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Theories Consistent Expectations and Exchange Rate Dynamics

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Abstract

This paper develops a new approach to modeling exchange rate expectations that brings the implications of the standard monetary models of the exchange rate more closely in line with actual exchange rate experience. The approach extends the work Frydman and Phelps [1990], which proposes an alternative expectational assumption called the Theories Consistent Expectations Hypothesis (TCEH). With TCE, market agents are endowed with a number of leading theories, all of which inform agents as to the algebraic signs of the weights attached to fundamental variables, rather than the true parameter magnitudes as in the standard RE approach. The paper shows that implications of the monetary approach with TCE include the following: 1) In a world where agents do not know the true value of the long-run exchange rate, exchange rate movements *should* be characterized by persistent movements away from established equilibrium values (e.g., PPP and/or current account balance); 2) These persistent movements will alternate in direction as market agents switch the set of fundamentals they use in forecasting and/or policy officials react and alter the way the driving variables are moving; 3) The divergent behavior generated in the model provides the rationale for such behavior on the part of market agents and policy officials; 4) Once movement in the exchange rate changes direction and moves toward the equilibrium level, there will be no tendency to stop at this level, and instead, shooting through will be the norm; and 5) Standard empirical exchange rate models *should* experience periodically structural instability that is proximate to the major turning points in the value of the currencies. These implications, together with the empirical record, lead to conclusion that the monetary approach with TCE provides a reasonable macroeconomic framework for examining exchange rate dynamics. An interesting difference between the approach with TCE and the alternative approach of Frankel and Froot [1987] with noise trading is that the former approach explains the seemingly anomalous behavior as the result of agents focusing on the wrong combination of fundamentals, whereas the latter approach relies on some agents ignoring fundamental news altogether.

1. Introduction

It has been apparent for some time now that the standard asset market models of exchange rate determination provide poor descriptions of exchange rate behavior. These models are usually solved using the Rational Expectations Hypothesis (REH) and it seems natural to inquire whether the problem lies in part with the expectational assumption. Studies that undertake this line of analysis in the exchange rate literature include Frankel and Froot [1988] and Kirman [1990]. In the present paper we pursue this line of research and explore the implications of an alternative expectational assumption recently proposed in Frydman and Phelps [1990]— the Theories Consistent Expectations Hypothesis (TCEH). The TCEH embodies the most appealing feature of the REH in that it supposes rational economic agents use extant economic theories in forming their forecasts. However, in other respects the TCEH attempts to dispense with the most objectionable aspects of the RE solution technique. The TCEH recognizes the existence of a pluralism of theories describing exchange rate dynamics and allows agents to base their forecasting functions on more than one of the existing theories. Furthermore, the TCEH does not assume that the precise magnitudes of the parameters of economic models are known to agents, i.e., the stock of extant theories provides qualitative rather than quantitative knowledge about the economy or the future course of payoff-relevant variables. Nevertheless, in contrast to other alternatives to the REH, the TCEH is not arbitrary and, as this paper shows, its use to close the monetary models of the exchange rate brings the implications of this class of models more closely in line with actual exchange rate experience.

The exercise conducted in this paper is the following. First, a composite model in semi-reduced form is specified which encompasses the semi-reduced forms of the following commonly used monetary models of the exchange rate: 1) The flexible-price model of Frenkel [1976] and Bilson [1978] (the FB model); 2) The sticky-price model of Dornbusch [1976] and Frankel [1979] (the DF model); and 3) The sticky-price model of Hooper and Morton [1982] (the HM model). No stand is taken initially on which of the encompassed semi-reduced-form models are correct. Since we assume that all agents subscribe to at least one of these theories (all of which imply a linear forecasting rule), the forecasting equation in the aggregate will be a linear function of the variables of these models, where the weights attached to each fundamental variable will be consistent in sign with at least one of the encompassed theories. Such an aggregate forecasting equation is said to be theories consistent. This assumption of TCE is then used to derive the dynamical equations of the system, which are solved for the reduced-form time paths of the endogenous variables. Once this is accomplished the dynamics of the system are examined under various assumptions concerning the true underlying structure of the economy and the particular combination of models used by agents.

We show in this paper that endowing agents with qualitative rather than quantitative knowledge within the TCE framework has important implications for the short-run and long-run dynamics of both the nominal and real variables of the system. The major finding is that when some agents believe in the sticky-price model (whether or not prices are actually sticky), the rate of change of the exchange rate and prices in the steady state (given the assumed growth rates of the driving variables) will neither be the same nor be equal to the growth rate implied by the movements in money and income. The consequence being that the model produces persistent movements in both the real exchange rate, real interest rate differential and real money balances in the long-run. The reason for this result stems from the fact that in the TCE setup agents do not know the true value of the long-run exchange rate and, in general, their estimate of this value will be changing at a different rate than that of the true value. It is this growing wedge between what agents believe to be the value of the long-run exchange rate and the true value that produces persistence in the real variables of the system.

An important characteristic of the model is that it is capable of generating endogenously persistent movements in the real variables of the system that can alternate in direction. There are two possibilities. First, TCE allows for agents to switch the set of fundamental variables they use when forming expectations. In the model, such a switch in expectations functions can cause the divergent movements in the real variables of the system to reverse course and move in the other direction. Although this switch in expectations functions is not formalized explicitly, the model does offer two reasons for such behavior: 1) The persistent movements in the real variables of the system signal to agents, after some threshold is reached, that they are on a divergent path; and 2) Agents commit forecasting errors that grow in the steady state (even though they may be on the right side of the market), which also signals to them eventually that they do not have it quite right.

The second possibility for persistent movements that alternate in direction is for policy officials to step in and change the way the driving variables of the system are moving. Again, we do not formalize this explicitly. But, as with case of switching expectations functions, the divergent behavior of the model provides a rationale for such a reaction on the part of policy officials.

The paper argues that because of the divergent behavior of the real variables of the system in the long-run, the monetary models with TCE imply that the system becomes altered before it has moved "too far", i.e., in order to make the long-run conclusions of the models reasonable, agents must be assumed to switch their expectations functions and/or policy officials react. We find that with this assumption, the monetary models of the exchange rate with TCE generate a reasonable description of the empirical record. This stands in sharp contrast to the common evaluation of the usefulness of such models with the REH.

