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THE CLOSED AND OPEN MACROECONOMY

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AN APPLICATION OF CATASTROPHE THEORY
TO THE CLOSED AND OPEN MACROECONOMY

By

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ABSTRACT

AN APPLICATION OF CATASTROPHE THEORY
TO THE CLOSED AND OPEN MACROECONOMY

By

Hassan Khademian

The existing literature in economic theory explains the continuous dynamic equilibrium values of economic variables. However, economic variables in general and the foreign exchange rate in particular may display discontinuous changes in their dynamic equilibrium values. The existence of such a phenomenon warranted this author and his dissertation committee members to search for the roots of this phenomenon for almost two years.

In my dissertation, I model both closed and open economies in the spirit of catastrophe theory. This theory argues that in a system (model), catastrophes occur when the equilibrium values of endogenous variables experience sudden discontinuous changes (jumps) as a result of continuous change in exogenous variables.

Catastrophes are not sudden discontinuous changes of great proportion. But simply, they are discontinuous changes in the equilibrium values, regardless of their magnitudes. Real economic variables, such as real income, may show discontinuous changes (catastrophes) of small magnitude. But financial variables, such as foreign exchange rate may show these characteristics in a large value.

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Hassan Khademian

This dissertation is a new approach to an old problem (i.e., exchange rate fluctuations). It will stir both anxiety and controversy. And this is the purpose of this dissertation: to produce at least a viable intellectual explanation of the problem and at most a breakthrough.

To My People

With Love

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ACKNOWLEDGMENT

I remember I read somewhere that 'school is not a preparation for life,' it is 'life.' I came to Michigan State young, inexperienced, and seeking adventures. I am leaving this beautiful campus young, experienced, and seeking adventures. I am happy that I came and sad to go.

I would like, first of all, to thank my parents, my sisters (Golnar and Sousan), and my brothers. It would be fair to say that it would have been much harder to finish my graduate work without Golnar's support.

I would also like to thank my thesis advisor, Lawrence H. Officer and other members of the dissertation committee: Stephen Martin and James Johannes.

Professor Officer's intellectual and maverick approach allowed my mental agility to thrive while holding a firm grip on the course of events.

Professor Martin's astute perception of economic theory was a key instrument in the production of this work.

However, I am personally responsible for any flaw in this thesis.

I thank Ms. Jo McKenzie for assuming the painstaking task of typing my dissertation.

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CHAPTER 1

Introduction

The foreign exchange rate, or simply the exchange rate, is the price or value associated with a currency being acquired or bought in terms of another currency. Small fluctuations in exchange rates are common phenomena. However, sudden large fluctuations, distinctively different from the rest, have warranted scholars' time and effort in the last decade or so.

"News" or "new information," by changing expectations, is considered a major contributing factor to these fluctuations.[1] However, this approach relies on the theoretical manipulations of ad hoc assumptions about expectation.

An alternative approach is the application of catastrophe theory to the theory of exchange-rate determination. De Grauwe (1983) is the only application of catastrophe theory (CT) to the theory of exchange-rate determination. He applies CT to a monetary model of exchange-rate determination. His work is interesting and enlightening. However, it suffers from some shortcomings.

First of all, the oscillatory fluctuations and the occurrence of catastrophes were explained in the framework of some ad hoc expectations formation assumptions. In this model, expectations formation is comprised of two parts: (a) non-linear regressive (b) extrapolative expectations. De Grauwe postulates the existence of an extrapolative expectations around the long run equilibrium values of exchange rate ($\bar{E}$). As a result, exchange rate moves away from $\bar{E}$ (due to extrapolative expectations) until regressive expectations become dominant. But, Salin (1983) raises some doubt about the occurrence of extrapolative expectations around $\bar{E}$. Secondly, De Grauwe (1983) applies two restrictive assumptions of interest parity and purchasing power parity conditions. Chapter six deals with these conditions and their shortcomings in models of exchange-rate determination. Third, De Grauwe takes prices and output as "slow" variables in a dynamic model of CT. I believe that this implies a wrong perception and understanding of the theory. "Slow" variables are parameters of a system in CT. Catastrophes (or discontinuous changes) in the equilibrium values of some endogenous variables occur as a result of continuous changes in the parameters of the system. Real income and price level are not slow variables. They can be easily considered endogenously determined variables in De Grauwe (1983) by relaxing some assumptions. But financial and open market operational policies are the parameters of the economic system. Finally, De Grauwe explains the oscillatory fluctuations of exchange rate within the framework of a catastrophic model. But, as was correctly understood by Salin (1983), it is the existence of large swings with short-run oscillations in the values of exchange rate which warrant our search and effort.

