International Finance Discussion Papers

Number 114

December 1977

INFLATION AND UNEMPLOYMENT IN OPEN ECONOMIES

by

Betty C. Daniel

Inflation and Unemployment in Open Economies

Betty Daniel*

I. Introduction

Since Phillips first introduced the notion of a stable, negative relationship between inflation and unemployment, economists have debated its validity on theoretical and empirical grounds. Opponents have argued that if labor supply and labor demand both depend on the same real wage, then unemployment is fixed at the natural rate implied by that real wage, regardless of the rate of inflation. This "Phillips Curve", interpreted loosely as the relationship between inflation and unemployment, is vertical instead of negatively sloped. To obtain a theoretical justification for the sometimes observed negative relationship, economists have appealed to the hypothesis that the real wage as perceived by the worker may differ from the real wage perceived by the employer. Specifically, an increase in the price level is immediately perceived by the employer as a reduction in the real wage since the price of his product has risen. Workers do not realize that the general price level has risen and therefore do not perceive a reduction in their real wage. Thus, with higher inflation, greater output is possible until workers learn that the real wage has fallen. The latter induces a

---

Economist; Division of International Finance; Board of Governors of the Federal Reserve System. This paper represents views of the author which are not necessarily those of the Board of Governors or of its staff. The author wishes to thank members of the Division of International Finance, and in particular, Dale Henderson, Peter Clark, and David Howard for extremely helpful criticisms of earlier drafts. Remaining errors are the author's responsibility.

bidding up of nominal wages returning real wages to their former levels. This hypothesis yields the negative relation between inflation and unemployment in the short-run, but requires a vertical Phillips Curve in the long-run. In his Nobel lecture, Friedman cites recent experience which suggests that there is a positive relationship between high rates of inflation and high unemployment.[1/] This paper offers a theoretical explanation for this phenomenon.

Most work relating rates of unemployment to rates of inflation has been done in the context of a closed economy. In the recent past, countries have become relatively more open and the system of floating exchange rates, adopted by the major industrial countries, has greatly impinged on domestic economic activity.

This paper investigates the concept of a natural rate of unemployment in the context of a small, open, flexible exchange rate country. In the long-run, a natural rate, dependent on real variables including the terms of trade, exists. In the short run, output can differ from the natural rate even when workers and employers have full information and rational expectations. This is because the real wage from the employer's point of view differs from the real wage from the worker's point of view; the latter must include the price of imports, not domestically produced, to adequately measure the purchasing power of wages. The short-run relationship between inflation and unemployment is investigated.

Recent work on countries with flexible exchange rates has explained the observed high degree of volatility of exchange rates using the assumption that asset markets adjust fast relative to goods markets. In the analysis presented here, wages and prices are sticky allowing for disequilibrium in the labor and goods markets at any point in time. Output and employment are determined by the minimum of supply and demand. Rates of return on assets adjust instantaneously, resulting in continous maintenance of equilibrium in these markets. The assumptions have interesting implications for the relationship between unemployment and inflation.

Specifically, the implications of monetary expansion and constraction are investigated. Monetary contraction yields observations of a low rate of inflation together with a high rate of unemployment implying the existence of the typical negative relationship between inflation and unemployment. Monetary expansion, however, yields observations of a high rate of inflation and low output and employment implying the recently observed positive correlation between inflation and unemployment. Furthermore, since the effectsof monetary expansion and contraction are asymmetrical, the analysis implies that there is no stable relationship between the two aggregates over the short run. The long-run Phillips Curve is vertical at the natural rate implied by the long-run terms of trade.

II. Model

A. Expectations and Perfect Capital Mobility

The model presented here is an adaptation of that used by Dornbusch in "Expectations and Exchange Rate Dynamics".[2/] As in Dornbusch,

domestic and foreign interest-bearing assets are assumed to be perfect substitutes. The domestic rate of interest equals the foreign interest rate, r*, plus the expected rate of depreciation of the domestic currency:

$$(1) \quad r = r^* + E(\dot{e}).$$

Also, as in Dornbusch, the expected rate of change of the exchange rate is assumed to be proportional to the difference between the long-run value of the exchange rate, which is assumed known, and its current value. This hypothesis is consistent with perfect foresight as is demonstrated later in the paper. Letting $\bar{e}$ and e denote respectively the logs of the long-run equilibrium exchange rate and the current rate, we obtain:

$$(2) \quad E(\dot{e}) = \theta(\bar{e} - e).$$

People also form expectations of the rate of inflation of the price of domestic commodities. Under perfect foresight, the expected rate of inflation, $E(\dot{p})$, equals the actual rate. This results in:

$$(3) \quad E(\dot{p}) = \dot{p}.$$

B. Goods and Labor Markets

The domestic country is completely specialized in the production of the domestic commodity, some of which is exported. It imports a commodity produced in the rest of the world whose price in terms of foreign currency is fixed. Domestic wages and the prices of domestically produced goods adjust slowly to equilibrate demand and supply in the markets for labor and for commodities. At a point in time, these markets can be characterized by disequilibrium. The quantity of labor used and the level

of output are determined by the minimum of supply and demand. In the long run, prices and wages equilibrate supplies and demands.

