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RELATIVE PRICES, EMPLOYMENT, AND THE EXCHANGE RATE IN AN ECONOMY WITH FORESIGHT

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Abstract

This paper studies the effects of monetary policy in a small, open economy with a floating exchange rate, sticky wages, and rational expectations in both the asset and labor markets. The model developed emphasizes the link between exchange-rate depreciation and nominal wage inflation, embodying it in an expectations-augmented Phillips curve. The economy studied produces both traded and non-traded goods, and thus provides a framework in which to explore the connection between the dynamic behavior of the exchange rate and the supply structure and degree of openness of the economy. In addition, the paper examines the "vicious circle" hypothesis, showing how an explosive cycle of exchange-rate depreciation and wage-price inflation may arise in response to an <u>expected</u> monetary expansion.

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1. Introduction

A striking feature of the recent experience with flexible exchange rates has been the widely-observed sensitivity of nominal wages and national price levels to exchange-rate fluctuations.[1] The close link between the exchange rate and domestic prices, operating through both demand-side substitution between home and tradable goods and through resistance in the labor market to real wage cuts, has helped undermine early beliefs--as expressed, for example, by Johnson [22]--that a regime of market-determined exchange rates can enhance the efficacy of monetary policy as a stabilization tool while ensuring balance-of-payments equilibrium.[2] Indeed, much recent policy discussion has centered on the possibility that freely floating exchange rates may be inherently unstable. This "vicious circle" view of the current arrangements holds that inflationary asset-market disturbances entail short-term exchange-rate movements which feed into domestic price levels and may set off successive, explosive rounds of wage-price inflation and further exchange-rate depreciation.[3] The concern is reflected in the emphasis on exchange-rate surveillance in the revised Articles of Agreement of the International Monetary Fund, in the adoption of informal exchange-rate targets by most central banks, and in the emergence of more formal arrangements to limit the degree of exchange-rate flexibility, such as the European Monetary System.[4]

This paper studies the effects of monetary policy in a small, open economy with a floating exchange rate, sticky wages, and rational expectations in both asset and labor markets. The model developed here emphasizes the link between exchange-rate depreciation and nominal wage inflation, embodying it in an expectations-augmented Phillips curve. The institutional assumption made below is that an economy-wide nominal wage is determined in advance of the period in which it is to prevail, with workers agreeing to supply all the labor required by employers during this period.[5] Expected real wages rise gradually over time whenever the demand for labor by firms persistently exceeds a fixed natural level of labor supply, and decline over time in the opposite situation. For the sake of analytical simplicity, the analysis below is carried out in continuous time. The assumption that the nominal wage is a predetermined variable that cannot jump instantaneously but must adjust gradually provides a rough approximation to the set of wage-setting arrangements described above. The model may be interpreted as one in which unions and firms interact to reverse the real-wage changes induced by unanticipated price fluctuations through successive wage bargains that push the real wage toward the level equating aggregate labor demand to full-employment labor supply.[6]

The interplay between various wage rigidities and the effects of monetary policy has been studied by Argy and Salop [1], Bilson [3], Burgstaller [9], and Sachs [30] in models based on the classic Mundell-Fleming framework of a single domestically-produced good with endogenously-determined terms of trade.[7] The economy studied in this paper comprises sectors producing both traded and non-traded goods, and thus provides a framework in which to explore the relationship between patterns of aggregate dynamics and the underlying supply structure and degree of openness of the economy.[8] Of particular interest are the model's predictions concerning the effects of monetary policy on the real exchange rate (defined as the domestic-currency price of foreign exchange deflated by the general price level),[9] on the domestic real interest rate (defined as the domestic nominal interest rate minus the expected instantaneous percentage rate of increase of the general price level), and the nominal interest rate itself. While recent discussions of exchange-rate dynamics, notably those of Dornbusch [12] and Mussa [26], have ascribed persistent movements in all these variables, in part, to speed-of-adjustment differentials between asset and domestic goods markets,[10] the approach followed here allows goods prices to adjust instantaneously to clear output markets. The temporary real effects of money and the dynamics of adjustment are consequences of the wage-setting process, which responds only over time to labor-market pressures and inflationary expectations.

The organization of the paper is as follows.

Section 2 presents a model of a small open economy producing traded goods only. The price level in this economy fully reflects any movement in the exchange rate, but a temporarily rigid nominal wage induces a dynamic adjustment to monetary disturbances. In the model of this section, the initial depreciation of the exchange rate in response to an unanticipated, permanent increase in the money supply falls short of its long-run depreciation, so that the exchange rate "undershoots" its eventual level.[11] Monetary policy exerts a transitory effect on output through its impact on the real wage, but can influence neither the real exchange rate nor the real interest rate, which are exogenously determined.

The model is made more realistic in Section 3 through the explicit introduction of non-traded or home goods that are regarded by consumers as imperfect substitutes for goods entering international trade. This modification weakens the link between the general price level--defined as a geometric average of the absolute prices of tradables and non-tradables--and the exchange rate. Accordingly, it enhances the ability of monetary policy to influence real economic variables.

Section 4 uses this extended model to study the effects of an unexpected, one-time increase in the money stock. A key determinant of the economy's response is the relative magnitude of the output-wage elasticities of supply in the economy's two sectors. When the supply elasticity in the home-goods sector is smaller than that in the traded-goods sector, an increase in money causes a rise in the real interest rate and an appreciation of the real exchange rate, both of which are reversed over time as the real wage is restored to its long-run equilibrium level. When the ranking of supply elasticities is reversed, monetary expansion has the opposite effects on the real interest rate and exchange rate. In the latter case, also, the exchange rate may, but need not, overshoot its long-run level in the short run. The exchange rate may thus exhibit the type of volatility studied by Dornbusch [12]. The likelihood that the exchange rate overshoots in this case is greater the lower the substitutability between home and traded goods, but need not increase with the share of non-traded goods in national output. There is thus no simple relation, in the framework explored below, between the degree of openness of the economy and exchange-rate volatility.

Section 5 investigates the effects of monetary disturbances that are anticipated in advance. The real effects of such disturbances are seen to disappear only when they are anticipated infinitely far in advance.[12] In addition, the belief that a monetary expansion will occur at some time in the future is likely to set off a period of explosive exchange-rate depreciation and wage-price inflation that corresponds well to the picture of the "vicious circle" emerging from policy discussions. The increase in money, when it occurs, appears to accommodate the increases in wages and prices, but in reality brings the vicious circle to an end by placing the economy on a convergent path along which money-wage growth decelerates.

Section 6 offers some concluding remarks. In addition, there are two appendices. Appendix A derives the local stability propositions invoked at various points in the text. Appendix B uses a linearized model to derive an approximate analytic representation of the path taken by the economy in response to an anticipated future change in the money supply.

2. Aggregate Dynamics in a Small Open Economy

A small country whose output consists exclusively of a composite tradable good also produced abroad provides the simplest setting in which to study the relationship between exchange-rate and wage-price dynamics.

The production technology of the economy exhibits constant returns to scale, and uses capital and labor as inputs.[13] Demand for labor is determined by the equality of the output-wage and the marginal physical product of labor. On the assumption that the available stock of capital is fixed and always fully employed, the home country's output level, y, can be expressed as a decreasing function of the ratio W/Q, where W is the nominal wage and Q the domestic price level:

$$y = y(W/Q), \quad y' < 0. \tag{1}$$

Corresponding to the output-supply schedule is the labor-demand schedule,

$$n = n(W/Q), \quad n' < 0. \tag{2}$$

Domestic residents divide their wealth among domestic money, domestic interest-bearing assets (bonds and capital), and foreign-currency bonds.[14] All non-money assets are viewed by wealth owners as perfect substitutes; their common nominal rate of return in terms of domestic currency is denoted by R. The demand for real money balances is an increasing function of domestic output and a decreasing function of R. Letting M denote the nominal money supply, asset-market equilibrium may be written as

$$M/Q = L(y,R), \; L_y > 0, \; L_R < 0. \tag{3}$$

The nominal exchange rate, E, is the price of foreign money in terms of domestic money. As the economy is small with respect to the international markets for both goods and assets, it can influence neither the foreign-currency price of its output, Q*, nor the nominal foreign bond rate, R*, both of which are assumed to be fixed. The domestic price level is related to Q* by the arbitrage condition

$$Q = EQ^*, \tag{4}$$

while under perfect asset substitutability, R is given by

$$R = R^* + \delta, \tag{5}$$

where δ is the expected percentage depreciation of the exchange rate. Equations (4) and (5) together imply that the real interest rate can never deviate from R*. The world price of tradables, Q*, is chosen to equal 1, so that the exchange rate may be identified with their domestic-currency price.