The exchange rate dynamics that emerges from our analysis suggests that both the nominal and real exchange rate *should be* characterized by persistent movements, to the extent that there are persistent movements in the underlying set of fundamentals. In addition, these persistent relationships will be inherently unstable, in that movements "too" far away from natural levels cause expectations functions to switch and/or policy officials to react. Furthermore, when there is a break and the persistent movements in the nominal and real variables change direction and begin to move toward their natural levels, there is no tendency to stop when the natural levels are reached. Instead, these movements will shoot through their natural levels, setting up the conditions for another countermovement. Finally, our analysis suggests that standard empirical exchange rate models should periodically experience structural instability that is proximate to the major turning points in the nominal and real variables of the system and that possibly involves different sets of significant variables during different time periods. It should be noted that this view of market behavior accords well with the work of Schulmeister [1983,1987] and Soros [1987].

The findings of our analysis shed light on many of the anomalies reported in the empirical literature on exchange rates.[2] Two of the more troubling of these anomalies are: 1) Persistent movements in the nominal and real exchange rate, especially during the period from the second quarter of 1984 through February 1985 when the dollar continued to rise in both nominal and real terms while at the same time the differential in U.S. and German nominal and real interest rates were falling (see Frankel and Froot [1990]); and 2) Structural instability on the part of the empirical asset market models involving different sets of significant variables during different time periods (see Goldberg and Frydman [1990]).[3]

This exchange rate experience has been the grist inspiring the many other alternative approaches developed in recent years. Prominent among these are two: 1) Allowing for rational bubbles (see Meese [1986]); and 2) Allowing for noise traders (see Frankel and Froot [1987]) and Kirman [1990]). Both of these approaches offer explanations for the persistence in real and nominal exchange rates and the structural instability. An important difference, however, between these other approaches and the view

[2] For studies that review the empirical record see Dornbusch and Frankel [1987] and Frankel and Meese [1987] and Goldberg [1991].

[3] Meese [1990] argues that researchers (and presumably market agents as well) have shifted their focus from real interest differentials during the early 1980s, to U.S. budget and current account deficits during the mid-1980s. In an earlier study he remarks that "the most menacing empirical regularity that confronts exchange rate modelers is the failure of the current generation of empirical exchange rate models to provide stable results across subperiods of the modern floating rate period (Meese [1986]. p.365) ".

offered here is that with these other approaches the apparently anomalous exchange rate behavior is unrelated to the underlying set of fundamentals. In contrast, the explanation offered here relies precisely on movements in fundamental variables. It is the *imperfect* knowledge of market agents concerning the correct relationship between the fundamentals and the exchange rate that leads to the problems of persistence and structural instability.

The paper is structured as follows. Section 2 sets out the semi-reduced form of our composite monetary model and briefly reviews the three reduced forms obtained using the RE solution technique. Section 3 offers a formulation of the TCEH, while section 4 solves the composite model using this expectational assumption. In section 5 we study the implications of closing the monetary models using the TCEH and in section 6 we briefly discuss these implications in light of the empirical record, focusing on the problems of persistence and structural instability.

2. The Composite Monetary Model

In this section the basic structure of the economy that will be used throughout the analysis is characterized. This is accomplished by making use of the monetary approach to exchange rate determination, where we focus on three of the more frequently used models: 1) The FB flexible-price model; 2) The DF sticky-price model; and 3) The HM sticky-price model. The basic (semi-reduced form) structure of these models can be expressed as special cases of the following composite model:

$$m = \gamma p + \phi y - \lambda i \tag{1}$$

$$\dot{p} = \nu(e - p - q_n) - \alpha(i - i_n) + \dot{\bar{p}} \tag{2}$$

$$\delta(e - p - q_n) + \beta(i - E(\dot{e})) = 0 \tag{3}$$

$$q_n = q_{n_0} - \eta k \tag{4}$$

where m, p, and y denote the log levels of domestic minus foreign money supply, price and income respectively, i denotes the level of the domestic minus foreign short-term interest rates, k is the de-trended level of domestic minus foreign cumulative trade balances, e is the log level of the exchange rate (defined as the domestic currency price of foreign currency), i_n and q_n are the natural levels (a term made precise below) of i and the log level of the real exchange rate, q_{n_0} is an initial condition on q_n, the symbols "$\bar{}$" and "$\dot{}$" denote steady-state value and time derivative respectively and $E(\dot{e})$ denotes the forecast of $\dot{e}$.

Equation (1) describes equilibrium in the money markets, where we use the standard assumption that the parameters of the domestic money demand function are equal to their foreign counterparts.[4] Equation (2) shows how prices adjust to the long-run when they are assumed to be sticky in the short-run (the DF and HM cases). Price adjustment is shown to be a function of excess demand, which depends on the deviation of the real exchange rate and the nominal interest rate from their natural levels. The natural level of the interest rate variable (i_n) is defined as the level that would produce zero excess demand when the real exchange rate is equal to its natural level. The natural level of the real exchange rate is defined in an analogous way. In order to tie down the level of i_n, and therefore the level of q_n, we assume that the domestic and foreign real interest rate levels implicit in i_n are constant and equal. This implies that i_n is equal to $E(\dot{\bar{p}})$.

Equation (3) is the equilibrium condition for the foreign exchange market, which adopts the specification used in Frenkel and Rodriguez [1982] and allows for imperfect capital mobility. It describes

[4] This difference restriction on the domestic and foreign money demand parameters is standard in the literature. It in no way alters the main conclusions of our analysis and we make use of it only for convenience.

an equilibrium flow relationship for the balance of payments. The first term in the equation is the balance on the trade account, whereas the second term is the balance on the capital account. The parameter ß represents the speed of adjustment in the asset market.[5] Finally, equation (4) makes use of the work in Hooper and Morton [1982] and assumes that if q_n changes over time, then its movements are related to movements in cumulative trade balances from trend. We assume that all such movements from trend are unexpected.[6]

The composite model in equations (1) through (4) admits two special cases. First, when prices are flexible (the FB case) we have $\dot{p} = \bar{\dot{p}}$, so that equation (2) reduces to $e\text{-}p\text{-}q_n = \frac{\alpha}{\nu}(i\text{-}i_n)$. In the standard RE case we have $i = E(\dot{p}) = \dot{p} = i_n$, where $\dot{p} = \frac{1}{\gamma}(\dot{m} - \phi\dot{y})$. This implies that with flexible prices and RE purchasing power parity (PPP) holds at every moment.[7] Second, when capital is perfectly mobile (implying that $\beta = \infty$), we have $\delta/\beta = 0$ and equation (3) reduces to the familiar condition of uncovered interest rate parity (UIP), i.e., $E(\dot{e}) = i$.

