THE MONETARY APPROACH TO EXCHANGE RATE

DETERMINATION: A GEOMETRIC ANALYSIS

Kenneth W. Clements
Department of Economics
University of Western Australia

Discussion Paper No. 81-02

May 1981

Forthcoming in Weltwirtschaftliches Archiv

THE MONETARY APPROACH TO EXCHANGE RATE DETERMINATION:
A GEOMETRIC ANALYSIS

by

Kenneth W. Clements*
University of Western Australia

Abstract

The monetary approach to the exchange rate is illustrated with simple geometric techniques. The analysis includes a discussion of traded and nontraded goods which allows interaction of the monetary and real economy in determining the exchange rate. Applications include the effects of monetary expansion, the overshooting of exchange rates, and the productivity bias in purchasing power parity.

* For helpful comments thanks are due to Victor Argy and Jeff Carmichael. Jenny Brough drew the figures.

The recently developed (or revived) monetary approach views the exchange rate as the relative price of domestic and foreign currencies.¹ In contrast to the conventional approach which treats the exchange rate as equilibrating the international flow of goods, services and capital, the monetary approach emphasizes the role of the determinants of equilibrium in the money (or asset) markets in understanding exchange rate behavior. The key insight of the monetary approach is that the domestic value of the currency is the inverse of the price level, while its foreign value is the exchange rate; arbitrage ensures that the two values coincide. Thus, an increase in domestic prices is associated with a depreciation of the currency. The final step in the analysis is to relate domestic prices to the demand and supply of money.

The objective of this paper is to give a simple geometric analysis of the monetary approach. We start with all goods traded internationally and then extend the analysis to a traded/nontraded goods world.

All Goods Traded

We first consider equilibrium in the domestic money market in order to determine prices. Let the demand for real cash balances (L) depend on real income (y) and the nominal rate of interest (i), and let the supply of real balances be M/P where M is the nominal quantity of money and P is the price level. Equilibrium in the money market means $L(y,i) = M/P$ or

$$(1) \quad P = M/L(y,i) .$$

This is the familiar (or famous) quantity theory result of proportionality of prices and the money supply. The implications of (1) are, *ceteris paribus*, (i) a rise in the money supply increases the price level equiproportionally and (ii) a rise in the real quantity of money demanded causes the price level to fall equiproportionally.

The second step is to link domestic and foreign prices by the purchasing power parity condition,

$$(2) \quad P = S P^*$$

where S is the exchange rate (the price of foreign currency in terms of domestic currency) and P^* is the foreign price level. Eq. (2) can be interpreted as an arbitrage condition, with the exchange rate equalizing goods prices in alternative currencies. Holding P^* constant, an increase in prices at home is associated with an equiproportional depreciation of the currency (a rise in S).

Combining (1) and (2) gives an expression for the exchange rate in terms of the domestic demand and supply of money and foreign prices,

$$(3) \quad S = \frac{M}{L(y, i)} \frac{1}{P^*}.$$

This expression summarizes the model and can be viewed as the reduced form exchange rate equation.²

The workings of (3) are illustrated in Fig. 1. The right panel is the relationship between money and prices [eq. (1)]. With income and the interest rate held constant at y_0 and i_0 , when the money supply increases from M_0 to M_1 the price level rises from P_0 to P_1 in order to keep real balances constant. Since the movement from E_0 to E_1 is along a ray from the origin, the percentage increase in prices $(P_1 - P_0)/P_0$ is equal to that of the money supply $(M_1 - M_0)/M_0$.³ The left panel of Fig. 1 is the purchasing power parity relationship [eq. (2)]. The initial exchange rate S_0 is given by the slope of the ray from the origin passing through the point P_0, P_0^* (the initial domestic and foreign prices). When monetary expansion causes prices at home to rise from P_0 to P_1 with foreign prices constant, the purchasing power parity line gets steeper and the exchange rate depreciates to S_1 . The percentage depreciation $(S_1 - S_0)/S_0$ is equal to the percentage increase in prices

$(P_1 - P_0)/P_0$.⁴ Since prices are proportional to the money supply and the exchange rate proportional to prices, it follows that the percentage depreciation is equal to the percentage increase in the money supply. This is a fundamental homogeneity result of the monetary approach.