A key assumption is that agents have rational expectations, so that

$$\delta = \dot{E}/E, \tag{6}$$

barring unpredictable events that bring about discrete jumps in E. Equations

(1), (4), (5), and (6) allow the equilibrium condition (3) to be written as

$$M/E = L(y(W/E),\ R^* + \dot{E}/E). \tag{7}$$

Equation (7), in turn, can be written as a differential equation in E,

$$\dot{E}/E = \varepsilon(E,W,M). \tag{8}$$

An increase in E, given W and M, raises output, leading to excess demand for real balances in the absence of a rise in $\dot{E}/E$. Similarly, as increase in W or M must be accompanied by a fall in $\dot{E}/E$ in order that (7) continue to hold. It follows that

$$\varepsilon_E > 0,\ \varepsilon_W < 0,\ \varepsilon_M < 0. \tag{9}$$

Unlike the exchange rate, the nominal wage, W, is assumed to be a predetermined variable that cannot jump instantaneously but must adjust to disturbances over time. Firms can always hire the amount of labor they desire at the prevailing nominal wage. But there exists a "natural" level of employment, $\bar{n}$, having the property that the expected real wage is increasing whenever labor demand $n(W/E)$ exceeds $\bar{n}$, and decreasing whenever $n(W/E)$ falls short of $\bar{n}$. The implied wage-adjustment scheme is an expectations-augmented Phillips curve,

$$\dot{W}/W = \phi(n(W/E) - \bar{n}) + \delta, \quad \phi > 0, \tag{10}$$

which may be written in the form

$$\dot{W}/W = \omega(E,W,M) \tag{11}$$

after making the substitution $\delta = \varepsilon(E,W,M)$.

Equation (10) implies the existence of a unique stationary or long-run real wage, dependent only on the technology of production and $\bar{n}$. The model may thus be interpreted as one in which workers and firms respond with a lag to move the real wage toward its long-run target level, thus allowing temporary fluctuations in employment and output.

An increase in the exchange rate, given the nominal wage, tightens the labor market, and, by (9), increases the expected inflation rate; both factors cause the growth rate of money wages to rise. In contrast, an increase in W or M dampens the rate of nominal wage inflation. Therefore,

$$\omega_E > 0, \ \omega_W < 0, \ \omega_M < 0. \tag{12}$$

For a given stock of money, (8) and (11) constitute a complete system of differential equations in the nominal exchange rate and wage. The phase portrait implied by the partial derivatives in (9) and (12) is displayed in Figure 1. $\bar{E}$ and $\bar{W}$ denote, respectively, the stationary or long-run equilibrium values of the exchange rate and money wage. Appendix A contains the proof that the locus along which $\dot{W}/W = 0$ has a slope exceeding that of the locus along which $\dot{E}/E = 0$ in a neighborhood of $(\bar{E},\bar{W})$, implying that the system, locally, has the saddlepoint property of a unique convergent path. We follow Sargent and Wallace [32] in assuming that when no change in exogenous variables is expected, market partcipants, given the nominal wage W_0 inherited from the past, always

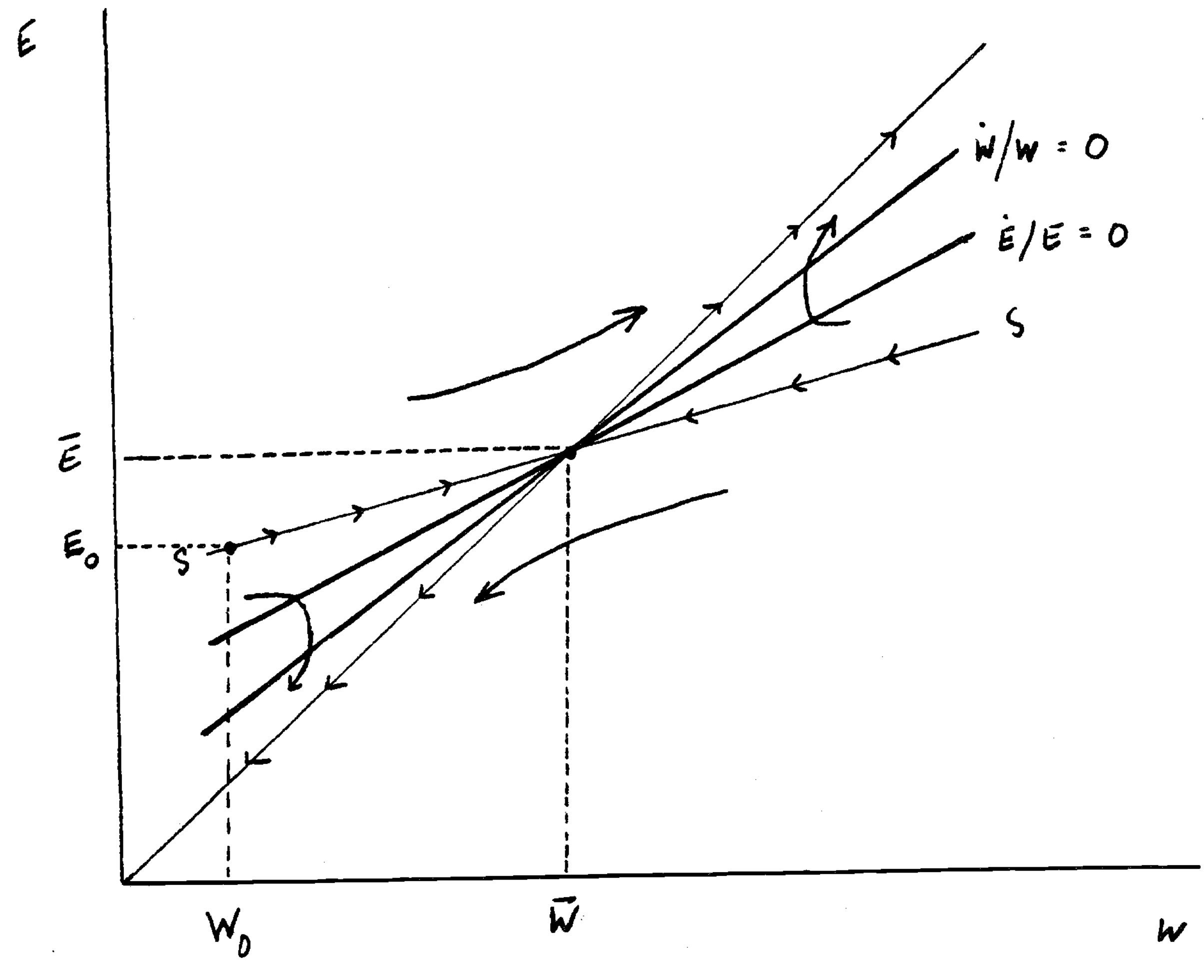

Figure 1

choose as the equilibrium exchange rate the unique value E_0 placing the economy on the saddlepath converging to long-run equilibrium.

Consider now the consequences of an unanticipated, permanent increase in the nominal money supply on the assumption that the economy is initially in long-run equilibrium. From (7) and (10), the long-run exchange rate and wage must both rise in proportion to the increase in the money stock. Accordingly, monetary expansion has no lasting effect on the real wage or output. This long-run neutrality is represented in Figure 2 by the proportionate outward shifts of the $\dot{E}/E = 0$ and $\dot{W}/W = 0$ schedules along the straight line connecting the initial stationary state and the origin.

The temporary rigidity of the nominal wage enables monetary policy to have real effects in the short run, however. At the initial exchange rate and interest rate, there is a momentary excess supply of money, which causes the exchange rate to depreciate immediately to the value E'_0 indicated by S'S' as wealth owners attempt to increase their holdings of foreign-currency assets. This impact depreciation is proportionally smaller than the increase in nominal money, but the expansion in output occasioned by the accompanying fall in the real wage increases the transactions demand for real balances by an amount sufficient to ensure that the higher real money stock is willingly held. Indeed, the increase in transactions demand actually pushes the nominal interest rate R upward, for at E'_0, further exchange-rate depreciation is expected.

The instantaneous equilibrium following the monetary expansion cannot persist in the face of overemployment and accurately-anticipated depreciation. The economy therefore moves to its new long-run equilibrium along a path characterized by a rising price level, a declining nominal interest rate, and levels of production and employment that fall over time as nominal wage growth outstrips inflation. The pattern of adjustment, in which wages, prices, and

