行政院國家科學委員會補助專題研究計畫成果報告

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計畫主持人：陳思寬教授

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行政院國家科學委員會專題研究計畫成果報告

實質有效匯率的恆定性探討：歐元區域的實證研究

Stationarity of the Real Effective Exchange Rates: Evidence from Euro-area Countries

計畫編號：NSC 90-2415-H-002-014

執行期限：90 年 8 月 1 日至 91 年 7 月 31 日

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一、中文摘要

本研究計畫擬修正前人模型，以建立一在資本不完全移動之下的開放經濟體系跨期最適化模型，來討論實質匯率波動的不確定性。而實質匯率波動的不確定性，有可能在跨期替代彈性較低的情況下發生。同時如果資本移動較完全，則在隨機環境假設下，本模型提供了實質匯率波動會很難與隨機漫步區隔的可能解釋。本研究計畫的提出，藉由模型的一般化，我們希望能稍微化解實質匯率動態的理論模型與實證結果之間的歧異。所以最後我們擬將模型應用在歐元區域國家的實質有效匯率上，來檢討在歐元正式上路之前後，歐元區域國家的實質有效匯率動態是否因金融市場的整合而有明顯的改變。

關鍵詞：實質有效匯率，不確定性，資本移動，結構性變動

Abstract

This research project proposes to modify previous models and to construct an intertemporal optimizing model of an open economy facing imperfect international capital markets. We find that indeterminacy of real exchange rates may arise if the intertemporal elasticities of substitution are sufficiently low. We also find that the stochastic version of our model can provide an explanation for the stylized fact that high-frequency real exchange rates are often hard to distinguish from random walk when capital is highly mobile. By proposing and generalizing this kind of models, we hope to somehow bridge the gap between the theoretical models and the empirical evidence of the real exchange rate dynamics. Therefore we apply the model to study the real effective exchange rate data of the euro area countries. We investigate whether the dynamics of the real effective exchange rates of the euro underwent significant changes when the euro was introduced and the financial markets started to integrate.

Keywords: real effective exchange rates, indeterminacy, capital mobility, structural breaks.

STATIONARITY OF THE REAL EFFECTIVE EXCHANGE RATES: EVIDENCE FROM EURO-AREA COUNTRIES

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1 Introduction

Among the puzzles which have emerged concerning the exchange rate over the past two decades is that empirically measured fundamentals only seem to explain a small fraction of real exchange rate movements in many industrial countries. Recently there has been a renewed interest in "indeterminacy", or alternatively put, in the existence of a continuum of rational expectations equilibria in dynamic economic models exhibiting increasing returns coupled with monopolistic competition or external effects. Following this line of research, this paper modified the model developed in Chen (2000) by assuming that the real rate of return of foreign bonds is dependent on the size of foreign bond holdings. The model can also be generalized to incorporate external economies of scale by assuming that both imported and exported goods are produced domestically. It is found that indeterminacy of real exchange rate equilibria may occur when external economies of scale are introduced into the model. If the equilibrium in the model turns out to be indeterminate, that is if there are a continuum of equilibria paths converging toward the steady state, stochastic self-fulfilling expectations (sunspots) may then generate endogenous fluctuations in real exchange rates in the absence of any shocks to fundamentals.

The paper is organized in five sections. Following this introduction, Sections 2 presents the basic model. Based on this model and its generalized version, Section explores the possibility of the existence of indeterminacy of real exchange rate equilibria. Section 4 applies the model to the real exchange rates in the Euro area. Section 5 concludes.

2 The Model

The basic framework is similar to those of Chen (2000) and Chen, Chen and Chou (2001) models except we assume that interest rate is a decreasing function of the net holdings of bonds. The economy we consider is inhabited by identical agents who consume both home and imported goods. The imported good, which is not produced by the home economy, is supplied perfectly elastically to the economy on the world market at constant price $p*$, assumed to be unity to save notation. A constant flow of domestic output, $\bar{Y}$, is produced with the aid of a fixed stock of physical capital. The fixed supply of home goods is partly consumed at home and partly exported to the rest of the world.[1] The price of home good, p, is freely flexible, as is the exchange rate (domestic currency price of foreign exchange), e. The economy is small in the imported good market but 'large' in the exported good market. The terms of trade, ep^*/p, which can also be interpreted as the real exchange rate (the relative price of foreign to home goods) in a two-good model, are therefore endogenously determined.