In order to close any variant of the composite model given in equations (1) through (4) it is necessary to specify the forecasting equation $E(\dot{e})$. The usual approach, which is followed in the FB, DF and HM cases, is to assume RE. The resulting forecasting equations for these three models are captured in the following two equations:

$$E(\dot{e}) = \theta(\bar{e} - e) + \frac{1}{\gamma}\pi \qquad (5)$$

[5] The specification of the trade and capital accounts in equation (3) is highly simplified. A richer specification -- such as allowing for the effects of income and interest on the current account or a risk premium (and thus asset supplies) in the capital account -- would not alter the basic conclusions of our analysis.

[6] For further details concerning equation (4) see Hooper and Morton [1982].

[7] We show below that even when prices are flexible, $i \neq i_n$ and PPP does not hold with TCE.

$$\bar{e} = \frac{1}{\gamma}(m - \phi y) + \frac{\lambda}{\gamma^2}\pi + q_{n_0} - \eta k \tag{6}$$

where π denotes the rate of growth of m in excess of the growth of relative money demand due to movements in y (i.e., $\pi = (\dot{m} - \phi\dot{y})$) and the parameter θ, which is redefined to be positive, is the stable root of the system. It can be shown that equations (5) and (6) result whether or not capital is assumed to perfectly mobile. The forecasting equation for the DF sticky-price model obtains when $\eta=0$, whereas the forecasting equation for the HM sticky-price model obtains when η is allowed to be nonzero. When prices are assumed to be flexible we have $i=i_n$, which from equation (2) implies that $q=q_n$ and $e=\bar{e}$. This in turn implies:

$$E(\dot{e}) = i \tag{7}$$

since $i=\pi/\gamma$. Equation (7) is the forecasting equation for the FB flexible-price model.

3. Theories Consistent Expectations: Formulation

The standard implementation of the REH assumes that the agents' forecasting equation is the same as the reduced form of the analyst's model. This solution technique makes the analysis determinate and seemingly precise at the cost of extreme assumptions concerning the information and knowledge that agents possess. In this section we offer an alternative expectational hypothesis that assumes agents base their forecast functions on theory, but it also allows for a number of extant theories. This alternative formulation seems plausible and appealing on rationality grounds.

In attempting to formulate a less informationally demanding hypothesis in the spirit of the REH, the basic difficulty is immediately encountered. It is not enough to say that the forecasting equations of agents are based on the extant economic models, since these models themselves contain forecasts of the endogenous variables, i.e., we are faced with the infinite regress problem that dates back to Keynes [1936].[8] The following hypothesis attempts to overcome this problem:

> **The Theories Consistent Expectations Hypothesis:** Agents are said to hold theories consistent expectations if their forecasting functions contain variables appearing with the same algebraic signs as in the reduced form of at least one of the extant models. The reduced forms of the models are defined to be the reduced forms obtained when using the RE solution technique.

In the spirit of the REH the theories consistent expectations hypothesis supposes that agents base their forecasts on the RE reduced form from one of the extant economic models. However, the TCEH does not attribute to agents the quantitative knowledge of the parameters of the existing models. Instead, agents are assumed to have a qualitative (intuitive) understanding of the models. This is formalized by assuming that they use their own estimates (guesses) of the parameters in place of the true values. The assumption is that these parameter estimates have the same algebraic signs as those of at least one of the RE reduced forms. Furthermore, the TCEH does not suppose that only one model (the analyst's) is known and used by agents. Instead, it allows for the possibility that different models or only some of the variables (although with parameter signs that are consistent with one of the models) are utilized by agents at different points in time.

As such, the TCEH closes the composite model in equations (1) through (4) by giving rise to an aggregate forecasting equation ($E(\dot{e})$) that is based on the three RE forecasting functions given in equations (5) through (7). This aggregate forecasting equation can be expressed as follows:

$$E(\dot{e}) = (1 - \sigma)\left[\tilde{\theta}(\tilde{\bar{e}} - e) + \frac{1}{a_1}\tilde{\pi}\right] + \sigma i \qquad \textbf{(8)}$$

[8] This infinite regress problem is analyzed in the context of the RE approach in Phelps [1983].

$$\tilde{\bar{e}} = \frac{1}{a_1}(m - a_2 y) + \frac{a_3}{a_1^2}\tilde{\pi} + \tilde{q}_n \quad (9)$$

$$\tilde{\pi} = \tilde{\dot{m}} - a_2\tilde{\dot{y}} = a_1\tilde{\dot{p}} = a_1\tilde{\dot{e}} \quad (10)$$

$$\tilde{q}_n = (1-\omega)\tilde{q}_n^{Df} + \omega(\tilde{q}_{n_0}^{HM} - a_4 k) \quad (11)$$

where σ is the share of agents subscribing to the FB flexible-price model, the symbol "~" denotes an estimate arrived at by agents, ω is the proportion of agents believing in sticky prices who subscribe to the HM model, and the superscript DF (HM) denotes a variable estimate by the section of the market subscribing to the DF (HM) sticky-price model.