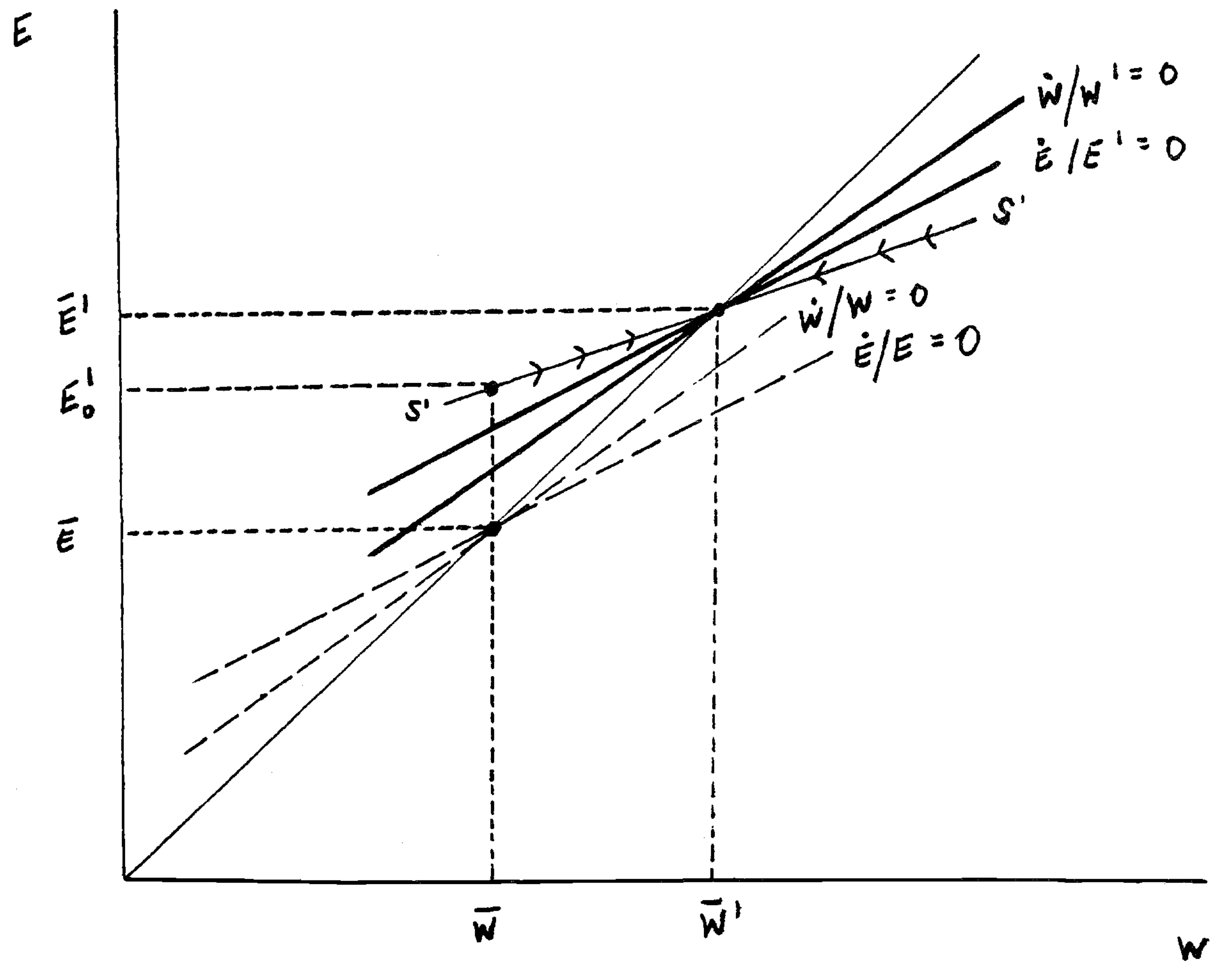

Figure 2

the exchange rate move together in the wake of inflationary money-market disturbances, is suggestive of the experience of several Western European economies during the recent period of exchange-rate flexibility. It stands in interesting contrast to the adjustment pattern described by Dornbusch [12], in which an inflationary shock leads to rising prices, but also to a rising interest rate and an appreciating exchange rate.

The Keynesian liquidity effect emphasized by Dornbusch [12], which depresses the nominal and real interest rates in the short run and forces the exchange rate to overshoot its eventual level, is absent in the case of a small open economy with no sector sheltered from international trade. Instead, the nominal interest rate adjusts to monetary expansion in Fisherian fashion, fully reflecting subsequent price-level inflation, and then returns to its initial level over time as inflationary expectations subside. The real rate of interest remains constant.

It is easy to see why this must occur. Because the price level increases one-for-one with the exchange rate, exchange-rate overshooting, in the present setting, would imply an initial net decline in real balances, but a simultaneous increase in both the income- and interest-sensitive components of money demand. This configuration of prices would be inconsistent with money-market equilibrium.

3. The Role of Non-Traded Goods

The existence of goods that do not enter into international trade weakens the link between the price level and the exchange rate, and frees the domestic real interest rate to diverge from the world bond rate. We now extend the previous section's model by adding to the economy described there a sector producing non-traded consumption goods. This modification is seen to alter the dynamic properties of the economy. A detailed analysis of the response to monetary shocks in the presence of non-tradables is reserved for the next section.

We now assume that both a composite non-traded or home good and a traded good are produced according to constant-return-to-scale technologies requiring capital and labor as inputs.[15] Both sectors of the economy--tradable and non-tradable--are endowed with fixed stocks of non-depreciating capital. But while labor is free to migrate between sectors at the time the nominal wage is set, inter-sector movements of capital are infinitely costly. On the assumption that each sector's capital is always fully utilized, supply of home goods and tradables may be expressed as decreasing functions of the respective output wages,

$$y_h = y_h(W/P), \quad y_h' < 0, \tag{13}$$

$$y_t = y_t(W/E), \quad y_t' < 0, \tag{14}$$

where P denotes the domestic-money price of non-traded goods. Corresponding to the supply schedules (13) and (14) are the sectoral labor-demand schedules

$$n_h = n_h(W/P), \quad n_h' < 0, \tag{15}$$

$$n_t = n_t(W/E), \quad n_t' < 0. \tag{16}$$

The introduction of a distinct, non-traded good makes necessary an explicit description of the demand side of the economy. Consumers are identical, and their utility is given by a <u>homothetic</u> function of their consumption rates of home and traded goods. Maximization of utility subject to a level of nominal expenditure, Y, leads to the demand functions for the two categories of consumption,

$$d_h = d_h(E,P,Y), \tag{17}$$

$$d_t = d_t(E,P,Y). \tag{18}$$

It is assumed, for simplicity, that domestic spending always equals domestic output, so that

$$Y = Py_h + Ey_t = Py_h(W/P) + Ey_t(W/E). \tag{19}$$

The roles of external asset accumulation and of wealth in general are neglected so that we may focus on the relationship between exchange-rate flexibility and the internal balance of the economy.[16]

The price of home goods is determined by the requirement that the supply of non-tradables equal the domestic demand. Using (13), (14), and (17), the equilibrium condition is written

$$y_h(W/P) = d_h(E,\ P,\ Py_h(W/P) + Ey_t(W/E)). \tag{20}$$

Equation (20) implicitly defines the equilibrium nominal home-goods price, P, as a function of the exchange rate and money wage:

$$P = P(E,W). \tag{21}$$

The properties of the function $P(.,.)$ defined by (20), and in particular the sign of P_W, will play a key role in the discussion below. An increase in E, with W held constant, stimulates demand for home goods by increasing income and inducing substitution away from tradables. This must be met by a rise in P if the home-goods market is to remain in equilibrium, and so the elasticity of P with respect to E is positive. The elasticity of P with respect to the nominal wage is ambiguous, however, for

$$(W/P)P_W = \frac{\eta_h - \eta_t}{\eta_h + (Y/Ey_t)\sigma} \gtreqless 0, \tag{22}$$

where $\eta_h \equiv -\partial\log(y_h)/\partial\log(W/P)$, $\eta_t \equiv -\partial\log(y_t)/\partial\log(W/E)$, and σ is the compensated own-price elasticity of demand for home goods (defined to be positive). Because demand is homothetic, the equilibrium price of non-tradables must fall when a rise in W leads to a proportionally smaller decrease in non-traded than in traded output, and must rise in the opposite case. Defining the output share $\theta_h \equiv Py_h/Y$, (22) may be written as

$$(W/P)P_W = \frac{\eta_h - \theta_h\eta_h - (1 - \theta_h)\eta_t}{\eta_h - \theta_h\eta_h + \sigma} .$$

The numerator of this expression gives the excess demand for home goods, expressed as a percentage of initial home-goods output, caused by a percentage rise in W, while the denominator shows the percentage excess supply occasioned by a percentage rise in P. The elasticity $(W/P)P_W$ is decreasing in σ, for a high degree of substitutability between home and traded goods dampens the proportional price change required to offset the excess demand caused by the rise in W. It is also decreasing in θ_h, for the greater the share of home goods in national output, the smaller is the percentage excess demand relative to the price elasticity σ. This point will be important in the next section when the relation between exchange-rate overshooting and the degree of openness of the economy is analyzed.

We note, for future reference, that because the commodity demand functions are homogeneous of degree zero in their arguments, P(.,.) is homogeneous of degree one, implying that

$$(W/P)P_W + (E/P)P_E = 1. \tag{23}$$

A ceteris paribus rise in E entails a less-than-proportional increase in P when $P_W > 0$, and a more-than-proportional increase when $P_W < 0$.[17]

Real balances are now defined as nominal balances deflated by a price-level index $Q(E,P) = P^{\alpha}E^{1-\alpha}$. The weight α is taken to be the share of home goods in stationary-state consumption. Demand for real balances is again a function of real income and the nominal interest rate, so that in perfect-foresight equilibrium,

$$M/Q(E,P) = L(Y/Q(E,P),\ R^* + \dot{E}/E). \tag{24}$$

Using (21) and (24), the condition that the goods and money markets clear is written

$$M/Q(E,P(E,W)) =$$
$$L((P(E,W)y_h(W/P(E,W)) + Ey_t(W/E))/Q(E,P(E,W)),\ R^* + \dot{E}/E). \tag{25}$$

The equilibrium condition may be inverted, as before, to yield the equation of motion for the exchange rate,

$$\dot{E}/E = \varepsilon(E,W,M). \tag{26}$$

It is easily verified that ε_E and ε_M have the same signs (cf. (9)) as in an economy that produces traded goods only. But the sign of ε_W is no longer unambiguously negative if $P_W > 0$. When $P_W < 0$, an increase in W (holding E constant) entails a fall in the output of both industries and a rise in real balances; the depreciation rate of E must fall, as before, to restore money-market equilibrium. When a rise in W is accompanied by an increase in P, however, the fall in home-goods output is dampened to some extent,[18] and the stock of real balances <u>declines</u>. The net outcome, in this case, of a rise in W at unchanged E may be either excess supply or excess demand in the money market. In the latter circumstance, the expected depreciation rate will have to rise to ensure equilibrium, and the sign of ε_W will be positive. In the neighborhood of long-run equilibrium $(\bar{E},\bar{W})$,

$$\varepsilon_W = \left(\frac{R^*}{W\mu_R}\right)\left[\theta_h(1 + \mu_y\eta_h)\left(\frac{\eta_h - \eta_t}{\eta_h + (\sigma/1-\theta_h)}\right) - \mu_y(\theta_h\eta_h + (1-\theta_h)\eta_t)\right], \tag{27}$$

where μ_y is the income elasticity of real money demand and μ_R is the interest elasticity (defined to be a positive number).[19]