Agent at home may save by foregoing consumption and accumulating instead the internationally traded bond, assumed to be indexed to the foreign good (currency). The international rate of interest r, is assumed to be a decreasing function of the net holdings of international bonds, B,

$$r_t = r(B_t), \qquad r' = \frac{\partial r}{\partial B} < 0, \tag{1}$$

where B_t is the representative agent's holding of foreign bonds at the end of period t and r_t the interest rate paid between period $t-1$ and t. Auernheimer (1987) and Obstfeld (1982) attributed the dependence of r_t on B_t to the imperfection of international capital markets faced by the home economy, whereas Calvo (1991) justified the same assumption on the basis of conventional arguments for medium-or-large-sized economies. Both factors are allowed for in this paper.

The representative agent's instantaneous utility is an additively separable utility function of its consumption of home and imported goods:

$$U_t = \ln y_t + d^b \frac{z_t^{1-b}}{1-b}, \quad b > 0, d > 0, \tag{2}$$

where y_t is period-t consumption of home goods (exportables), z_t is period-t consumption of imported goods, and d is a scale factor. $1/b$ represents the corresponding elasticity for imported good consumption, while home good consumption has perfectly elastic intertemporal substitution. The domestic consumption of home goods is simply a residual. The foreign residents import whatever quantity they want from the home economy at the given terms of trade; agents at home simply consume whatever quantity of home goods

[1]The assumption that imported goods are not produced and production of exportables is fixed is analytically equivalent to assuming that production factors are sector-specific in the short term (Roggof 1992) so that production of both importables and exportables are fixed. Thus, the specialized endowment model in this paper can also be taken as a short-term version of a more general model.

is left: $y_t = \bar{Y} - X_t$. This assumption is implicit in stylized international macroeconomic model of Mundell-Fleming-Dornbusch vintage. This functional form has been used by Hansen and Singleton (1982) and Amano and Wirjanto (1997), among others, in studying the intertemporal elasticities for different components of consumption. The objective of the representative agent is to maximize the expected value of her lifetime utility

$$E_t \sum_{s=t}^{\infty} (\frac{1}{1+\delta})^{s-t} U_s, \tag{3}$$

where E is the expectation operator and δ is the constant subjective rate of time preference. In maximizing (3), the agent is bound by a flow budget constraint linking the excess of her income over her expenditure to her accumulation of foreign assets:

$$q_t(B_t - B_{t-1}) = \bar{Y} + q_t r_{t-1} B_{t-1} - y_t - q_t z_t, \tag{4}$$

where $r_{t-1}B_{t-1}$ is the interest earning in terms of foreign goods (currency) at the end of period $t-1$. To prevent agents in the home economy from engaging in Ponzi-games, the following transversality condition must hold:

$$\lim_{t \to \infty} (\prod_{s=0}^{t-1} (1 + r_s)^{-1}) B_t = 0. \tag{5}$$

Let λ_t denote the Lagrange multiplier associated with the flow budget constraint. From the point of view of the maximizing agent both r_t and q_t are market parameters. The first-order conditions with respect to y_t and z_t ($1/y_t = \lambda_t$ and $d^b z_t^{-b} = \lambda_t q_t$) imply that the demand for imported goods is simply a decreasing function of the terms of trade:

$$z_t = d q_t^{-\frac{1}{b}}, \tag{6}$$

where the intertemporal elasticity $1/b$ coincides with the price elasticity. The first-order condition with respect to bond holdings implies

$$1 + r_t = (1+\delta) \frac{\lambda_t q_t}{E_t \lambda_{t+1} q_{t+1}} = (1+\delta) \frac{z_t^{-b}}{z_{t+1}^{-b}}. \tag{7}$$