The effect of an increase in income from y_0 to y_1 is illustrated in Fig. 2. This causes the demand for money to rise from $L(y_0, i_0)$ to $L(y_1, i_0)$ and, with the money supply held constant at M_0 , the additional demand is satisfied by prices falling from P_0 to P_2 .⁵ As indicated by the left panel of Fig. 2, to maintain purchasing power parity the lower prices mean that the exchange rate appreciates to S_2 . Other things equal, a growing economy experiences a strong currency.

The effect of increasing the domestic interest rate is the opposite to that of the increase in income. The higher interest rate induces people to economize on their holdings of money, which increases prices and depreciates the exchange rate. This result is best understood when the rise in the interest rate is due to inflationary expectations; a higher expected rate of inflation depreciates the currency.

A Nontraded Goods Extension

In eq. (2) the purchasing power parity condition is applied to aggregate price levels, which assumes that all goods are internationally traded. This assumption can be weakened by taking the parity to apply to traded goods only,

$$(4) \quad P_T = S P_T^*,$$

where P_T is the domestic price of traded goods and P_T^* is the corresponding foreign price.

The domestic price level is a linear homogeneous function of the prices of traded and nontraded goods (P_N),

$$(5) \quad P = P(P_T, P_N),$$

with

$$(6) \quad \lambda P = P(\lambda P_T, \lambda P_N).$$

Fig. 3 illustrates eq. (5). Along the curve labeled AA the price level is held constant at P_0 . AA gives the various combinations of P_T , P_N which are consistent with P_0 ; the schedule is negatively sloped because a higher P_T must be compensated by a lower P_N in order to keep P constant.⁶ We call AA the absolute price schedule.

If P_T and P_N increase equiproportionally, then (6) states that P also rises by the same proportion. This means that an increase in the price level shifts the absolute price schedule in an outward parallel fashion.⁷ An increase in the price level from P_0 to P_1 shifts the absolute price schedule to A'A' in Fig. 3. The proportionate outward shift (as measured along any ray from the origin) is equal to the percentage increase in the price level $(P_1 - P_0)/P_0$.

It is clear that the absolute price schedule cannot determine the values of P_T and P_N individually, only possible pairs of values; some further information about the real economy is needed. In particular, we need to specify how relative prices are determined. Let the relative price of traded to nontraded goods be α so that

$$(7) \quad P_T = \alpha P_N.$$

The most natural assumption is that the relative price α is determined by the real economy, i.e. by things such as factor endowments, income, technology, etc. Taking these determinants as being constant, eq. (7) is represented in Fig. 3 as the ray OR. This schedule gives the various combinations of P_T , P_N consistent with the constant relative price α ; it is a straight line from the origin because P_T and P_N must change equiproportionally in order to keep their ratio constant. We call OR the relative price schedule.

With the price level initially at P_0 , the economy must be located somewhere on the absolute price schedule AA. It must also be somewhere on OR for the relative price to equal α . It is clear that only the point E_0 satisfies both requirements simultaneously. E_0 is therefore the equilibrium, with prices P_{T0} and P_{N0} . When the price level rises to P_1 the equilibrium shifts to E_1 , corresponding to P_{T1} and P_{N1} . As the two equilibrium points lie on the ray from the origin OR, P_T and P_N increase equiproportionally. Also, the percentage increase in P_T and P_N is equal to the proportionate outward shift of the absolute price schedule $(OE_1 - OE_0)/OE_0$.⁸ As indicated previously, this shift is equal to the percentage increase in the price level $(P_1 - P_0)/P_0$. It follows that all three prices increase equiproportionally, $(P_{T1} - P_{T0})/P_{T0} = (P_{N1} - P_{N0})/P_{N0} = (P_1 - P_0)/P_0$.