The nominal wage again responds over time to both labor-market pressure and anticipated price-index inflation. Its equation of motion is now

$$\dot{W}/W = \phi(n_h(W/P) + n_t(W/E) - \bar{n}) + \dot{Q}/Q$$

$$= \phi(n_h(W/P) + n_t(W/E) - \bar{n}) + \alpha(\dot{P}/P) + (1 - \alpha)(\dot{E}/E).$$

Since $\dot{P}/P = (W/P)P_W[\dot{W}/W] + (E/P)P_E[\dot{E}/E]$, the reduced form equation for $\dot{W}/W$ is

$$\dot{W}/W = \frac{\phi}{1 - \alpha(W/P(E,W))P_W(E,W)}(n_h(W/P(E,W)) + n_t(W/E) - \bar{n}) + \varepsilon(E,W,M) = \omega(E,W,M). \quad (28)$$

Note that $W/P(E,W) = 1/P(E/W,1)$, and because $P_E > 0$, the real wage in terms of tradables and the real wage in terms of non-tradables must always vary in the same direction. Thus, (28) implies that W/E and W/P always move monotonically toward their long-run levels.

As in the one-good model, ω_E and ω_M are, respectively, positive and negative. The sign of ω_W is uncertain. A rise in W causes underemployment and puts downward pressure on money wages, but also leads to a higher expected inflation rate if (27) is positive. ω_W is negative when the first factor dominates, but is positive when the second outweighs the first.

The system in E and W described by equations (26) and (28) is locally saddlepoint stable. When $\varepsilon_W < 0$, the system can again be represented by Figure 1. But when $\varepsilon_W > 0$, the system can assume either of two configurations, depending on whether ω_W is negative (Figure 3) or positive (Figure 4). In both configurations, the $\dot{E}/E = 0$ locus slopes downward, as does the convergent saddlepath.[20]

An important difference between the present model and that of section 2 is that full-employment output-wages are no longer independent of the domestic expenditure pattern. Sectoral demand shifts, whether autonomous or induced by official fiscal measures, will shift the P(.,.) function, causing a fall in the output - wage paid by the industry that benefits from the shift and a rise in the output-wage paid by the industry that is hurt. The adjustment to the shift will in general require a realignment of nominal as well as relative prices, and in particular a period of labor-market imbalance as money wages change.

