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EXCHANGE RATE AND ASSET PRICE DYNAMICS IN A SMALL OPEN ECONOMY

The Ohio State University

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300 N. Zeeb Road, Ann Arbor, MI 48106
EXCHANGE RATE AND ASSET PRICE DYNAMICS
IN A SMALL OPEN ECONOMY

DISSERTATION

Presented in Partial Fulfillment of the Requirement for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

By

Mei-Lie Chu, B.A.

* * * *

The Ohio State University
1986

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To God, My Parents, and My Husband
I am very grateful to my dissertation committee, namely, Professors Robert Driskill, Stephen McCafferty, and Nelson Mark. Professor Driskill served as my principal advisor. I had the great fortune of receiving his guidance in the past two years, as his thesis advisee. He stimulated the selection of this topic and gave me very warm support along the way. Without his stimulation, patience and guidance, this thesis could never have been written. Professor McCafferty reviewed every draft and helped me to solve the reduced-form solutions to the stochastic model. His contribution is valuable. It was Professor Mark who introduced me to the simulation technique and helped me find the way out when the issues became complicated. I admired his style of teaching and feel both guilty and grateful for having used so much of his precious time at various stages of writing this thesis. My thanks also go to Professor Pok-Sang Lam for his useful advice of numerical simulation. In addition, I thank all teachers who taught me economics. Their encouragement was of great value.

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Chapter I
Introduction

A number of studies have focused on the appreciation of the dollar from 1980 to September 1985. Some theorists explain this phenomenon on the basis of fundamentals. For example, Martin Feldstein (1984) argues that the high real long-term interest rate and the substantial decline in the expected inflation rate induce investors worldwide to shift in favor of dollar securities. However, with market interest rates in the United States declining since mid-1982 by considerably more than in other major countries, his view fails to explain the continuous appreciation of the dollar through September 1985. Why has the dollar risen and even set record highs after the decline in the relative interest rates? What are the major factors which eventually led to its decline?

Some market participants point out that the strong performance of the equity market is one of several major elements that induce capital inflows and push the value of the dollar up after mid-1982. The expected lower interest rates and anticipated expansion in output attract investors worldwide to the U.S. equity market. Therefore, the equity market reflects the public's long-term expectation of future
variables and, in turn, affects the determination of the exchange rate.

Niehans (1984) has pointed out that the inclusion of equities as international assets renders ambiguous the overall effect of interest rate change on international capital flows. While a decrease in relative interest rates lowers the yields of domestic bonds, the domestic equity market is boosted and becomes more attractive for investors. Whether there are net capital outflows or inflows depends on which asset market is dominant.

However, there is a limit to foreign investors' willingness to increase their dollar assets, and eventually the dollar has to fall to balance the current account. The question is, what would cause investors to lose their enthusiasm for accumulating further dollar assets? Niehans provides one answer: if the equity price is eventually depressed and the bond market influence dominates the equity market, then a decline in the relative interest rates leads to capital outflows. According to this argument, there is a probability at a certain point in time that the dollar peaks and then declines.

Yet, the inclusion of the equity market in the international literature seems to be an exception rather than a rule. There are two issues associated with this exclusion. First, there is no adequate explanation why the equity market has to be excluded, while either the money or bond market has to be matched with the determination of interest rates and then of the exchange rate. To exclude the equity market is to treat it as residuals offsetting the sum of excess demand
over the other markets. Logically, this is not true. Indeed, as Hicks (1958) states in Value and Capital, "(Walras' Law) simply enables us to eliminate one out of n+1 equations; it does not matter in the least which equation we choose to eliminate." This readily elicits the quip that if we eliminated the bond market, what then? Would the interest rates and exchange rate behave in the same manner as in the absence of the equity market? Although there is always a redundant demand and supply equation, Walras' Law does not tell us which market should be eliminated.

Second, there is no particular reason why the disturbance in the money market has to be transmitted completely to bond rates but not to equity yields or a combination of bond rates and equity yields. Most of the literature ignores the equity market and simply claims that any increase in the money supply will generate an excess supply of money and then a corresponding excess demand for goods and bonds. As a result, the bond price has to rise and then the bond rate has to decline. This raises a number of interesting questions: if the equity market also serves as another buffer to absorb the disturbance in the money market, what would the bond rate change? Which market would respond more to the monetary disturbance? The bond market or the equity market? What factors could cause such different responses in different asset markets? What are their implications in terms of the impact of monetary policies under a floating exchange rate? Few papers deal explicitly with these issues. This thesis attempts to fill this gap.
The main purpose of this thesis is to explore the implications of exchange-rate dynamics with the inclusion of equities as international assets; specifically, it focuses on the joint determination of the exchange rate and the equity value. The analysis draws on the analytical framework developed by Dornbusch (1976) and Blanchard (1981). Dornbusch develops a model with instantaneous adjustment and perfect capital substitutability in the asset markets. This characteristic of the asset market, coupled with the slow adjustment in the commodity market, leads to the overshooting of the exchange rate in the short run. Blanchard develops a model for the determination of output, the equity value, and interest rates in a closed economy. There are two cases which Blanchard describes as either "the good news" or "the bad news", depending on whether output effect dominates interest rate effect. In the good news case, the output effect dominates: the equity market initially undershoots its steady-state value and then increases after an unexpected monetary expansion. In this case, interest rates and equity prices have a similar qualitative behavior. The opposite holds in the bad news case: after the initial overshooting of the equity market, interest rates and equity prices move in opposite directions. Using Blanchard's formulation of the equity market, this thesis introduces equities as international assets into the open economy. The open-economy version of Blanchard's model carries key characteristics of Dornbusch's: perfect substitutes among assets and slow adjustment in the commodity market.
This dissertation is organized in the following way. Chapter II surveys selected related literatures. Chapter III investigates exchange-rate dynamics and the equity value in a perfect foresight context. Chapter IV recasts the model in a stochastic framework and examines the dynamic properties of the model with numerical simulation. Chapter V summarizes this chapter and suggests directions for further research.
Since the 1973 collapse of the Bretton Woods fixed exchange rate system, the theory of exchange-rate determination has been completely transformed. In the late 1960s, the standard model of the foreign exchange market had supply and demand as stable functions of exports and imports, with an expectation that a floating rate would move gradually with relative prices changes. However, the period of floating rates, which began in the early 1970s, has revealed that the exchange rate shows the volatility of financial market prices.

There were various models to explain exchange-rate movements during these years. Branson (1985) maintained that the experience of the floating exchange rate led first to the "monetary" approach to the exchange rate determination and then to the "asset market" approach. The monetary approach to exchange rate determination primarily featured one-way causation from money to exchange rates, sometimes via purchasing power parity. The broader asset market approach assumed two-way causation. From the asset market perspective, the spot exchange rate, is essentially determined by financial-market equilibrium conditions. It, in turn, influences the trade balance and
the current account, which is the accumulation of national claims on foreigners. This, again, feeds back into financial market equilibrium. Thus, the asset market approach consists of a dynamic feedback mechanism in foreign assets and exchange rates.

The above process outlines what is called a "fundamental" model of exchange rate dynamics. The fundamental model explains exchange-rate movements based on economic fundamentals, such as money growth, short-term interest rates, long-term interest rates, trade deficits, and risk factors. Recent work on rational expectations adds a layer of expectations to the model. It is assumed that following an unanticipated disturbance, the market attempts to anticipate where the fundamentals will move the system, and move the exchange rate in anticipation of the path of the fundamentals.

Two versions of fundamental model have been developed: an equilibrium or a disequilibrium version. The original formulation of the overshooting hypothesis in a disequilibrium context was presented by Dornbush (1976). The most notable implication of the Dornbush model is that the exchange rate may "overshoot" in the short run in response to a change in relative money supplies among countries: the exchange rate may immediately change by more than its long-run equilibrium value. Another implication of the model is that after an initial overshoot, the exchange rate then monotonically approaches its long-run equilibrium value. Both of these implications result from the key assumption that goods markets do not adjust as rapidly as asset markets. Thus, exchange rate overshooting, like deviations from
purchasing power parity, is viewed as a phenomenon of disequilibrium, which is due to the failure of the goods market to clear instantaneously. Further elaboration and modification of this type of model can be found in Niehans (1977), Wilson (1979), and Frenkel and Rodriguez (1982).

Some economists use an equilibrium framework to attempt to explain the overshooting of the exchange rate and short-run deviations from purchasing power parity. For example, Kimbrough (1983) demonstrates that if "effective" information travels more rapidly in asset markets than in goods market, the short-run deviation from purchasing power parity will occur. He also shows that even with goods and assets markets clearing continuously, exchange rate overshooting may occur. Therefore, exchange rate overshooting is caused by the differential effect of new information on goods and asset markets. In Kimbrough's paper, it is the previously formed price level expectation that has replaced sticky prices as the source of the differences between the short-run and long-run response of the economy. As a consequence, the volatility of the exchange rate is not necessarily indicative of the goods market disequilibrium. Rather, it reflects economists' prior belief in features of model specification. For additional discussions of exchange-rate movements in an equilibrium formulation, see Swoboda (1983) and Weber (1981).

However, either the equilibrium or disequilibrium model always assumes that all international assets take the form of bonds. The inclusion of the equity market seems to be an exception rather than a
rule. Only a few papers, such as Lucas (1982), Fischer (1984) and Niehans (1985), explicitly include equities in their model specification. The omission of the equity market may have far-reaching consequences for the theory of monetary policy under a floating exchange rate. As Niehans (1984) notes, the inclusion of the equities as international assets makes ambiguous the overall effect of interest rate change on capital flows. While an increase in relative interest rates raises the yields of domestic bonds, the equity price would be depressed by high interest rates. Whether there are net capital outflows or inflows depends on the particular dominant asset market. If a restrictive monetary policy begins by depressing the domestic equity market and then the equity market response dominates the bond market, higher interest rates may eventually result in capital outflow instead of capital inflow. Hence there is no particular association between capital flow and interest rate changes.