There are several simplifying assumptions implicit in equation (8) which do not alter the main conclusions of the analysis. First, we assume agents know that the parameters of the true domestic money demand function are equal to their foreign counterparts. Second, all of the parameters and variables with a "~" are weighted averages of the parameter and variable estimates from the two groups believing in sticky-prices, i.e., $\tilde{\theta} = (1-\omega)\tilde{\theta}_{DF} + \omega\tilde{\theta}_{HM}$, $a_1 = (1-\omega)a_1^{DF} + \omega a_1^{HM}$, etc.. This implies that $\tilde{\bar{e}} = (1-\omega)\tilde{\bar{e}}_{DF} + \omega\tilde{\bar{e}}_{HM}$, $\tilde{q} = (1-\omega)\tilde{q}_{DF} + \omega\tilde{q}_{HM}$ and $\tilde{\pi} = (1-\omega)\tilde{\pi}_{DF} + \omega\tilde{\pi}_{HM}$. Third, we assume that $\tilde{\dot{m}}$ and $\tilde{\dot{y}}$ are positively related to $\dot{m}$ and $\dot{y}$ respectively so that $\tilde{\pi}$ is positively related to π. Finally, equation (8) assumes that as the market switches from the flexible-price model to the sticky-price model and vice versa (i.e., σ changes), ω is not affected. This implies that movements in σ do not affect any of the other parameters of the aggregate forecasting equation, and therefore do not affect $\tilde{\pi}$, $\tilde{\bar{e}}$ and $\tilde{q}_n$.

The class of theories consistent expectations functions also contains forecasting functions relating $E(\dot{e})$ to a subset of all of the variables (with the same algebraic signs) appearing explicitly or implicitly on the right-hand side of (8). It will be seen that allowing for subsets of fundamental variables to dominate in the aggregate is needed in order to prevent the real variables of the system from diverging "too" far.

4. Solving the Composite Model with the TCEH

One of the main differences between the RE and TCE solution techniques is that the aggregate forecasting equation in the latter is specified partly from outside of the analyst's model. The mathematical solution of the model with TCE reflects this difference. The first step is to use equations (1) through (4) and (8) in order to derive the two equations of motion (i.e., the $\dot{e}$ and $\dot{p}$ equations) as functions of the endogenous and exogenous variables of the model. With TCE, however, $\dot{e}$ and $E(\dot{e})$ are not assumed to be equal and, as such, the equation for $\dot{e}$ must be obtained via a different route than that used in the standard RE case. This is accomplished by first substituting equations (1) and (8) into equation (3). The result of this is then differentiated with respect to time and substituted into equation (2), giving rise to the $\dot{e}$ equation. The resulting dynamical system with TCE can be written in matrix form as follows:

$$\begin{bmatrix} \dot{p} \\ \dot{e} \end{bmatrix} = \begin{bmatrix} \dfrac{-(\nu\lambda + \alpha\delta)}{\lambda} & \nu \\ \dfrac{[(1-\sigma)\beta\gamma - \delta\lambda](\nu\lambda + \alpha\gamma)}{[(1-\sigma)\beta\bar{\theta} + \delta]\lambda^2} & -\dfrac{[(1-\sigma)\beta\gamma - \delta\lambda]\nu}{[(1-\sigma)\beta\bar{\theta} + \delta]\lambda} \end{bmatrix} \begin{bmatrix} p \\ e \end{bmatrix}$$
$$+ \begin{bmatrix} \dfrac{\alpha}{\lambda}(m - \phi y) - \nu q_n + \alpha i_n + \dot{\bar{p}} \\ \dfrac{[(1-\sigma)\beta\gamma - \delta\lambda]}{[(1-\sigma)\beta\bar{\theta} - \delta]\lambda} \Bigg[\dfrac{\alpha}{\lambda}(m - \phi y) - \dot{\bar{p}} - \alpha i_n + \dfrac{(1-\sigma)\beta}{[(1-\sigma)\beta\gamma - \delta\lambda]}(\pi + \lambda\bar{\theta}\dot{\bar{\bar{e}}}) + \nu q_n \Bigg] \end{bmatrix} \quad (12)$$

In the standard RE case, the analyst assumes stability and constant growth rates for money and income and solves the system of motion for the time paths of the endogenous variables. With the TCEH, however, a different procedure is required. The problem is that the transition matrix in (12) is singular, indicating at least one zero root. The presence of a zero root would ordinarily cause the steady-state values of the endogenous variables to be functions of initial conditions and speed of adjustment parameters (see Giavazzi and Wyplosz [1982], Goldberg [1991a,b]). However, for reasons discussed shortly this is not the case here.

The following is a compact version of the general solution to (12), which is derived in a mathematical appendix (available from the authors on request):

$$p(t) = c_1 + c_2 e^{\theta_2 t} + \phi_{p_p} \tag{13}$$

$$e(t) = c_1 \frac{(\nu\lambda - \alpha\gamma)}{\lambda\nu} - c_2 \frac{[(1-\sigma)\beta\gamma - \delta\lambda]}{[(1-\sigma)\beta\bar{\theta} + \delta]\,\lambda} e^{\theta_2 t} + \phi_{p_e} \tag{14}$$

where ϕ_{p_p} and ϕ_{p_e} are the particular solutions for p and e respectively and θ_2, which is the nonzero root of the system, is given as follows: $\theta_2 = -\frac{(1-\sigma)\beta\bar{\theta}(\nu\lambda + \alpha\gamma) - \gamma[(1-\sigma)\beta\nu + \delta\alpha]}{[(1-\sigma)\beta\bar{\theta} + \delta]\lambda} < 0.$

There are three aspects which are noteworthy of the general solution in equations (13) and (14). First, stability does not need to be assumed, since θ_2 is negative. This is a consequence of the fact that under the TCEH the algebraic sign of the parameter θ in the forecasting function in (8) is positive. Second, because of the zero root ϕ_{p_p} and ϕ_{p_e} are both functions of initial conditions and the speed of adjustment parameters ν, α, β and δ. Finally, the system of equations in (13) and (14) possesses two unknowns, c_1 and c_2, and only one equation to tie them down. This is because there is only one variable p that can be tied down at time t_0, since e is assumed to be able to jump at t_0. The solution to this problem is found by recognizing that $c_1 + \phi_{p_p} = \bar{p}$ and the fact that $\bar{p}$ can be derived directly from equations (1) through (4) and (8). It can be shown that although ϕ_{p_p} and ϕ_{p_e} depend on initial conditions and the speed of adjustment parameters, the fact that $c_1 + \phi_{p_p} = \bar{p}$ implies that these initial conditions and speed of adjustment parameters drop out of the solution.

