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Anticipated Shocks and Exchange Rate Disequilibrium Beyond the Short Run

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The literature on small open economies has compared the response of exchange rates to anticipated and unanticipated policy changes. One key result states that the announcement of shocks dampens the initial jump of the exchange rate at the point of policy announcement, and also reduces exchange rate disequilibrium at the moment of policy implementation below the respective effects which occur when policy changes unexpectedly. The present paper proceeds from this result and provides an analysis of the comparative time profiles of the exchange rate under different policy implementation lags. The analysis arrives at some novel insights regarding the desirability of policy announcement within this theoretical framework.

Dornbusch's (1976) extensively cited article analyses the impact of an unanticipated money supply increase on price and exchange rate dynamics. *Wilson* (1979) demonstrates that any announcement preceding the money supply increase decomposes the Dornbusch effect into two separate discrete effects. The first is a jump of the exchange rate at the point of announcement. The second is a discrete drop of the domestic interest rate at the moment of the money supply increase. As a major result, Wilson argues that shock anticipation reduces the initial jump as well as the maximum impact beeing observed at the point of policy change below the respective effects (which collapse into a single effect) under the Dornbusch assumption of no anticipation. The present paper sets out to demonstrate that shock anticipation reduces initial exchange rate reactions only at the cost of a slower medium and long run return to exchange rate equilibrium.

Section I briefly restates the Dornbusch model and some of Wilson's results. Sections II and III shift the emphasis from the diagrammatic presentation in the p/e-plane, which is characteristic for the Dornbusch and Wilson papers, to a comparative analysis of *time profiles* of the nominal and the real exchange rate under varying assumptions. The implications of this analysis are summed up in Section IV.

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I. Anticipated shocks in the Dornbusch model

The Dornbusch model consists of two domestic markets, the goods market and the money market. Domestic goods prices are assumed to inflate proportionally to the logged ratio of domestic goods demand to supply:

$$\dot{p} = \pi (d - y) = \pi \left[u + \delta (e - p) + (\gamma - 1) y - \sigma r\right] \ . \tag{1}$$

$\dot{p}$ is domestic price inflation, d and y denote logs of the demand for and the supply of domestic goods, respectively, e is the log of the exchange rate, p the log of the domestic price level, and r the domestic interest rate. y is exogenous and u is an arbitrary constant. The money market is assumed to be in permanent equilibrium. Proceeding from a standard money demand function, this yields

$$- \lambda r + \varphi y = m - p \tag{2}$$

where m denotes the log of nominal balances. Open interest parity ties the domestic money market to international asset markets. If shocks are anticipated, the exchange rate expectation formation process used by Dornbusch is not compatible with perfect foresight any more. Therefore, Wilson directly assumes $\dot{e}^e = \dot{e}$, i.e. the expected rate of depreciation equals the actual one. Hence

$$r = r^* + \dot{e} \tag{3}$$

where r^* is the exogenous world interest rate.

Solution paths for the exchange rate are characterized by the general equation

$$e(t) = \bar{e}(m) + c_1 \exp(\mu_1 t) + c_2 \exp(\mu_2 t) \tag{4}$$

c_1 and c_2 are constants defined in the appendix. Further $\mu_{1,2} = \pi(\sigma + \lambda\delta)/2\lambda \pm \{[\pi(\sigma + \lambda\delta)/2\lambda]^2 + \pi\delta/\lambda\}^{1/2} >, < 0$.[1] $\bar{e}(m)$ is the equilibrium exchange rate given by m.