This optimality condition equates the marginal rate of substitution of present for future imported good consumption to the price of future consumption in terms of present consumption, $(1 + r_t)^{-1}$. An implication is that the agent smoothes the expected marginal utility of imported good consumption over time. We can derive the bond holdings function from (1) and (7) as

$$B_t = F(E_t q_{t+1}/q_t), \tag{8}$$

with

$$F' = \frac{\partial B_t}{\partial(E_t q_{t+1}/q_t)} = -(1+\delta)/r' > 0. \tag{9}$$

3 Local Dynamics of Market Equilibrium

Since the home good market must clear each period, domestic consumption of home goods plus exports must equal the fixed supply of exportables each period, so

$$y_t + X_t = \bar{Y}, \tag{10}$$

where X_t denotes the export demand of the home economy (the import demand of the rest of the world). Substituting (10) into the budget constraint (4), we obtain

$$B_t - B_{t-1} = X_t/q_t - z_t + r_{t-1}B_{t-1}. \tag{11}$$

Under a regime of floating exchange rates, accumulation of foreign assets (net capital outflow) has to be 'financed' by a surplus in the current account.

Expressing the downward slopping export demand function faced by the home economy by[2]

$$X_t \equiv g(\frac{1}{q_t})^{-\frac{1}{f}} = g q_t^{1/f}, g, f > 0, \tag{12}$$

[2]Attaching stars to all 'foreign' variables, we may write the utility function and the budget constraint of the representative agent in the rest of the world as

$$U_t^* = z_t^{*1-c}(1-c)^{-1} + j^f y_t^{1-f}(1-f)^{-1},$$

$$(B_t^* - B_{t-1}^*) = Z^* + r_{t-1}B_{t-1}^* - z_t^* - (1/q_t)y_t^*,$$

where z_t^* and y_t^* are respectively home and imported good consumption and Z^* domestic endowment of the foreign agent. Note that $B_t^* = -B_t$. The first order conditions with respect to z_t^* and y_t^* are $z_t^{*-c} = \lambda_t^*$ and $j^f z_t^{*-f} = \lambda_t^*(1/q_t)$. Since z_t in the text is by assumption negligible as compared to z_t^* and Z^*, z_t^* is practically equal to Z^*. Thus, we have $\lambda_t^* = (Z)^{*-c}$ and $y_t^* = jZ^{*\frac{c}{f}}(1/q_t)^{-\frac{1}{f}}$. To save notation, we set $g = jZ^{*-\frac{c}{f}}$. In our model, $y_t^* = X_t$. Consequently, $X_t = y_t^* = g(1/q_t)^{-\frac{1}{f}}$, which is identical to equation (12).

we can write the balance of trade in terms of imported goods, T_t, as

$$T_t = X_t/q_t - z_t = gq_t^{\frac{1}{f}-1} - dq_t^{-\frac{1}{b}}. \tag{13}$$

Substituting (13) and (8) into (11), we obtain, under the assumption of perfect foresight, a nonlinear difference equation in q_{t+1}, q_t and q_{t-1}:

$$F(q_{t+1}/q_t) - (1+\delta)(q_{t-1}/q_t)F(q_t/q_{t-1}) = gq_t^{\frac{1}{f}-1} - dq_t^{-\frac{1}{b}}, \tag{14}$$

by noting that $1+r_{t-1} = (1+\delta)(q_{t-1}/q_t)$ from (7). Money is neutral even in the short term in this flexible-price model.[3] Without loss of generality, if we set the steady-state value of the real exchange rate to be unity: $q_{t+1} = q_t = q_{t-1} = \bar{q} = 1$, then the steady-state values of the remaining variables will be as follows: $\bar{r} = \delta$, $\bar{X} = g$, $\bar{z} = d$, $\bar{T} = g - d$, and $\bar{B} = (d-g)/\bar{r}$. For simplicity of exposition, we assume that $\bar{Y} = 1 + g$ so that $\bar{y} = 1$ and $\bar{X}/\bar{y} = g$.

