price level may well be small because the appreciation of the exchange rate and the resulting fall in the domestic price of imported manufactured goods offsets some if not all of the rise in the price of commodities.

The paths of prices and stocks during the adjustment period follow the adjustment paths labeled 1 or 2. The improved terms of trade for the home country induces a current account deficit, which runs down the stock of foreign exchange, and a flow excess supply of commodities, which builds up commodity stocks. If commodity stocks adjust more rapidly than stocks of foreign exchange, both commodity stocks and commodity prices overshoot their long-run equilibrium values (adjustment paths 1). If foreign exchange stocks adjust more rapidly, then both the exchange rate and the stock of foreign exchange would overshoot (adjustment paths 2). When long-run equilibrium is finally restored, spot prices equal the long-run equilibrium prices, $\bar{p}$ and $\bar{e}$, and stockholders have obtained the new mix of assets they desire: a portfolio containing a larger fraction of commodities and a smaller fraction of foreign exchange. The fraction of assets held in the form of domestic money remains unchanged.

Inflation hedge - The effects of the portfolio shift are quite different when the shift is out of domestic money instead of foreign exchange. In this case, it can be shown from equations (1)-(5), (17), and (18) that long run equilibrium can only be restored if $\bar{p}$ and $\bar{e}$ rise in proportion to the downward shift in money demand and the physical stock of commodities rises to satisfy the increased demand.[20] Given the assumption of long-run perfect foresight, asset holders immediately realize the implications of the shift in preferences and revise their estimates of $\bar{p}$ and $\bar{e}$ from $(\bar{e}_0,\bar{p}_0)$ to $(\bar{e}',\bar{p}')$ in figure 4b on p. 39. In figure 4a, the FF and CC curves shift up, now intersecting at a point due north of (F_0,C_0), indicating that while the stock of foreign exchange consistent with long-run equilibrium remains unchanged, the physical stocks of commodities in long-run equilibrium now need to be larger to satisfy the increased demand.

The dynamics of adjustment are analogous to the adjustment to a bad harvest. At initial stock levels there is excess demand for commodity stocks that immediately bids up the spot price of commodities above the new long-run equilibrium price $\bar{p}'$. Whether the spot exchange rate depreciates by more or less than the change in $\bar{e}$ is ambiguous and depends on equations (13). These price changes in turn induce a current account deficit and a further, gradual depreciation of the exchange rate

IV. Summary

Commodity market disruptions of the magnitude that occurred in 1973-74 can be expected to have significant effects on prices, exchange rates, trade flows, and capital flows -- effects that persist long after the initial shock has passed. Asset markets, defined to include commodity markets, play a central role in transmitting these shocks in the short run throughout the world economy. While this paper concentrated on disruptions that took place in the past, the approach should be equally fruitful for studying current commodities issues such as the effects of massive intervention in commodity markets on the scale envisioned by UNCTAD's Integrated Programme for Commodities.

Appendix

Evaluating the [PA+W] matrix is messy and unenlightening, so to analyze the stability of the model it is necessary to transform the matrix. The procedure used here makes use of the homogeneity properties of the demand functions for manufactured goods and commodities and equations (14), which show the effects of changes in asset stocks on the terms of trade.

Demand functions in the $\dot{C}$ and $\dot{F}$ equations, equations (17) and (18), are homogeneous of degree zero, so each of the arguments can be deflated by e, leaving $\dot{C}$ and $\dot{F}$ unchanged. In the transformed equations, demands become functions of the terms of trade, where $T = p/e$, and of real income and real wealth, defined in terms of imported manufactured goods. Substitute the definitions of nominal income and wealth, take a Taylor's series expansion in the neighborhood of long-run equilibrium, and partition the resulting matrix into terms of trade and direct wealth effects:

$$\begin{bmatrix} \dot{F} \\ \dot{C} \end{bmatrix} = \tilde{G} \begin{bmatrix} dT \\ dF \\ dC \end{bmatrix} = \tilde{P}\,[dT] + W \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{A1}$$

where

$$\tilde{P} = \begin{bmatrix} X+\tilde{X}_1-\tilde{D}_1^m-\tilde{D}_3^m\cdot\overline{S}-\tilde{D}_4^m(C-M\frac{de}{dT}) \\ -\tilde{D}_1^c-\tilde{X}_1-\tilde{D}_3^c\cdot\overline{S}+\tilde{D}_4^c(C-M\frac{de}{dT}) \end{bmatrix}$$

The matrices $\tilde{G}$ and $\tilde{P}$ are analogous to the matrices G and P in section II.C of the text; $\tilde{D}_1^m$ is the partial derivative of D^m with respect to the first argument, $p/e = T$, in the transformed equations for $\dot{C}$ and $\dot{F}$, and so forth. The matrix W equals $\tilde{W}$ because prices are normalized.