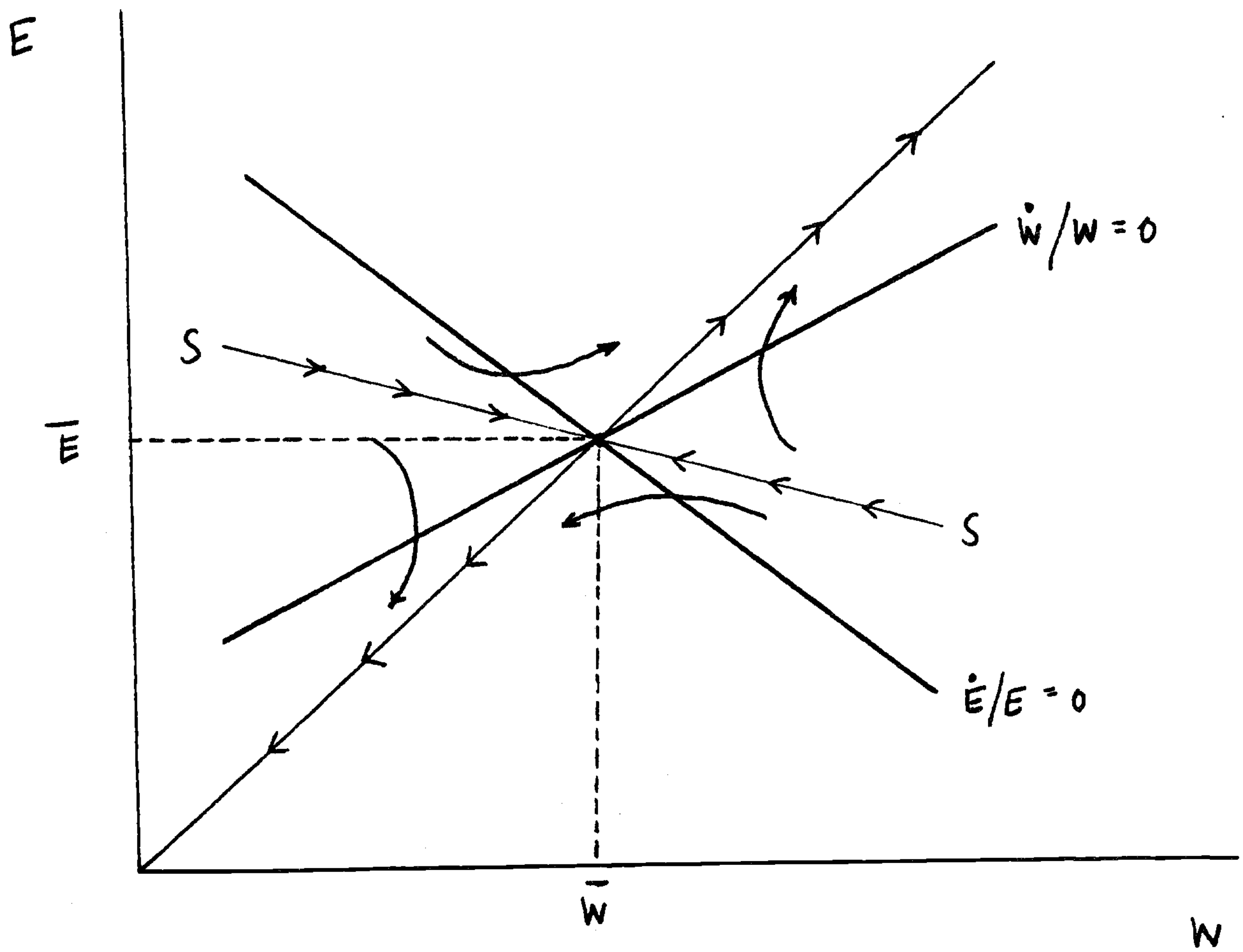

Figure 3

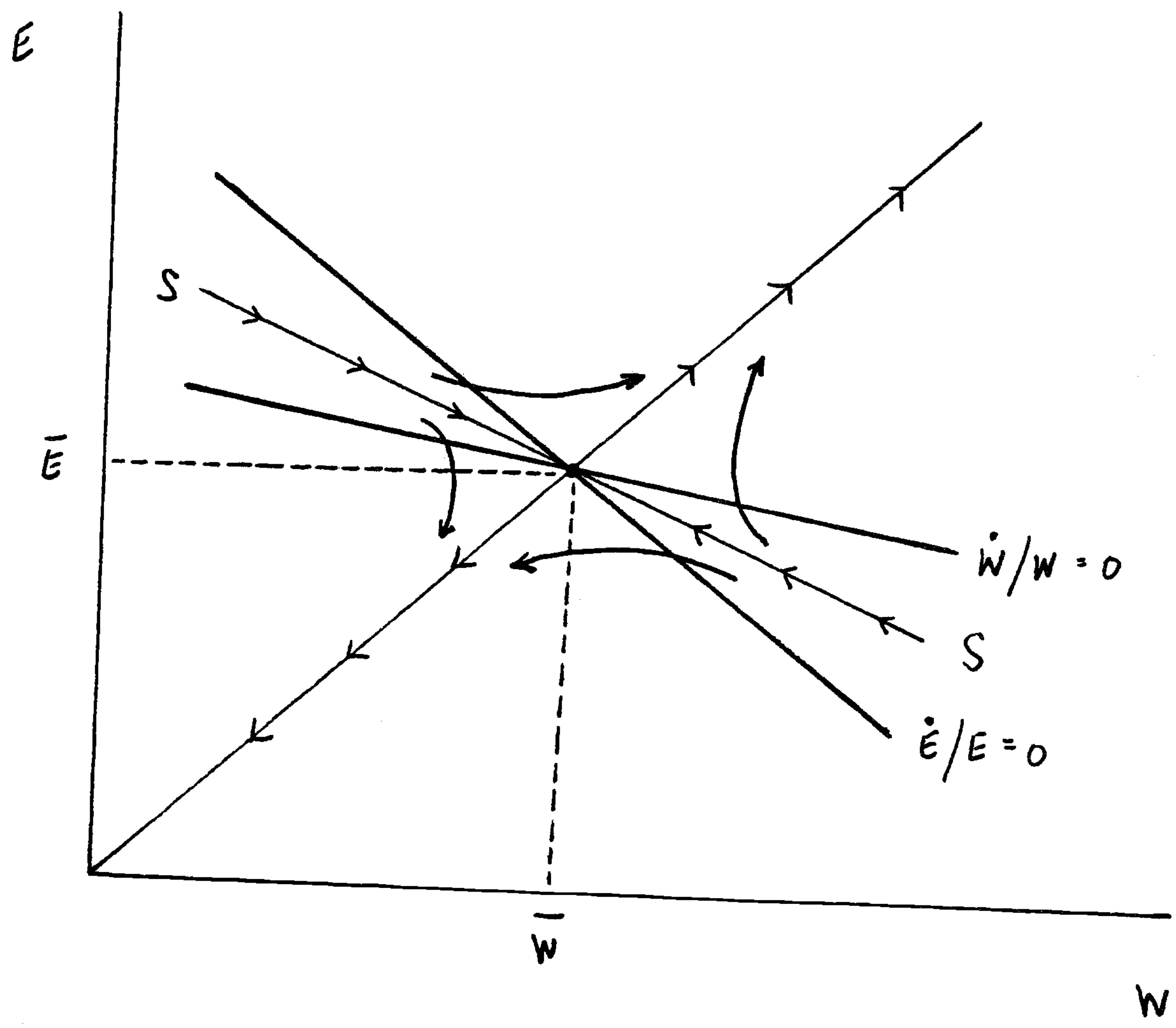

Figure 4

4. Monetary Disturbances and Patterns of Adjustment with Non-Traded Goods

This section studies the effects of money-supply disturbances in economies producing non-tradable commodities. The adjustment to monetary perturbations is seen to differ in several respects from that in the simple one-good economy of section 2. Three of these differences are of particular interest. First, monetary disturbances induce persistent deviations from purchasing power parity that disappear only in the long run. Second, monetary disturbances induce movements in the real rate of interest. Third, the exchange rate may overshoot its eventual, long-run level in response to a nominal shock. Our aim here is to relate the economy's response to monetary shocks to its production structure, highlighting in particular the importance of sectoral output elasticities and the degree of openness. The latter is defined in terms of both the share of tradable goods in overall output and the substitutability in consumption between traded and non-traded goods.

Consider first the effects of an unanticipated, permanent increase of the money stock on an economy in which $\eta_h - \eta_t < 0$. It must be the case, in such an economy, that $\varepsilon_W < 0$. Figure 2 shows the paths of the exchange rate and nominal wage on the assumption that the economy is initially at rest.

The long-run exchange-rate and wage again rise in proportion to the increase in money. The exchange rate depreciates in the short run, too, but by an amount necessarily smaller than its long-run depreciation. The reason for this is that, by (22) and (23), the relative price of home goods in terms of tradables must <u>rise</u> initially if $\eta_h < \eta_t$, implying an appreciation (i.e., a fall) of the <u>real</u> exchange rate, $E/Q(E,P)$. As in section 2, exchange-rate overshooting would be inconsistent with money-market balance.

The initial real exchange rate appreciation must be reversed during the transition to the stationary state, for money is neutral in the long run. It follows that the price of home goods in terms of tradables, and with it, the output share of home goods, declines during the adjustment process. This is possible only if the rate of increase of the price-level index, Q(E.P), falls short of the rate of increase of the exchange rate, E.[21] An interesting, and counterintuitive, implication is that when $\eta_h < \eta_t$, the real rate of interest, $R - \dot{Q}/Q = R^* + \dot{E}/E - \dot{Q}/Q$, must rise in response to an increase in money, and fall subsequently to its original level, R*, if no further shocks buffet the economy.

The effects of the disturbance are different when η_h exceeds η_t. In this case, the sign of ε_W is ambiguous (cf. (27)). The adjustment path can again be described by Figure 2 when $\varepsilon_W < 0$, and is as shown in Figure 5 when $\varepsilon_W > 0$.[22]

The configuration of supply elasticities assumed now implies that a *ceteris paribus* increase in the exchange rate is accompanied by a *less*-than-proportional increase in the nominal price of home goods, P. Thus, the initial depreciation occasioned by an increase in the money stock is also a real depreciation in the present case: both E and the ratio E/Q(E,P) rise on impact. This relative price change is reversed during the adjustment to long-run equilibrium, and so, the rate of price-level inflation must always exceed the rate of depreciation of the exchange rate.

When $\varepsilon_W < 0$, the exchange rate undershoots its eventual level in the short run, as Figure 2 shows. In this case, the output expansion caused by the initial fall in real wages increases money demand sufficiently to push the nominal interest rate upward, even though the price level fails to rise point-for-point with the exchange rate. While the nominal interest

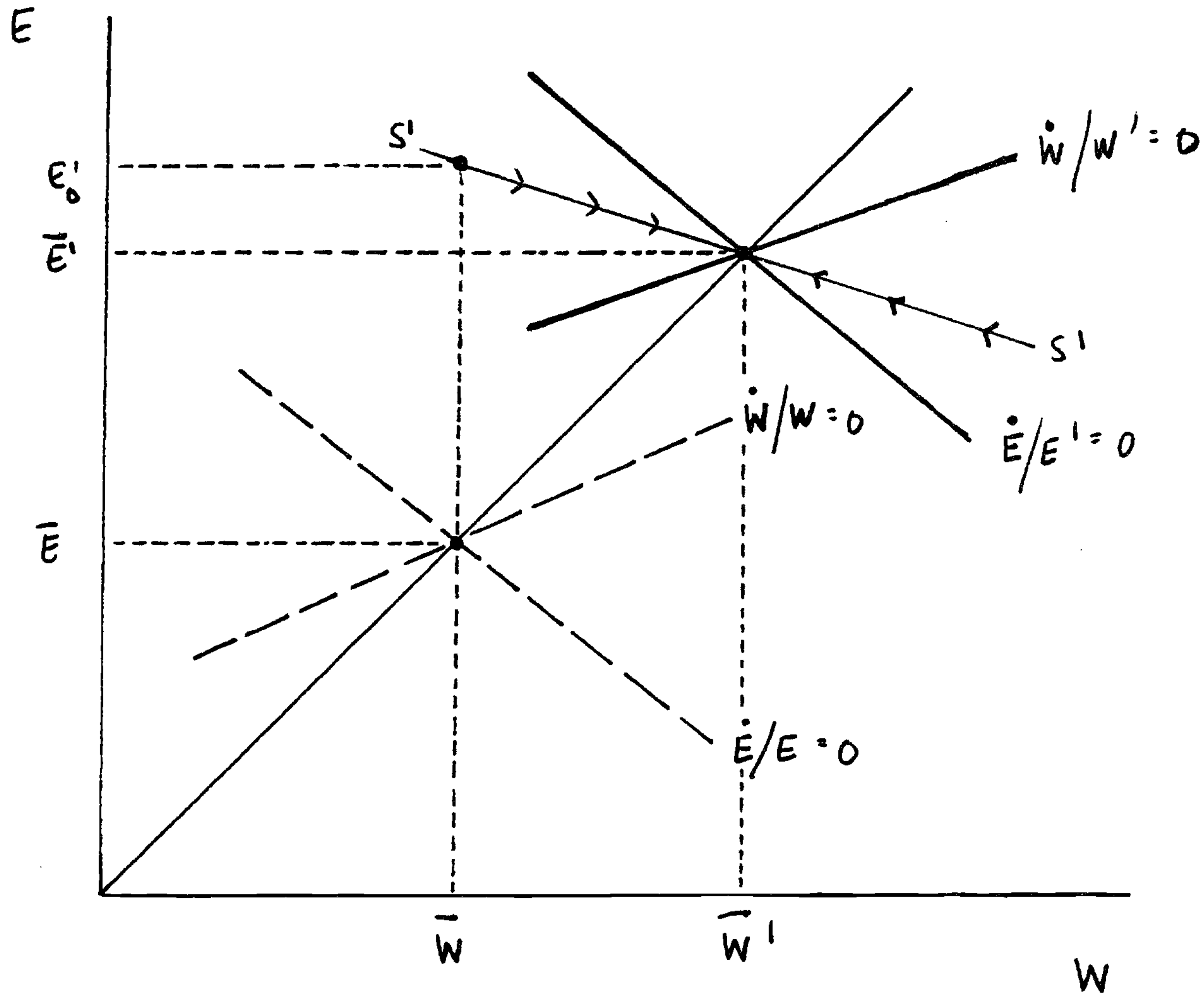

Figure 5

rate rises, the real interest rate falls, for the overall rate of price-index inflation is expected to exceed the rate of increase of E during the transition. Nominal depreciation is accompanied by real appreciation along the path to the stationary state.

When $\varepsilon_W > 0$, however, the exchange rate must overshoot its asymptotic level in the short run, depreciating on impact from $\bar{E}$ to E_0', and then appreciating to $\bar{E}'$, as shown in Figure 5. This is so because the increase in the transaction demand occasioned by the intial rise in output falls short of the increase in real balances, necessitating a fall in the nominal interest rate and so, an appreciating exchange rate. Because the relative price of non-tradables must rise during the adjustment process to reverse the initial real depreciation, the real interest rate falls as well. Indeed, the overall price level must rise throughout the transition, even though the exchange rate is falling. Only a declining path of real balances is consistent with falling real income and a rising nominal interest rate.

This last pattern of adjustment--in which the price level and nominal interest rate rise and the exchange rate falls following an increase in the money supply--is essentially the one described by Dornbusch [12]. As we have seen, it is possible in the present model only when $\eta_h > \eta_t$; and it is more likely to occur the larger is the income elasticity of money demand, μ_y. Overshooting becomes a possibility when there are non-traded goods because the aggregate price level, Q, no longer moves point-for-point with the exchange rate. If Q initially rises in response to a monetary expansion by an amount less-than-proportional to the rise in E, the real supply of money may rise even if the exchange-rate overshoots its long-run value. This means that a decline in the nominal interest rate--an expected appreciation--cannot be ruled out, as it was in the traded-goods-only model, on the grounds that it would necessarily entail excess demand in the money market.