The log of aggregate demand for the domestic commodity depends on the log of relative prices, e-p, on the log of real income, y, and on the domestic interest rate, r, according to:[3/]

$$(4) \quad \ln D = u + \delta (e-p) + \gamma_y - \sigma r.$$

The demand for labor is, in turn, assumed to depend on aggregate demand. With a fixed marginal product of labor,[4/] labor demand equals the labor/output ratio times aggregate demand. The log of labor demand therefore equals:

$$(5) \quad \ln L^D = \ln \pi + u + \delta(e-p) + \gamma_y - \sigma r.$$

At any instant, labor supply depends on the purchasing power of the nominal wage. The relevant index to deflate the money wage is therefore a consumer price index which contains the price of imports as well as the price of domestic goods. t_i are fixed weights used to construct the index, and $\Sigma t_i = 1$. The log of labor supply is therefore:

$$(6) \quad \ln L^S = \alpha (w - t_p p - t_e e)$$

where α is the elasticity of supply with respect to the real wage.[5/]

In the short run, wages and prices of domestic goods are sticky resulting in disequilibrium in the labor and goods markets. The quantity of labor actually utilized is determined by the minimum of labor supply and labor demand, as in (7):

$$(7)\quad \ln L = \min.\ [(-\ln\pi + u + \delta(e-p) + \gamma_y - \sigma r);\ \alpha\,(w - t_p p - t_e e)].$$

Output in the short run must equal the minimum of demand-determined and supply-determined output, resulting in :

$$(8)\quad y = \min.\ [\frac{1}{1-\gamma}\,(u + \delta(e-p) - \sigma r);\ \ln\pi + \alpha\,(w - t_p p - t_e e)],$$

where $1 - \gamma > 0$.

Over time, the anticipated real wage, the nominal wage deflated by the expected consumer price index, adjusts to eliminate excess demand in the labor market. The price of domestic commodities is bid down to costs as the real wage is adjusted to the fixed marginal product of labor. Under the expectations formation hypothesis described previously, the expected rate of increase in the consumer price index, $\dot{\Omega}$, can be expressed as:

$$(9)\quad \dot{\Omega} = t_p\dot{p} + t_e\,\theta(\bar{e}-e).$$

Therefore the rate of change in wages and prices is determined by:

$$(10)\quad \dot{p} = \dot{w} = \beta[-\ln\pi + u + \delta(e-p) + \gamma_y - \sigma r - \alpha\, t_e(p-e)] + t_p\dot{p} + t_e\theta(\bar{e}-e).$$

Labor supply is expressed as $\alpha\, t_e(p-e)$ using the substitutions that $w = p$ and $t_e = 1 - t_p$.

The foregoing specification of the labor and goods markets is a simplification of a more thorough specification which would require distinct adjustment mechanisms for $\dot{p}$ and for $\dot{w}$. Little generality is lost by fixing the real wage (through the assumption of a fixed marginal product

of labor) when the analysis is confined to monetary as opposed to real shocks, since the former do not require a change in the equilibrium real wage.[6/]

In the long run, equilibrium is attained in the goods and labor markets; $\dot{p} = \dot{w} = 0$; $r = r^*$, and demands and supplies of commodities and of labor services are equated. The long-run level of output, and identically, the natural rate of unemployment, depend ultimately on the long-run terms of trade $(\bar{p}-\bar{e})$.[7/] The monetary shocks analyzed in this paper do not affect these relative prices, but real shocks could. Improved terms of trade, resulting from an increase in demand, imply a lower natural rate of unemployment and a higher level of output. Analogously, deteriorated terms of trade decrease the natural rate of unemployment. The long-run equilibrium level of output is endogenous to the system to the extent that the long-run terms of trade are endogenous.