The purpose of this thesis is to deal with the subject of exchange rate, real income, and interest rate fluctuations within the mathematical framework of CT. I concentrate on the real sector of the economy rather than regressive and extrapolative expectations formulations as the major contributing factor in these cyclical fluctuations of exchange rates. Furthermore, exchange rate and interest rate behavior are explained according to portfolio-selection criteria. As explained in Chapter six, this model has a better capability than monetary models of exchange-rate determination in explaining the behavior of our variables. In addition, the model explains large swings in the values of the exchange rate and other economic variables as a result of continuous changing financial policies.

This thesis is comprised of two parts. Chapter two through five comprise part one. In this part, the occurrence of catastrophes in a closed economy will be examined. The investment function plays a key role and provides an essential building block in this dissertation. Chapter two deals exclusively with the shape and importance of the investment function. In Chapter three an examination of macroeconomic model is conducted. Based on the shape of the investment function derived in Chapter two, goods market equilibrium conditions are specified. Chapter four examines the essentials of CT. Its examination is in a non-technical, non-mathematical term.[2] In an economic system, catastrophes occur when the equilibrium values of endogenous variables experience sudden discontinuous changes (jumps) as a result of continuous change in exogenous variables. In the jargon of CT (and in my model), the exchange rate, real income, and interest rate all are "fast" variables and financial policies are the "slow" variables. The characteristics of a Keynesian macroeconomic model are examined in Chapter five. This chapter shows that financial policies can cause the equilibrium value of real income to move in a discontinuous manner.

Chapters six through eight comprise the second part of the thesis. In this section, real and financial models of exchange rate, real income, and interest rate determination are examined. This is an extension of the closed economy to an open (i.e., international) economy.

Chapter six presents a brief review of the exchange-rate determination literature.[3] This chapter lays a foundation for the next ones. The theoretical building blocks of exchange-rate behavior, to be developed in the next two chapters, are based on the concept that the various theories are supplementary rather than mutually exclusive in explaining exchange-rate behavior.

Chapter seven constructs a real and financial model of income and exchange-rate determination. This model is based on equilibrium conditions in both goods and financial markets. The goods market clearing conditions in conjunction with the portfolio selection equilibria conditions (developed in Chapter six) will be used to determine equilibrium values of real income and exchange rate. In this chapter, home and foreign bonds are considered perfect substitutes. The expectations, inflation, and the dynamic behavior of this model are explained respectively.

In Chapter eight, I relax the assumption of perfect substitution (interest parity) between home and foreign bonds. Private home wealth holders face a portfolio selection problem of choosing between real balances, home bonds, and foreign bonds. Thus this chapter presents an extended version of real and financial model examined in Chapter seven. A simultaneous solution of goods, home bonds, and foreign bonds market clearing conditions determines equilibrium values of real income, home interest rate, and exchange rate, respectively.

Chapter nine provides my conclusions and suggestions for future research.

The possibility of changing signs in the slope of the LM curve can contribute to further investigation of the occurrence of large swings in the equilibrium values of an economic system. This is examined in Appendix A.

Appendix B presents a critical examination of De Grauwe (1983) in explaining cyclical fluctuations of the exchange rate.

CHAPTER 1--Footnotes

[1]See Frenkel (1981) and Mussa (1979).