We conclude by examining the extent to which the degree of openness of the economy influences the likelihood that the exchange rate overshoots, i.e., that ε_W is positive. The degree of openness is most naturally defined in terms of both the degree of substitutability in consumption between home and traded goods, measured by the substitution elasticity σ, and the share of traded goods in domestic product, θ_t.[23]

As (27) shows, ε_W is more likely to be positive the <u>smaller</u> the degree of substitutability on the demand side between traded and non-traded goods. Indeed, when tradables and non-tradables are perfect substitutes, σ is infinite, and the model reduces to that of section 2, in which the exchange rate always undershoots. The more limited the possibilities for substitution in consumption, the weaker the link between the prices of tradables and non-tradables, and the greater the likelihood that an exchange-rate depreciation less-than-proportional to a given increase in money leaves an incipient excess supply of real balances requiring further depreciation and a fall in the nominal return on bonds. If the openness of the economy is measured by the degree of substitutability between home and international goods, exchange-rate overshooting will tend to be associated with less open economies.

If the degree of openness is measured by the share of tradables in domestic output, however, the association between overshooting and openness becomes less compelling. A less open economy, in this sense, is one in which exchange rate depreciation has a relatively small <u>direct</u> effect on real output and the money-stock deflator. This, by itself, would imply a tendency for the domestic interest rate to fall in response to an increase in the money supply. But an increase in E has, in addition to its direct effect, an indirect effect on real output and the price level through its influence on the price of home goods, P. And a decrease in the traded-goods share θ_t, as we have seen, lowers $(W/P)P_W$, and, by (23), raises $(E/P)P_E$, which measures the sensitivity of the price of non-tradables to exchange-rate movements. A decrease in θ_t thus affects the likelihood of overshooting in a second, possibly offsetting, manner by strengthening the link between the prices of domestic and foreign goods.

To summarize, while lower substitutability between tradables and non-tradables makes overshooting more likely, there is in general no monotonic relation between the output share of non-tradables and the likelihood that the exchange rate overshoots its long-run level in response to monetary perturbations.

5. Anticipated Monetary Disturbances and the "Vicious Circle" Phenomenon

The analysis has, so far, been limited to monetary disturbances that take the public by surprise. We ask, in this section, how the analysis must be modified when the same monetary disturbances are instead anticipated by the public some time before their occurrence. Three points of particular interest emerge. First, the exchange rate, like any nominal asset price, responds immediately and discontinuously to new information about future monetary developments, subsequently evolving along a smooth path in the absence of further news. Thus, while the exchange rate must, in the long run, change in proportion to any change in the nominal money supply, exchange-rate movements may bear no relation to actual contemporaneous movements of the money stock over finite intervals of time. Second, monetary disturbances that are expected in advance in general have real relative-price effects that persist after the disturbance has occurred. Only a monetary shock anticipated infinitely far in advance is fully neutral, having no effect on relative prices at any time. Finally wages and the exchange rate are likely to evolve explosively during the period between the announcement of a monetary change and its implementation. This pattern of nominal price movements corresponds well to the so-called "vicious circle" of exchange-rate depreciation and money-wage inflation that has played a prominent role in recent discussions of exchange-rate policy.

On the assumption that the economy is initially at rest, Figure 6 shows the effects of an announcement by the monetary authority that the money stock will increase from its current value M to $(1 + \gamma)M$ at a known time τ in the future. The path displayed is derived from three considerations. First, while the money supply is at its initial level M, the motion of the exchange rate and the nominal wage must be governed by equations (26) and (28). Thus, these variables move along a path of the initial differential-equation system between the announcement and the moment the monetary expansion occurs. Second, once the expected event has occurred, the economy must be on the convergent path of the system associated with the higher money stock $(1+ \gamma)M$. This is a consequence of the assumption that the economy chooses the saddlepath equilibrium when no future exogenous changes are anticipated. Finally, there can be no discrete jump in the exchange rate when the increase in money actually occurs. Under perfect foresight, this would imply an anticipated deviation from the interest parity condition (5) at time τ, which is impossible.[24] These three requirements can be satisfied simultaneously only if, in response to the announcement, the exchange rate jumps to place the economy on the unique unstable path of the original system intersecting the saddlepath of the new system at time τ.

The initial depreciation of the exchange rate entails a fall in real wages measured in terms of either good: the belief that an increase in the

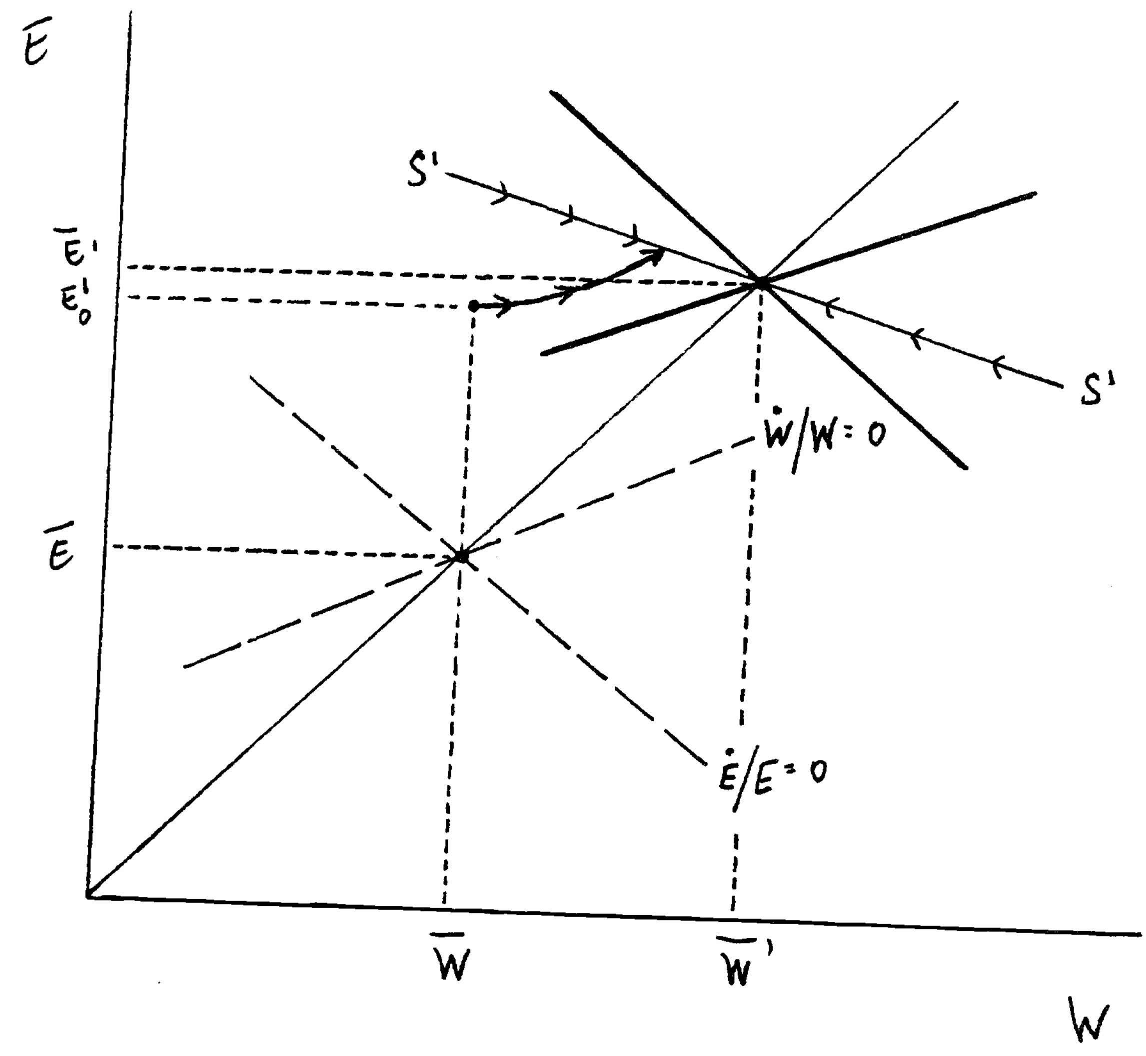

Figure 6

money supply is imminent has an immediate expansionary effect. As E and P both rise, the stock of real balances is reduced, and money-market equilibrium requires a rise in the nominal domestic interest rate and, by (5), a depreciating exchange rate.

The exchange rate and nominal wage rise together until τ, the moment at which the monetary change takes place. Because the nominal money supply rises discontinuously at τ but prices and output cannot jump, the nominal interest rate R necessarily falls at this point. The expected depreciation rate thus declines, actually becoming negative if the saddlepath slopes downward as in Figure 6. Thereafter, the economy moves along the convergent path to the long-run equilibrium associated with money stock $(1 + \gamma)M$.

It is of particular interest to trace the paths of output and employment. The real wage in terms of tradables rises steadily until time τ, as Figure 6 shows, and this implies that the real wage measured in terms of home goods rises as well.[25] The nominal wage thus "catches up" to the price level as excess labor demand allows workers to conclude ever more favorable wage bargains over time, and a smooth fall in output and employment is thereby induced. As noted above, nominal prices cannot jump at time τ, and the expected increase in money therefore has no effect on output and employment at the moment it occurs. Real wages continue to rise smoothly toward their long-run levels, while output and employment remain above their natural levels until the economy returns to its stationary state.