Wilson[2] has demonstrated that, if agents learn at time 0 that the money supply will increase at time T, the following relations hold:

$$e(0) < e(T) \qquad \text{for } T > 0 \tag{5}$$

$$de(0)/dT < 0 \qquad \text{for } T \geq 0 \tag{6}$$

$$de(T)/dT < 0 \qquad \text{for } T \geq 0 \ . \tag{7}$$

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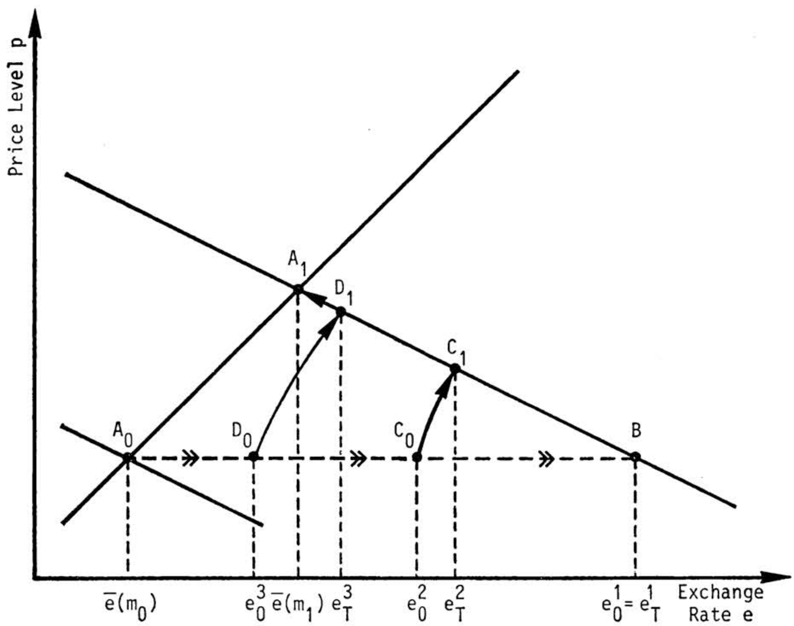
[1] See *Wilson* (1979), 642.

[2] In deriving his results, Wilson further has to assume that p and e eventually converge to their respective equilibrium values p and e (see his footnote 3, p. 743). This assumption is common in rational expectations models with saddle-type equilibria.

The implications of shock anticipation for exchange rate dynamics as stated by inequalities (5) - (7) are illustrated in Figure 1.



Legend:

Superscript	Scenario Referred to
1	$T = T_1 = 0$
2	$T = T_2 > 0$
3	$T = T_3 > T_2 > 0$

Superscripts on exchange-rate symbols indicate different scenarios as explained in the text and summarized in the legend.

Figure 1

Dornbusch's analysis of an unanticipated money supply increase on exchange rate dynamics is equivalent to scenario 1, which assumes $T = T_1 = 0$. The exchange rate follows the path depicted as $A_0\,BA_1$. If the anticipation period becomes positive ($T_2 > 0$) under scenario 2, the exchange rate moves along $A_0\,C_0\,C_1\,A_1$. Increasing T further, say to $T_3 > T_2 > 0$, will eventually eliminate initial exchange rate overshooting and produce a path depicted as $A_0\,D_0\,D_1\,A_1$.

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These results appear to suggest that early policy announcements are an important and unambiguous means for reducing exchange rate volatility. However, such a conclusion would be premature at this stage, as graphs in the p/e-plane give an inadequate picture of the effect of shock announcement on exchange rate *dynamics*. To clarify things, we will now turn to an analysis of the *time profiles* of the exchange rate under scenarios 1 - 3.

II. Comparative time profiles of the exchange rate

Two types of policy problems may be analysed in this context:

In the *first case*, policy makers conclude at time 0 that the money supply should be expanded. The question they are facing is whether this should be done right away, and, hence, unexpectedly, or at some time $T > 0$ in the future. The latter would give an opportunity to announce the shock.

In the *second case*, the shock is fixed to occur at time T, and policy makers face the question of whether they should let this happen unexpectedly or announce it at time $T' < T$.