In order to obtain specific solutions, the standard assumption that the growth rates of money and income are expected to remain constant for the indefinite future is used. (Note, the assumption of stability is not needed here.) This gives rise to the following specific solutions:

$$p(t) = c_2 e^{\theta_2 t} + \bar{p} \tag{15}$$

$$e(t) = \frac{-c_2[(1-\sigma)\beta\gamma - \delta\lambda]}{[(1-\sigma)\beta\tilde{\theta} + \delta]\,\lambda} e^{\theta_2 t} + \bar{e} \tag{16}$$

$$\begin{aligned}\bar{p} = \frac{1}{\gamma}(m - \phi y) + \frac{\lambda\tilde{\theta}}{d\gamma + \tilde{\theta}\lambda}\left[\frac{1}{a_1}(m - a_2 y) - \frac{1}{\gamma}(m - \phi y) + (\tilde{q}_n - q_n)\right] \\ + \frac{\lambda(a_1 + \tilde{\theta}a_3)}{(d\gamma + \tilde{\theta}\lambda)a_1^2}\tilde{\pi} + \frac{df\lambda}{d\gamma + \tilde{\theta}\lambda}\, i_n\end{aligned} \tag{17}$$

$$\begin{aligned}\bar{e} = \frac{1}{\gamma}(m - \phi y) + q_n + \frac{(\alpha\gamma + \nu\lambda)\tilde{\theta}}{(d\gamma + \tilde{\theta}\lambda)\nu}\left[\frac{1}{a_1}(m - a_2 y) - \frac{1}{\gamma}(m - \phi y) + (q_{\tilde{n}} - q_n)\right] \\ + \frac{(\alpha\gamma + \nu\lambda)(a_1 + \tilde{\theta}a_3)}{(d\gamma + \tilde{\theta}\lambda)\nu a_1^2}\tilde{\pi} + \frac{df(\alpha\gamma + \nu\lambda) - \alpha(d\gamma + \tilde{\theta}\lambda)}{(d\gamma + \tilde{\theta}\lambda)\nu}\, i_n\end{aligned} \tag{18}$$

where $c_2 = p_0 - \bar{p}_0$.

The solutions in equations (15) and (16) are similar to those that would be obtained with RE. The difference lies in the solutions for $\bar{p}$ and $\bar{e}$ in equations (17) and (18). With TCE, $\bar{p}$ and $\bar{e}$ are not only functions of the true parameters and variables of the economy, but they are also functions of the agents' estimates of the these parameters and variables. This is also the case with the steady-state values of i and q, which are given in the following:

$$\bar{i} = \frac{\gamma\tilde{\theta}}{d\gamma + \tilde{\theta}\lambda}\left[\frac{1}{a_1}(m - a_2 y) - \frac{1}{\gamma}(m - \phi y) + (\tilde{q}_n - q_n)\right] + \frac{\gamma(a_1 + \tilde{\theta}a_3)}{(d\gamma + \tilde{\theta}\lambda)a_1}\tilde{\pi} + \frac{df\gamma}{d\gamma + \tilde{\theta}\lambda}i_n \tag{19}$$

$$\bar{q} = \bar{e} - \bar{p} = \frac{\alpha\gamma\tilde{\theta}}{(d\gamma + \tilde{\theta}\lambda)\nu}\left[\frac{1}{a_1}(m - a_2 y) - \frac{1}{\gamma}(m - \phi y) + (\tilde{q}_n - q_n)\right] + \frac{\alpha\gamma(a_1 + \tilde{\theta}a_3)}{(d\gamma + \tilde{\theta}\lambda)\nu a_1^2}\tilde{\pi} + \frac{df\alpha\gamma - \alpha(d\gamma + \tilde{\theta}\lambda)}{(d\gamma + \tilde{\theta}\lambda)\nu}i_n + q_n \tag{20}$$

Furthermore, the steady-state values of the endogenous variables in equations (17) through (20) (and therefore the steady-state values of real money balances ($\overline{\frac{m}{p}}$) and the real interest rate ($\bar{r}$)) are functions of the speed of adjustment parameters ν, α, β, and δ. This is not the case with RE. We examine these differences and study the implications of the steady-state solutions in the next section.

5. The Implications of the TCEH

In this section we show that using the TCEH to close the monetary models of the exchange rate has significant implications for the short-run and long-run dynamics of this class of models. The analysis leads to the following six conclusions: 1) When some agents believe in sticky prices the model generates persistent movements in the steady-state values of the real variables of the system, whether or not prices are sticky; 2) If capital is imperfectly mobile in the short-run, then UIP will not hold either in the short-run or the long-run and the deviations in the long-run will grow with time; 3) Movements in the market's estimate of the long-run value of the exchange rate ($\tilde{\bar{e}}$) can cause $\bar{e}$ to move in the opposite direction than that implied in a world with RE; 4) Agents commit forecasting errors in the steady state, which grow over time, but under certain conditions they are able to predict accurately the right side of the market; 5) When all agents believe that prices are flexible, the model generates behavior consistent with the standard flexible-price model, whether or not prices are flexible; and 6) The model allows for agents to switch the set of fundamental variables they use from one time period to the next and for policy officials to change the way the driving variables are moving due to events endogenous to the model.

The reason for these non-standard conclusions stems from the fact that although agents know a lot about the economy, they do not know the true parameter magnitudes and, as such, form estimates of the long-run exchange rate that differ from the true value. It is also the case that the rate at which their estimate of the long-run exchange rate changes over time ($\dot{\tilde{\bar{e}}}$) differs from $\dot{\bar{e}}$, since the weights they attach to the driving variables when estimating $\bar{e}$ differ from the true weights. This implies that the gap between $\tilde{\bar{e}}$ and $\bar{e}$ grows in the steady state. It is this growing gap between $\tilde{\bar{e}}$ and $\bar{e}$ that leads to the persistent movements in the real variables of the system in the long-run.