These real effects of an anticipated monetary change disappear only when the change is anticipated infinitely far in advance. To make this point formally, it is convenient to work with a linear approximation of the differential-equation system, valid in a neighborhood of the initial long-run equilibrium

$(\overline{E},\overline{W})$:

$$\begin{bmatrix} \dot{E} \\ \dot{W} \end{bmatrix} = \begin{bmatrix} \overline{E}\varepsilon_E(\overline{E},\overline{W},M) & \overline{E}\varepsilon_W(\overline{E},\overline{W},M) \\ \overline{W}\omega_E(\overline{E},\overline{W},M) & \overline{W}\omega_W(\overline{E},\overline{W},M) \end{bmatrix} \begin{bmatrix} E - \overline{E} \\ W - \overline{W} \end{bmatrix}. \qquad (29)$$

The linearization (29) is used in Appendix B to calculate an analytic description of the path taken by the exchange rate in response to an anticipated future monetary change. If $(\overline{E}',\overline{W}')$ denotes the stationary position of the system associated with money stock $(1 + \gamma)M$, the exchange rate and wage at time τ are given approximately by

$$E(\tau) = \overline{E}' + \gamma\overline{W}(\overline{E}\varepsilon_W/(\overline{E}\varepsilon_E - \lambda_2))\exp([\lambda_2 - \lambda_1]\tau), \qquad (30)$$

$$W(\tau) = \overline{W}' - \gamma\overline{W}\exp([\lambda_2 - \lambda_1]\tau), \qquad (31)$$

where $\lambda_1 > 0$ and $\lambda_2 < 0$ are the characterictic roots of (29), and must be real and of opposite sign by the saddlepoint-stability established in Appendix A. A necessary condition for the monetary change to have no real effects at any time is that the adjustment to the new long-run equilibrium $(\overline{E}',\overline{W}')$ be complete the moment it occurs. But as (30) and (31) show, this requires that the adjustment period τ be infinite. In addition, as $\tau \to \infty$, the path of the economy converges to the segment of the line $E(t) - \overline{E} = (\overline{E}/\overline{W})(W(t) - \overline{W})$ between $(\overline{E},\overline{W})$ and $(\overline{E}',\overline{W}')$.[26] Along this path, relative prices are at the long-run values while absolute prices rise explosively with no real effects; and so, the condition that the monetary change be anticipated infinitely far in advance is also sufficient to ensure full neutrality.[27]

A more detailed analysis of the economy's path up until time τ shows how an asset-market disturbance--in this case, the arrival of news concerning the future behavior of the money supply--can give rise to an a period of accelerating depreciation and inflation even in the absence of any accommodation by the monetary authority. While this "vicious circle" has been widely discussed in the last decade's policy debate over the flexible exchange-rate system, its existence has received curiously little support in the theoretical literature. The latter has, in partcular, failed to capture the possibly explosive nature of the process (see Basevi and De Grauwe [2] and Bilson [3]).

Using the linear approximation (29), the path of the exchange rate between t = 0 and t = τ is described by

$$E(t) - \bar{E} = \gamma\bar{E}\,\exp(\lambda_1(t - \tau)) + \frac{\gamma\bar{E}\bar{W}\varepsilon_W}{\bar{E}\varepsilon_E - \lambda_2}\exp(\lambda_2 t - \lambda_1\tau) \tag{32}$$

(see the appendices). When $\varepsilon_W > 0$ (the "overshooting" case), $\ddot{E}(t)$ is unambiguously positive for all t, i.e., the exchange rate depreciates at an ever-increasing rate up until the moment the expected increase in money takes place. Because the real wage must be rising, the nominal wage also increases at an increasing rate. Finally, if $\varepsilon_W > 0$, $P_W > 0$, and so the general price level rises monotonically.[28]

When $\varepsilon_W < 0$, the exchange rate may not begin to accelerate until the final stages of the period of anticipatory adjustment. But as $t \to \tau$, the explosive term $\exp(\lambda_1(t - \tau))$, which pushes all nominal magnitudes upward at the exponential rate λ_1, tends to dominate the term associated with λ_2. So in this case, too, it is possible that the anticipated monetary change ultimately results in a period of accelerating depreciation and wage-price inflation.

The "vicious circle" phenomenon is often linked to a monetary policy that systematically accommodates money wage increases in order to avoid unemployment. But the present analysis shows that no such permissive policy is necessary. Nonetheless, the expected increase in the money supply may well appear to accommodate the increase in wages and prices, particularly since output declines and the nominal interest rate generally rises along the path following the initial depreciation. Actually, it is the belief that this monetary increase will occur that sets off the depreciation-inflation spiral. The expected event brings the vicious circle to an end by pushing down the nominal interest rate, reducing the rate of exchange-rate depreciation, and allowing a smooth transition to a convergent path.

6. Conclusion

This paper has developed a model of exchange-rate determination and nominal wage adjustment in a two-sector economy with foresight. The model assumes that goods prices adjust immediately to clear markets, but that the nominal wage is sticky in the short run. The persistent effects of monetary disturbances are thus ascribed to the gradual adjustment of expected real wages to labor-market imbalance, rather than to the short-run rigidity of the domestic price level postulated in much recent literature. This is in accord with the observation that exchange-rate fluctuations are immediately reflected in import prices, while domestic goods' prices are often closely linked to the prices of internationally-traded goods.

The model predicts a variety of macroeconomic adjustment patterns, linking these to the supply structure of the economy and to some key economic parameters. Also, the model generates the "vicious circle" of depreciation and wage-price inflation as the response to anticipated future monetary expansion.

A major shortcoming of the model is its neglect of the external balance and of factors such as wealth influencing aggregate spending and saving. It is probably best interpreted as applying to the intermediate run in which labor-market pressures have their full impact but current-account adjustment is incomplete. On this interpretation, the model presents only a partial picture of macroeconomic adjustment under flexible rates, but one that nonetheless captures some prominent features of the recent experience.

Appendix A

This appendix establishes that the model developed in the text is saddlepoint-stable in a neighborhood of its long-run equilibrium. When linearized in a neighborhood of $(\overline{E},\overline{W})$, the associated differential-equation system has the representation (29). This linear system has the saddlepoint property of a unique convergent path if and only if the characteristic roots of the matrix in (29) are real and of opposite sign. To demonstrate this, we show that the determinant of (29), which equals the product of the characteristic roots, is negative (see Hirsch and Smale [21]).

In a neighborhood of the stationary state,

$$\overline{W}\omega_E = \frac{\phi}{(1 - \alpha(\overline{W}/\overline{P})P_W)}(P_E y_h \eta_h + y_t \eta_t) + \overline{W}\varepsilon_E, \tag{A1}$$

$$\overline{W}\omega_W = \frac{-\phi\overline{E}/\overline{W}}{(1 - \alpha(\overline{W}/\overline{P})P_W)}(P_E y_h \eta_h + y_t \eta_t) + \overline{W}\varepsilon_W, \tag{A2}$$

where all derivatives are evaluated at $(\overline{E},\overline{W})$. The determinant of (29) therefore becomes

$$\overline{E}\varepsilon_E\overline{W}\omega_W - \overline{E}\varepsilon_W\overline{W}\omega_E = \frac{-\phi}{(1 - \alpha(\overline{W}/\overline{P})P_W)}(P_E y_h \eta_h + y_t \eta_t)[(\overline{E}/\overline{W})\overline{E}\varepsilon_E + \overline{E}\varepsilon_W],$$

which is negative if and only if $\overline{E}\varepsilon_E + \overline{W}\varepsilon_W > 0$.

The function $\varepsilon(E,W,M)$ is homogeneous of degree zero in its arguments (by (25)), and so Euler's theorem implies that $\overline{E}\varepsilon_E + \overline{W}\varepsilon_W + \overline{M}\varepsilon_M = \varepsilon(\overline{E},\overline{W},M)/\overline{E} = 0$. Because $\varepsilon_M < 0$, $\overline{E}\varepsilon_E + \overline{W}\varepsilon_W$ must therefore be positive. This shows the local saddlepoint stability of the system.

By direct substitution of (A1) and (A2) into the characteristic equation

$$\lambda^2 - (\overline{E}\varepsilon_E + \overline{W}\omega_W)\lambda + (\overline{E}\varepsilon_E\overline{W}\omega_W - \overline{E}\varepsilon_W\overline{W}\omega_E) = 0,$$

it is easy to verify that the characteristic roots of the system (29) are:

$$\lambda_1 = \overline{E}\varepsilon_E + \overline{W}\varepsilon_W > 0, \quad \lambda_2 = \overline{W}\omega_W - \overline{W}\varepsilon_W < 0. \tag{A3}$$

Appendix B

This appendix presents an algebraic solution of the linearized model of exchange-rate and wage dynamics, and calculates the path taken by the economy during the period preceding an anticipated permanent change in the money stock.[29] The economy is assumed to be at the long-run equilibrium $(\overline{E},\overline{W})$ the moment the future change in the money stock becomes known. The initial money supply is M.