Substitute equations (14) for dT to complete the transformation:

$$\begin{bmatrix} \dot{F} \\ \dot{C} \end{bmatrix} = [\tilde{P}\tilde{A}+W] \begin{bmatrix} dF \\ dC \end{bmatrix} \tag{A2}$$

where

$$\tilde{A} = [a_{21}-a_{11} \quad a_{22}-a_{12}] \quad .$$

Note that the matrix $[\tilde{P}\tilde{A}]$ is the outer product of the column vector $\tilde{P}$ and the row vector $\tilde{A}$, so it has the same order as W. Hence $[\tilde{P}\tilde{A}]$ and W may be added as indicated.

The $[\tilde{P}\tilde{A}+W]$ matrix, which is equal to $[PA+W]$, can now be used to analyze the stability of the system. Stability requires the trace to be negative and the determinant to be positive. From equations (A2):

$$[\tilde{P}\tilde{A}+W] = \begin{bmatrix} \overset{-}{\tilde{p}_1}\overset{+}{(a_{21}-a_{11})}+\overset{-}{w_{11}} & \overset{-}{\tilde{p}_1}\overset{-}{(a_{22}-a_{12})}+\overset{-}{w_{12}} \\ \overset{+}{\tilde{p}_2}\overset{+}{(a_{21}-a_{11})}+\overset{-}{w_{21}} & \overset{+}{\tilde{p}_2}\overset{-}{(a_{22}-a_{12})}+\overset{-}{w_{22}} \end{bmatrix} \tag{A3}$$

where $\tilde{p}_1$ and $\tilde{p}_2$ are the two elements of $\tilde{P}$. The signs over each term are the signs implied by the five stability conditions listed in the text. If these conditions are met, the trace condition is obviously satisfied. The determinant of the matrix, $\tilde{\Delta}$, is:

$$\tilde{\Delta} = (\overset{-}{w_{22}}\overset{-}{\tilde{p}_1}-\overset{-}{w_{11}}\overset{+}{\tilde{p}_2})[\overset{+}{(a_{21}-a_{11})}-\overset{-}{(a_{22}-a_{12})}] > 0 \tag{A4}$$

which is unambiguously positive if the stability conditions are met. Note that the five stability conditions are sufficient, but not necessary, for stability.

To confirm that $\tilde{p}_1 < 0$ is indeed a variant of the familiar Marshall-Lerner condition, take the definition of $\tilde{p}_1$ from equations (A1), convert to elasticities, and rearrange terms:

$$\tilde{p}_1 < 0 \quad \text{iff} \quad \eta_1^* - \eta_1 > 1 - \eta_3^*(c - m\frac{de}{dT}) \tag{A5}$$

where η_1^* is the home country's total elasticity of demand for imports of manufactured goods (containing both income and substitution effects of changes in the terms of trade), and η_3^* is the wealth elasticity of demand for imports in the home country. The primary difference between equation (A5) and the standard Marshall-Lerner condition is the inclusion of the wealth term. If $c - m\frac{de}{dT} > 0$, then equation (A5) is less restrictive than the standard Marshall-Lerner condition; the increase in real wealth accompanying an improvement in the home country's terms of trade stimulates the home country's demand for imports of manufactured goods, reinforcing the substitution effects on the trade balance.

Footnotes

1. Between 1973 and 1976, exports of primary products less fuels ranged from 19 percent to 24 percent of total world exports (GATT 1977, table 7).

2. The value of net private asset holdings denominated in foreign currencies is approximately equal to the value of U.S. direct investments abroad -- about $140 billion at the end of 1976 -- because nearly all other private U.S. assets abroad and foreign assets in the United States are payable in dollars. Of course, financial intermediation greatly increases the liquidity of net holdings of foreign assets for individual asset holders. The value of farm inventories at the end of 1976 was about $60 billion. Speculation was not limited to agricultural commodities, however. The value of inventories of materials and supplies, a rough measure of nonagricultural commodity stocks, was roughly $75 billion, so the total value of commodities was on the order of $135 billion. Data are drawn from the *Survey of Current Business* and the *Federal Reserve Bulletin*.