1. Fixed announcement date (T′ = 0); variable implementation lag (T)

Before we can set out to depict the time profiles of the exchange-rate paths given in Figure 1 that occur under this particular assumption, we have to clarify how the exchange rate at any point $t^* > T$ responds to a marginal increase of T (where we assume $dT < t^* - T$). As the appendix proves, we have

$$\lim_{T \to \infty} \frac{de\,(t^*)}{dT} > 0 \qquad t^* > T \tag{8}$$

and

$$\frac{d^2\,e\,(t^*)}{dT^2} > 0 \qquad t^* > T\ . \tag{9}$$

(8) states that $de\,(t^*)/dT$ will eventually become positive as T approaches infinity. According to (9), $de\,(t^*)/dT$ becomes smaller as T is reduced and *may* eventually turn negative if T falls below some crucial level $\dot{T} \geq 0$. In economic terms, inequalities (8) and (9) stage that if the known implementation lag T of a money supply increase announced at time 0 is increased, this

(i) *increases* exchange rate disequilibruim from time $T + dT$ through infinity, if T exceeds some crucial lag $\dot{T}$, but

(ii) *decreases* exchange rate disequilibrium from time $T + dT$ through infinity, if T falls short of $\dot{T}$.

Since $\infty > T \geq 0$, this second effect may vanish under appropriate parameter constellations; the first effect never does.

Combined with Wilson's results that any increase in T reduces both the initial jump and the amount of disequilibrium of the exchange rate at time T, (i) and (ii) imply the following:

(1) For small values of $T < \dot{T}$, any marginal increase in T reduces both short-run volatility and long-run disequilibrium of the exchange rate.[3]

(2) For larger values of $T > \dot{T}$, a marginal increase in T reduces short-run volatility, but now at the expense of *increased* long-run disequilibrium of the exchange rate. Hence we are facing a *trade-off at the margin.*

What is more, the appendix further proves that

$$\lim_{T \to \infty} e(t^*) > \lim_{T \to 0} e(t^*) \qquad t^* > T \tag{10}$$

This means that for T exceeding some other critical level $\ddot{T}$ ($> \dot{T}$), long-run adjustment of the exchange rate to its new equilibrium is even slower than in the unexpected-shock scenario ($T = 0$).

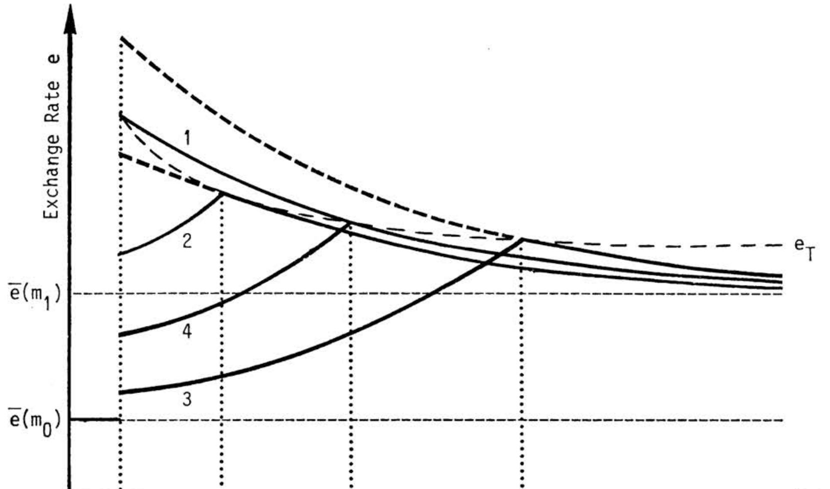

Figure 2

[3] Note again, that $T = 0$ would eliminate this effect.

Figure 2 illustrates these points. The time profiles numbered 1, 2 and 3 correspond to scenarios 1 - 3. Profile 4 depicts the special case that $T = \ddot{T}$, which leaves long-run adjustment the same as when $T = 0$.

2. Fixed implementation date (T = 0); variable announcement lead (− T′)

The time profiles of the nominal exchange rate which result from announced and unannounced money supply increases at a fixed implementation date $T = 0$ are obtained by simply shifting all time paths given in Figure 2 to the left by T time units. The result obtained in this case is clearly less surprising than the result derived in Section 1 above, and is illustrated in Figure 3 by comparing the cases $T = 0$ and $T = T_3 > 0$.