A general solution of (29) takes the form

$$\begin{bmatrix} E(t) - \overline{E} \\ W(t) - \overline{W} \end{bmatrix} = \begin{bmatrix} \dfrac{-k_1\overline{E}\varepsilon_W}{\overline{E}\varepsilon_E - \lambda_1} & \dfrac{-k_2\overline{E}\varepsilon_W}{\overline{E}\varepsilon_E - \lambda_2} \\ k_1 & k_2 \end{bmatrix} \begin{bmatrix} \exp(\lambda_1 t) \\ \exp(\lambda_2 t) \end{bmatrix}, \tag{B1}$$

where k_1 and k_2 are constants determined by the initial position of the system (see Hirsch and Smale [21]). Because the term $\exp(\lambda_1 t)$ is explosive, the convergent saddlepath must be associated with the initial condition $k_1 = 0$. The equation describing this saddlepath is therefore

$$E - \overline{E} = \frac{-\overline{E}\varepsilon_W}{\overline{E}\varepsilon_E - \lambda_2}(W - \overline{W}). \tag{B2}$$

The slope of the saddlepath depends on the sign of ε_W at long-run equilibrium in the manner described in the text.

In what follows, we shall make use of the fact that the matrix coefficients of the linear approximation (29) are not altered by a proportional increase in M, $\overline{E}$, and $\overline{W}$. This is a consequence of the fact that $\varepsilon(E,W,M)$ and $\omega(E,W,M)$ are both homogeneous of degree zero in their arguments, so that their partial derivatives are homogeneous of degree -1. In particular, the characteristic roots λ_1 and λ_2 are invariant with respect to changes in the money supply.

To determine the path of the economy up until an expected increase in the money supply from M to $(1 + \gamma)M$ at time τ, it is necessary to determine the appropriate values for the arbitrary coefficients k_1 and k_2. The first initial condition comes from the assumption that the nominal wage is predetermined at the initial time t = 0. This means that while the exchange rate will jump from $\overline{E}$ to E(0) when agents learn about the future increase in money, W is constrained to remain at the value $\overline{W}$ determined in the past. Using (B1), the implied constraint on k_1 and k_2 is

$$W(0) - \overline{W} = 0 = k_1 + k_2. \tag{B3}$$

The second initial condition comes from the continuity condition ruling out anticipated, discrete jumps in the exchange rate. By assumption, the economy must be on the stable trajectory of the system associated with money stock $(1 + \gamma)M$ at all times $t \geq \tau$. Thus, the initial conditions k_1 and k_2 must place the economy on an unstable path of the original system bringing it to the new system's saddlepath at time τ. For if this were not the case, the exchange rate would have to move sharply to attain the new saddlepath.

What information does this second set of constraints give us about k_1 and k_2? Let $(\overline{E}',\overline{W}')$ denote the stationary position of the economy after the increase in money; clearly, $\overline{E}' = (1 + \gamma)\overline{E}$ and $\overline{W}' = (1 + \gamma)\overline{W}$. By (B1), the position of the economy at time $t = \tau$ is

$$E(\tau) - \overline{E} = \frac{-k_1\overline{E}\varepsilon_W}{\overline{E}\varepsilon_E - \lambda_1}\exp(\lambda_1\tau) + \frac{-k_2\overline{E}\varepsilon_W}{\overline{E}\varepsilon_E - \lambda_2}\exp(\lambda_2\tau), \tag{B4}$$

$$W(\tau) - \overline{W} = k_1\exp(\lambda_1\tau) + k_2\exp(\lambda_2\tau). \tag{B5}$$

The condition that $(E(\tau),W(\tau))$ lie on the stable arm of the system associated with the higher money stock is

$$E(\tau) - \overline{E}' = \frac{-\overline{E}'\varepsilon_W(\overline{E}',\overline{W}',(1 + \gamma)M)}{\overline{E}'\varepsilon_E(\overline{E}',\overline{W}',(1 + \gamma)M) - \lambda_2}(W(\tau) - \overline{W}')$$

$$= \frac{-\overline{E}\varepsilon_W(\overline{E},\overline{W},M)}{\overline{E}\varepsilon_E(\overline{E},\overline{W},M) - \lambda_2}(W(\tau) - \overline{W}'), \tag{B6}$$

by (B2) and the homogeneity noted above. Conditions (B4)-(B6) together imply

$$k_1 = \frac{\exp(-\lambda_1\tau)[(\overline{E}\varepsilon_E - \lambda_1)(\overline{E}\varepsilon_E - \lambda_2)\gamma\overline{E} + \overline{E}\varepsilon_W(\overline{E}\varepsilon_E - \lambda_1)\gamma\overline{W}]}{\overline{E}\varepsilon_W(\lambda_2 - \lambda_1)}. \tag{B7}$$

Using (A3), (B3), and (B7), we find that

$$k_1 = \gamma\overline{W}\exp(-\lambda_1\tau) = -k_2$$

is the set of initial conditions associated with the economy's path between $t = 0$ and $t = \tau$.

Notes

1. Dornbusch and Krugman [13], Bruno [5, 6], and Spitäller [33] provide some preliminary econometric evidence.

2. This development has not been surprising to readers of Nurkse [27], Triffin [34], and Mundell [25], however.

3. See Dornbusch and Krugman [13], Basevi and De Grauwe [2], and Bilson [3].

4. Additional concerns lie behind these developments, of course, but a complete discussion would lead beyond the scope of this paper.

5. Hall [19] argues that many U.S. labor contracts do have this feature of demand-determined labor supply over limited periods. The assumption of predetermined nominal wages is familiar from the closed-economy macroeconomics literature exemplified by Fischer [14] and by Phelps and Taylor [28].

6. Some econometric evidence on the extent of real-wage resistance in Western Europe in the 1970's can be found in Branson and Rotemberg [4] and Sachs [31].

7. See Mundell [24]. These authors generally extend the Mundell-Fleming framework by fleshing out the labor market, allowing wages and prices to adjust gradually to market disequilibrium, and introducing expectations. The approach of this paper is closest to that of Burgstaller [9], who studies anticipated and unanticipated changes in the monetary growth rate and public spending in a neighborhood of an inflationary stationary state.

8. Gordon [17] develops a two-sector fixed-exchange-rate model in which a Phillips curve mechanism ensures a long-run real wage that clears the labor market. Buiter's [7] model is of related interest.

9. The existence and persistence of real exchange rate movements (i.e., deviations from purchasing-power parity) during the recent period of floating have been documented by Kravis and Lipsey [23] and Frenkel [16], among others. Calvo and Rodriguez [11] develop an alternative theory of real exchange rate movements based on external asset accumulation.

10. Like this paper's model, that of Mussa [26] describes a two-sector economy. Mussa's model abstracts from the labor market and from endogenous fluctuations in output, however.

11. Dornbusch [12] has made the point that exchange-rate undershooting may occur when the level of real output rises in the short run as a result of monetary expansion. In the model of Section 2, however, undershooting necessarily occurs.

12. The possible real effects of anticipated money under rational expectations are widely discussed in the literature on the macroeconomics of closed economies. See, for example, Fischer [15].

13. As usual, the production function exhibits positive but diminishing marginal returns to either factor.

14. All bonds carry a fixed nominal face value.

15. Both production functions are as decribed in footnote 13, above.

16. Burgstaller [8] and Henderson [20] develop sticky-wage models that take these factors into account. Note also that the effect of the real interest rate on expenditure is neglected as well. The explicit introduction of this factor into the present model would complicate the analysis considerably be adding a third differential equation (in P) to the system.

17. The degree-one homogeneity of P(.,.) in its two arguments would not obtain if real balances were a determinant of aggregate spending.

18. By (23), if $P_W > 0$, $(W/P)P_W < 1$, so the concomitant rise in P cannot offset the effect of a rise in W on the wage in terms of home goods.

19. All functions are henceforth evaluated at $(\overline{E},\overline{W})$ unless otherwise indicated.

20. See Appendix A.

21. The possibility that the aggregate price level falls during the transition cannot be ruled out under the present ranking of supply elasticities.

22. In Figure 5, it is assumed that $\omega_W < 0$ near long-run equilibrium.

23. Bilson [3] touches on this issue in the context of an extended Mundell-Fleming model.

24. An anticipated discrete jump in the exchange rate would involve an instantaneously infinite percentage rate of capital loss on domestic-currency assets. This anticipated loss would provide wealth-owners with an incentive to shift their portfolios toward real and foreign assets an instant before τ. Calvo [10] provides a more detailed discussion of this continuity condition.

25. Recall that by the homogeneity of the function $P(.,.)$, W/E and W/P must always vary in the same direction.

26. In the notation of Appendix B, this is the unstable path of the original system obtained by imposing the initial condition $k_2 = 0$. It is clearly the only path passing through $(\overline{E}',\overline{W}')$.

27. It is of interest to note that in the model of Dornbusch [12], the real effects of an anticipated monetary disturbance do not disappear as $\tau \rightarrow \infty$: even a monetary change anticipated infinitely far in advance requires that some relative price adjustment take place "after" its occurrence. See Gray and Turnovsky [18], Rogoff [29], and Wilson [35]. This counter-intuitive result follows from the fact that in Dornbusch's model, the locus obtained by imposing the initial condition mentioned in the previous footnote has a slope differing from the long-run equilibrium terms of trade. As Mussa [26] has emphasized, the problem is caused by the model's price-adjustment mechanism. The latter builds into the model a form of money illusion by postulating that the (sticky) nominal price of domestic output, rather than its price in terms of foreign goods, adjusts over time in response to goods-market disequilibrium. This problem is avoided in the present model by the expectational, forward-looking component of the wage-adjustment scheme, which automatically adjusts the nominal wage over time to offset expected increases in the absolute price level even in the absence of labor-market imbalance.

28. By (5), the nominal interest rate R must also rise monotonically until time τ.

29. The analysis in this appendix draws heavily on Rogoff [29] and Wilson [35].

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