To investigate the system's dynamic properties in the neighborhood of the stationary state, we linearize the nonlinear dynamic system (14) around the stationary state. The resulting system of difference equations is

$$\begin{bmatrix} q_t - \bar{q} \\ q_{t+1} - \bar{q} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -(1+\bar{r}+r'\bar{B}) & 2+\bar{r}+r'\bar{B}+\frac{T'}{F'} \end{bmatrix} \begin{bmatrix} q_{t-1} - \bar{q} \\ q_t - \bar{q} \end{bmatrix}, \tag{15}$$

where $T' = \partial(X_t/q_t - z_t)/\partial q_t = \frac{g}{f} + \frac{d}{b} - 1$ and $F' = -(1+\delta)/r' > 0$. The characteristic equation of (15) is

$$\lambda^2 - \gamma\lambda + \Delta = 0, \tag{16}$$

where

$$\gamma = \lambda_1 + \lambda_2 = 2 + \bar{r} + r'\bar{B} + \frac{T'}{F'}, \tag{17}$$

[3] Insofar as the central issue of this paper is the dynamics of the real exchange rate, we may just introduce a cash-in-advance constraint to complete the model. Since domestic money is used solely for purchases of home goods, imported goods and foreign assets,

$$M_{t-1} = p_t(\bar{Y} - X_t) + e_t z_t + e_t(B_t - B_{t-1}) - e_t r_{t-1} B_{t-1} = p_t\bar{Y} - e_t(T_t - K_t + r_{t-1}B_{t-1}),$$

where $K_t = B_t - B_{t-1}$ is the net capital export and $T_t = X_t/q_t - z_t$ is the trade balance, and since the balance of payments always balances under floating exchange rates, $T_t + r_{t-1}B_{t-1} - K_t = 0$, we therefore obtain $M_{t-1} = p_t\bar{Y}$. If the quantity of money is held constant, so will be the domestic price.

$$\Delta = \lambda_1 \lambda_2 = 1 + \bar{r} + r'\bar{B}. \tag{18}$$

Local indeterminacy requires that both roots of the system have modulus less than 1. An equivalent condition is that the following three inequalities be fulfilled simultaneously:

$$1 + \Delta - \gamma = -T'/F' > 0, \tag{19}$$

$$1 + \Delta + \gamma > 0, \tag{20}$$

$$\Delta = 1 + \bar{r} + r'\bar{B} < 1. \tag{21}$$

For inequality (19) to hold, it requires that (given $F' > 0$)

$$T' = g/f + d/b - 1 < 0. \tag{22}$$

Note that if the balance of trade is zero in the steady state, (22) reduces to $T' = g(\frac{1}{f} + \frac{1}{b} - 1) < 0$. The intuition for the reliance of indeterminacy in our model on the negative relationship between the balance of trade and the real exchange rate (terms of trade) is quite straightforward. Consider starting with a stationary state with zero current account balance[4], and inquire whether a decision of the representative agent to increase the net holding of the foreign asset would lead to a new equilibrium. From Euler equation (7) with $a = 0$, we know that this would require an increase in z_t and a fall in q_t coupled with a reduction of z_{t+1} and a rise in q_{t+1} to equate the fall in r_t caused by an increase in B_t. If the fall in q_t (improvement in the terms of trade) leads to an improvement in the trade account (and hence the current account) due to inelastic import and export demands, the increase in net holdings of foreign assets and expected rise in real appreciation of foreign currency will be realized. The economic forces behind the indeterminacy can also be seen from changes in domestic absorption. The total expenditure measured in terms of exportables, C_t, can be expressed as

$$C_t \equiv y_t + q_t z_t = (\bar{Y} - g q_t^{\frac{1}{f}}) + q_t(d q_t^{-\frac{1}{b}}). \tag{23}$$

If import and export demands are inelastic, we will have, with $g = d$,

$$\frac{\partial C}{\partial q_t} = g(1 - \frac{1}{f} - \frac{1}{b}) > 0. \tag{24}$$

[4]For simplicity of exposition, we assume that $\bar{B} = 0$ and $g = d$ so that initial current and trade accounts are identical.