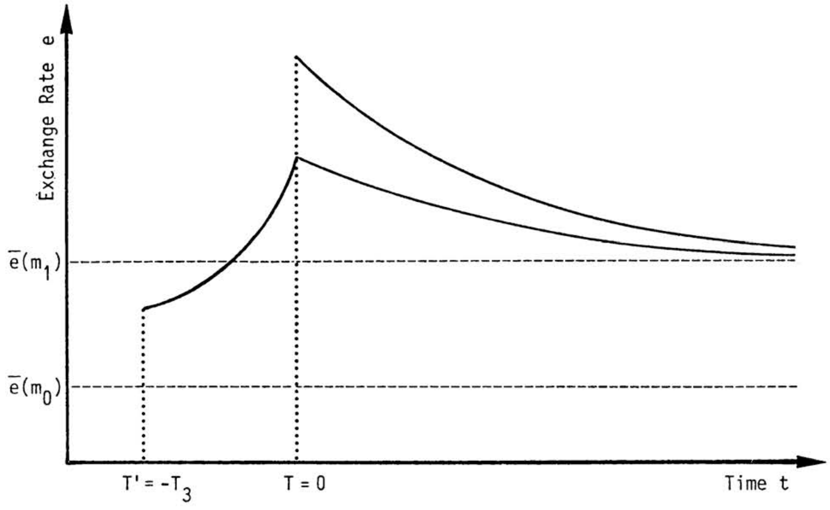

Figure 3

Policy announcement clearly succeeds in reducing the size of the overshoot at implementation date T and, also, of disequilibrium after T. The price that has to be paid for this is a period of disequilibrium (as compared with the old equilibrium) of length $-T'$ *prior to* T. But this is a familiar feature of saddle path rational expectations models and is not really surprising.

It may be argued, that the relevant criterion for comparing the policy alternatives of announced versus unannounced money supply growth is not the behavior of the *nominal* exchange rate, but rather the behavior of the *real* exchange rate, since the latter constitutes the relevant argument in the aggregate demand function for domestic goods. Therefore, Section III analyzes the dynamic response of the real exchange rate under the policy alternatives distinguished in Section II.

III. Comparative time profiles of the real exchange rate

1. Fixed announcement date (T′ = 0); variable implementation lag (T)

The real exchange rate is defined as $e - p$. Measurement of e may always be transferred to the ordinate and measurement of p may always be transferred to the abscissa by means of the 45°-line. Hence $e - p$ is nothing more than the horizontal or, which is the same, the vertical deviation of any point from the 45°-line, i.e., from the purchasing-power-parity line. With this graphical interpretation in mind, a number of characteristics of real exchange rate time profiles may be directly derived from Figure 1:

(i) The impact behavior of the real exchange rate is identical to the impact behavior of the nominal exchange rate, since prices are sticky.

(ii) After the increase of the money supply, i.e. after time T, the real exchange rate monotonically approaches its equilibrium value of 0.

(iii) There is a monotonous mapping of the adjustment paths observed for time $t > T$ from nominal to real exchange rate profiles. In other words, the longer the announcement lag, the larger is real exchange rate disequilibrium at and beyond the point of policy change.

Previously derived results do not suffice, though, to depict real exchange rate movements between time 0 and time T.

As the appendix proves, the following propositions characterize real exchange rate time profiles during this interval:

Proposition 1: $\dot{e}(0) - \dot{p}(0) < 0$ für $T > 0$; i.e. *the time profile has a negative slope at time 0 for all finite* $T > 0$.[4] Also $\lim [\dot{e}(0) - \dot{p}(0)] = 0$, i.e. the slope approaches zero as T approaches infinity.

Proposition 2: $d[\dot{e}(0) - \dot{p}(0)]/dT > 0$ for $T > 0$; i.e. *as T increases, the slope at time* 0 *flattens.* Also $\lim_{T \to \infty} \{d[\dot{e}(0) - \dot{p}(0)]/dT\} = 0$; i.e. the effect of an increase of T on the slope at $t = 0$ falls to zero as T approaches infinity.