To show what happens to the exchange rate when the domestic price of traded goods rises is just a matter of using purchasing power parity (4). The parity is illustrated in the left panel of Fig. 4, which is the same as

before (Fig. 1) except that price levels are now replaced with traded goods prices. The right panel of Fig. 4 reproduces Fig. 3. As can be seen, the effect of the rise in P and P_T is to depreciate the currency from S_0 to S_1 . It can be easily shown that the percentage depreciation equals the common percentage increase in all prices at home.

The result is that an x per cent rate of monetary expansion increases all prices at home and depreciates the currency by x per cent. This means that the extension of the model to take account of nontraded goods preserves the fundamental homogeneity result.

This homogeneity result is probably more applicable to the long run when all prices are fully flexible. Some interesting results emerge if we take the price of nontraded goods to be sticky in the short run. This stickiness could be due to the usual information lags, adjustment costs, etc. Fig. 5 illustrates the situation of increasing the price level when the price of nontraded goods is fixed at its initial value P_{N0} . The equilibrium shifts from E_0 to E_2 , that point on the absolute price schedule $A'A'$ corresponding to P_{N0} . The price of traded goods increases from P_{T0} to P_{T2} . As the nontraded goods price is fixed, P_T bears the entire burden of adjustment and its percentage increase is greater than that of the price level. This can be readily established by comparing the movement from E_0 to E_1 , where all prices increase equiproportionally, to the movement E_0 to E_2 , where P_T increases more than previously and where the increase in P is the same as before. As indicated in the left panel of Fig. 5, the higher price of traded goods depreciates the exchange rate from S_0 to S_2 .

At the new equilibrium point E_2 the price of traded goods in terms of nontraded is above that at E_0 . As the real economy has remained unchanged, this means there is an excess demand for nontraded goods. Over time this causes the relative price to fall, until it returns to its original value α . Consequently, E_2 is only the short-run equilibrium point; E_1 is the long-run (steady-state) equilibrium with the corresponding exchange rate S_1 . It should

be noted that in the transition from E_0 to E_2 the exchange rate depreciates, while from E_2 to E_1 it appreciates. This means that the exchange rate initially "overshoots" its long-run value, i.e. it initially depreciates too much so that a later appreciation is required. Therefore, the effect of sticky prices is to produce a time path which resembles the observed short-run instability of exchange rates.

The model can also be used to illustrate Balassa's (1964) hypothesis that purchasing power parity (PPP) has a systematic bias when based on price levels (which include both traded and nontraded goods). He argues that relative to a low productivity (poor) country, in a high productivity (rich) country the price of traded goods in terms of nontraded will be lower, due to productivity differences being more pronounced in the traded goods sector. This is illustrated in Fig. 6 where the relative price for the poor country is α_p and α_r is that for the rich country. To isolate the effects of the differing relative price structures, both countries share the same absolute price schedule AA. The equilibrium for the poor country is E_p and E_r for the rich, with exchange rates S_p and S_r . By construction, the price level in the two countries is the same so that PPP based on these price levels indicates that the two exchange rates should also be the same. Since the actual exchange rate for the rich country is lower than that for the poor ($S_r < S_p$), the conclusion is that this type of PPP calculation indicates that the rich country's currency is overvalued. This result is known as the productivity bias in PPP.

The framework can be used for a number of other applications. First, if nontraded goods are luxuries, then real income growth may lower the relative price of traded in terms of nontraded goods⁹; i.e. the slope of the relative price schedule falls. Income growth also shifts in the absolute price schedule on account of the higher demand for money. These two effects reinforce each other to lower the price of traded goods and appreciate the currency. Second, a trade tax increases P_T/P_N , i.e. it increases the slope of the relative price

schedule. For a given absolute price schedule, this increases P_T and lowers P_N (nominal prices), which depreciates the currency. Finally, foreign inflation increases P_T^* which appreciates the currency.