A temporary improvement in the terms of trade (a fall in q_t) causes a reduction in expenditure on imported goods which exceeds the increase in expenditure on home goods ($|1 - \frac{1}{b}| > \frac{1}{f}$), both in terms of home goods, thus leading to a reduction in domestic absorption and consequently an improvement in the trade and current account balance. The improvement in the current account offsets the deterioration in the capital account, keeping the balance of payments in equilibrium.

Given that $\gamma > 0$, which is likely to obtain if capital mobility is reasonably high (r' relatively low and F' relatively large), inequality (20) holds as long as (19) holds. Finally, for inequality (21) to hold, it requires that $\bar{r} + r'\bar{B} < 0$, that is, an increase in foreign assets would decrease interest receipts in the neighborhood of the stationary state. As the interest rate perceived by individual households differs from the economy's true marginal rate of return on foreign bonds, the economy's net holdings of foreign assets may be socially excessive. This would happen if the household's subjective rate of time preference is relatively low.[5] The social marginal rate of return on foreign assets will coincide with the market interest rate perceived by the agents if structurally the net holdings of foreign assets are zero in the stationary state. In this case $\bar{r} + r'\bar{B} = \bar{r}$, and hence $\gamma = 2 + \bar{r} + T'/F'$, and $\Delta = 1 + \bar{r} > 1$. The modulus of the two roots of the system will have a value greater than unity, a classic case of Hopf bifurcation which indicates the emergence of cycles. All perfect foresight equilibria beginning near the stationary state may diverge from the stationary state and be attracted to an invariant circle. In this case we would still have indeterminacy in the sense that the equilibrium trajectories converge to the limit cycle (Woodford 1992, p. 225). In this paper we have chosen to focus on the indeterminacy associated with the stable stationary state since it seems more relevant for reality.[6]

The analysis in this section tells us that the negative relationship between the balance of trade and the terms of trade is crucial for the possible existence of indeterminacy in our

[5]If (1) is written explicitly in a linear form as $r_t = \omega - \phi B_t$, then $\bar{r} + r'\bar{B} = 2\delta - \omega \gtrless 0$ as $\delta \gtrless \frac{\omega}{2}$.

[6]Local indeterminacy may still occur for the case of $\bar{B} = 0$, if the lagged real exchange rate q_{t-1} is introduced into the demand function for the exported goods. For example, we may introduce government consumption of tradables G_t into the model and assume that it does not affect the utility of private consumption and that there is an one period delay between actual purchase and decision: $G_t = G(q_{t-1})$ with $G' < 0$. Under these conditions, $\Delta = 1 + \bar{r} + G'/F' \gtrless 1$ as $-G'/F' \lessgtr \bar{r}$.

model. Summing up recent contributions of the intertemporal approach to the current account on the Lausen-Metzler effect, Ostry (1988, p,54) argues that a temporary deterioration in the terms of trade has an ambiguous impact on the current account. While the "consumption-smoothing" motive dictates that the agent will maintain spending in the face of a temporary decline in real income caused by a deterioration in the terms of trade, a temporary deterioration in the terms of trade raises the cost of current consumption in terms of future consumption and consequently encourages saving. If the latter intertemporal substitution effect is weak, the consumption-smoothing motive dominates and a temporary deterioration in the terms of trade may cause a reduction in the current account. This explains why we obtain $T' < 0$ in our model when $1/b$ and $1/f$ are sufficiently low. Within a short-term time framework, it seems justified for us to assume that the elasticities of substitution (intertemporal and intratemporal) are low.

But in the medium-term time framework, the negative relationship between the balance of trade and the terms of trade may no longer exist. Following Chen, Chen and Chou (2002) by assuming increasing external returns to scale in the production of traded goods, we can derive similar linearized system of real exchange rate equilibrium dynamics and associated characteristic equation. It is found that indeterminacy of real exchange rate equilibria results with a certain, minimum value of the externality in the traded good sector.

4 An Empirical Application to the Euro Area Real Exchange Rates

In this section we will apply our model to study the quarterly real effective exchange rates of the euro-area currencies from 1978 to 2001. The cases of Euro area countries are suitable for testing the model in this paper because the process of financial markets integration may cause the capital mobility to change from relatively low in the earlier period to the higher in the latter period.