3. The stock approach is the standard way to formulate dynamic commodity market models (Labys 1973, 1975), and it has been part of the conventional wisdom in the commodity futures literature for nearly 30 years (e.g., Working (1949) and the articles collected in Peck (1977, sec. 2)). Indeed, the stock approach is implicit in Keynes' famous chapter on investment in liquid capital in his *Treatise on Money* (1930). McRae (1978) presents empirical results showing that the markets for non-replenishable resources in fact behave like perfect asset markets.

4. This asset market model is consistent with the theoretical and empirical research on the short-run determination of commodity prices (see footnote 3) and the short-run determination of exchange rates (e.g., Kouri (1976), Dornbusch (1976), or Black (1977), and Branson, Halttunen, and Masson (1977)). Krugman (1976) discusses the formal similarities between these approaches to modeling commodities and foreign exchange markets, but he does not integrate financial and commodity markets into one model.

5. But contrast with Schnittker (1975). In a strong critique of the recent performance of commodity markets, Schnittker states that "markets today lack enough information to function effectively in the new political and economic climate.... Both officials and large companies are...in a position to present, and often do present, the public with obsolete or intentionally misleading information..."(p. 863). See Van Duyne (1978b) for an attempt to incorporate forecasting errors in expectations models of this sort.

6. Equation (10) will be recognizable to anyone familiar with the literature on the asset market approach to exchange rate determination. Commodity

market specialists, familiar with the literature on futures markets, might find equation (11) puzzling, though, because $\bar{p}$ is a long-run equilibrium price, not the price of a futures contract for delivery a few months hence. But the three prices are closely related. The one-period futures price, p_f, equals the spot price plus the adjustment in the spot price (from equation (11)) expected during the period:

$$p_f = p - \delta(p - \bar{p}) \quad . \tag{F1}$$

Rearranging (F1) yields:

$$p_f = (1 - \delta)\ p + \delta\bar{p} \quad . \tag{F2}$$

The one-period futures price is a weighted average of the spot price and the long-run equilibrium price, with weights $(1 - \delta)$ and δ.

7. If $a_{12} < 0$ and $\delta >> \theta$, it is possible for changes in commodity stocks to have perverse effects on the terms of trade. Similarly, if $a_{21} < 0$ and $\theta >> \delta$, changes in F could have perverse effects on the terms of trade. These perverse cases are extremely unlikely to occur and will be ignored hereafter.

8. In section III below, only temporary shifts in the demand for manufactured goods arise. The unresponsiveness of manufactured goods prices to temporary fluctuations in demand is consistent with Hicks's (1974) and Okun's (1975) discussions of pricing in fixprice or customer goods markets and Popkin's (1978) empirical study of pricing in 16 U.S. manufacturing industries. If the fixprice assumption is valid for foreign manufacturing as well, then equation (15) is consistent with Isard's (1977) conclusions about the "law of one price."

9. The income argument in the foreign demand functions is suppressed because nominal income in the foreign country is constant from the specialization, full employment, and fixprice assumptions. The wealth argument is suppressed, with little loss of generality, to simplify the analysis.

10. The problems associated with the periodicity of the harvest and the resulting seasonal variation in commodity stocks as usually defined can be sidestepped by interpreting equation (17) as follows: Think of C as *total* stocks of agricultural commodities, comprising harvested and stored crops *plus* unharvested crops. The stock of unharvested crops is growing at the constant rate $\bar{S}$, while the stock of harvested and stored crops is declining at a rate $D^c + X$ to satisfy flow demand,

both foreign and domestic. Hence total stocks, as well as income on an accrual basis, show no seasonal variation. Once a year the harvest replenishes stored stocks.

11. In the foreign country, prices and production of manufactured goods are fixed, so shifts in the demand for manufactured goods must be accommodated by passively adjusting manufactured goods inventories. Hence desired inventories always equal actual inventories. Asset holders in the foreign country hold only one other asset, stocks of their own money, so from the balance sheet constraint, their desired stocks of money must also respond passively to changes in holdings in this case. Cf. Brainard and Tobin (1968). The curious nature of asset market equilibrium in the foreign country permits keeping the foreign country in the background.