Proposition 3: $d[\dot{e}(t) - \dot{p}(t)]/dt > 0$ for all T and $0 \leq t \leq T$; i.e. as t increases, the slope of the time profile increases in absolute terms. Hence, *the time path of the real exchange rate is sort of U-shaped between* 0 *and T.*

[4] More precisely, when I speak of the "slope" of the time profile at time 0, I really mean the right-hand-side limit.

Proposition 4: (i) $\lim_{T\to\infty} [\dot{e}(T) - \dot{p}(T)] < 0$; (ii) $\lim_{T\to\infty} [\dot{e}(T) - \dot{p}(T)] > 0$; (iii) $d\,[\dot{e}(T) - \dot{p}(T)]/dT > 0$ for finite $T > 0$. I.e. the slope of the time profile at time T depends on the magnitude of T.[5] For very small T close to zero it is negative. As T increases, this slope increases monotonically and is positive for large $T \to \infty$.

Hence, some finite T^* exists where $e(T^*) - p(T^*) = 0$. Thus, *for large enough implementation lags $T > T^*$, the time profile includes part of the positively sloped segment of a U-shape.*

Proposition 5: (i) $e(0) - p(0) > 0$ and $d\,[e(0) - p(0)]/dT < 0$ for finite T; (ii) $\lim_{T\to\infty} [e(0) - p(0)] = 0$ and $\lim_{T\to\infty} \{d\,[e(0) - p(0)]/dT\} = 0$; (iii) $e(T) - p(T) > 0$ and $d\,[e(T) - p(T)]/dT < 0$ for finite T; (iv) $\lim_{T\to\infty} [e(T) - p(T)] > 0$ and $\lim_{T\to\infty} \{d\,[e(T) - p(T)]/dT\} = 0$. Hence for some large enough T the time profile has its global maximum at time T. *As T approaches infinity, the negatively sloped segment of the U-shape vanishes.*

We may now proceed to illustrate the essential features of real exchange rate movements by means of three characteristic patterns (see Figure 4).

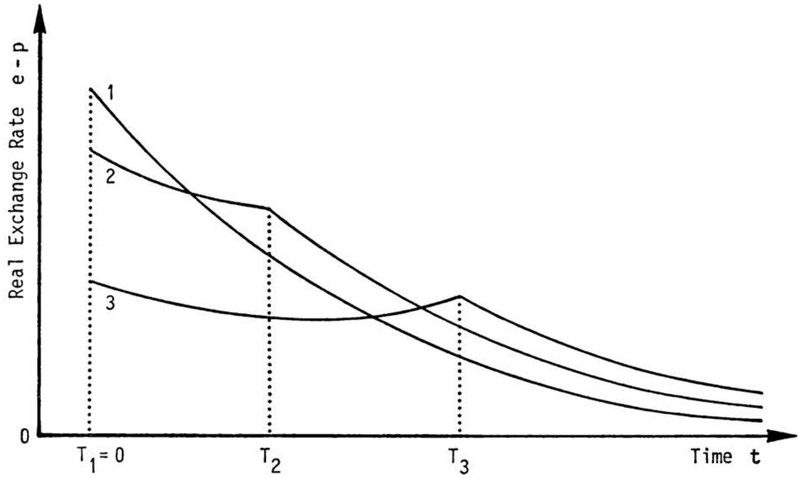

Figure 4

Scenario 1 depicts the unannounced-shock case, in which the real exchange rate moves in a way which is qualitatively equivalent to the

[5] To be precise, for the purposes of this section, the "slope" at time T really is the left-hand-side limit.

nominal exchange rate. Scenarios 2 and 3 illustrate the emerging U-shape between 0 and T as T increases, with the slope at time 0 becoming flatter, and the slope at T becoming steeper.

2. Fixed implementation date ($T = 0$); variable announcement lead ($-T'$)

In analogy to the nominal exchange rate case, time profiles of the real exchange rate which result from announced and unannounced money supply increases at a fixed implementation date $T = 0$ are obtained by simply shifting all time paths given in Figure 4 to the left by T time units (see Figure 5).