[2]But the chapter provides references to the mathematical treatment of the theory.

[3]See Whitman (1975), Dornbusch (1980a), Murphy and Duyne (1980) and Pearce (1983).

CHAPTER 2

Investment Function

Introduction

The investment function plays a key role in this dissertation. Being of such vital importance, a thorough analysis is imperative. This chapter will endeavor to serve two purposes. First, in section I, I will specify the investment function. A survey of empirical studies on conventional theories of investment behavior indicates that capacity utilization or output and the interest rate are the two major explanatory variables in the function.[1] Second, sections II and III present the structure and characteristics of the investment function which I rely upon to explain drastic changes in economic variables (both in closed and open economies).

Linearized theories of investment behavior present researchers with a much simplified paradigm of the economic world. However, these theories fail to explain turning points in investment and employment.[2] remedy to this situation is to base my investigation on a non-linear model. Section II will deal with this. This will involve a discussion the impact of real economic variables on investment behavior. Also influence of monetary factors on investment and other economic variables will be examined in section II.

As a final note, it is important to stress that investment is intended to be the unique paramount actor on stage in Chapter two.

Any reference to other issues--such as economic fluctuations or the trade cycle--are used only to clarify the nature and role of the investment function. In section III, I attempt to produce an integrated synthesis of both real and monetary factors in the theory of investment behavior. The rationale for this modification will be made clear throughout the rest of this work.

I. General Literature on Conventional Theories of Investment Behavior

A starting point for the investigation of alternative theories of investment behavior is found in Jorgenson and Siebert (1968a) and Jorgenson (1971). It is a valuable starting point to become familiar with these theories, even though their empirical conclusions have been challenged and rejected by Elliot (1973) and Eisner (1974). The following review of the literature is based on Jorgenson and Siebert (1968a), and Jorgenson (1971).

The flexible accelerator model of investment was originated by henery (1952) and Koyck (1954). According to this model, the actual evel of capital (K_t) is adjusted toward its desired level (K_t^*) by a ertain proportion of the discrepancy between desired and actual capital each period.

$$K_t - K_{t-1} = (1-\lambda)(K_t^* - K_{t-1})$$

ich implies that actual capital is a weighted average of all past vels of desired capital:

$$K_t = (1-\lambda) \sum_{\zeta=0}^{\infty} K_{t-\zeta}$$

where the weights decline geometrically. The latter form of the flexible accelerator is referred to as a "distributed lag function," and the average lag of adjustment is $\lambda/(1-\lambda)$.

In order to turn this model into a complete theory of investment behavior, additional specifications for replacement investment and desired level of capital are required:

$$K_t - K_{t-1} = I_t - \delta K_{t-1}$$

here δ is a fixed rate of replacement of capital.[3] Therefore:

$$I_t = (1-\lambda)(K_t^* - K_{t-1}) + K_{t-1}$$

In investigating the specification of desired level of capital ock, the main theories of investment behavior--namely, the capacity ilization theory and the theory that desired capital depends on the vel of profit--diverge. The capacity utilization theory is supported the empirical work of Chenery and Koyck. According to this theory, level of desired capital was assumed to be proportional to output, re high levels of investment expenditure are associated with high ios of output to capital and low levels of investment with low ratios output to capital.[4]

An alternative to capacity utilization is the theory that red capital depends on the level of profits. This theory of stment behavior was first proposed by Tinbergen (1938, 1939) and equently developed by Klein (1950, 1951).

Both capacity utilization and profit theories of the flexible erator model were developed as alternatives to the rigid accel-r theory of Clark (1917). In the Clark model, the adjustment

coefficient (1-λ) is taken to be unity, so that actual capital is equal to desired capital and net investment is proportional to the change in desired capital.

$$K_t - K_{t-1} = K_t^* - K_{t-1}^*$$

where desired capacity is proportional to output. The rigid accelerator theory was rejected empirically by Kuznets (1935), Tinbergen (1938), Chenery (1952), Koyck (1954), and Hickman (1957).