Niehan's argument can be elaborated as follows. If we assume that two countries have bonds and equities as their international assets, bonds can be regarded as representing all interest-bearing assets, while equities, which may be regarded as titles to physical capital, earn dividends equal to the rental on the use of physical capital. The net foreign asset position of a country can be taken as the difference between foreign assets held by domestic residents and domestic assets held by foreign residents. The exchange rate is assumed to be normalized at $e = 1$, and the prices of equities are all equal to $1$. If $F$ denotes the net foreign asset position, then
\[ F = B_f^f + S_f^f - B_d^d - S_d^d = (B_f^f - B_d^d) + (S_f^f - S_d^d) \]

where \( B_f^f \) and \( S_f^f \) denote the foreign bonds and equities held by domestic residents, and \( B_d^d \) and \( S_d^d \) denote the domestic bonds and equities held by foreign residents. Since capital flows are defined as the change in net foreign assets, they can be similarly decomposed into the accumulation or decumulation of individual assets.

When a restrictive monetary policy is adopted, a rise in interest rates will reduce the domestic demand for foreign bonds and equities, that is, a decrease in both \( B_f^f \) and \( S_f^f \), while the foreign demand for domestic bonds goes up, an increase in \( B_d^d \). All of these changes tend to reduce the net foreign asset holdings. However, the foreign demand for domestic equities declines (\( S_d^d \) is lower) at the same time, which will raise \( F \), the net foreign asset position. If the decline in the foreign demand for domestic equities dominates the others, then the net foreign asset position may eventually increase. As a result, a capital outflow occurs. Therefore, the effect of interest rate change on capital flows is ambiguous.

As to the relationship between the equity price and interest rates, Blanchard's (1981) thorough investigation on this issue concludes that there is no clear association between equity prices and interest rate movements where an output expansion occurs. After a money increase, output increases profits directly and then equity prices. Interest rates also increase due to the higher demand for
money and tend to lower equity prices. Depending on whether output or interest effect dominates, equity prices may rise or decline after the jump in the equity market. If the output effect dominates, equity prices rise and move in the same direction as interest rates (the good news case). If the interest rate effect dominates, then equity prices decline and change in a direction opposite to that of interest rates (the bad news case).

While Niehans gives a motivating discussion on interest rates and capital flows by incorporating the equity market, he does not explicitly explore its further implication for exchange rate movements. Using Blanchard's formulation of the equity market, this paper attempts to add an additional aspect to the exchange rate dynamics.
Notes

1. The alternative to the fundamental model is treating the movements of the dollar as a speculative bubble. When economic fundamentals failed to explain the continued appreciation of the dollar, especially after mid-1984, more economists began to consider that the dollar was on a speculative bubble path. For papers in this view, see Marris(1985), Krugman(1985), and Frankel and Froot(1986).
Chapter III
Equity Value And Exchange Rate Dynamics
In A Perfect Foresight Model

I. Introduction

This chapter develops a model of the determination of output, interest rates, the equity value, and exchange rates in a perfect foresight framework. This model allows the output to expand and examines the joint response of the exchange rate and equity value to an unanticipated monetary expansion. Output is anticipated to expand and interest rates are anticipated to decline. Such expectations will be reflected in asset markets via asset prices changes. But the question remains: is there any systematic relation which can be found between the equity value and exchange rate movements? It is this question which this chapter intends to answer.

The model is an open-economy extension of Blanchard's model. Using his equity market specification, the model describes a small open economy where domestic consumption is divided between two goods: an exportable (locally produced) and an importable (no domestic production). These two goods are regarded by domestic agents as imperfect substitutes in consumption. All goods are perishable;
therefore, domestic wealth owners have to allocate their wealth to the following assets: equities that are titles to the physical capital, the short- and long-term bonds issued and held by individuals, outside money, and foreign bonds. All of the assets are assumed to be perfect substitutes. There is no currency substitution: domestic residents do not hold foreign currencies. While the domestic price level is held constant to focus on the interaction between asset values and output, output adjusts to changes in excess demand over time.

The remainder of this chapter is organized as follows. Section II sets up a model based on the perfect foresight assumption. Section III describes steady state and dynamics of the model with constant prices. Section IV illustrates the effects of an unanticipated monetary expansion on output, the equity value, and the exchange rate. Section V first studies the dynamic interrelation of the exchange rate and the equity value, and then examines the overshooting behavior of the exchange rate. Section VI summarizes the chapter.

II. The Model

A. The goods market

Suppose that the domestic economy is so small that all foreign goods are supplied elastically at an exogenous, fixed price, $p_f$, set for convenience at one. Hence $\log p_f = 0$. The aggregate demand for
domestic output by domestic and foreign residents is given in eq. (3.1):

\[ d = ay + bq + \eta(e-p). \]  

(3.1)  

\[ 1 > a > 0, \quad b > 0, \quad \eta > 0 \]

where \( d \) is the log of the aggregate demand for domestic output, \( y \) is the log of real income, \( q \) is the value of equities, \( e \) is the log of the spot exchange rate, and \( p \) is the log of the domestic price level.

Eq. (3.1) states that the demand for domestic goods depends on income, the value of equities, and the relative price of domestic goods. Current income may affect aggregate demand independently of wealth if consumers or firms are liquidity constrained. Following Blanchard’s specification, the value of equities is a major determinant of aggregate demand. Being part of wealth, it affects consumption; determining the value of capital relative to its replacement cost, it affects investment. \(^1\) A decrease in the relative price of domestic goods (that is, an increase in \( e - p \)) switches demand toward home goods.

Output adjusts to changes in excess demand over time:

\[ \dot{y} = \beta(d - y), \]  

(3.2)  

where \( \beta > 0. \)
B. The money market

The domestic interest rate is determined by the condition of equilibrium in the domestic money market. The demand for real money balances is assumed to depend on the domestic short-term nominal interest rate and real income, and is equal to the real money supply. With a conventional demand for money, the log of which is linear in the log of real income and in interest rate, the money market equilibrium is as follows:

\[ m - p = \phi y - \lambda i. \quad (3.3) \]

\( \phi > 0, \lambda > 0, \)

where \( m \) and \( i \) denote the logs of the nominal money supply and the short-term nominal interest rate. The short-term expected real interest rate is defined as,

\[ r^* = i - \dot{p}^*. \quad (3.4) \]

An asterisk denotes an expectation; \( \dot{p}^* \) is the expected rate of inflation.

The long-term interest rate \( R \) is defined as the rate of return earned from a perpetuity. Its price is \( 1/R \). The total returns of holding perpetuity are \( R \) plus the expected capital gain or loss.
d(1/R)/dt. The perfect substitution between the short-term and long-term bonds implies that

\[ r^* = R - \frac{R^*}{R}. \]  

(3.5)

C. The equity market

Since \( q \) is the real value of equities, the expected real rate of return on equity holding is \( \frac{\dot{q}^*}{q} + \frac{\pi}{q} \), where \( \pi \) is real profit, which is assumed to be an increasing function of output:

\[ \pi = \alpha y, \quad \alpha > 0. \]  

(3.6)

Arbitraging between short-term bonds and equities therefore implies

\[ \frac{\dot{q}^*}{q} + \frac{\alpha y}{q} = r^*. \]  

(3.7)
D. The foreign exchange market

Bonds denominated in terms of domestic and foreign currency are assumed to be perfect substitutes, given a proper premium or discount to offset anticipated exchange rate changes. Accordingly, if domestic currency is expected to depreciate, interests on assets denominated in terms of domestic currency will exceed those abroad by the expected rate of depreciation. This relationship is expressed as

\[ \dot{e}^* = i - i_f \]

where \( i_f \) is the yield on foreign bonds and \( \dot{e}^* \) is the expected rate of depreciation of domestic currency.

III. Steady state and dynamics with fixed prices

Eqs. (3.1)-(3.8) characterize output, the equity market, interest rates, and the exchange rate as functions of the money supply, foreign interest rate, and the expectations of \( q^* \), \( p^* \), and \( \dot{e}^* \). The link between assets and goods markets is the exchange rate and equity value. For analytical simplicity, the price is assumed to be fixed. So, there is no actual and no expected inflation; real and nominal rates are identical. The system simplifies as follows:
\[ d = ay + bq + η(e-p) \]  \hspace{1cm} (3.1)

\[ \dot{y} = β(d-y) \]  \hspace{1cm} (3.2)

\[ m - p = ψy - λx \]  \hspace{1cm} (3.3')

\[ r = R - \frac{R^*}{R} \]  \hspace{1cm} (3.5')

\[ \frac{\dot{q}^* + \alpha y}{q} = r \]  \hspace{1cm} (3.7')

\[ \dot{e}^* = r - r_f \]  \hspace{1cm} (3.8')

The real rate substitutes for the nominal rate in both eqs. (3.3') and (3.8'). It is no longer an expected rate and is denoted by \( r \), the short-term real rate, instead of \( r^* \), the short-term expected real rate in eqs. (3.5') and (3.7').