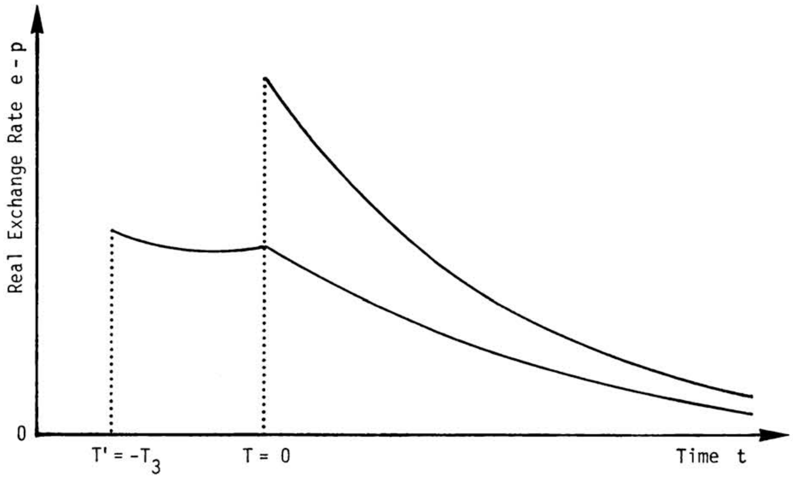

Figure 5

Policy announcement manages to reduce the size of the jump of the real exchange rate at the moment of policy change and also to speed up adjustment during the time after. But just as in the nominal exchange rate case, this goes at the expense of deviations from purchasing power parity *prior to* the eventual implementation of the new policy.

Summary

This paper attempts to extend *Wilson's* and *Rogoff's* analysis of the Dornbusch model into fields not considered by these authors. It turns out that no clearcut answer exists to the question whether new monetary policies should be implemented without or very little warning, or should be announced well ahead of time. Beyond some finite announcement lag, policy makers appear to be facing a *trade-off between short-run volatility and long-run deviation*

of the exchange rate from equilibrium. This trade-off applies both to the nominal and the real exchange rate. In the light of this trade-off, recommendations regarding announcement policies thus crucially depend on the specific social welfare function assumed to govern policy choices.

As it stands, of course, this result only holds for the particular model considered. Extensions to that variant of the Dornbusch model which uses a domestic price index are straigthforward and leave the qualitative results untouched. Other modifications of the model, however, in particular those which endogenize domestic output or modify expectations formation and price adjustment rules, may lead to different conclusions.

Zusammenfassung

Wilson (1979 und *Rogoff* (1979) haben gezeigt, daß man durch die Ankündigung von Geldmengenänderungen sowohl den Sprung des Wechselkurses zum Zeitpunkt der Ankündigung reduzieren als auch das Wechselkursungleichgewicht zum Zeitpunkt der Politikimplementation verringern kann. Die vorliegende Arbeit knüpft an diese Ergebnisse an und entwickelt die Zeitprofile des Wechselkurses, welche sich bei Implementationslags unterschiedlicher Länge ergeben. Diese Zeitprofile deuten auf ein mögliches Dilemma hin: Die Ankündigung von Politikänderungen verringert zwar die kurzfristige Volatilität des Wechselkurses, verlangsamt aber u. U. die nach erfolgter Geldmengenexpansion einsetzende Anpassung des Wechselkurses an sein langfristiges Gleichgewicht.