Using the definition of the long run described above and equation (10), the wage-price equation can be written as:

$$(11)\quad \dot{p} = \frac{\beta}{t_e}\left[(\delta + \alpha t_e)(\bar{p}-p) - \left(\delta + \alpha t_e + \sigma\theta - \frac{\theta t_e}{\beta}\right)(\bar{e}-e) - \gamma(\bar{y}-y)\right].$$

C. Money Market

The money market is identical to that used by Dornbusch. Real money demand depends positively on real output and negatively on the domestic interest rate. The function is log linear in the interest

rate and in the logs of the nominal money supply, the price level and real income:[8/]

$$(12) \quad m - p = \varphi_y - \lambda r.$$

Imposing the assumptions of perfect capital mobility and perfect foresight results in:

$$(13) \quad m - p = \varphi y - \lambda r^* - \lambda\theta(\bar{e}-e).$$

Equation (13) can be solved for the relationship between the current exchange rate, the price level, and the long-run exchange rate under conditions of asset market equilibrium. A bar (-) denotes the long-run equilibrium value of the variable. The short-run price level from equation (13) can be expressed as:

$$(14) \quad p = m - \varphi y + \lambda r^* + \theta\lambda(\bar{e}-e).$$

In the long run, current and long-run exchange rates are equal, and $y = \bar{y}$, yielding an expression for the long-run equilibrium price level, $\bar{p}$.

$$(15) \quad \bar{p} = m - \varphi\bar{y} + \lambda r^*$$

Using equations (14) and (15) we derive a relationship between the exchange rate and the price level and output under conditions of asset market equilibrium:

$$(16) \quad e = \bar{e} - \frac{1}{\theta\lambda}(p-\bar{p}) - \frac{\varphi}{\theta\lambda}(y-\bar{y}).$$

D. Solutions--time paths

Since output is determined by the minimum of supply and demand, there are two sets of time paths for the variables depending on whether output is supply, or demand-determined. Using equations (8) and (16) to solve for the short-run values of the exchange rate and the level of output as functions of their long-run equilibrium levels and of the deviation of short from long-run price, under the assumption that output is supply-determined, yields:

$$(17) \quad e = \bar{e} + \frac{1 + \varpi\alpha t_e}{\theta\lambda - \varphi\alpha t_e} \; (\bar{p}-p);$$

$$(18) \quad y = \bar{y} - \frac{(\theta\lambda+1)(\alpha t_e)}{\theta\lambda - \varphi\alpha t_e} \; (\bar{p}-p).$$

$\theta\lambda - \varphi\alpha t_e$ can be signed positive under the assumption that an increase in the exchange rate must reduce the excess supply of money allowing for the effect of the exchange rate on output. The exchange rate moves in the opposite direction of the price level and output moves with the price level when output is supply determined.

Analogous expressions can be derived for the exchange rate and for the level of output under the assumption that output is demand determined:

$$(17^*) \quad e = \bar{e} + \frac{(1-\gamma) - \varphi\delta}{(1-\gamma)\theta\lambda + \varphi(\delta+\sigma\theta)} \; (\bar{p}-p);$$

$$(18^*) \quad y = \bar{y} + \frac{\delta + \sigma\theta + \delta\theta\lambda}{(1-\gamma)\theta\lambda + \varphi(\delta+\sigma\theta)} \; (\bar{p}-p).$$

The exchange rate moves ambiguously with the price level and output changes negatively with the price level when the system is demand-constrained.

Substituting (17) and (18) into (11) yields an expression for the rate of inflation as a function of current and long-run prices when output is supply-determined:

$$(19)\quad \dot{p} = V\,(\bar{p}-p), \text{ where}$$

$$V = \frac{\beta}{te[\theta\lambda-\varphi\alpha t_e]}\,[(1-\gamma)(\alpha t_e\theta\lambda + \alpha t_e) + \sigma\theta(1+\varphi\alpha t_e) + \delta(1+\theta\lambda) - \frac{\theta t_e}{\beta}(1+\varphi\alpha t_e)]$$

When output is demand determined, the rate of inflation is determined by (19*) which is derived by substituting (17*) and (18*) into (11).

$$(19^*)\quad \dot{p} = V^*\,(\bar{p}-p), \text{ where}$$

$$V^* = \frac{\beta}{t_e[(1-\gamma)\theta\lambda+\varphi(\delta+\sigma\theta)]}[(1-\gamma)(\sigma\theta\lambda + \alpha t_e\theta\lambda + \alpha t_e - \frac{\theta t_e}{\beta}) + \sigma\theta(1+\varphi\alpha t_e) + \delta + \theta\lambda\gamma\delta + \frac{\theta t_e}{\beta}\varphi\delta]$$

The foregoing expressions for the movement of prices are consistent with perfect foresight when $\theta = V$ and $\theta^* = V^*$.