This can be seen from the following two equations:

$$\bar{q} - q_n = \frac{\alpha}{\nu}(\bar{i} - i_n) \tag{21}$$

$$\bar{i} = \frac{(1-\sigma)\beta\nu}{(1-\sigma)\beta\nu + \alpha\delta}\left[\tilde{\theta}(\tilde{\bar{e}} - \bar{e}) + \frac{1}{a_1}\tilde{\pi} + \frac{\delta\alpha}{(1-\sigma)\beta\nu}i_n\right] \tag{22}$$

where we have taken steady-state values in equation (2) and used equations (2), (3) and (8) in order to obtain an equation for $\bar{i}$ in terms of $\tilde{\bar{e}}$ and $\bar{e}$. In the standard RE case we have $\tilde{\bar{e}} = \bar{e}$ and $\bar{i} = i_n$, so that equation (22) reduces to the UIP condition, where $\bar{i} = \pi/a_1 = E(\dot{e})$. But, with TCE $\tilde{\bar{e}}$ and $\bar{e}$ are not equal in general and, as a consequence, movements in $\tilde{\bar{e}}$ and $\bar{e}$ will have real effects in terms of both $\bar{i}$ (and therefore $\bar{r}$) and $\bar{q}$. This gap between $\tilde{\bar{e}}$ and $\bar{e}$ also implies that UIP does not hold either in the short-run or in the long-run when capital is imperfectly mobile. These steady-state relationships hold whether or not prices are assumed to be sticky in the short-run, since by definition prices are free to move in the steady state.

It is interesting to note that equations (21) and (22) contain the speed of adjustment parameters ν, α, β and δ, which is another way to see that the solutions for all of the steady-state values of the endogenous variables depend on these parameters. But, equations (21) and (22) also show that this result does not depend on the presence of a zero root. Instead, the speed of adjustment parameters show up because even in the steady state, agents are speculating on their belief that $\dot{e}$ is nonzero. This speculation leads to capital flows, the impact of which (as in the short-run with RE) depends partly on the speed of adjustment parameters.

If equation (22) is differentiated with respect to time, we find that the absolute value of $\bar{i}$ (and therefore $\bar{q}$ from equation (21)) grows whenever $\dot{\tilde{\bar{e}}} \neq \dot{\bar{e}}$:

$$\dot{\bar{i}} = \frac{(1-\sigma)\beta\nu\theta}{(1-\sigma)\beta\nu + \alpha\delta} \left(\dot{\tilde{\bar{e}}} - \dot{\bar{e}}\right) \tag{23}$$

Since agents know only the algebraic signs of the true parameters of the model and not their magnitudes, the weights they attach to the driving variables of the system (m and y) in estimating e will differ from the true weights. As such, $\dot{\tilde{\bar{e}}}$ and $\dot{\bar{e}}$ will in general not be equal, implying that persistent movements in $\bar{i}$ and $\bar{q}$ away from their natural values and growing departures from UIP in the steady state (when $\beta < \infty$) will occur to the extent that there are persistent movements in the driving variables of the system.

This can be seen directly by differentiating the solutions for $\bar{i}$ and $\bar{q}$ in equations (19) and (20):

$$\dot{\bar{i}} = \frac{\gamma\tilde{\theta}}{d\gamma + \tilde{\theta}\lambda}\left[\frac{1}{a_1}(\dot{m} - a_2\dot{y}) - \frac{1}{\gamma}(\dot{m} - \phi\dot{y})\right] \tag{24}$$

$$\dot{\bar{q}} = \frac{\alpha\gamma\tilde{\theta}}{(d\gamma + \tilde{\theta}\lambda)\nu}\left[\frac{1}{a_1}(\dot{m} - a_2\dot{y}) - \frac{1}{\gamma}(\dot{m} - \phi\dot{y})\right] \tag{25}$$

Equations (24) and (25) show that whenever the quantity $g = \frac{1}{a_1}(\dot{m} - a_2\dot{y}) - \frac{1}{\gamma}(\dot{m} - \phi\dot{y})$ is less than (greater than) zero $\bar{i}$ and $\bar{q}$ will be falling (rising) in the steady state, i.e., when agents' beliefs concerning the true combination of fundamental variables for forecasting the exchange rate are incorrect, their speculative behavior causes the nominal interest rate and the real exchange rate to move persistently away from their natural values even in the steady state. In addition, since $\bar{\pi}$ is assumed to be constant, the persistent movement in $\bar{i}$ translates into a persistent movement (in the same direction) in the steady-state value of the real interest rate, $\bar{r}$. Finally, the solution for $\bar{p}$ in equation (18) indicates that $\dot{\bar{p}} \neq \pi$, even when $\gamma = 1$. This implies that the steady-state value of real money balances ($\frac{\bar{m}}{\bar{p}}$) diverges as well, either to ∞ or 0.

In terms of the steady state value of the nominal exchange rate, differentiating the solution for $\bar{e}$ in equation (20) shows that a persistent nominal depreciation of the domestic currency may be associated with either a falling i and q or a rising i and q:

$$\dot{\bar{e}} = \frac{(1-h)}{\gamma}(\dot{m} - \phi\dot{y}) + \frac{h}{a_1}(\dot{m} - a_2\dot{y}) \tag{26}$$

$$h = \frac{(\alpha\gamma + \nu\lambda)\tilde{\theta}}{(d\gamma + \tilde{\theta}\lambda)\nu} < 1 \quad \textbf{(27)}$$

If $\frac{1}{\gamma}(\dot{m} - \phi\dot{y})$ and $\frac{1}{a_1}(\dot{m} - a_2\dot{y})$ are both positive and $g<0$ ($g>0$), then i and q will be falling (rising) while e will be rising. An analogous case holds when $\frac{1}{\gamma}(\dot{m} - \phi\dot{y})$ and $\frac{1}{a_1}(\dot{m} - a_2\dot{y})$ are both negative. An interesting case is when $\frac{1}{a_1}(\dot{m} - a_2\dot{y}) < 0$ and large enough in absolute terms so that even though $\frac{1}{\gamma}(\dot{m} - \phi\dot{y}) > 0$, we have $\dot{\bar{e}} < 0$. For example, suppose a_2 is very large (i.e., agents pay a lot of attention (focus on) income). In this case $g<0$ and falling values of i and q will be associated with a falling exchange rate in the steady state. Agents' beliefs concerning the magnitudes of the models' parameters (and therefore $\bar{\bar{e}}$) cause $\bar{e}$ to move in the opposite direction than the direction implied by the case with RE.[9]