Kuh (1963) cites studies from diverse sources on the formal ethods of accepted capital theory and the accepted theory of invest- ent. The purpose of his work was to summarize the then current state f empirical information about the relative importance of profit and cceleration determinants of investment. The main conclusion to be rawn from his paper is that:

> "... capacity accelerator motivation is more important than profits or internal funds in explaining the cyclical path of investment although profits still have a significant, if secondary, role to play." Kuh (1963), pp. 264.

rgenson and Siebert (1968a) argue that although profit expectations termine investment behavior, the results of Grunfeld (1960) and Kuh 63) suggest that these expectations cannot be adequately repre- ted by current realized profits. Therefore, in their classifica- ns of investment behavior, Jorgenson and Siebert retain the profit el as a possible specification of the desired level of capital. flow of internal funds available for investment was chosen as a ure of profit. The main idea behind this is that the supply of s schedule rises sharply at the point where internal funds are austed." This was dubbed the "liquidity theory" of investment.

The last theory of investment behavior explained by Jorgenson and Siebert (1968a) was the neoclassical theory of optimal capital accumulation. It is based on an optimal time path for capital accumulation. It also implies a theory of the cost of capital. This has been developed by Modigliani (1958, 1959, 1965, 1966), Modigliani and Miller (1963), and Miller and Modigliani (1961). The cost of capital was shown to be independent of the financial structure of the firm and of the dividend policy (in contrast to the cost of capital assumed in the liquidity theory of investment behavior).

Under the neoclassical framework it is required, above all, that capital accumulation be based on the desire to maximize profit. In other word, the firm maximizes profit subject to a production function by relating the flow of output to the flows of labor and capital services. The second important feature of the theory is that the firm's present value maximization is consistent with utility maximization. This approach to the theory of optimal capital accumulation was originated by Fisher (1930) and has been revived and extended by Bailey (1959) and Hirshleifer (1959).

The neoclassical theory of investment behavior has been fully veloped by Jorgenson.[5] To assess the effects of variations in the te of change of the price of investment goods on the level of investt, Jorgenson and Siebert (1968a, 1968b) consider two alternative sions of the neoclassical theory. First, capital gains on assets d by the firm may be regarded as transitory so that return to equity the price of capital should be measured excluding capital gains classical A). Second, capital gains on assets may be regarded as of the return to investment so that return to equity and the

price of capital services should include gains (neoclassical B).

Based on their empirical results, Jorgenson and Siebert (1968a) come to the conclusion that the neoclassical theory of investment behavior is superior to theories based on capacity utilization or profit expectations. In addition, the former are superior to a theory based on internal funds available for investment. But these findings have been criticized and challenged by Eisner (1970), Eisner and Nadiri (1968), Elliot (1973), Clark (1979), and Hall (1977).

Jorgenson's (1971) econometric studies of investment behavior investigate the relevancy of investment behavior determinants, the time structure of the investment process and replacement investment, at the firm and industry levels. He concludes that capacity utilization or output and interest rate provide the only significant determinants of desired capital for several of the models of investment behavior included in his survey.

Mussa (1977) argues that there is no essential conflict between the "supply function theory" and the "adjustment cost theory" of the investment function. The former was developed by Clower (1954), Witte (1963), Foley and Sidrauski (1970, 1971), and Purvis (1973), who view the investment function as the supply function of capital goods producers. In these models, the demand for the stock of capital by asset holders, together with the size of the existing stock, determines the price of a unit of capital. This price, together with the supply function of capital goods producers, determines the rate of capital accumulation. Derived from the supply function theory model, the investment function is the aggregate supply function of capital goods producers. In contrast, the adjustment cost theory, developed by Eisner and

Strotz (1963), Gould (1968), Lucas (1967), Treadway (1969), and Uzawa (1969), views the investment function as the demand function for capital accumulation of the user capital. Explained by Mussa, increasing marginal costs of investment (internal to the firm) limit the rate at which the firm wishes to accumulate capital. These adjustment costs give rise to a demand function for capital accumulation which is distinct from the demand for the stock of capital.