$$\theta = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \quad \text{and} \quad \theta^* = \frac{-B^* \pm \sqrt{B^{*2} - 4A^*C^*}}{2A^*}$$

where $A = \lambda t_e$

$$B = -\varphi\alpha t_e^2 - \beta(1-\gamma)\alpha t_e\lambda - \beta\sigma(1+\varphi\alpha t_e) - \beta\lambda\delta + t_e(1+\varphi\alpha t_e)$$

$$C = -\beta(1-\gamma)\alpha t_e - \beta\delta$$

$$A^* = \lambda t_e (1-\gamma) + \varphi\sigma$$

$$B^* = \varphi\delta - \beta(1-\gamma)(\alpha t_{e\lambda} + \sigma\lambda - \frac{t_e}{\beta}) - \beta\sigma(1 + \varphi\alpha t_e) - \beta\lambda\gamma\delta - t_e\varphi\delta$$

$$C^* = -\beta(1-\gamma)\alpha t_e - \beta\delta$$

Since $-4AC$ and $-4A^*C^*$ are unambiguously positive, a stable root for θ, consistent with perfect foresight, can be chosen. Stable θ and θ^* are positive.

The time paths for the price level are expressed as:

$$(20) \quad p(t) = \bar{p} + (p_o - \bar{p}) \exp(-Vt);$$

$$(20^*) \quad p(t) = \bar{p} + (p_o - \bar{p}) \exp(-V^*t).$$

For supply determined output, the paths for the exchange rate and the level of output can be derived using (17), (18) and (20):

$$(21) \quad e(t) = \bar{e} + \frac{1+\varphi\alpha t_e}{\theta\lambda - \varphi\alpha t_e}(p_o - \bar{p}) \exp(-Vt);$$

$$(22) \quad y(t) = \bar{y} - \frac{(\theta\lambda+1)\alpha t_e}{\theta\lambda - \varphi\alpha t_e}(p_o - \bar{p}) \exp(-Vt).$$

For demand-determined output, the paths are analagously:

$$(21^*) \quad e(t) = \bar{e} + \frac{1-\gamma-\sigma\delta}{(1-\gamma)\theta\lambda + \varphi(\delta+\sigma\theta)}(p_o - \bar{p}) \exp(-V^*t);$$

$$(22^*) \quad y(t) = \bar{y} + \frac{\delta+\sigma\theta+\delta\theta\lambda}{(1-\gamma)\theta\lambda + \varphi(\delta+\sigma\theta)}(p_o - \bar{p}) \exp(-V^*t).$$

E. Short and long-run equilibrium

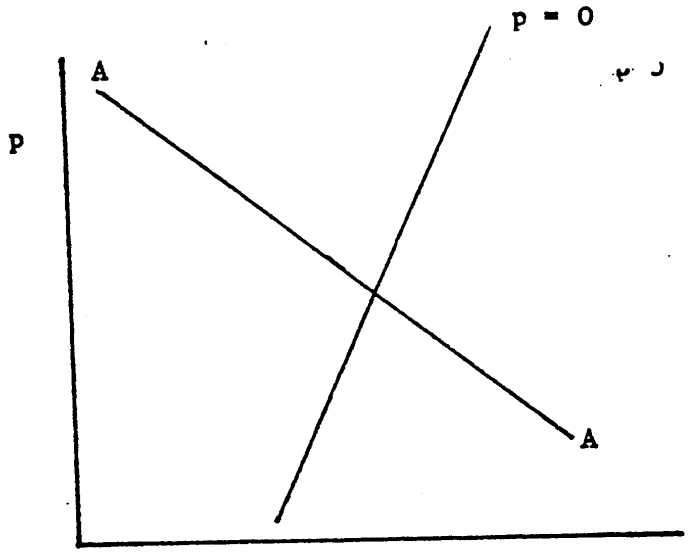

Figure I e

Figure I can be used to describe short and long-run equilibrium positions. The AA schedule requires equilibrium in the asset markets for a given level of output. An increase in e creates the expectation of a future fall in e thereby lowering the domestic interest rate. This creates an excess demand for money, requiring a fall in the price level to maintain money market equilibrium. The AA curve shifts right with an increase in the money supply since a higher price and exchange rate are necessary to reduce the excess supply of money. An increase in output, creating excess money demand, requires a fall in the price level an

in the exchange rate shifting the AA curve left. Since asset market equilibrium is instantaneously attained, the economy must always be on the AA schedule.

The $\dot{p} = 0$ schedule describes the condition for goods market equilibrium. Output supplied must equal output demanded ($y=\bar{y}$). An increase in the exchange rate creates excess demand for the domestic good which can be alleviated only by an increase in price. $\frac{dp}{de} > 1$ since an increase in e decreases the interest rate increasing aggregate demand. The economy attains goods market equilibrium only over time.