Clearly, the mechanism of expectation formulation needs to be specified in order to complete the specification of the model. Dornbusch (1976) discusses an arbitrary regression expectation hypothesis that is consistent with a convergent perfect foresight path in his setup. However, in what follows, we focus on the class of perfect foresight paths that the model implies without any reference to a specific expectational scheme. As will be seen, the perfect foresight steady state of the model involves a saddle point, and we discuss the adjustment paths that force the system into the stable arm of the saddle.
A. Steady state

Let the stationary equilibrium of the model be described by $\bar{y}$, $\bar{q}$, and $\bar{e}$ respectively. With the assumption of perfect foresight, $q^* = \dot{q}$ and $\dot{e}^* = \dot{e}$. The steady state of the economy is attained when $\dot{y} = \dot{q} = \dot{e} = 0$ and is given as follows:

\[ \bar{y} = \frac{1}{\phi} (m - p + \lambda r_f), \]  \hspace{1cm} (3.9)

\[ \bar{q} = \frac{n}{r_f} = \frac{\alpha}{r_f} \bar{y}, \]  \hspace{1cm} (3.10)

\[ \bar{e} = \frac{1}{\eta} [(1-a) - (b\alpha/r_f)]\bar{y} + p, \]  \hspace{1cm} (3.11)

where the value of the equities is the ratio of the steady-state profit to the steady-state interest rate. The exchange rate depends on both the price and output. With constant price, the long-run exchange rate will change as output changes.
B. Dynamics

Linearizing the system about the stationary equilibrium, the dynamics can be reduced to the following matrix equation in $y$, $e$ and $q$:

\[
\begin{bmatrix}
\dot{e} \\
\dot{q} \\
\dot{y}
\end{bmatrix} =
\begin{bmatrix}
0 & 0 & \frac{\phi}{\lambda} \\
0 & \bar{r} & \bar{q} \frac{\phi}{\lambda} - \alpha \\
\beta \eta & \beta b & -\beta(1-a)
\end{bmatrix}
\begin{bmatrix}
e - \bar{e} \\
q - \bar{q} \\
y - \bar{y}
\end{bmatrix}
\tag{3.12}
\]

It can be shown that the three eigen values $\theta_1$, $\theta_2$, and $\theta_3$ have the following properties:

\[
\theta_1 \theta_2 \theta_3 = -\beta \eta \bar{r} \left(-\frac{\phi}{\lambda}\right) < 0
\]

\[
\theta_1 \theta_2 + \theta_2 \theta_3 + \theta_1 \theta_3 = -\beta (1-a) + b \bar{q} \frac{\phi}{\lambda} - \alpha + \eta \left(\frac{\phi}{\lambda}\right) < 0.
\]

From the above two conditions, there must be one negative and two positive roots, that is, $\theta_1 < 0$, $\theta_2 > 0$, $\theta_3 > 0$. The system, therefore, possesses saddle point behavior. By assuming that the economy
converges to its steady-state values, the solution is unique. We also assume that while output evolves continuously, both the exchange rate and the equity value can jump discontinuously in response to unanticipated disturbances. In other words, the initial values of the exchange rate and the equity value must adjust so as to place the system on the stable arm of the saddle passing through the corresponding equilibrium.

Because of the third-order dynamic equations, we are unable to give a three-dimensional illustration of the phase diagram in $y$, $e$ and $q$. However, we can show that after an unanticipated monetary expansion occurring at time $t = 0$, all $y$, $e$, and $q$ follow the pairs of linear relationships, which assure stable adjustment of the economy after $t > 0$; that is,

\[ e_t - \bar{e} = \frac{\phi}{\lambda \theta_1} (y_t - \bar{y}) \]  
(3.13)

\[ e_t - \bar{e} = \frac{\phi(\theta_1 - \bar{r})}{\lambda \theta_1 [q(\phi/\lambda) - \alpha]} (q_t - \bar{q}) \]  
(3.14)

\[ q_t - \bar{q} = \frac{(q \frac{\phi}{\lambda} - \alpha)}{(\theta_1 - \bar{r})} (y_t - \bar{y}) \]  
(3.15)
The relationships between $e_t - \bar{e}$ and $q_t - \bar{q}$, and between $q_t - \bar{q}$ and $y_t - \bar{y}$ will depend on the sign of $(\bar{q} \frac{\phi}{\lambda} - \alpha)$. If the interest rate effect dominates, then an increase in output will have the net effect of decreasing the equity value, which makes the sign of $(\bar{q} \frac{\phi}{\lambda} - \alpha)$ positive.

IV. The effects of an unanticipated monetary expansion

A. Long-Term Effects

With a fixed price assumption, money is no longer neutral even in the long run. The long-term effects of a once-and-for-all increase in the money supply can be derived from eqs. (3.9), (3.10), and (3.11) as follows:

\[
\frac{d\bar{y}}{dm} = \frac{1}{\phi}, \quad (3.16)
\]

\[
\frac{d\bar{q}}{dm} = \frac{\alpha}{\phi r_f}, \quad (3.17)
\]

\[
\frac{d\bar{e}}{dm} = \frac{1}{\eta \phi} \left[ (1-a) - \frac{\alpha b}{r_f} \right]. \quad (3.18)
\]
Clearly, output increases after an unanticipated monetary shock. The rise in the steady state equity value follows an increase in output, which is directly related to profits distributed to shareholders. Since the interest rate is exogenously given by the world interest rate and profits increase in the long run, the long-run effect of monetary expansion on the equity value is positive. It is of great interest that the exchange rate may appreciate rather than depreciate when either \( \alpha \) or \( \beta \) or both are substantially large. If either \( \alpha \) or \( \beta \) is very small, the exchange rate will depreciate. If the value of both \( \alpha \) and \( \beta \) equal zero, then the exchange rate depreciation is mainly decided by the income elasticity of demand for money \( \phi \), the marginal propensity to save \( 1 - \alpha \), and the relative price elasticity of demand for domestic goods \( \eta \).

B. The Short-Term Effects and Dynamic Adjustment Paths

The short-term effects of an unanticipated monetary expansion on the exchange rate, output, the equity value, and interest rate dynamic paths for these variables are illustrated in figs. 1, 2, and 3.

Fig. 1 describes the adjustment path of the exchange rate and output in the phase path. Let \( E_1 \) depict the original steady state. An increase in the money supply raises both the exchange rate and income in the long run. The new equilibrium is at \( E_2 \). The exchange
rate jumps instantaneously from $E_1$ to $A$ after a monetary expansion and then begins to appreciate gradually, while output starts to rise. The overshooting of the exchange rate is caused by the sluggish adjustment in output.

Fig. 2 illustrates the dynamic path for the equity value and output. When the increase in money takes place and output is given, it is the short-term rate which falls to maintain portfolio balance. To understand why the equity market jumps, we can integrate forward the arbitrage equation (3.7). This gives $q$ as the present discount value of profits:

$$q_t = \int_t^\infty \pi(s)e^{\int_s^t r(v)dv} ds$$

The jump is then easily understood by looking forward to the adjustment path: we anticipate that interest rates will be lower than before and that profits will be higher. But what happens to the equity market over time? As time passes, the initial low discount rate and low profits disappear from the integral and are replaced by higher discount rates and profits. When the discount rate effect dominates, the equity value initially overshoots its steady-state level and decreases thereafter. This is shown in fig. 2 by an initial jump from point $E_1$ to $A$, and then a movement to long-run equilibrium at point $E_2$. 

The time path of interest rates is illustrated in fig. 3. After the increase in money, the short-term rate is immediately driven below the world rate $r_f$. When the income is rising and money equity is fixed at the new level, the increase in the transaction demand for money drives the short-term rate back toward the previous level. What happens to the long rate? Although the short-term rate initially falls, the expectation of increasing output leads to an expected increase in the demand for money and thus an expected increase in the short-term rate. The long-term rate falls but by less than the short; the term structure slopes upwards after the increase in money.

V. Overshooting of the exchange rate

The dynamic relationship between the exchange rate and the equity value along the stable arm can be seen in eq. (3.14). Given the new equilibrium values, the jump in the exchange rate and the equity value can be determined via eq. (3.14), that is,

$$e_0^+ - \bar{e} = \frac{\phi(\theta_1 - \bar{r})}{\lambda \phi [q(\phi/\lambda) - \alpha]} (q_0^+ - \bar{q})$$

(3.19)

where $e_0^+$ and $q_0^+$ refer to the exchange rate level and the equity value following the jump.
The jump in the exchange rate and the equity value following a monetary expansion is

\[
\frac{\text{de}_0^+}{\text{dm}} - \frac{\text{de}}{\text{dm}} = \frac{\phi(\theta_1 - \bar{r})}{\lambda \theta_1 [q(\phi/\lambda) - \alpha]} \frac{\text{dq}_0^+}{\text{dm}} - \frac{\text{dq}}{\text{dm}}.
\]  

(3.20)

There are two issues which can be addressed concerning eq. (3.20). First, since \((\bar{q} - \frac{\phi}{\lambda} - \alpha) > 0\), the extent of the overshooting of the exchange rate and of the equity value are related each other. At the initial output level, the unanticipated monetary expansion reduces interest rates and leads to the anticipation of an expansion in output. Both factors serve to increase the attractiveness of the equity market, raising the demand for equities and creating a jump in the equity value. However, a capital loss will be expected when the public anticipates that the rising interest rate effect more than offsets the increase in profits over time. The initial jump in the equity value has to be sufficient to give rise to the anticipation at just a sufficient rate to validate the anticipated capital loss. With an expected capital loss in the equity market, the currency must depreciate enough so that its expected subsequent appreciation will compensate for the expected capital loss. The greater the jump of the equity value, the higher the anticipated capital loss; then, the
greater the expected subsequent appreciation of the exchange rate, the
greater initial overshooting of the exchange rate.

Secondly, the above proportional relationship between the degree
of overshooting of the exchange rate and of the equity value is
directly affected by the adjustment speed of the system, \( \theta_1 \)\(^3\). The
faster the system adjusts toward the new steady state, the greater the
intimate relation between the jump in the exchange rate and the
equity value.

VI. Summary

This chapter has shown that there is a potentially interesting
relationship between the dynamic paths of the exchange rate and the
equity value. A monetary expansion reduces the interest rates and
leads to the anticipation of a depreciation in the long-run exchange
rate. Both factors serve to reduce the attractiveness of domestic
bonds, lead to an incipient capital outflow, and thus cause the spot
rate to depreciate. However, the lower interest rates and the
anticipation of higher profits also increase the attractiveness of the
domestic equities relative to domestic and foreign bonds. The
resulting increase in the demand for domestic equities thus creates a
jump in the equity market. If a capital loss is anticipated in the
equity market, the currency must depreciate enough so that its
expected subsequent appreciation will compensate for the expected capital loss in the equity market. This means that when the rising interest effect is anticipated to dominate output expansion and a capital loss is created in the equity market, the dynamic relationship between the exchange rate movements and the equity value changes is positive: both e and q decrease over time. The exchange rate tends to appreciate when the equity value declines. In addition, the extent of the overshooting of the exchange rate is directly related to the jump in the equity value.
Notes

1. See James Tobin, "Monetary Policies and the Economy". A more detailed specification of aggregate demand would distinguish between the marginal and average value of capital. The former affects investment while the latter affects consumption.