Because of indeterminacy of perfect-foresight equilibrium, agents now face uncertainty about next period's price (real exchange rate). Generalizing the deterministic equation

(14) by a stochastic equation, we have

$$F(E_t q_{t+1}/q_t) - (1+\delta)(q_{t-1}/E_{t-1}q_t)F(E_{t-1}q_t/q_t) = T(q_t). \tag{25}$$

Linearizing the above equation around the steady state, we obtain

$$E_t q_{t+1} = C + Aq_t - Bq_{t-1} + DE_{t-1}q_t \tag{26}$$

where

$$A = 1 + T'/F',$$

$$B = D = 1 + \bar{r} + r'\bar{B},$$

$$C = -T'/F'.$$

It will be assumed that A, B, $D < 1$ and $C > 0$ to imply that nonstochastic perfect-foresight equilibrium is indeterminate.. If we follow Benhabib and Farmer (1996, pp.438-39) in assuming that sunspot or belief shocks are *i.i.d.*, and are driven by the same stochastic process as the real shock, we may define $\epsilon_{t+1} = q_{t+1} - E_t q_{t+1}$ and $\epsilon_t = q_t - E_{t-1}q_t$ where ϵ_t denotes expectations errors. Substituting these expressions into equation (26), we obtain

$$q_{t+1} = C + (A+D)q_t - Bq_{t-1} + \epsilon_{t+1} - D\epsilon_t, \tag{27}$$

or in lag operator form,

$$[1 - (A+D)L + BL^2]q_t = C + (1-DL)\epsilon_t, \tag{28}$$

where ϵ_t is a mean-zero, serially uncorrelated random variable with $E\epsilon_t^2 = \sigma^2$. It turns out that an ARMA(2,1) process is a solution to the functional equation (26). The AR(2) process is obtained because expectations about q_{t+1} are formed from a weighted sum of q_t and q_{t-1}. The MA(1) process arises because the equilibrium process of capital flow is disturbed by present and past transient shocks. From (26) we can notice that if capital mobility is sufficiently high, i.e., if F' is large, A, B, and D will be roughly of the same magnitude (less than but close to unity), The ARMA(2,1) equation (28) now reduces to an AR(1) equation,

$$(1 - AL)q_t = v + \epsilon_t, \tag{29}$$

Table 1: Breakdates for the Euro-area Countries

Austria	France	Germany	Ireland	Italy	the Netherlands	Spain
1985QIII	1993QIV	1995QIV	1985QI	1992QII	1982QIV	1988QII

where v is a constant. Since the magnitude of A is not substantially less than unity, real exchange rates may become indistinguishable econometrically from a random walk, even if the underlying shocks are *i.i.d.*.[7]

The real exchange rate is by definition the relative price of home and foreign goods. It depends on two different relative prices: the price of nontraded goods in terms of traded goods, and the price of imports in terms of traded goods (the terms of trade). The theoretical framework in the present paper focuses entirely on fluctuations in the terms of trade. Part of the justification for this simplification is that the relative price of nontraded goods are the terms of trade are generally positively correlated. In the rest of this section, we will apply the ARMA(2,1) model to the IFS quarterly data of the real effective exchange rate index (adjusted by the relative value-added deflators).

The theoretical model in this paper has assumed that capital markets faced by the home economy are open. However, the introduction of the euro and the integration of financial markets may cause structural changes to the evolution of real exchange rate dynamics, from relatively low capital mobility to high capital mobility. Applying the Zivot-Andrews (1992) test for structural break to the IFS quarterly data for the real effective exchange rate index (divided by 100) over the period of 1978QI to 2001QIV, we estimated the break dates for the seven euro area countries as following: We therefore divide the sample period into two subperiods accordingly.

We now may proceed to estimate the ARMA(2,1) equations for the first period of low capital mobility. The results are reported in Table 2–8. The autoregressive process is persistent but nonetheless stationary.

[7]Rogoff (1992, p.2) argues that many of the underlying fundamental variables suggested by the major theories of exchange rate determination tend to have mean-reverting components.