III. Policy and its Implications

A. Monetary Expansion

Consider the long-run effects of monetary expansion. No real variables are affected requiring $\frac{d\bar{p}}{dm} = \frac{d\bar{e}}{dm} = 1$ and $\frac{d\bar{y}}{dm} = 0$. In Figure IA, the AA curve must shift out along the 45° line, such that these results hold, to $\bar{\bar{A}}\bar{\bar{A}}$. In Figure IIA, aggregate supply and demand curves for the domestic

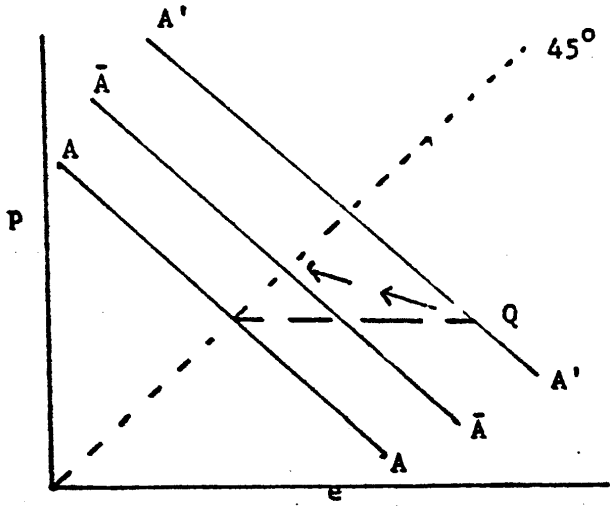

Figure IA

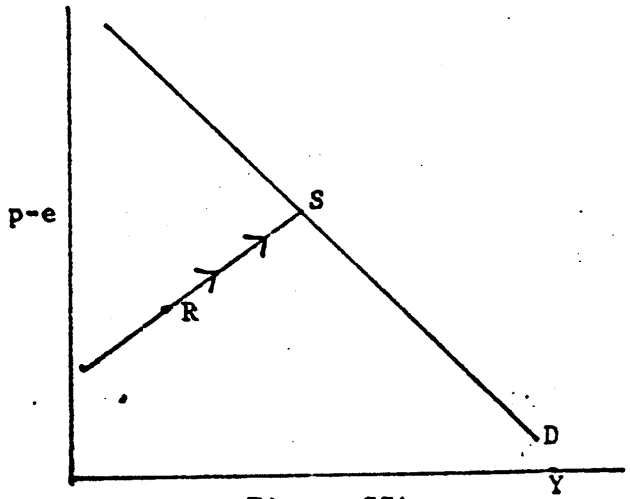

Figure IIA

commodity are represented. Notice that the supply of output is coincident with the demand for output until the relative price falls enough such that labor actually utilized is constrained by the quantity of services workers are willing to provide. No real variables are affected when the money supply changes and there are no shifts in the supply or demand curves. Long-run real output is unchanged.

Consider next the impact effects of monetary expansion. Monetary expansion increases $\bar{p}$ causing a reduction in output of $\frac{-(\theta\lambda+1)\alpha^{t}e}{\theta\lambda-\varphi\alpha^{t}e}$ according to equation (18). From (17), the exchange rate increases by $1 + \frac{1+\varphi\alpha^{t}e}{\theta\lambda-\varphi\alpha^{t}e}$. It should be noted here that overshooting of the exchange rate exceeds that attained when output is assumed to be fixed. Dornbusch found the impact effect on the exchange rate under conditions of fixed output to be $1 + \frac{1}{\theta\lambda}$. Overshooting is greater in this case because the induced fall in output reduces money demand, exacerbating the excess supply of money. An even larger decline in the interest rate, caused by a movement of the spot exchange rate relative to the long-run equilibrium rate is necessary to equilbriate the money market. According to (19), the rate of inflation increases.

The intuitive explanation is as follows. The increase in the money supply depreciates the exchange rate. This reduces the real wage from the workers' point of view because it increases the consumer price index. The economy instantaneously moves down along the

supply curve in Figure IIA to R. Quantity demanded increases due to the lower relative price of the domestic good, but output falls since quantity supplied falls. The fall in output exacerbates the excess supply of money causing AA to shift further right than implied by its long-run equilibrium position. Increased money supply and a lower domestic income require a fall in the domestic interest rate to maintain money market equilibrium. This is accomplished when the domestic currency depreciates beyond its long-run equilibrium value thereby generating expectations of future appreciation. Upon impact, then, the economy settles at an exchange rate implied by point Q in Figure IA and at a level of output implied by point R in Figure IIA. The rate of inflation of wages and prices is higher.