2. From eq. (3.6), which is the arbitrage parity between short-term bonds and equities, we know that at the steady state, \( q = 0 \). Taking total derivatives, we obtain

\[
(q \frac{\phi}{\lambda} - \alpha) = -r \frac{dq}{dy}.
\]

When the interest rate effect dominates, an increase in output will have the net effect of decreasing rather than increasing the equity value. For this case, \((q \frac{\phi}{\lambda} - \alpha)\) is greater than zero and there exists only one negative root. If the output effect dominates, then \((q \frac{\phi}{\lambda} - \alpha)\) is negative. In this case, there may be one or three negative roots, and no definite conclusions can be drawn. In order to proceed with the analysis in a simple way, \((q \frac{\phi}{\lambda} - \alpha)\) is assumed to be positive.

3. Let \( K = \left\{(\phi)(\theta_1 - r)\right\}/(\lambda \theta_1)\right\}\{(\theta_1)\left[q(\phi/\lambda) - \alpha\right]} \)

then \[
\frac{dK}{d\theta_1} = \frac{\phi r}{\lambda \theta_1^2 [q(\phi/\lambda) - \alpha]} > 0.
\]
Figure 1: The adjustment path of the exchange rate and output
Figure 2: The adjustment path of the equity value and output
Figure 3: The response of interest rates to a monetary expansion
I. Introduction

This chapter recasts the model in Chapter III in a stochastic version. In order to explicitly incorporate future uncertainty in an analytically tractable manner, the model specified in the previous chapter is rewritten in discrete time. Three points distinguish it from the Chapter III model. First, the expectation scheme is based on rational expectations. Second, although output is allowed to be varied in the short run, it returns to the initial value in the long run. Third, the price is no longer fixed and adjusts to the disequilibrium in the goods market after a money increase.

The main purpose of this chapter is to study how the exchange rate moves under uncertainty, in particular, how rational agents' expectations of the equity value affect returns on other financial assets and, therefore, exchange rate dynamics. The second purpose is to examine how the fraction of output distributed to shareholders influences the exchange rate movements and variabilities.
The model consists of four basic building blocks: both output and price adjustment equations in the goods market, a money market equilibrium condition, an uncovered-interest-arbitrage equations, and an equity market specification.

The rest of the chapter is organized in the following way. Section II sets up a stochastic model. In section III, the reduced-form equation of the exchange rate and the equity value are derived with the method of undetermined coefficients. Section IV illustrates the solutions to the reduced-form coefficients with graphical methods. Section V uses simulation procedures to examine the dynamic properties of the model. In section VI, the sensitivity test is performed to check the robustness of the model. Section VII examines the effect of supply shock on the nominal exchange rate. Section VIII investigates the exchange-rate variability. Section IX concludes the chapter.

II. The Stochastic Model

A. The goods market

As explained in Chapter III, the aggregate demand for domestic goods depends on income, the value of equities, and the relative price of domestic goods; i.e.,

\[ d_t = ay_t + bq_t + \eta(e_t - p_t). \]  \hspace{1cm} (4.1)
\[ d_t = ay_t + bq_t + \eta(e_t - p_t). \quad (4.1) \]

\[ 1 > a > 0, \quad b > 0, \quad \eta > 0 \]

Output adjusts to excess demand over time:

\[ y_{t+1} - y_t = \beta(d_t - y_t) + w_{t+1}, \quad 0 < \beta < 1, \quad (4.2) \]

where \( w_t \) is a serially uncorrelated disturbance with zero-mean, and finite variance \( \sigma_w^2 \).

If prices were perfectly flexible, changes in the level of money would be neutral even in the short run, leaving output and the equity value unaffected. But this would not be of considerable interest for our purposes. We want to allow for the movement of output and the equity value, at least temporarily, and to see their impacts on the exchange rate path. The actual price adjustment is assumed as

\[ p_{t+1} - p_t = \theta(m_t - p_t) + \mu_{t+1}, \quad 0 < \theta < 1, \quad (4.3) \]

where \( \mu_t \) is a serially uncorrelated error term with zero mean and finite variance \( \sigma_{\mu}^2 \). With an increase in the money supply at the beginning of the period, the real balance rises, creating an excess
demand for goods, which will be partially adjusted via the change in the price level in the next period.

B. The money market

As seen in Chapter III, the demand for money is

\[ m^d_t = Pt + \phi y_t - \lambda i_t. \]  \hspace{1cm} (4.4)

Rearranging the above eq.,

\[ i_t = \delta y_t - h(m^d_t - p_t), \] \hspace{1cm} (4.5)

where \( \delta = (\phi / \lambda) \) and \( h = (1 / \lambda) \).

The log of the money supply is assumed to follow a random walk:

\[ m_t = m_{t-1} + \epsilon_t, \] \hspace{1cm} (4.6)

where \( \epsilon_t \) is a zero-mean serially uncorrelated random variable with known variance \( \sigma^2_\epsilon \). This assumption makes all monetary changes unanticipated and makes the model correspond to the Dornbusch treatment of a one-time unanticipated monetary change.
Assuming the money market is in equilibrium each period, the equilibrium condition is:

$$i_t = \delta y_t - h(m_t - p_t).$$  \hfill (4.7)

C. The foreign exchange market

The building block of the foreign exchange market is the joint assumption of perfect capital mobility and uncovered interest arbitrage, which is written as:

$$E_{t} e_{t+1} - e_t = i_t - i_f,$$  \hfill (4.8)

where exchange rate expectations are formed in a rational manner. That is, \( E_{t} e_{t+1} \) is the expected exchange rate at time \( t+1 \) conditional on information available at time \( t \). The interest rate parity states that expected nominal returns on foreign bonds are equal to returns on domestic bonds. Therefore, assets with equal risks, arbitrage sees to it that the interest differential corresponds to the expected change of the exchange rate. The more a currency is expected to depreciate, the higher its relative interest rate.
D. The equity market

As \( q \) is the real value of the equity market, the arbitrage between short-term bonds and equities implies that the expected real rate of return on holding equities is equal to the short-term interest rate with perfect substitution assumption. To avoid problems caused by nonlinearity in a rational expectation model, eq. (3.7') is first linearized around the unconditional means and then expressed in terms of discrete time as follows:

\[
\bar{E}q_{t+1} - (1 + \bar{r})q_t + \alpha y_t = \bar{q}[i_t - (E_p_{t+1} - p_t) - \bar{r}]. \tag{4.9}
\]

The above equation will be used later to derive the reduced-form equations. However, more elaboration would be helpful to understand its further implications. In a small open economy, the interest rate is exogenously determined by the world interest rate in the long run. Replacing \( \bar{r} \) in eq. (4.9) with \( r_f \) in the left-hand side and with \( (e_t^e e_t + i_t) \) in the right-hand side,

\[
(Eq_{t+1} + \alpha y_t - (1 + r_f)q_t)/(\bar{q}) = E(e_{t+1}^e p_{t+1} - (e_t - p_t)). \tag{4.9'}
\]

The above parity states that the rate-of-return differential on domestic equities and foreign bonds corresponds to the expected change
of the real exchange rate. The higher the relative rate of return of domestic equities to foreign bonds, the more the real exchange rate is expected to depreciate.

III. The Exchange Rate And Equity Value Equations

From eq.(4.3'), the reduced-form equation of the price can be written as:

\[ p_t = (1 - \Theta)p_{t-1} + \Theta m_{t-1} + u_t. \]  \hspace{1cm} (4.10)

Combining equations (4.1), (4.2) and (4.10), the reduced-form equation of income can be expressed as:

\[ y_t = c_0y_{t-1} + c_1q_{t-1} + c_2(e_{t-1} - p_{t-1}) + w_t, \]  \hspace{1cm} (4.11)

where \( c_0 = 1 - \beta(1 - a), \ c_1 = \beta b, \ c_2 = \beta \eta. \)

Substituting (4.10) and (4.11) into the money market equilibrium condition (4.7), the interest rate is given as

\[ i_t = \delta c_2e_{t-1} + \delta c_1q_{t-1} - hm_t + h\theta m_{t-1} + ((1 - \Theta)h - \delta c_2)p_{t-1} \]

\[ + \delta c_0y_{t-1} + \delta w_t + h\mu_t. \]  \hspace{1cm} (4.12)
Combining equations (4.8) and (4.12), we derive the following exchange rate equation:

\[
e_t = e_t^{t+1} - \delta c_2 e_{t-1} - \delta c_1 q_{t-1} + h_m t - h \theta m_{t-1} - ((1-\theta)h - \delta c_2)^p t_{t-1} - \delta c_0 y_{t-1} - \delta u_t - h u_t + i_f.
\] (4.13)

Combining equations (4.9), (4.10), (4.11), and (4.12), we derive the following equity value equation:

\[
q_t = (1+r)^{-1}(\tilde{e}_q t+1 + v c_2 e_{t-1} + v c_1 q_{t-1} + \tilde{q}(h+\theta)m_t - \tilde{q}(h+\theta)m_{t-1} + [-(v c_2 - \tilde{q}(1-\theta)(h+\theta)p t_{t-1} + v c_0 y_{t-1} + v w_t - \tilde{q}(h+\theta)u_t + \tilde{q} r]).
\] (4.14)

where \( v = \alpha - \tilde{q} \delta \).