FOOTNOTES

1. See, for example, Bilson (1978), Clements and Frenkel (1980), Dornbusch (1976a, b), Frenkel (1976), Frenkel and Clements (1978), Kouri (1976), Mussa (1976) and the various studies in Frenkel and Johnson (1978).
2. Most empirical applications replace P^* in (3) with an expression obtained from equilibrium in the foreign money market, $M^*/L^*(y^*, i^*)$ where an asterisk indicates a foreign country variable.
3. If the monetary expansion raises income, then the demand for money rises and prices increase less than proportionally. In this case the relationship between M and P in Fig. 1 would not be a ray from the origin, it would have an elasticity of less than 1. The situation is similar if monetary expansion lowers the rate of interest.
4. In terms of Fig. 1, $S_0 = OP_0/OP_0^*$ and $S_1 = OP_1/OP_0^*$. Thus the percentage depreciation $(S_1 - S_0)/S_0 = (OP_1 - OP_0)/OP_0$, which is the percentage increase in domestic prices $(P_1 - P_0)/P_0$.
5. The more realistic situation would be (exogenous) income growth accompanied by an (exogenous) increase in the money supply, so that prices rise by less than they otherwise would (rather than actually falling).
6. The slope of AA is

$$-\frac{\partial P/\partial P_N}{\partial P/\partial P_T},$$

which is obviously negative.

7. The iso-value contours for any homogeneous function are radial expansions of each other and the distance of a contour from the origin is proportional to the value of the function.

8. I.e., since $\sin \alpha = OP_{T0}/OE_0 = OP_{T1}/OE_1$, it follows that $OE_1/OE_0 = OP_{T1}/OP_{T0}$ or $(OE_1 - OE_0)/OE_0 = (OP_{T1} - OP_{T0})/OP_{T0}$. In words, the proportionate outward shift in the absolute price schedule is equal to the percentage increase in P_T .
9. For the relative price to change in this way, we require an excess demand for nontraded goods at the initial relative price. If the source of the additional income is increased production of nontraded goods, then the demand for these goods must have a sufficiently large income elasticity for demand to grow at a faster rate than supply.

REFERENCES

- Balassa, B. (1964). "The Purchasing Power Parity Doctrine: A Reappraisal." Journal of Political Economy 72:584-96.
- Bilson, J.F.O. (1978). "The Current Experience with Floating Exchange Rates: An Appraisal of the Monetary Approach." American Economic Review 68:392-97.
- Clements, K.W. & Frenkel, J.A. (1980). "Exchange Rates, Money and Relative Prices: The Dollar-Pound in the 1920's." Journal of International Economics 10:249-62.
- Dornbusch, R. (1976a). "Capital Mobility, Flexible Exchange Rates and Macroeconomic Equilibrium." In Claassen, E. and Salin, P. (eds.) Recent Issues in International Monetary Economics. Amsterdam: North-Holland. Pp. 29-48.
- _____ (1976b). "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy." Scandinavian Journal of Economics 78: 255-75. Reprinted in Frenkel, J.A. and Johnson, H.G. (eds.) The Economics of Exchange Rates: Selected Studies. Reading, Mass.: Addison-Wesley, 1978.
- Frenkel, J.A. (1976). "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence." Scandinavian Journal of Economics 78:200-24. Reprinted in Frenkel, J.A. and Johnson, H.G. (eds.) The Economics of Exchange Rates: Selected Studies. Reading, Mass.: Addison-Wesley, 1978.
- _____ & Clements, K.W. (1978). "Exchange Rates in the 1920's: A Monetary Approach." Forthcoming in M.J. Flanders and A. Razin (eds.) Development in an Inflationary World. New York: Academic Press.
- _____ & Johnson, H.G. (eds.) (1978). The Economics of Exchange Rates: Selected Studies. Reading, Mass.: Addison-Wesley.

Kouri, P.J.K. (1976). "The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach."

Scandinavian Journal of Economics 78:280-304.

Mussa, M. (1976). "The Exchange Rate, the Balance of Payments and Monetary and Fiscal Policy under a Regime of Controlled Floating."

Scandinavian Journal of Economics 78:229-48. Reprinted in

Frenkel, J.A. and Johnson, H.G. (eds.) The Economics of Exchange Rates: Selected Studies. Reading, Mass.: Addison-Wesley, 1978.

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

FIGURE 6