As prices increase, equations (21) and (22) describe the paths of the exchange rate and of income. The exchange rate falls and output increases. The economy moves up along the supply curve in Figure IIA. As output increases, A'A' in Figure IA shifts left toward $\bar{A}\bar{A}$. The exchange rate is falling to its new long-run value, $\bar{e}$.

Consider now the implications of this analysis for the relationship between inflation and unemployment. $\bar{y} - y$ is used to represent unemployment in Figure IIIA. Full employment is defined as long-run output. This implies that positions where labor is on its supply curve, but where the quantity of labor firms wish to hire at the given real wage is not satisfied, full employment does not exist.

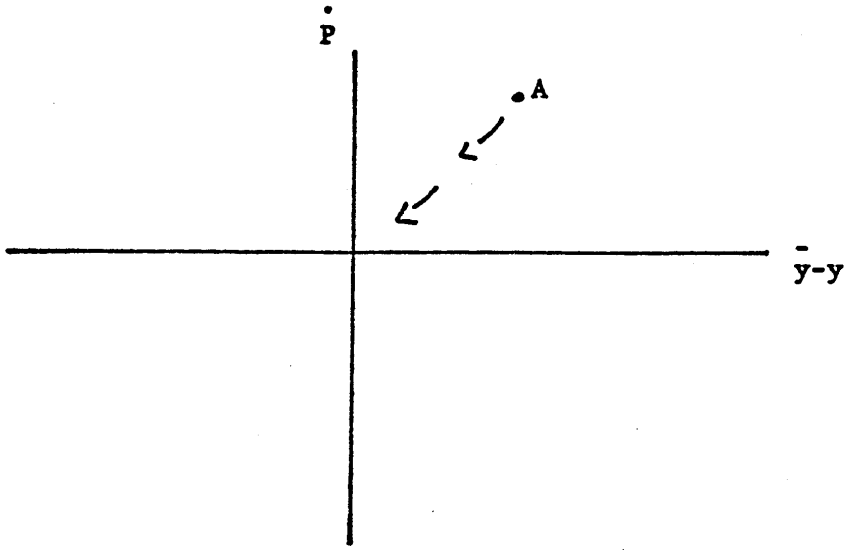

Figure IIIA

The impact effect of monetary expansion is to create higher inflation and lower output (higher unemployment) moving the economy from the origin to say, point A, in Figure IIIA.[9/] As adjustment proceeds, with rising prices, the rate of inflation and unemployment both fall moving the economy back to the origin. One observes a positive correlation between unemployment levels and rates of inflation during the period of adjustment.

It should be noted that the foregoing was a consideration of monetary expansion from a point of equilibrium. If monetary expansion were undertaken from a disequilibrium position caused by monetary contraction such that excess supply exists in the labor market and output is demand-determined, monetary expansion, by depreciating the exchange rate, could increase the demand for labor and output without reducing the supply of labor to the point where the supply constraint becomes binding. This would result in a monetary expansion increasing real output. This same result is derived in aggregate demand models where the supply constraint is never binding, either because there is an excess supply of labor or because labor supply is infinitely elastic.

B. Monetary Contraction

The long-run effects of monetary contraction are exactly opposite those of monetary expansion. No real variables are affected requiring $\frac{d\bar{p}}{d(-m)} = \frac{d\bar{e}}{d(-m)} = 1$ and $\frac{d\bar{y}}{d(-m)} = 0$. In Figure IB, the AA curve must shift leftward to $\bar{A}\bar{A}$ such that these results hold.