It is useful to guess that the final solution of \( e_t \) and \( q_t \) will have the form:

\[
e_t = \pi_{11} e_t - 1 + \pi_{12} q_{t-1} + \pi_{13} m_t + \pi_{14} m_{t-1} + \pi_{15} p_{t-1} + \pi_{16} y_{t-1} \] (4.13')

\[
+ \pi_{17} w_t + \pi_{18} u_t.
\]

\[
q_t = \pi_{21} e_t - 1 + \pi_{22} q_{t-1} + \pi_{23} m_t + \pi_{24} m_{t-1} + \pi_{25} p_{t-1} + \pi_{26} y_{t-1}
\]
Now, under the assumption of rational expectation and using the well-known method of undetermined coefficients, it can be shown that:

\[ \pi_{11} = \frac{1}{\Delta} \left\{ \left( 1 + \bar{r} - \pi_{22} \right) (\pi_{16} - \delta)c_2 + \pi_{12} (\pi_{26} + v)c_2 \right\} \]  \hspace{1cm} (4.15)

\[ \pi_{12} = -\frac{c_1}{c_2} \pi_{11} \]  \hspace{1cm} (4.16)

\[ \pi_{13} = \frac{1}{\Delta} \left\{ \left( 1 + \bar{r} - \pi_{22} \right) (\pi_{13} + \pi_{14} + h) + \pi_{12} \left[ \pi_{25} + \pi_{24} + \bar{q}(h + \Theta) \right] \right\} \]  \hspace{1cm} (4.17)

\[ \pi_{14} = \frac{1}{\Delta} \left\{ \left( 1 + \bar{r} - \pi_{22} \right) (\pi_{15} - h) \Theta + \pi_{12} \left[ \pi_{25} - \bar{q}(h + \Theta) \right] \Theta \right\} \]  \hspace{1cm} (4.18)

\[ \pi_{15} = \frac{1}{\Delta} \left\{ \left( 1 + \bar{r} - \pi_{22} \right) \left[ -(\pi_{16} - \delta)c_2 + (1 - \Theta)(\pi_{15} - h) \right] + \pi_{12} \left[ -(\pi_{26} + v)c_2 + (1 - \Theta)(\pi_{25} - \bar{q}(h + \Theta)) \right] \right\} \]  \hspace{1cm} (4.19)

\[ \pi_{16} = -\frac{c_0}{c_2} \pi_{11} \]  \hspace{1cm} (4.20)

\[ \pi_{17} = -\frac{1}{c_2} \pi_{11} \]  \hspace{1cm} (4.21)
\( n_{18} = \frac{1}{\theta} - n_{14} \) \hspace{1cm} (4.22)

\( n_{21} = \frac{1}{\Delta} \{ n_{21} (n_{16} - \delta) c_{2} + (1 - n_{11}) (n_{26} + \nu) c_{2} \} \) \hspace{1cm} (4.23)

\( n_{22} = \frac{c_{1}}{c_{2}} - n_{21} \) \hspace{1cm} (4.24)

\( n_{23} = \frac{1}{\Delta} \{ n_{21} (n_{13} + n_{14} + \nu) + (1 - n_{11}) [ n_{23} + n_{24} + q (h + \theta) ] \} \) \hspace{1cm} (4.25)

\( n_{24} = \frac{1}{\Delta} \{ n_{21} (n_{15} - h) \theta + (1 - n_{11}) [ n_{25} - q (h + \theta) ] \theta \} \) \hspace{1cm} (4.26)

\( n_{25} = \frac{1}{\Delta} \{ n_{21} [ -(n_{16} - \delta) c_{2} + (1 - \nu) (n_{15} - h) ] + (1 - n_{11}) [ -(n_{26} + \nu) c_{2} + (1 - \theta) (n_{25} - q (h + \theta)) ] \} \) \hspace{1cm} (4.27)

\( n_{26} = \frac{c_{0}}{c_{2}} - n_{21} \) \hspace{1cm} (4.28)

\( n_{27} = \frac{1}{c_{2}} - n_{21} \) \hspace{1cm} (4.29)

\( n_{28} = \frac{1}{\theta} - n_{24}, \) \hspace{1cm} (4.30)
where \( \Delta = (1 + \bar{r})(1 - \pi_{11}) - \pi_{22} \).

Other constraints on \( \pi_{ij} \) are as follows:

\[
\pi_{11} + \pi_{13} + \pi_{14} + \pi_{15} = 1 \tag{4.31}
\]

\[
\pi_{21} + \pi_{23} + \pi_{24} + \pi_{25} = 0 \tag{4.32}
\]

Eq. (4.31) means that PPP holds in the long run. Eq. (4.32) means that money is neutral in the long run. In equilibrium, \( \bar{p} = \bar{m} = \bar{e} \) and \( \bar{q} = \bar{y} = \bar{r} = 0 \).

IV. Graphical Solution For The Reduced-Form Coefficients

Applying the equilibrium nature of \( \bar{q} \) and \( \bar{r} \) and substituting eqs. (4.16), (4.20), and (4.28) into eq.(4.15) and the latter two equations into eq.(4.23), we obtain the following two equations in terms of \( \pi_{11} \) and \( \pi_{21} \) as follows:

\[
\pi_{11}^2 + (c_1/c_2)\pi_{11}\pi_{21} - (1 - c_0)\pi_{11} = \delta c_2 \tag{4.33}
\]
It can be shown that the above two equations imply the following relationship between \( \pi_{11} \) and \( \pi_{21} \):

\[
\pi_{21} = -(\alpha/\delta)\pi_{11}
\]  

(4.35)

Eq. (4.33) can be simplified by replacing \( \pi_{21} \) with (4.35) as

\[
(1-(b\alpha/\eta\delta))\pi_{11}^2 - \beta(1-a)\pi_{11} - \delta\beta\eta = 0,
\]

(4.36)

which is a second order polynomial in \( \pi_{11} \).

Fig. 4 depicts the graphical solution for \( \pi_{11} \) and \( \pi_{21} \) when \( 1-(b\alpha/\eta\delta) > 0 \). It is readily verified that the relation implied by eq. (4.36) generates two distinct values for \( \pi_{11} \). Two corresponding values for \( \pi_{21} \) can be obtained through eq. (4.35).

It is clear that the solution involves two distinct pairs \((\pi_{11}^*, \pi_{22}^*)\) denoted by A and B in the diagram. First, consider the pair denoted by B where \( \pi_{11}^*>0 \) and \( \pi_{22}^*<0 \). This violates the stability requirement of the reduced-form equation system and, therefore, must
be rejected (see Appendix C). Only the pair A will satisfy the stability condition.

The same analytical technique can be applied to Fig. 5, which is for \(1 - (\beta \alpha / \eta \delta) < 0\). It can be shown that with this configuration, only the pair A satisfies the stability condition and again pair B should be rejected.

Once both \(\pi_{11}\) and \(\pi_{21}\) are determined, then \(\pi_{12}, \pi_{16}, \pi_{17}, \pi_{22}, \pi_{26},\) and \(\pi_{27}\) are automatically obtained. After combining eqs. (4.19) and (4.27) to solve for values of \(\pi_{15}\) and \(\pi_{25}\), \(\pi_{14}\) and \(\pi_{24}\) can be obtained with eqs. (4.18) and (4.26). The values of \(\pi_{13}\) and \(\pi_{23}\) can be solved using eqs. (4.17) and (4.25). Then \(\pi_{18}\) and \(\pi_{28}\) can also be found with eqs. (4.22) and (4.30).

V. Simulation Procedures

The coefficients appearing in the reduced-form equations are themselves complex functions of the underlying parameters of the structural model. The nonlinearities introduced into the model by incorporating various expectation variables in assets markets and the goods market appear to rule out purely analytical insights for the time paths following the money increase. Therefore, this section utilizes numerical methods in order to develop an understanding of the dynamic properties of the proposed model.
Dynamic simulation will be used to trace the response of this model to a one-time increase in money stock. Before introducing simulation procedures, we have to solve the reduced-form coefficients, which are a system of nonlinear equations in the structural parameters. Table 1 indicates a set of reference parameter values, and Table 2 shows the corresponding reduced-form coefficients.

The choice of the structural parameters is based mainly on reasonable empirical analysis. The income elasticity of the demand for money $\phi$ is 0.8. The semi-elasticity of the demand for money with respect to the nominal interest rate $\lambda$ is 0.5. The relative price elasticity of the demand for domestic output $\eta$ is 0.4. The values of both $a$ and $b$ in the aggregate demand function are more problematical. The initial chosen values are $a=0.3$ and $b=1.0$.

How fast the goods market adjusts to the equilibrium is indicated by $\beta$. The coefficient $\theta$ is the adjusting speed in the price adjustment scheme. The fraction of output distributed to equity holders is $\alpha$, and, therefore, dividends on equities are proportional to the level of output by a factor $\alpha$. These are the coefficients in which we are interested. Changes in the values of these coefficients not only provide one test for model sensitivity but also embody economic implications for the exchange rate dynamic path, which will become clear in the next section. In the base set of parameters, $\beta=0.1$, $\theta=0.1$, and $\alpha=0.15$. 
Simulation starts from equilibrium at t=0. The starting values for dynamic simulation are given in Table 3. The exchange rate is the U.S. dollar/U.K. pound rate for the end of 1982. By $p = \bar{m} = \bar{e}$, the initial values for $\bar{p}$ and $\bar{m}$ are the same as $\bar{e}$. There is a 20% increase in the money supply at $t=12$ and then the money supply is maintained at the new level after that. The dynamic patterns of the exchange rate, the equity market, output, interest rate, and real exchange rate are depicted in figs. 6 to 10, respectively.

The dynamic properties of the model based on the base set of parameters can be illustrated as follows:

(1) The neutrality of money is held in the long run. Output, the real value of the equity, and the real exchange rate would eventually return to initial values after a money increase. This is not surprising since there is no capital accumulation in this model.

(2) With no money illusion or long-run price inflexibility, the exchange rate will rise proportionally to the increase in the price and in nominal money. Thus, the model is characterized by the quantity theory of money and the homogeneity postulate between the exchange rate and nominal price in the long run.

(3) From fig.6, we can see that the exchange-rate path to the long-run value is nonmonotonic, showing periods of both appreciation and depreciation. This contrasts with the analysis of Dornbusch (1976),
where the exchange rate necessarily overshoots and then monotonically adjusts toward the long-run rate. Note that the impact multiplier of the money on the exchange rate $\pi_{13}$ is greater than one. However, this is not necessarily true for other sets of parameter values. We can see from Tables 4 and 5 that $\alpha$ could be positive or negative depending on the relative magnitudes of various structural parameters. The impact effect of a monetary expansion on the exchange rate, therefore, depends on the relative magnitudes of various structural parameters of the model. Compared to Dornbusch’s model, an added volatility of the exchange rate can be observed. The exchange rate appreciates continuously right after overshooting, and appreciates in such a degree that it drops below the initial value before it rebounds toward the long-run level.