Mussa argues that:

> " ... the investment function is both a supply function and a demand function and that the form and properties of the investment function are influenced by both external and internal adjustment costs" Mussa (1977), p. 163.

In order to complete the list of alternative theories of investment behaviors I discuss first, the "putty-clay hypothesis" and next Tobin's "Q theory" of investment.

A strict putty-clay hypothesis asserts that the supply of output from existing capital is unresponsive to the service price of capital; a stimulus to investment operating through the interest rate, for example, affects only the investment to increase output and does not cause substitution toward less labor-intensive use of the existing capital.[6] This is in direct contrast to a strict putty-putty hypothesis where installed capital is just as flexible as new capital.[7] Hall (1977) has serious reservations about the importance of the putty-clay hypothesis. He argues that:

> " ... this paper demonstrates a serious problem in the major existing attempts to measure the influence of the putty-clay phenomenon in the investment equation" Hall (1977), p. 63.

Modigliani attacks Hall's fitting of Bischoff-type equation using total investment, while ignoring several other existing putty-clay

quations based on new orders and hence subject to a simultaneity ias.[8]

The previous theories of investment behavior had one thing in ommon: even though there were various specifications of other vari- bles in all of them, investment was primarily a function of changes n output. Tobin's "Q theory" or securities-value (Q) model attempts o explain investment on a financial basis in terms of portfolio alance. If the market value of firm exceeds the replacement cost of ts assets, it can increase its market value by investing in more fixed apital. Conversely, if the market value of a firm is less than the eplacement cost of its assets, it can increase the value of share- lders' equity by reducing its stock of fixed assets.[9] Clark (1979) nsiders the Q theory as a "supplement" rather than a direct competi- r to output based models. The security value model does not show a od performance compared to output-based models in Clark's paper. deed Clark argues:

> " ... output is clearly the primary determinants of non-residential fixed investment" Clark (1979), p. 103.

Investment and Theories of Income Determination

It is at this point that I have to consider the impact of real nomic and monetary factors on investment and, hence output fluctu- ons. Specific references to theories of trade cycles or income ctuations are meant to clarify the role of the investment function respect to them. As shall be demonstrated shortly, investment is idered the most significant factor in explaining employment fluctu- ns. This led to an explosion of research on theories of investment

behavior is a non-linear form. Hicks', Goodwin's, and Kaldor's non-linear sigmoid-shape investment function revolutionarized this particular field of economics.

In this section and the next, it will be evident that my investment function is a modified version of the Kaldorian investment function.

IIa. Real Theories of Investment Behavior

Besides Haberler (1941), Hansen (1951) is one of the most authoritative work on cycle theory. As explained by Hansen, Tugan-Baranowsky (1901), at the turn of the century, recognized (correctly) the fact that fluctuations in the rate of investment are an essential characteristic of the cycle. This made a drastic departure from previous theories of turning points. It is the inherent characteristics of the modern economy which make economic fluctuations inevitable. The great influence of Tugan-Baranowsky on the literature of cycles after the turn of the century can be clearly recognized in the work of Spiethoff (1902) and Cassel. The early roots of the acceleration principle can be found in Cassel (1932), where he makes a distinction between those durable means of production which work for the consumer and those employed in the production of further means of production. The rate of interest occupies a central role in explaining cycles by influencing investment expenditures. But to Cassel, the cycle is a recurrent phenomenon caused by growth and progress.

Wicksell (1934) ascribes fluctuations in output to real causes, technological and growth factors. In explaining investment determination, Wicksell (1936) comes very close to what was later developed by

Keynes, i.e., the marginal efficiency of capital.