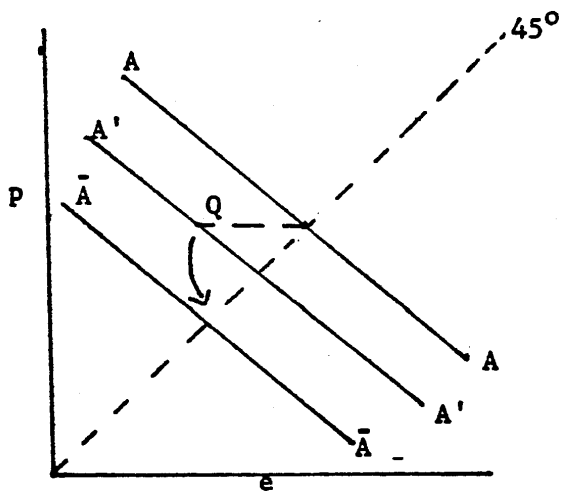

Figure IB

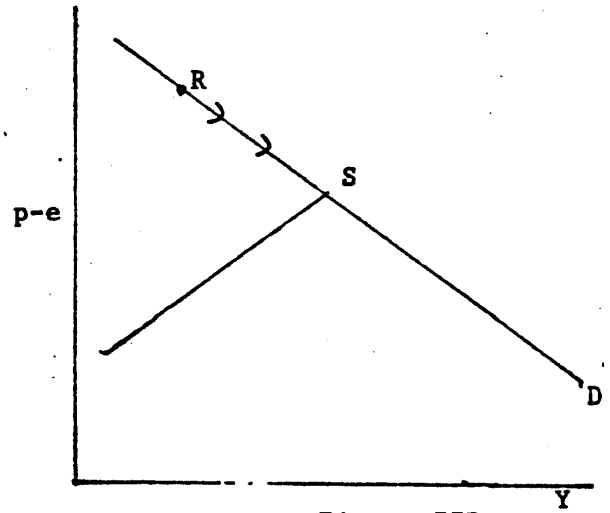

Figure IIB

The supply and demand curves in Figure IIB are unaffected as no real variable changes. Therefore, long-run real output is unchanged.

Consider next the impact effects of monetary contraction. $\bar{P}$ falls causing a reduction in output of $-\frac{\delta+\sigma\theta+\delta\theta\lambda}{(1-\gamma)\theta\lambda+\varphi(\delta+\sigma\theta)}$ according to equation (18*). From (17*) the exchange rate falls by $-1-\frac{(1-\gamma-\varphi\delta)}{(1-\gamma)\theta\lambda+\varphi(\delta+\sigma\theta)}$. Notice that since the second term is ambiguous, the exchange rate does not necessarily fall below its new long run equilibrium value. According to (19*), the rate of inflation increases.

Monetary contraction creates an excess demand for the domestic currency leading to an appreciation of the exchange rate. The appreciation reduces the demand for domestic goods reducing output to the level implied by R in Figure IIB. The reduction in output alleviates some of the excess demand for money. It is not necessary for the domestic interest rate to rise to equilibrate the money market. Therefore, the exchange rate does not necessarily fall below its new long-run equilibrium level and subsequently rise. Graphically, the fall in output prevents AA from shifting as far as $\bar{A}\bar{A}$ upon impact. The exchange rate immediately falls, as indicated by point Q but it could subsequently remain constant, rise, or fall, depending on the magnitude of the AA shift. The impact effect is to move the economy to a lower exchange rate implied by point Q in Figure IB and to a lower level of output implied by point R in Figure IIB. The rate of inflation of wages and prices is lower.

As prices fall, equations (21*) and (22*) describe the paths of the exchange rate and income. Output increases and the exchange rate can be rising or falling. The economy moves down along the demand curve in Figure IIB. In Figure IB, the economy stays along the AA curve as it shifts to $\bar{A}\bar{A}$ implying an ambiguous movement in the exchange rate during the approach to long-run equilibrium.

Consider the implications of monetary contraction for the relationship between inflation and unemployment. The impact effect is to create lower inflation and lower output (higher unemployment) moving the economy from the origin to a point like A in Figure IIIB.[10/]

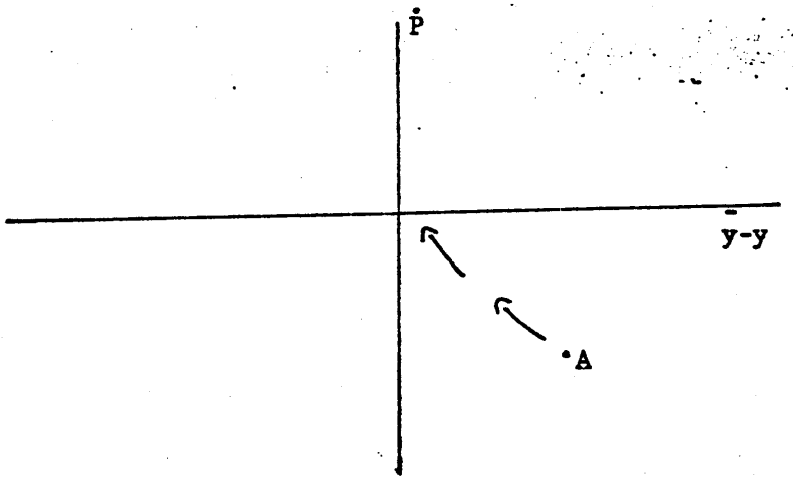

Figure IIIB

As prices fall, the rate of change of prices approaches zero and unemployment falls moving the economy back toward the origin. During adjustment, one observes the traditional positive correlation between unemployment and inflation.