(4) As shown in fig. 7 and Tables 4, 5 and 6, the impact multiplier of the money on the equity value $\pi_{23}$ is always greater than zero. So, the equity market jumps initially and then declines exponentially toward the long-run value. The jump is caused by the anticipation of higher profits and of lower discount rates. During the first several periods, the equity value moves in the opposite direction to the change in the interest rate ($q$ declines while $r$ rises). After that, both move in the same direction (both $q$ and $r$ decrease). The dynamic pattern of the equity value indicates that the interest rate effect dominates output effect at the beginning and output effect dominates the interest rate effect at the end.
(5) In fig. 8, we see that output increases for the first several periods and then exponentially declines toward the initial level. The primary reason for these movements is that asset value is the main determinant of aggregate demand and output is demand determined. At the first beginning, the jump in the equity value stimulates aggregate demand, which more than offsets the unfavorable effect of the increase in the relative price (a decrease in e-p) of domestic goods on aggregate demand and leads to an expansion in output. With the equity value declining continuously, the output eventually declines.

(6) Comparing fig. 10 to fig. 6, we can see that the real exchange rate (e - p) pattern is quite similar to the nominal exchange rate path because of sticky prices. The real exchange rate initially depreciates, then appreciates even below zero, and then depreciates again. Notice that deviations from purchasing power parity are positive for only the first two periods. After that, e - p remains negative. This means that exports are stimulated and imports suppressed because of increased relative prices for only two periods. The effects are then reversed.

(7) An increase in the money stock raises real money balances immediately. As time passes, the increase in the price gradually reduces real balances to the initial constant level.
VI. Sensitivity Test

While the values in the base parameter set seem reasonable, they are arbitrary. In Part B of Table 1, variants of these parameter values are used to test for model sensitivity. The approach is to begin with the base parameter set and then to introduce one parameter change at a time. This gives a total of 22 parameter sets. Changing those parameters shows that there is no model instability and, in general, dynamic patterns are quite similar to those obtained from the base parameter set. However, a number of interesting aspects can be addressed by looking at cases of changes in \( \alpha, \theta \) and \( \beta \).

A. Change in the value of \( \alpha \)

\( \alpha \) is the fraction of output distributed to shareholders. A sensitivity test has been done for \( \alpha \) ranging from 0.05 to 0.30. Results show that \( \alpha \) can influence the direction and degree of the jump in the exchange rate and determines whether there is an overshooting, undershooting, or even an immediate appreciation after a money increase. From fig. 11, it is clear that as the value of \( \alpha \) is increased, the exchange-rate pattern is switched from overshooting to undershooting, or even an immediate appreciation.

When the value of \( \alpha \) is quite small, for example, \( \alpha = 0.05 \), an overshooting but non-monotonic pattern of the exchange-rate adjustment
occurs. α close to zero means that almost no dividends are distributed to shareholders; i.e., no direct output influence on the returns of equities. In this case, the returns on equities are decided entirely by capital gains or losses, which are primarily determined by discount rates. However, when α is significantly large, output expansion tends to boost the equity market substantially because dividends distributed to equitiesholders are proportional to α. Since assets are assumed to be perfect substitutes, the return on bonds—the interest rate—has to go up to match the rise in the returns on equities. The required increase in the interest rate induced by equating real returns on equities and bonds could more than offset the decrease in interest rates caused by monetary expansion, and eventually raises interest rates. As a result, equalization of net yields internationally would require an immediate appreciation of the exchange rate after a monetary expansion.

Table 4 indicates that an increase in the value of α will tend to decrease π_{13} and increase π_{23}. Fig. 11 clearly shows that the relatively large values of α most likely reduce the possibility of the overshooting of the exchange rate and vice versa.

B. Change in the value of θ

θ shows the adjustment speed with which prices adjust to the long-run value. The reduced-form coefficients for various θ are
listed in Table 5. Different values of $\theta$ (0.15, 0.30 and 0.95) have been simulated. The simulation results indicated by figs. 13, and 14 show that if $\theta$ is large, prices adjust more flexibly to a money increase, leaving little impact on the output and the equity value, and the exchange rate is less volatile. If $\theta$ is small, the sluggish price adjustment gives monetary policy the power to alter real variables in the short run, creating a substantial influence on output and equity value, and much more variability in the exchange rate.

From fig. 13, it seems that the exchange rate movement is more volatile with $\theta=0.15$ than $\theta=0.95$. Fig. 14 indicates that the equity value fluctuates more with $\theta = 0.15$ than with $\theta = 0.95$. Therefore, if $\theta$ is small, there are simultaneous fluctuations among the equity value, and the exchange rate.

C. Change in the value of $\beta$

It is not surprising that the adjustment speed in the goods market, $\beta$, affects the dynamic properties of the exchange rate. The cases of $\beta = 0.10$, 0.25 and 0.95 have been simulated. It can be seen from Table 6 that, as $\beta$ is increased, $\pi_{23}$ rises and $\pi_{13}$ declines. The relatively large value of $\beta$ tends to reduce the potential for and the degree of the overshooting of the exchange rate, which is shown in fig. 15.
VII. Supply Shocks and the Nominal Exchange Rate

In this section, the effect of the supply shock on the nominal exchange rate is examined. A supply shock is defined to be a disturbance that changes the level of any equilibrium real output. Again, simulation starts from the equilibrium at $t = 0$, and the starting values are given in Table 3. With an 0.1 unit exogenous increase in $w$ (supply shock) at $t = 12$, the output increases immediately. The dynamics of the system arise in response to the perceived change in output.

The dynamic simulation based on the base set of the structural parameters leads to the following results:

(1) A positive supply shock causes an appreciation in the nominal exchange rate. An increase in output raises the demand for money. Since there is no change in the nominal money supply and the interest rate is exogenously determined by $r_f$, the real balance equal to the desired money balance can be achieved only by a fall in the price level. This leads to an appreciation in the exchange rate, which is shown in fig. 16.

(2) As shown in fig. 17, the nominal exchange rate appreciates more in the long run as $\alpha$ increases. Since the higher rate of return on equities is associated with the higher $\alpha$, there is a direct relation
between the appreciation in the exchange rate and the yield on equities.

(3) No persistent dynamic pattern of the nominal exchange rate can be found as the value of \( \beta \) changes. It can be seen from fig. 18 that the exchange rate monotonically appreciates when \( \beta = 0.10 \). With \( \beta = 0.25 \), the exchange rate appreciates such that it overshoots its long-run value and then depreciates again, as shown in fig. 19. In fig. 20, a completely different dynamic pattern of the exchange rate appears for \( \beta = 0.95 \). The exchange rate oscillates around the new level.

(4) Both the output and equity value increase and monotonically adjust toward the higher levels.

(5) The real money balance rises after a positive supply shock since the nominal money supply is constant and the price goes down.

VIII. Exchange-Rate Variability

Further properties of the model can be discovered by examining the implication of \( \alpha \) for exchange-rate variability. Knowing the explicit reduced-form equation for the exchange rate, the conditional variance of the exchange rate can be easily derived as
explicit reduced-form equation for the exchange rate, the conditional variance of the exchange rate can be easily derived as

\[ \sigma_{\epsilon, t}^2 = \mathbb{E}_{t-1} (e_t - \mathbb{E}_t e_t)^2 = \pi_{13} \sigma_{\epsilon, t}^2 + \pi_{17} \sigma_{w, t}^2 + \pi_{18} \sigma_{u, t}'^2 \quad (4.37) \]

where we assume that \( \text{cov}(\epsilon, w) = \text{cov}(\epsilon, \mu) = \text{cov}(w, \mu) = 0 \) at period \( t \).

Clearly, exchange-rate variance increases with the increase in \( \sigma_{\epsilon, t}^2, \sigma_{w, t}^2, \) and \( \sigma_{u, t}'^2 \), the underlying structural variances of stochastic disturbances.

Now consider the effects of change in \( \alpha \) on the exchange-rate variability. First note the effect on that part of the exchange-rate variance due to monetary disturbances, which we denote by

\[ V_{\epsilon, t} = \pi_{13}^2 \sigma_{\epsilon, t}^2. \quad (4.38) \]

Since \( \pi_{13} \) is a complex function of the underlying parameters of the structural model, it is analytically difficult to characterize the relationship between \( \alpha \) and \( \pi_{13} \) in detail. However, from Table 4, we find that as \( \alpha \) increases, the value of \( \pi_{13} \) changes from positive, to zero, to negative. Therefore, there exists a specific value of \( \alpha \), which will minimize \( \pi_{13} \) and hence the part of the exchange-rate
variability due to monetary shock. This part of the variability will vanish when $\pi_{13} = 0$.

Next, we turn to the effects of changes in $\alpha$ on exchange-rate variability due to supply shock, which we shall denote by

$$V_{w,t} = \pi_{17}^2 \sigma_{w,t}^2 = \left(\frac{1}{c_2}\right)^2 \pi_{11}^2 \sigma_{w,t}^2 .$$

(4.39)

Since the absolute value of $\pi_{11}$ increases as $\alpha$ goes up as seen in Table 4, increasing the fraction of output distributed to shareholders increases the part of the exchange rate variability arising from real stochastic disturbances.

Therefore, changing the value of $\alpha$ has asymmetric effects on the exchange-rate variability, depending on whether the underlying stochastic disturbances are real or monetary. The increase in $\alpha$ increases the portion of exchange-rate variability attributable to supply shock, but either increases or decreases the portion of the exchange-rate variability attributable to monetary shock, depending on where $\alpha$ ranges. In fact, there exists a specific value of $\alpha$, which will make this portion of the exchange-rate variability completely vanish.
IX. Concluding Remarks

The present analysis, by incorporating the equity market, provides a richer adjustment pattern for the exchange rate than that predicted by previous models in international literature. In particular, the exchange rate may appreciate immediately after a monetary expansion and continue to do so before it rebounds toward the long-run level. Therefore, the short-run exchange rate change can be heading away from rather than toward its long-run value. The essential reason for an immediate appreciation of the exchange rate is that the interest rate may rise instead of decline after a monetary expansion. In addition, an added volatility of the exchange rate can be observed.