12. Dynamic adjustment is noncyclical if the roots of the characteristic equation of [PA+W] are real. It can easily be shown that if the diagonal elements are negative, the roots are real if the off-diagonal elements have the same sign. This is a sufficient but not necessary condition for the absence of cycles.

Although it will not be considered further in the text, the case in which one or both of the off-diagonal elements is negative has an interesting interpretation. This could occur only if the three assets were such close substitutes or if asset holders expected such rapid price adjustment following an unexpected shock (i.e., large δ and θ) that only negligible price changes would be necessary to restore asset market equilibrium. In this case the direct wealth effects could dominate price effects not because flow markets do not respond elastically to changes in prices, but because changes in prices, determined in asset markets, are so small.

13. *Economic Report of the President, February 1975*, p. 160. Discussions of recent developments in agriculture in this section were drawn from the *Economic Report of the President*, various issues.

14. Modeling a bad harvest as a fall in commodity stocks is common in the commodity futures literature, e.g., Weymar (1969). Because the fall in income, which equals $p(C_0 - C_1)$, takes place at a point in time, consumption of the two goods is assumed to change only to the extent that prices or wealth are affected.

15. Note that in the asset market model as specified, the largest possible increase in the spot price of commodities is in the same proportion as commodity stocks originally fell. This would occur only in the case of static expectations ($\delta = 0$), and it would restore asset

market equilibrium by restoring the nominal value of commodity stocks. But the proportional rise in commodity prices from 1973 to 1974 shown in chart 1 greatly exceeded the proportional fall in commodity stocks. There are at least two possible explanations: First, Malthusian asset holders initially may have revised upward their estimates of the long-run equilibrium price of commodities, then corrected their error later (cf. Van Duyne 1978b). Second, holders of commodity stocks may receive a nonmonetary convenience yield from holding physical stocks of commodities. The marginal convenience yield might have risen rapidly as physical stocks got smaller, necessitating a much larger rise in the spot price of commodities and a much greater expected capital loss to holding commodities to restore asset market equilibrium. The second explanation is conventional wisdom in the commodity futures literature (e.g., Working (1949) and Peck (1977, sec. 2)). Both explanations could easily be incorporated into the asset market model with little change in the results.

16. From equations (23), the exchange rate will gradually depreciate during the first stage of the adjustment process as long as a_{12} is such that $a_{11}z_{12} + a_{12}z_{22} < 0$. For this condition to be violated, a_{12} must be large in absolute value and negative, which from equations (13) is unlikely.

17. Recall from equations (23) that the exchange rate in general does *not* begin to appreciate back to its long-run equilibrium value at the same time the current account starts showing a surplus. If a_{12} is small but positive, the assumption used to draw figure 2b, then the exchange rate continues depreciating for some time after the current account first shows a surplus.

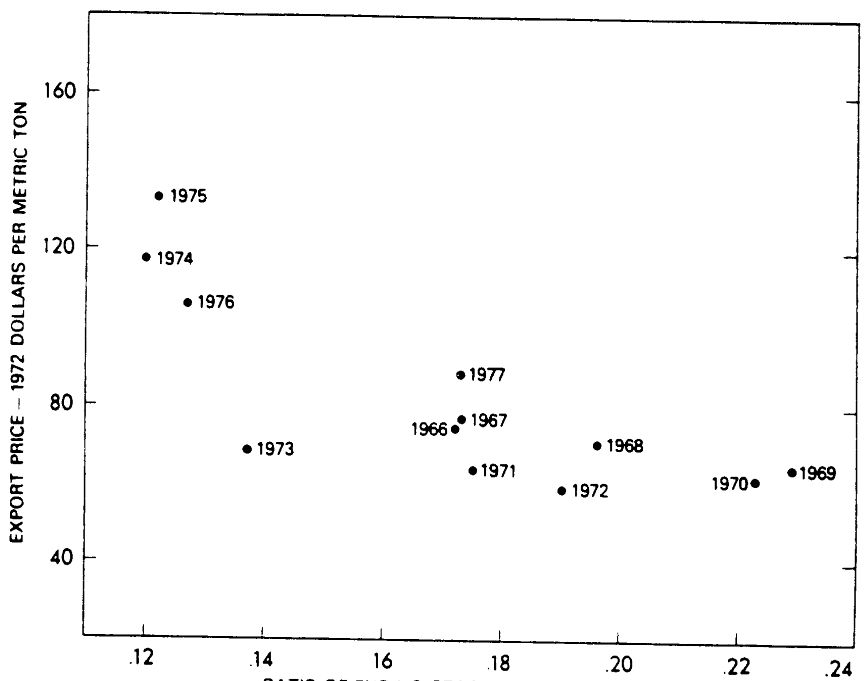
18. Indeed, the foreign country could bear 100 percent or more of the burden. The fraction it bears depends on the integral of the improvement in the home country's terms of trade, appropriately discounted, from the time of the shock until long-run equilibrium is regained. The integral in this case is too messy to evaluate, but in a similar but simpler commodity market model, Van Duyne (1978a) shows that a temporary production cutback by a commodity cartel, which has analogous effects on commodity stocks and commodity prices, can increase the present value of the cartel's export earnings if the initial rise in the spot price is large enough and if the adjustment of the spot price back to long-run equilibrium is slow enough. In the case of a bad harvest, it seems plausible that similar conditions obtain: the larger the initial improvement in the home country's terms of trade and the slower the terms of trade return to normal, the greater the burden borne by the foreign country.