Another interesting case is when all agents believe in the flexible price model. In this case the aggregate forecasting function is given by equation (7). This implies, along with the balance of payments equation (3), that $e = p + q_n$ at every moment, whether or not prices are flexible. If prices are sticky in the short-run, then they will be slow to adjust in response to changes in the other variables of the model. But, even during the adjustment process PPP will hold. The reason for this is because agents automatically believe that UIP holds at every moment and, as a consequence, do not speculate and force the exchange rate away from the PPP level. Instead, the trade account completely dominates exchange rate movements (even if capital is highly mobile), with the result that PPP always holds.[10]

An important issue concerns the extent to which market agents commit forecasting errors. Equation (22) reveals that market agents do commit forecasting errors in the steady state which grow with time. However, as shown in Goldberg and Frydman [1991], market agents are able to predict the right

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[9] With RE we have $\dot{\bar{e}} = \frac{1}{\gamma}(\dot{m} - \phi\dot{y}) > 0$.

[10] Note, that if capital is perfectly mobile such that $\beta = \infty$, then e becomes undetermined.

side of the market under certain conditions. The fact that market agents are able to predict the right side of the market should be contrasted with the model of Frankel and Froot [1987], wherein agents are continually on the wrong side of the market.

An important feature of the model with TCE is that it allows for market agents to switch the set of fundamental variables used in forming expectations. The model also provides two intuitively appealing reasons for such behavior. Either the persistent movements in the real variables of the system signal to agents, after some threshold has been reached, that their perception of the world is incorrect and that they should alter their forecasting rule, or the growing forecasting errors provide a similar signal. Another important feature of the model is that switching expectations functions can cause the persistent movements in the real variables to change direction if the switch leads to a change in sign of g. For example, if agents focus on rising U.S income during one period and then growing U.S. trade deficits in the next (i.e., a_2 is large and a_4 is small during one period while in the next a_2 is small and a_4 is large), then the sign of g may change. A separate treatment of this issue is provided in Goldberg and Frydman [1991]. The fact that g changes sign implies that once altered, the system will continue to produce persistent movements, but in the opposite direction. Such endogenously produced cycles can also occur if policy officials step in and influence the way the driving variables of the system are moving. The rationale for such behavior follows along similar lines, in that policy officials are signaled to react when the real variables have moved too far away from natural levels.

Hence, the sticky-price monetary model with TCE generates divergent movements in the real variables of the system in the long-run. But, the model allows for two possibilities, which endogenously arise, that prevent the real variables from diverging too far, i.e., either agents switch their expectations functions and/or policy officials react. Although such behavior on the part of market agents and policy officials is not formalized explicitly, it is necessary to make the long-run conclusions of the model sensible. This leads to the conclusion that the sticky-price monetary model with TCE imply that periodically market agents switch expectations functions and/or policy officials alter the way the driving variables of the system are moving.

The exchange rate dynamics that emerge from our analysis parallels closely the description of market behavior offered in Schulmeister [1983,1987] and Soros [1987]. If market agents are unable to correctly estimate the long-run value of the exchange rate, then the market will be characterized by persistent movements in both the nominal and real variables of the system, to the extent that there are persistent movements in the underlying set of fundamentals. In addition, these persistent relationships will be inherently unstable, in that movements "too" far away from natural levels cause expectations functions to switch and/or policy officials to react. Furthermore, when the persistent movements in the nominal and real variables change direction and begin to move toward their natural levels, there is no tendency to stop when the natural levels are reached. Instead, the movements in the fundamental variables will shoot through their natural levels, setting up the conditions for another countermovement. Finally, standard empirical exchange rate models should periodically experience structural instability which is proximate to the major turning points in the nominal and real variables of the system and which possibly involves different sets of significant variables during different time periods.[11]

6. Examining Some Aspects of the Empirical Record

The preceding section showed that the TCEH has significant implications for the conclusions of the monetary models of exchange rate determination. In a companion study (Goldberg and Frydman [1991]) we examine whether these implications help to explain some of the many anomalies reported in other studies. The list is long and includes the following: 1) Parameter estimates that are either insignificant or significant and of the wrong sign (see Dornbusch [1980] and Frankel [1983]); 2) An

[11] We show in Goldberg and Frydman [1990] that if agents switch the set of fundamental variables used in forecasting, then different variables can enter the reduced form.

inability on the part of structural models to outperform the random walk model in out-of-sample fit (see Meese and Rogoff [1983]); 3) A failure of the UIP condition, even when allowance is made for a standard risk premium (see Frankel and Meese [1987]); 4) A lack of cointegrating relationships among the set of supposed fundamentals (see Meese and Rose [1988,1989]); 5) Empirical exchange rate models that experience structural instability involving different sets of significant variables during different time periods (see Goldberg and Frydman [1990]; and 6) Persistent movements in nominal and real exchange rates when the supposed set of fundamentals point in a direction contrary to current movements (see Frankel and Froot [1990]).[12] We undertake an analysis of all of these anomalies in Goldberg and Frydman [1991]. In this section we draw on some of this work and briefly examine the implications of the TCEH for the last two anomalies.

Figure 1, which is taken from Goldberg and Frydman [1990], illustrates these two problems. The figure plots both the actual and PPP DM/$ exchange rate from March 1973 through March 1988. It also reports the results of structural change tests for a model encompassing the FB, DF and HM models, where the break points are indicated by the dotted vertical lines. It should be emphasized that these break points are not imposed a priori, but rather are the outcome of structural change tests that search the data for the possibility of break points.[13] The structural change results in figure 1 confirm the basic character of the monetary models with TCE. They show the monetary models break down on five occasions during the post-Bretton Woods era of floating rates and that many of the break points are proximate to the major turning points in the dollar. In addition, we find that the set of statistically significant variables within the implied regions of relative structural stability differ from one exchange rate regime to the next. (The

[12]A detailed discussion of these anomalies is also provided in Goldberg [1991b].

[13] The structural change tests employed are the cusum test and Quandt ratio technique. For further details on the method of analysis and a fuller discussion of the results see Goldberg and Frydman [1990].

estimated models for the first two exchange rate regimes are reported at the bottom of the figure.[14]) These results are consistent with the view arising from our model with TCE that market agents focus on different sets of fundamentals during different time periods.