The inclusion of the equity market brings in an additional channel through which the change in nominal money affects portfolio choices and then the exchange rate change. While the increase in nominal money tends to reduce the returns on bonds, the returns on equities rise due to the lower discount rates and anticipated increase in output. Since assets are perfect substitutes, the returns on bonds have to go up to match the rise in the returns on equities and, therefore, offset part of the impact of monetary expansion on interest rates. As a result, the interest rates decline less than they would in the absence of the equity market. Moreover, the interest rate may rise instead of decline after a money increase. We suspect that the interest-rate movements are closely related to the magnitude of $\alpha$, 
which is a key parameter to determine the yield on equities. It is the interaction among output, the equity market, and interest rates that generates a complicated exchange rate dynamic path.

It is also shown that the impact effect of monetary expansion on the exchange rate will depend on the sign and magnitude of the impact multiplier $\pi_{13}$, which in turn is affected by $\alpha$: the fraction of output distributed to shareholders. When $\alpha$ is close to zero, $\pi_{13}$ is greater than one, showing an overshooting of the exchange rate. With an increase in $\alpha$, $\pi_{13}$ becomes smaller and the exchange rate turns out to be a case of undershooting. However, when $\alpha$ is significantly larger, $\pi_{13}$ is negative and an immediate appreciation of the exchange rate occurs.

Finally, it shows that the fraction of output distributed to shareholders has asymmetric effects on the exchange-rate variability, depending on whether the underlying stochastic disturbances are real or monetary. The increase in $\alpha$ increases the portion of exchange-rate variability attributable to supply shock, but either increases or decreases the portion of the exchange-rate variability attributable to monetary shock, depending on where $\alpha$ ranges. In fact, there exists a specific value of $\alpha$ which will completely eliminate this portion of the exchange-rate variability.
Notes

1. There are many controversies concerning the values of these elasticities. However, representative elasticities of the demand for real balances from Goldfeld's 1973 article are about 0.7 with respect to changes in real income and 0.25 with respect to changes in interest rate.

2. Currie and Levine(1985) take the relative price elasticity of the demand for domestic output as 0.3. Carlozzi and Taylor(1985) run into the same problems and regard linkage effects as small, assuming η to be 0.1. However, Miller and Salmon(1985) take a larger value of 1.

3. So far, no paper has estimated the aggregate demand function as shown in eq.(4.1). If q is regarded as a proxy for wealth, then b can be assumed to be 1.

4. The solution for $\pi_{11}$ given in eq.(3.36) is

$$\pi_{11} = \left( \frac{1}{2} \frac{\beta(1-a)}{1-(b\alpha/\eta\delta)} \right) + \left[ \left( \frac{1}{2} \frac{\beta(1-a)}{1-(b\alpha/\eta\delta)} \right)^2 + \frac{\delta\beta\eta}{1-(b\alpha/\eta\delta)} \right]^2 .$$

It can be shown that $\frac{d\pi_{11}}{d\alpha} > 0$. 
Table 1

Parameter Values of the Structural Model

A. Base Set (Par. Set 1)

\[ a=0.3, \ b=1.0, \ \eta=0.4, \ \phi=0.8, \ \lambda=0.5, \ \alpha=0.15, \ \theta=0.1, \ \beta=0.1 \]

B. Variants (Par. Sets 2–22)

\[ a: 0.4, 0.5 \]
\[ b: 0.7, 0.9 \]
\[ \eta: 0.5, 0.6 \]
\[ \phi: 0.6, 0.9 \]
\[ \lambda: 5.0, 7.0 \]
\[ \alpha: 0.05, 0.15, 0.20, 0.25, 0.30 \]
\[ \theta: 0.15, 0.30, 0.95 \]
\[ \beta: 0.10, 0.25, 0.95 \]
Table 2

The corresponding parameter values of the reduced-form coefficients for par. set 1

\[ \begin{align*}
\pi_{11} &= -0.2470 & \pi_{21} &= 0.0231 \\
\pi_{12} &= -0.6175 & \pi_{22} &= 0.0578 \\
\pi_{13} &= 3.0586 & \pi_{23} &= 1.6819 \\
\pi_{14} &= -0.2058 & \pi_{24} &= -0.1682 \\
\pi_{15} &= -1.6058 & \pi_{25} &= -1.5369 \\
\pi_{16} &= -5.7427 & \pi_{26} &= 0.5383 \\
\pi_{17} &= -6.1750 & \pi_{27} &= 0.5775 \\
\pi_{18} &= -2.0580 & \pi_{28} &= -1.6820
\end{align*} \]

Table 3

The starting values for simulation

\[ \begin{align*}
\bar{e} &= \bar{p} = \bar{m} = 1.6705 \\
\bar{y} &= \bar{q} = \bar{r} = 0
\end{align*} \]
Table 4

The reduced-form coefficients for various $\alpha$

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Table 5
The reduced-form coefficients for various $\theta$

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Table 6
The reduced-form coefficients for various $\beta$

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Figure 4: The graphical representation of solutions for the reduced-form coefficients when \[ 1 - \frac{b\alpha}{\eta\delta} > 0 \]
Figure 5: The graphical representation of solutions for the reduced-form coefficients when \( 1 - \frac{b\alpha}{\eta\delta} < 0 \)
Figure 6: The dynamic path of the nominal exchange rate
Figure 7: The dynamic path of the equity value
Figure 8: The dynamic path of real output
Figure 9: The dynamic path of the nominal interest rate
Figure 10: The dynamic path of the real exchange rate
Figure 11: The dynamic paths of the exchange rate at various values of $\alpha$
Figure 12: The dynamic paths of the equity value at various values of $\alpha$
Figure 13: The dynamic paths of the exchange rate at various values of $\theta$
Figure 14: The dynamic path of the equity value at various values of $\theta$
Figure 15: The dynamic paths of the exchange rate at various values of $\beta$
Figure 16: The dynamic path of the exchange rate after a positive supply shock
Figure 17: The dynamic path of the exchange rate after a positive supply shock at various values of $\alpha$. 
Figure 18: The dynamic path of the exchange rate after a positive supply shock for $\beta=0.10$
Figure 19: The dynamic path of the exchange rate after a positive supply shock for $\beta=0.25$
Figure 20: The dynamic path of the exchange rate after a positive supply shock for $\beta=0.95$
Chapter V
Concluding Summary

This paper explicitly explores the implication for exchange rate dynamics when shares are considered as international assets. Following Blanchard's specification of the equity market, we find a potentially interesting relationship between the exchange rate and the equity value.

Chapter III explored the joint response of the equity value and the exchange rate to a change in the money supply in a model where output expands. It is shown that after an unanticipated monetary expansion, the equity market overshoots and the exchange rate tends to appreciate. A monetary expansion reduces the interest rates and leads to the anticipation of an expansion in the long-run output. Both factors serve to increase the attractiveness of the domestic equities relative to the domestic and foreign bonds. The resulting increase in the demand for domestic equities by both domestic and foreign investors thus creates a jump in the equity market. When a capital loss is anticipated in the equity market, the currency must depreciate enough so that its expected subsequent appreciation will compensate for the expected capital loss in the equity market.

Chapter IV recasts the model in a stochastic framework. Since the price level is adjusting to the change in the nominal money
supply, the neutrality of money is held in the long run. Output, the real value of the equity, and the real exchange rate would eventually return to initial values after a money increase. However, the short-run and the intermediate-run exchange rate movements are more complicated than what are predicted by the previous models. In particular, the exchange rate may appreciate immediately after a monetary expansion and continue to do so before it rebounds toward the long-run level. Consequently, the short-run exchange rate change can be heading away from rather than toward its long-run value.

The impact effect of monetary expansion on the exchange rate will depend on the sign and magnitude of the impact multiplier \( \pi_{13} \), which in turn is affected by \( \alpha \): the fraction of output distributed to shareholders. When \( \alpha \) is small, an overshooting of the exchange rate occurs. An increase in \( \alpha \) tends to increase the possibility of the undershooting of the exchange rate. In addition, changes in \( \alpha \) have asymmetric effects on the exchange-rate variability, depending on whether the underlying stochastic disturbances are real or monetary. The increase in \( \alpha \) increases the portion of exchange-rate variability attributable to supply shock, but either increases or decreases the portion of the exchange-rate variability attributable to monetary shock, depending on where \( \alpha \) ranges. This suggests that there exists a certain value of \( \alpha \) which will totally eliminate this portion of the exchange-rate variability.

The major limitation of the model is the admittedly simplified assumption of perfect substitutes of financial assets. In an
extension to deal explicitly with capital flows and exchange rate movements, the arbitraging equations in Chapter IV should be replaced. Second, it would be preferable to have a model integrating the influence of trade balance and current account, constituting a more complete feedback mechanism for foreign assets and exchange rates.
Appendix A

The General Solution to
the Dynamic System in Chapter III

To derive the general solution to the model in Chapter 3, we shall write the dynamic system (3.12) as

\[
\begin{bmatrix}
\dot{e} \\
\dot{q} \\
\dot{y}
\end{bmatrix} =
\begin{bmatrix}
0 & 0 & h_{13} \\
0 & h_{22} & h_{23} \\
h_{31} & h_{32} & h_{33}
\end{bmatrix}
\begin{bmatrix}
e - \bar{e} \\
q - \bar{q} \\
y - \bar{y}
\end{bmatrix}
\]

(1)

where \( h_{ij} \) are identified by the corresponding elements in the matrix in (3.12). We assume that at time 0, the system is in steady state. An unanticipated change in the money supply occurs at time 0. The new steady state is given by \( \bar{e}, \bar{q}, \) and \( \bar{y} \).