19. Strictly speaking, asset holders in this case are hedging against a rise in the price level, not an increase in the rate of inflation.

20. This statement is true if and only if the rise in nominal income brought about by the increase in the domestic price level does *not* increase the transactions demand for nominal money balances. This is a plausible assumption in this context, implying that asset holders are shifting away from domestic money held for both transactions and speculative purposes.

Chart 1

World Wheat and Coarse Grains: Export Prices and Ratio of Stocks to Consumption

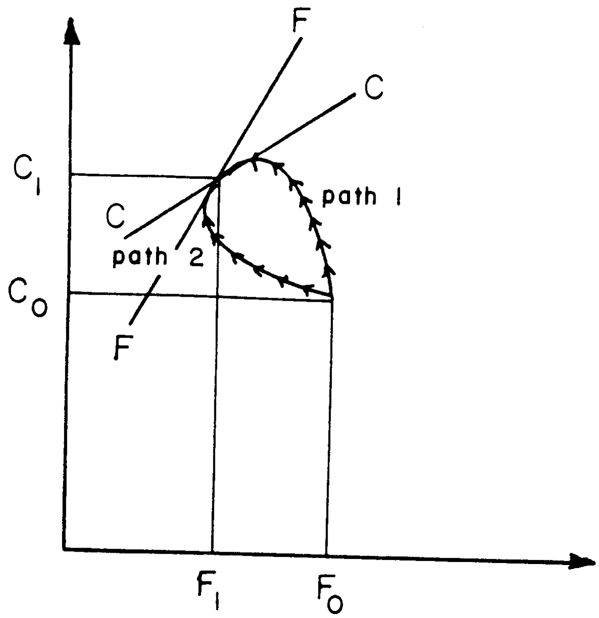


NOTE: DATA RELATE TO MARKETING YEAR ENDING IN YEAR SHOWN AND EXCLUDE THE U.S.S.R.
SOURCE: DEPARTMENT OF AGRICULTURE.

Source: *Economic Report of the President, January 1978*, p. 200.