In terms of the problem of persistence, figure 1 reveals that both nominal and real exchange rates move persistently in one direction for long periods of time. There does not seem to be any tendency for the nominal exchange rate to stay close to its PPP level. The figure shows that when the deviations become "too" big (e.g., in 1979 and early 1985) the relationship governing movements in the exchange rate and fundamentals experiences a structural break involving a return to PPP. But, the figure also shows that once this return has set in there is no tendency to stop at the PPP level. Instead, the movement in the exchange rate shoots through this benchmark, setting up the conditions for another reversal. Again, these observations match up closely with the basic character of the model with TCE.

Researchers have highlighted the period from the second quarter of 1984 through February 1985 as particularly disturbing, because during this period the value of the dollar continues to rise in both nominal and real terms, while at the same time the differential in U.S. and German real (and nominal) interest rates was falling (see Frankel and Froot [1990]). We show in Goldberg and Frydman [1991] that if agents focused on the superior performance of the U.S. economy during this period in terms of income, then the sticky-price monetary model with TCE not only explains the dollar appreciation during this period, but it also predicts the fall in U.S. nominal and real interest rates relative to Germany!

Hence, this study finds that the monetary approach to exchange rate determination provides a reasonable macroeconomic framework in which to examine exchange rate dynamics. The key to this finding lies in relaxing the strict assumptions of the RE framework in a way that preserves the spirit of the standard approach. With TCE, market agents use the stock of extant theories in which to interpret

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[14] Since the macro variables of the asset market models are found to be integrated of order one (I(1)), we used the systems approach of Phillips [1988]. This systems approach specifies the unit roots explicitly and in doing so produces estimators that possess standard asymptotics.

the world. But, because they have only qualitative knowledge their estimate of the long-run exchange rate causes the system to diverge. It is precisely this divergent behavior that provides insight into the problems of persistence and structural instability.

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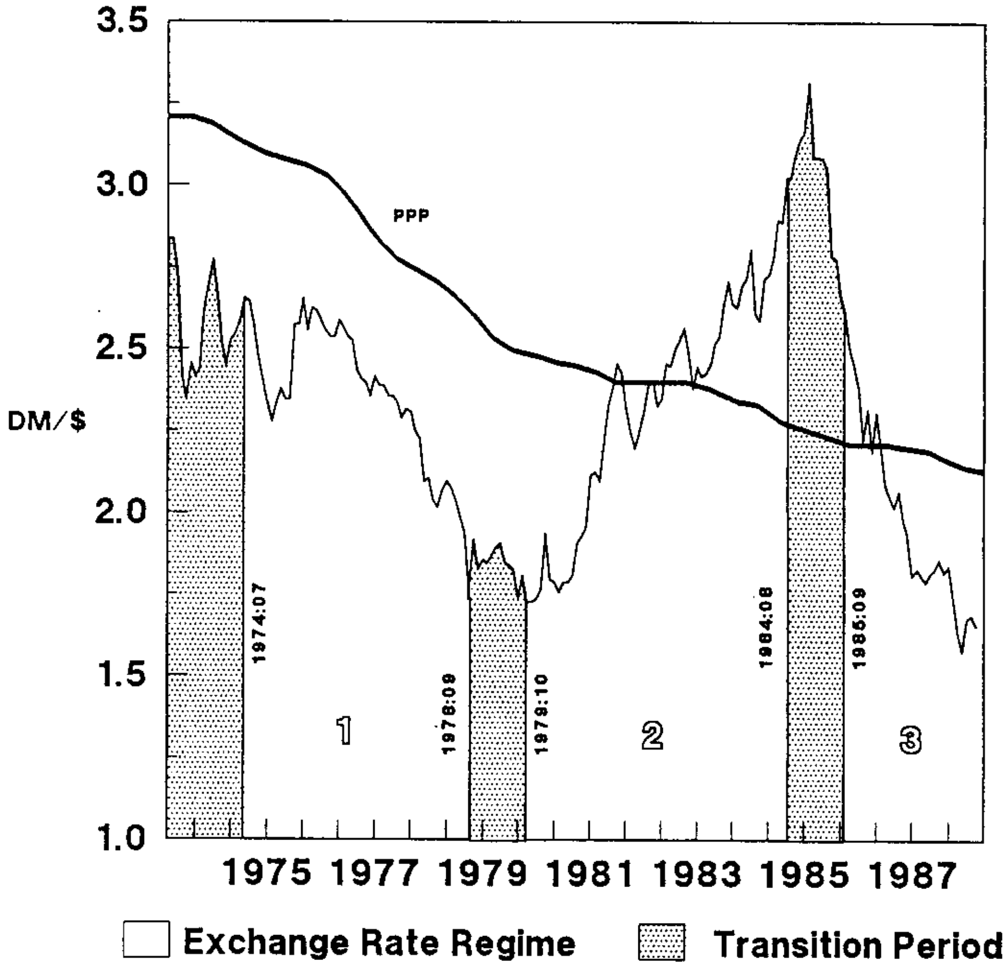
Figure 1
Exchange Rate Regimes and Transition Periods
Sample Period 1973:03 - 1988:03



Composite Model:

$$e = h_0 + h_1 m + h_2 m^* + h_3 y + h_4 y^* + h_5 i + h_6 i^* + h_7 \pi + h_8 \pi^* + h_9 k + h_{10} k^*$$

Reduced Models:

$$1:\ e = \underset{(-9.18)}{-0.916y} + \underset{(10.48)}{1.15y^*} - \underset{(-5.76)}{1.472i} + \underset{(5.62)}{2.39i^*} - \underset{(-2.79)}{0.067k} + \underset{(16.99)}{.618k^*}$$

$$2:\ e = \underset{(-3.36)}{-0.407m} + \underset{(6.29)}{0.912m^*} - \underset{(-8.29)}{0.873y} + \underset{(2.64)}{0.310y^*} + \underset{(6.78)}{1.803i} + \underset{(3.08)}{0.701i^*} - \underset{(-6.73)}{0.285\pi^*}$$