The solution to (1) is as follows:

\[
e_t - \bar{e} = \sum_{i=1}^{3} c_i \exp \Theta_t^i,
\]

(2)
\[ q_t - \bar{q} = \sum_{i=1}^{3} k_i \exp \theta_i, \]  
(3)

\[ y_t - \bar{y} = \sum_{i=3}^{3} v_i \exp \theta_i, \]  
(4)

where \( k_i = \frac{c_i \lambda_i \theta_i (\bar{q} \phi - \alpha)}{(\phi)(\theta_i - \bar{r})} \), and

\[ v_i = \frac{c_i \lambda_i \theta_i}{\phi}. \]

From the text, we know that there must be one negative and two positive roots, say \( \theta_1 < 0, \theta_2 > 0, \theta_3 > 0 \). In order for the system to remain bounded as \( t \to \infty \), we require that \( c_1 = c_2 = 0 \). Accordingly, the solutions are reduced to the following:

\[ e_t - \bar{e} = c_1 \exp \theta_1, \]  
(5)

\[ q_t - \bar{q} = k_1 \exp \theta_1, \]  
(6)

\[ y_t - \bar{y} = v_1 \exp \theta_1. \]  
(7)
Appendix B

Derivation of the Exchange-Rate and the Equity Value Equation in Chapter IV

Again it helps to note that the solution will take the following form:

\[ e_t = \pi_{11} e_{t-1} + \pi_{12} q_{t-1} + \pi_{13} m_t + \pi_{14} m_{t-1} + \pi_{15} p_{t-1} + \pi_{16} y_{t-1} \]

\[ + \pi_{17} v_t + \pi_{18} u_t, \quad (8) \]

\[ q_t = \pi_{21} e_{t-1} + \pi_{22} q_{t-1} + \pi_{23} m_t + \pi_{24} m_{t-1} + \pi_{25} p_{t-1} + \pi_{26} y_{t-1} \]

\[ + \pi_{27} v_t + \pi_{28} u_t. \quad (9) \]

Hence, the expected exchange rate and the expected equity value at time \( t+1 \) conditional on information available at time \( t \) would be

\[ E e_{t+1} = \pi_{11} e_t + \pi_{12} q_t + (\pi_{13} + \pi_{14}) m_t + \pi_{15} p_t + \pi_{16} y_t. \quad (10) \]

\[ E q_{t+1} = \pi_{21} e_t + \pi_{22} q_t + (\pi_{23} + \pi_{24}) m_t + \pi_{25} p_t + \pi_{26} y_t. \quad (11) \]
Substituting eqs. (4.6), (4.10), and (4.11) in the text into the above two equations, we have $E_{t+1}$ and $Q_{t+1}$ as follows:

\[ E_{t+1} = \pi_{11}e_t + \pi_{12}q_t + (\pi_{13} + \pi_{14})m_t + \pi_{15}n_{t-1} \]

\[ + (\pi_{15}(1-\theta) - \pi_{16}c_2)p_{t-1} + \pi_{16}c_0y_{t-1} \]

\[ + \pi_{16}c_2q_{t-1} + \pi_{16}c_2e_{t-1} + \pi_{15}u_t + \pi_{16}v_t, \]  \hspace{1cm} (12)

\[ Q_{t+1} = \pi_{21}e_t + \pi_{22}q_t + (\pi_{23} + \pi_{24})m_t + \pi_{25}n_{t-1} \]

\[ + (\pi_{25}(1-\theta) - \pi_{26}c_2)p_{t-1} + \pi_{26}c_0y_{t-1} \]

\[ + \pi_{26}c_2q_{t-1} + \pi_{26}c_2e_{t-1} + \pi_{25}u_t + \pi_{26}v_t, \]  \hspace{1cm} (13)

Again substituting $E_{t+1}$ and $Q_{t+1}$ in eqs. (4.13) and (4.14) of the text and solving for $e_t$ and $q_t$ simultaneously, we find:

\[ e_t = \frac{1}{\delta} - \{(1+\delta-n_{22})(\pi_{16}-\delta)c_2 + \pi_{12}(\pi_{26}+\nu)c_2\}e_{t-1} \]
The equity value equation $q_t$ is

$$q_t = \frac{1}{\Delta} \{ \pi_{21} (\pi_{16} - \delta) c_2 + (1 - \pi_{11})(\pi_{26} + v)c_2 \} e_{t-1}$$
\[ + \frac{c_1}{c_2} \cdot \frac{1}{\Delta} \{ \pi_{21} (\pi_{16} - \delta) c_2 + (1 - \pi_{11}) (\pi_{26} + \nu) c_2 \} q_{t-1} \]

\[ + \frac{1}{\Delta} \cdot (\pi_{13} + \pi_{14} + h) + (1 - \pi_{11}) [\pi_{23} + \pi_{24} + \bar{q}(h + \Theta)] \] \[ m_t \]

\[ + \frac{1}{\Delta} \cdot \{ \pi_{21} (\pi_{15} - h) \Theta + (1 - \pi_{11}) [\pi_{25} - \bar{q}(h + \Theta)] \Theta \} m_{t-1} \]

\[ + \frac{1}{\Delta} \cdot \{ \pi_{21} (\pi_{15} - h) \Theta + (1 - \pi_{11}) [\pi_{25} - \bar{q}(h + \Theta)] \Theta \} m_{t-1} \]

\[ + \frac{1}{\Delta} \cdot \{ \pi_{21} (\pi_{16} - \delta) c_2 + (1 - \Theta)(\pi_{15} - h) + (1 - \pi_{11}) [\pi_{25} - \bar{q}(h + \Theta)] \Theta \} \]

\[ p_{t-1} \]

\[ + (\frac{c_0}{c_2}) \cdot \frac{1}{\Delta} \cdot \{ \pi_{21} (\pi_{16} - \delta) c_2 + (1 - \pi_{11}) (\pi_{26} + \nu) c_2 \} y_{t-1} \]

\[ + (\frac{1}{c_2}) \cdot \frac{1}{\Delta} \cdot \{ \pi_{21} (\pi_{16} - \delta) c_2 + (1 - \pi_{11}) (\pi_{26} + \nu) c_2 \} v_t \]

\[ + (\frac{1}{\Theta}) \cdot \frac{1}{\Delta} \cdot \{ \pi_{21} (\pi_{15} - h) \Theta + (1 - \pi_{11}) [\pi_{25} - \bar{q}(h + \Theta)] \Theta \} u_t, \quad (15) \]

where \( \Delta = (1 + \bar{r})(1 - \pi_{11}) - \pi_{22} \).

The rationality requires that the coefficient of each variable in eqs. (8) and (9) equals the coefficient of each variable in eqs. (14)
and (15), respectively. Therefore, the system of the equations from eqs. (4.15) to (4.30) is derived.
APPENDIX C
The Stability Condition of the Dynamic System in Chapter IV

In the model, the dynamic aspect of the analysis requires the simultaneous determination of the time paths of endogenous variables; that is \( e_t, q_t, y_t \) and \( p_t \). Therefore, we have a system of linear difference equations:

\[
e_t = \pi_{11} e_{t-1} + \pi_{12} q_{t-1} + \ldots + \pi_{14} m_{t-1}^{2} + \ldots + \pi_{16} y_{t-1} + \ldots + \pi_{18} w_t + \pi_{19} u_t. \quad (16)
\]

\[
q_t = \pi_{21} e_{t-1} + \pi_{22} q_{t-1} + \ldots + \pi_{24} m_{t-1}^{2} + \ldots + \pi_{26} y_{t-1} + \ldots + \pi_{28} w_t + \pi_{29} u_t. \quad (17)
\]

\[
y_t = c_0 y_{t-1} + c_1 q_{t-1} + c_2 (e_{t-1} - p_{t-1}) + w_t. \quad (18)
\]

\[
p_t = (1-\theta)p_{t-1} + \theta m_{t-1} + u_t. \quad (19)
\]

The dynamic stability of the system depends on the values of the characteristic roots of the following matrix:

\[
\begin{bmatrix}
\pi_{11} & \pi_{12} & \pi_{14} & \pi_{16} \\
\pi_{21} & \pi_{22} & \pi_{24} & \pi_{26} \\
0 & 0 & 1-\theta & 0 \\
c_2 & c_1 & -c_2 & c_0
\end{bmatrix}
\]
A total of four characteristic roots can be found. Let \( r_i \) denote the characteristic root of the above matrix, it can be proved that

\[
\begin{align*}
    r_1 &= 1 - b(1-a) + \left( 1 - \frac{b\alpha/\eta\delta}{1-\alpha} \right) \pi_{11}, \\
    r_2 &= 1 - \theta, \\
    r_3 &= 0, \\
    r_4 &= 0.
\end{align*}
\]

The stability condition will require that all of the \( r_i \)'s range between 1 and -1. Hence, the absolute value of \( r_i \) should be less than one, which is equivalent to

\[
- \frac{\beta(1-a)}{1-(\alpha\delta/\eta)} < \pi_{11} < \frac{\beta(1-a)}{1-(\alpha\delta/\eta)} \quad \text{if} \quad 1 - \frac{b\alpha/\eta\delta}{1-\alpha} > 0, 
\]

and

\[
- \frac{\beta(1-a)}{1-(\alpha\delta/\eta)} > \pi_{11} > \frac{\beta(1-a)}{1-(\alpha\delta/\eta)} \quad \text{if} \quad 1 - \frac{b\alpha/\eta\delta}{1-\alpha} < 0.
\]

The solutions for \( \pi_{11} \) given in eq.(4.36) is
\[ \pi_{11} = (-\frac{1}{2} - \frac{\beta(1-a)}{1-(b\alpha/\eta \delta)}) \pm \left( \frac{(-\frac{1}{2} - \frac{\beta(1-a)}{1-(b\alpha/\eta \delta)})^2 + \frac{\delta \beta \eta}{1-(b\alpha/\eta \delta)}}{2} \right). \] (27)

When \( 1 - (\beta\alpha/\eta \delta) > 0 \), the value of \( \pi_{11} \) denoted by pair B in Fig. 4.1 is greater than \( \beta(1-a)/(1-(b\alpha/\eta \delta)) \). This obviously violates the stability requirement imposed by eq.(25); therefore, pair B should be rejected. As to the case where \( 1 - (\beta\alpha/\eta \delta) < 0 \), the value of \( \pi_{11} \) denoted by pair B in Fig. 4.2 is smaller than \( (1/2)(\beta(1-a))/(1-(b\alpha/\eta \delta)) \), which clearly does not satisfy the stability condition of eq.(26): \( \pi_{11} > \beta(1-a)/(1-(b\alpha/\eta \delta)) \). So, pair B should be rejected too.
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