FIGURE 3

a



b

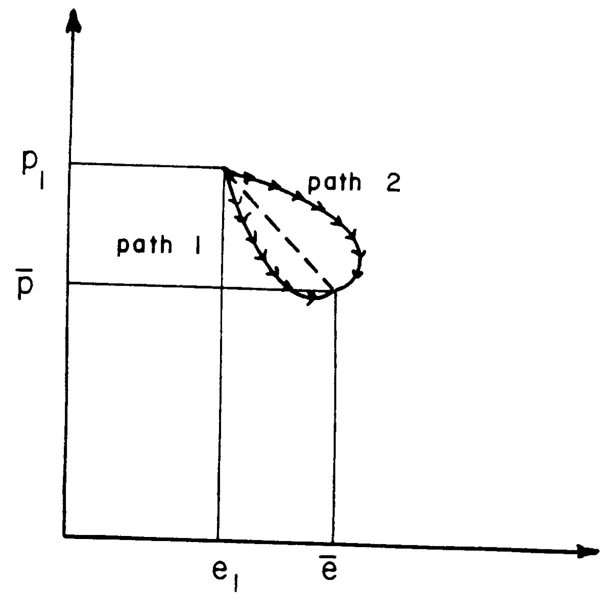
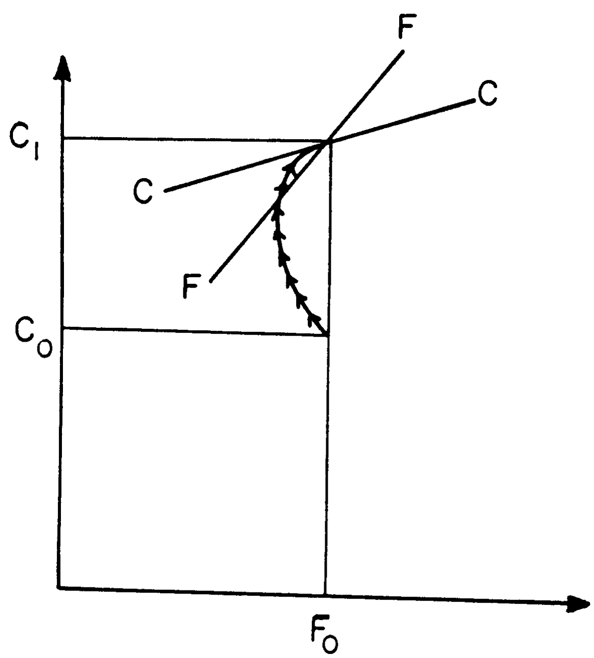