Table 2: Estimation of ARMA(2,1) equation: Austria's Real Effective Exchange Rate, 1978Q1 to 1985Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	129.5381	3.8229	33.88502
AR(1)	0.22868	0.17104	1.33700
AR(2)	0.38030	0.15334	2.48020
MA(1)	0.70770	0.16891	4.18969
$\bar{R}^2$	0.68190	σ	8.79376
μ	129.2528	SER	4.95974

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations; μ denotes the mean of dependent variable, and SER the standard error of the regression.

Table 3: Estimation of ARMA(2,1) equation: France's Real Effective Exchange Rate, 1978Q1 to 1993Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	107.3012	5.13600	20.89196
AR(1)	0.50416	0.13652	3.69311
AR(2)	0.40528	0.13866	2.92281
MA(1)	0.87835	0.06554	13.40155
$\bar{R}^2$	0.91400	σ	6.64268
μ	108.4373	SER	1.94803

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations; μ denotes the mean of dependent variable,and SER the standard error of the regression.

Table 4: Estimation of ARMA(2,1) equation: Germany's Real Effective Exchange Rate, 1978Q1 to 1995Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	79.02801	37.86104	2.08732
AR(1)	0.50069	0.04984	10.04422
AR(2)	0.48915	0.05932	8.24569
MA(1)	0.99712	0.03088	32.29459
$\bar{R}^2$	0.97449	σ	11.79222
μ	74.5321	SER	1.88337

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations;μ denotes the mean of dependent variable,and SER the standard error of the regression.

Table 5: Estimation of ARMA(2,1) equation: Ireland's Real Effective Exchange Rate, 1978Q1 to 1985Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	190.4403	9.80765	19.41751
AR(1)	0.37824	0.12263	3.08435
AR(2)	0.36944	0.06808	5.42663
MA(1)	0.99746	0.01591	62.68675
$\bar{R}^2$	0.80285	σ	15.69307
μ	191.7884	SER	6.96803

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations; μ denotes the mean of dependent variable,and SER the standard error of the regression.

Table 6: Estimation of ARMA(2,1) equation: Italy's Real Effective Exchange Rate, 1978Q1 to 1992Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	126.8567	1.85243	68.48130
AR(1)	0.31284	0.09515	3.28794
AR(2)	0.29895	0.07695	3.88482
MA(1)	0.82895	0.08066	10.27674
$\bar{R}^2$	0.78912	σ	6.53425
μ	126.1490	SER	3.00068

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations; μ denotes the mean of dependent variable,and SER the standard error of the regression.

Table 7: Estimation of ARMA(2,1) equation: The Netherlands' Real Effective Exchange Rate, 1978Q1 to 1982Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	93.66948	53.44097	1.75277
AR(1)	0.16293	0.10470	1.55616
AR(2)	0.76964	0.06737	11.42361
MA(1)	0.99747	0.15342	6.50167
$\bar{R}^2$	0.92159	σ	12.16049
μ	122.5810	SER	3.40514

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations; μ denotes the mean of dependent variable,and SER the standard error of the regression.

Table 8: Estimation of ARMA(2,1) equation: Spain's Real Effective Exchange Rate, 1978Q1 to 1988Q4

Variable	Coefficient	Std. Error	t-Statistic
Constant	93.69181	2.29030	40.90809
AR(1)	1.77437	0.06911	25.67573
AR(2)	-0.80416	0.06996	-11.49420
MA(1)	-0.96120	0.02076	-46.30134
$\bar{R}^2$	0.87494	σ	9.13585
μ	97.8889	SER	3.23079

Note: $\bar{R}^2$ denotes the adjusted coefficient of determinations; μ denotes the mean of dependent variable,and SER the standard error of the regression.

5 Concluding Remarks

Existing literature on exchange rate dynamics has proved unsuccessful in proving explanation based *solely* on economic fundamentals of real exchange rate movements. This paper has demonstrated the possibility of deterministic and stochastic *endogenous* fluctuation of the real exchange rate in an semi-small open economy facing a downward slopping export demand function. A useful byproduct of the stochastic version of our model is a plausible, *a priori* explanation for the stylized fact that real exchange rates are often hard to distinguish from random walk.

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