Appendix

I. Time profiles of the nominal exchange rate

For $t^* > T$ the general solution given by (4) holds with the restriction $c_1 = 0$. Hence

$$e(t^*) = \bar{e}(m) + c_2^1 \exp(\mu_2 t^*) \ . \tag{A1}$$

Pre and post-expansion coefficients are characterized by superscripts of 0 and 1, respectively. c_2^1 may be computed by noting that

$$c_1^0 \exp(\mu_1 T) + c_2^0 \exp(\mu_2 T) = \Delta m + c_2^1 \exp(\mu_2 T) \tag{A2}$$

and that

$$c_2^0 = -\frac{\mu_1}{\mu_2}\left(\frac{\Delta \bar{p} - \lambda\mu_2 \Delta \bar{e}}{\lambda\mu_1 - \lambda\mu_2}\right)\exp(-\mu_1 T) > 0 \tag{A3}$$

and also

$$c_1^0 = -c_2^0 \frac{\mu_2}{\mu_1} \tag{A4}$$

Taking into account the long-run homogenity property $\Delta m = \Delta \bar{p} = \Delta \bar{e}$, we thus obtain

(A5) $$c_2^1 = -\Delta m \exp(\mu_1 T) + \Delta m \left(\frac{1-\lambda\mu_2}{\lambda\mu_1 - \lambda\mu_2}\right) \exp(-\mu_2 T) - \Delta m \frac{\mu_1}{\mu_2} \left(\frac{1-\lambda\mu_2}{\lambda\mu_1 - \lambda\mu_2}\right) \exp(-\mu_1 T)$$

Inserting (A5) into (A1) and differentiating with respect to T yields

(A6) $$\frac{de(t^*)}{dT} = \Delta m \exp(\mu_2 t^*) \left[\frac{\mu_1^2}{\mu_2} \left(\frac{1-\lambda\mu_2}{\lambda\mu_1 - \lambda\mu_2}\right) \exp(-\mu_1 T) - \mu_2 \left(\frac{1-\lambda\mu_2}{\lambda\mu_1 - \lambda\mu_2} - 1\right) \exp(-\mu_2 T)\right]$$

The sign of $de(t^*)/dT$ is soley determined by the expression given in brackets. Noting that $\lambda\mu_1 < 1$ (Rogoff, p. 77), $\mu_1 > 0$ and $\mu_2 < 0$, (A6) implies

$$\lim_{T\to\infty} \frac{de(t^*)}{dT} > 0 \ .$$

This proves proposition (8).

Differentiation of (A6) with respect to T yields

$$\frac{d^2 e(t^*)}{dT^2} = \exp(\mu_2 t^*) \Delta m \left[\mu_2^2 \left(\frac{1-\lambda\mu_2}{\lambda\mu_1 - \lambda\mu_2}\right) \exp(-\mu_2 T) - \frac{\mu_1^3}{\mu_2} \left(\frac{1-\lambda\mu_2}{\lambda\mu_1 - \lambda\mu_2}\right) \exp(-\mu_1 T)\right]$$

All terms given in brackets are positive, which proves proposition (9).

Finally, $\lim\limits_{T\to 0} e(t^*) - \lim\limits_{T\to\infty} e(t^*)$ may be evaluated by using the solution obtained for $e(t^*)$ by substituting (A5) into (A1) and letting T approach the indicated limits. (Recall that we assume $t^* > T$). The only term which does not vanish is $-[1-\lambda\mu_2)/(\lambda\mu_1 - \lambda\mu_2) - 1]$, which is negative. Hence proposition (10) holds.

II. Time profiles of the real exchange rate

The real exchange rate in the interval $0 \leq t \leq T$ is defined as

(B1)
$$\dot{e}(t) - \dot{p}(t) = c_1^0 \exp(\mu_1 t) + c_2^0 \exp(\mu_2 t) - c_1^0 \lambda\mu_1 \exp(\mu_1 t) - c_2^0 \lambda\mu_2 \exp(\mu_2 t) \ ,$$

which implies

(B2) $$\dot{e}(t) - \dot{p}(t) = (1-\lambda\mu_1)\mu_1 c_1^0 \exp(\mu_1 t) + (1-\lambda\mu_2)\mu_2 c_2^0 \exp(\mu_2 t)$$

1. Substitution of (A4) into (B2) and setting $t = 0$ yields

$$\dot{e}(0) - \dot{p}(0) = \mu_1 c_1^0 (\mu_2 - \mu_1) < 0 \ .$$

Further, because of (A3) and (A4)

$$\lim_{T \to \infty} [\dot{e}(0) - \dot{p}(0)] = 0 \ .$$

These results prove proposition 1.