FIGURE 4

a



b

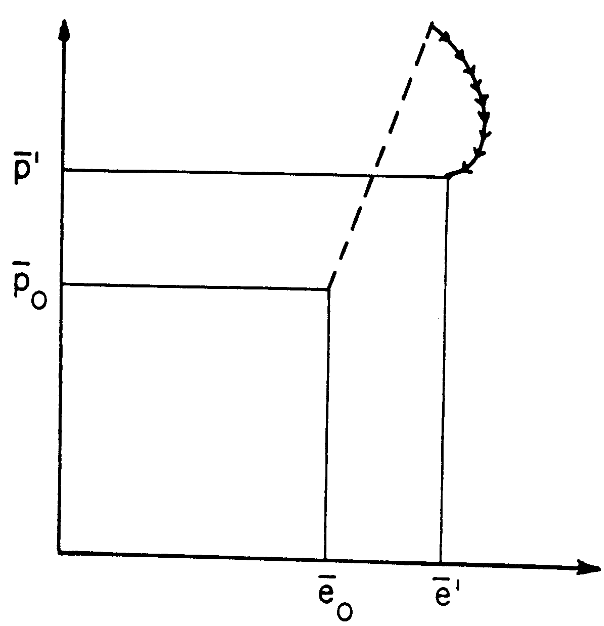


FIGURE 1

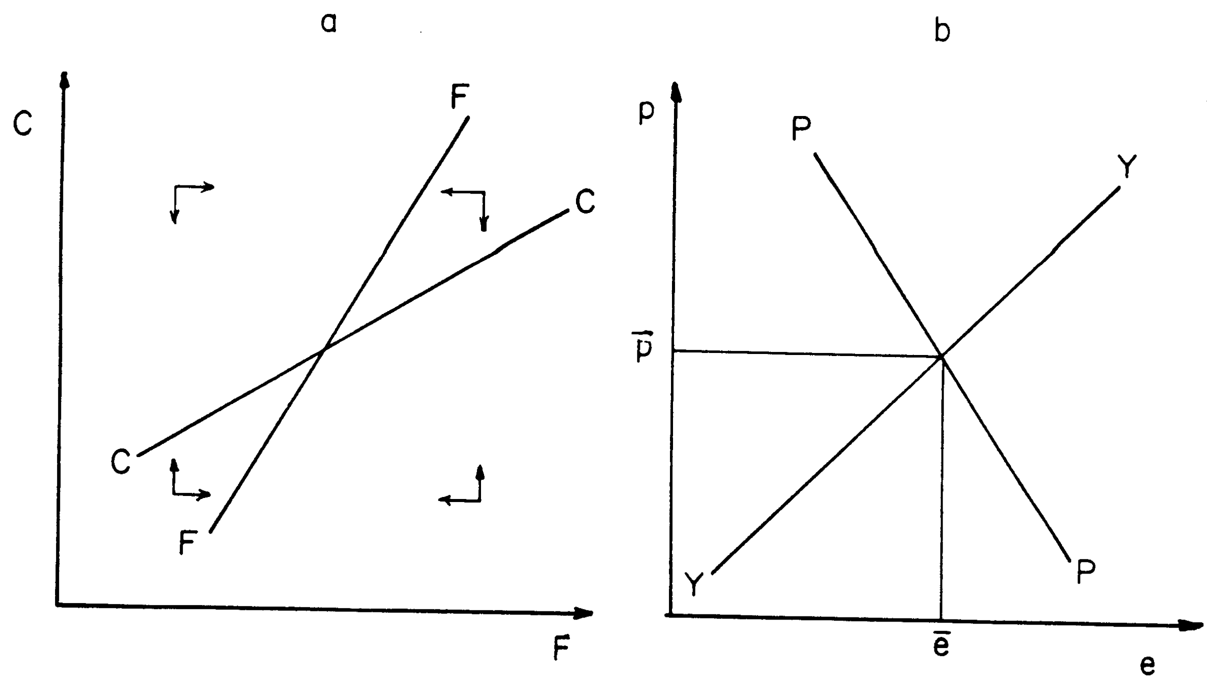
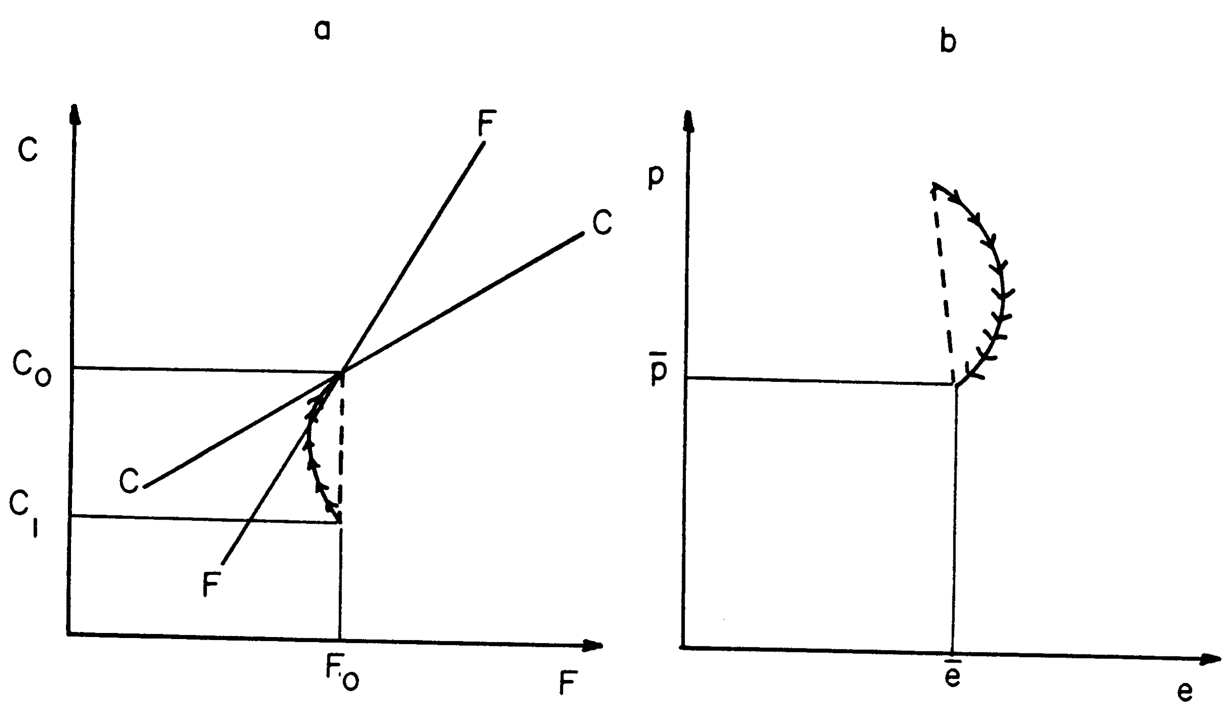


FIGURE 2



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