IV. Conclusions

This analysis demonstrates that if asset markets adjust fast relative to goods markets in an open economy, then there is no stable short-run relationship between inflation and unemployment. Expansionary monetary policy reduces supply, yielding a positive relationship between inflation and unemployment, while contractionary monetary policy reduces demand resulting in the traditional negative relationship between inflation and unemployment. In the long-run, output and employment are

determined by the terms of trade, implying that any policy which affects the long-run terms of trade can affect long-run output. The long-run Phillips Curve is vertical at the level implied by the long-run terms of trade, but there is no stable short-run relationship between inflation and unemployment.

Footnotes

1/ In his Nobel Lecture, Friedman succinctly summarizes the theoretical and empirical history of the relationship between inflation and unemployment. Milton Friedman, Nobel Lecture: Inflation and Unemployment." Journal of Political Economy, 85, #3 (June, 1977), pp. 451-472.

2/ Rudiger Dornbusch, "Expectations and Exchange Rate Dynamics," Journal of Political Economy 84, (December 1976).

3/ Assuming that aggregate demand depends on nominal income deflated by the consumer price index, $p + y - t_e e - t_p p = y + t_e(p-e)$, adds a terms of trade effect of a change in relative prices. In this analysis, it is assumed that the substitution effect dominates the terms of trade effect, and for clarity in presentation, the terms of trade effect is not carried through.

Also, aggregate demand could be dependent on the real interest rate $r - t_e\theta(\bar{e}-e) - t_p\dot{p}$. The analysis becomes more cumbersome under this assumption, but is not qualitatively changed. Imposing perfect foresight requires $r = r^* + \theta(e-e) = r - t_e\theta(e-e) - t_p\dot{p}$. The $\theta(\bar{e}-e)$ term enters with a different weight and the $\dot{p}$ term affects magnitudes, as in Dornbusch, 1976, but no signs.

4/ The marginal product of labor can be fixed when there is only one variable factor of production or underutilized capital stock.

5/ Specification of labor supply as a function of this real wage is found in Joanne Salop, "Devaluation and the Balance of Trade Under Flexible Wages," in Trade, Stability and Macroeconomics: Essays in Honor of Lloyd A. Metzler, ed., George Horwich and Paul Samuelson (1974), pp. 129-52.

6/ When a real shock is considered, fixing one real variable forces all the adjustment on the remaining real variables reducing the generality of the result.

7/ To see this, merely note that in the long-run, output must be produced along the supply curve where it intersects demand. Exogenous factors can shift the demand curve along the supply curve affecting the equilibrium terms of trade.

8/ Alternatively the stock of money could be deflated by the price index $t_e e + t_p p$ and nominal income deflated by the price index, $y + t_e(p-e)$, could be used as the real income measure. This would not change the analysis qualitatively because an increase in price would reduce the excess supply of money as before by reducing the real money supply but also by increasing real income and real money demand. Also, an increase in the exchange rate reduces the excess supply of money both by reducing real money demand through a lower interest rate when the assumption of perfect foresight is imposed, and by reducing the real supply of money.

9/ The direction of the effect is the same if inflation of the consumer price index is considered instead of the producer price index.

10/ Again, the direction of the effect is the same when the rate of inflation of the consumer price index is considered instead of inflation in the producer price index.

References

Barro, R.J. and Grossman, H.K., 1971, "A General Disequilibrium Model of Income and employment," American Economic Review, 61: 82-93.

Brito, D.L. and Richardson, David J. "Some Disequilibrium Dynamics of Exchange Rate Changes." Journal of International Economics, 5 (1975): 1-13.

Dornbusch, Rudiger. "Expectations and Exchange Rate Dynamics." Journal of Political Economy 84 (December 1976): 1161-76.

Dornbusch, R. "Exchange Rate Expectations and Monetary Policy. Journal of International Economics 6 (1976): 231-245.

Frenkel, A.K. "A Monetary Approach to the Exchange Rate." The Scandinavian Journal of Economics 78 (1976): 200-224.

Henderson, Dale. "Exchange Market Intervention Policy and Expectations Formation." Discussion Paper, International Finance Division, Board of Governors of the Federal Reserve System, March 1977.

Muth, John F. "Rational Expectations and the Theory of Price Movements." Econometrica 29 (July 1961): 315-35.

Mundell, Robert A. "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates." Canadian Journal of Economics and Political Science 29 (Nov. 1963): 475-85.

Salop, Joanne. "Devaluation and the Balance of Trade Under Flexible Wages," in Trade, Stability and Macroeconomics: Essays in Honor of Lloyd A. Metzler, ed., George Horwich and Paul Samuelson (1974): 129-52.