2. Combination of (A3), (A4) and (B2) and differentiation with respect to T yields

$$d\,[\dot{e}(0) - \dot{p}(0)]/dT = \mu_1^2 (\mu_1 - \mu_2) K \exp(-\mu_1 T) > 0 \ ,$$

where $K = (\Delta\,\bar{p} - \lambda\mu_2\,\Delta\,\bar{e})/\lambda\,(\mu_1 - \mu_2) > 0$

and

$$\lim_{T \to \infty} \{[\dot{e}(0) - \dot{p}(0)]/dT\} = 0 \ .$$

These results prove proposition 2.

3. Differentiation of (B2) with respect to t gives

$$d\,(\dot{e} - \dot{p})/dt = \mu_1^2 c_1 \exp(\mu_1 t)(1 - \lambda\mu_1) + \mu_2^2 c_2 (1 - \lambda\mu_2) \exp(\mu_2 t) > 0 \ .$$

This proves proposition 3.

4. Substituting (A3), (A4) and $t = T$ into (B2) and rearranging terms yields

$$\dot{e}(T) - \dot{p}(T) = \mu_1 K (1 - \mu_1 \lambda) - \mu_1 K (1 - \mu_2 \lambda) \exp[(\mu_2 - \mu_1) T] \ .$$

Making use again of $\lambda\mu_1 < 1$ and $\mu_2 < 0 < \mu_1$ yields

(i) $$\lim_{T \to 0} [\dot{e}(T) - \dot{p}(T)] < 0 \ ,$$

(ii) $$\lim_{T \to \infty} [\dot{e}(T) - \dot{p}(T)] > 0 \ ,$$

(iii) $$d\,[\dot{e}(T) - \dot{p}(T)]/dT = \mu_1 K (1 - \mu_2 \lambda)(\mu_1 - \mu_2) \exp[(\mu_2 - \mu_1) T] > 0 \ .$$

This proves propositions 4(i) - (iii).

5. Setting $t = 0$ in (1) yields, after rearranging terms,

$$e(0) - p(0) = (1 - \lambda\mu_1) c_1^0 + (1 - \lambda\mu_2) c_2^0 > 0 \ .$$

Further, using (A3) and (A4),

$$d\,[e(0) - p(0)]/dT = -\mu_1 (1 - \lambda\mu_1) K \exp(-\mu_1 T + \frac{\mu_1^2}{\mu_2} K (1 - \lambda\mu_2) \exp(-\mu_1 T) < 0 \ .$$

This proves proposition 5(i).

Evaluation of the two preceding equations as the limit $T \to \infty$ yields

$$\lim_{T\to\infty} [e(0) - p(0)] = 0 \quad \text{and} \quad \lim_{T\to\infty} \{d\,[e(0) - p(0)]/dT\} = 0 \ ,$$

which proves proposition 5(ii).

Setting $t = T$ in (B1) and substituting (A3) and (A4) yields

$$\mathrm{e}(T) - p(T) = (1 - \lambda\mu_1)\,K - \frac{\mu_1}{\mu_2}\,K\,(1 - \lambda\mu_2)\exp\,[(\mu_2 - \mu_1)\,T] > 0 \ ,$$

and, after differentiation with respect to T,

$$d\,[e(T) - p(T)]/dT = -\,(\mu_2 - \mu_1)\,\frac{\mu_1}{\mu_2}\,K\,(1 - \lambda\mu_2)\exp\,[(\mu_2 - \mu_1)\,T] < 0 \ ,$$

This proves proposition 5(iii).

Evaluation of the two preceding equations as the limit $T \to \infty$ yields

$$\lim_{T\to\infty} [e(T) - p(T)] > 0 \quad \text{and} \quad \lim_{T\to\infty} \{d\,[e(T) - p(T)]\} = 0 \ ,$$

which finally proves proposition 5(iv).

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