Fisher (1907, 1930) seems to agree with Wicksell that technological progress, discoveries, and inventions have something to do with fluctuations in output and the increase of the rate of return over cost--Wicksell's natural rate, Keynes's marginal efficiency of capital. However, in his subsequent work he ignores the importance of output fluctuations.[10]

In _A Treatise on Money_ (1930) and _General Theory of Employment, Interest and Money_ (1934), Keynes argues that cycles were believed to be essentially caused by a fluctuation in the rate of investment. He sought the causes of output changes, as well as cyclical changes in the marginal efficiency of capital, in changes in the state of liquidity preferences (through expectations). He attributes recessions not to a rise in the rate of interest, but to a sudden collapse in the marginal efficiency of capital.[11]

Aftalion attributes fluctuations in the rate of investment to the dynamics of consumer wants.[12] It is the capitalistic, time consuming process of production that transforms the small oscillations of consumer demand into large swings of output fluctuations (the acceleration principle). He perceives a violent fluctuation of aggregate demand around a relatively stable growth in consumer demand.

Pigou (1927) insists that variations in profit expectations contribute to the cycle. Autonomous monetary changes, real factors, psychological factors cause the variations. In his theory of cycles, expectations, though influenced by the pattern of the modern technique of production, still predominate. Monetary factors play a large conditioning factor.

The essential elements of the modern theories of business cycles have been developed through an evolutionary process. Tugan-Baranowsky, Spiethoff, Cassel all stressed the role of fluctuations in the rate of investment as an important factor in explaining cycles. Wicksell and Keynes contributed greatly to the analysis of the determinants of investment. Spiethoff and Harrod enhanced the process by discussing the rate of dynamic factors, such as technology, resources, and population growth as determinants of investment. Aftalion, Pigou, and Clark developed and stressed the role of technique or production (time lags involved) and the principle of acceleration; Keynes and Kahn developed the concepts of the investment multiplier and investment function. Therefore, modern theory of cycles evolved around three main building blocks (forces). These self-limiting forces are: the falling marginal efficiency of capital, the acceleration principle, and the slope of the consumption function. The theory reveals that, so long as the economy remains dynamic, and so long as the requirements of growth and progress require investment expenditure, these strong forces make the occurrence of investment and output fluctuations inevitable.

As mentioned, Aftalion's theory of business cycle was the forerunner of the accelerator principle. It was fully developed by Clark (1917). These theories of the determinants of the optimal stock of capital were criticised by Goodwin and Chenery because of the absence of an adjustment process. The deficiencies in the dynamic adjustment process of the original acceleration principle formulation have since been largely cleared up. This was done partly due to the distributed lag accelerator of Hicks (1950), but especially through the work of Goodwin (1951a) and Chenery (1954). They developed an

adjustment process designed to eliminate the disequilibrium between the desired and actual capital stock according to a distributed lag pattern rather than instantaneously as spelled out in the original acceleration theory.

At this stage, I examine the characteristics of the investment function. I rely upon this investment function to explain sudden changes (i.e., catastrophes) in economic variables (in closed and open economies).

Kaldor (1940, 1954) presented a non-linear theory of investment and output fluctuations. Goodwin (1948, 1951b, 1955) developed a non-linear investment function broadly resembling Kaldor's investment function. Kalecki's (1939, Chapter 6), Tinbergen and Polak (1950), Ichimura (1954, 1955), Black (1956), Rose (1967), Bober (1968), Evans (1969), Klein and Preston (1969), Chang and Smyth (1971), and Varian (1979) have elaborated on the non-linear sigmoid-shape investment function and output fluctuations of Kaldor's model. The Hicks and Goodwin models have striking similarities.[13]

First, I introduce Kaldor's model. In this model, it is assumed that gross investment (I_t) depends positively on the level of output (Y_t) and negatively on the amount of existing capital stock (K_t):

$$I_t = f(Y_t) - mK_t, \qquad m > 0 \qquad (2\text{-}1)$$

$$(\partial I/\partial Y) > 0, \qquad (\partial I/\partial K) < 0$$

where $f(Y_t)$ is a non-linear function of Y_t. The investment function will shift down as capital stock increases, other things being constant, and is shown in Figure 2.1.

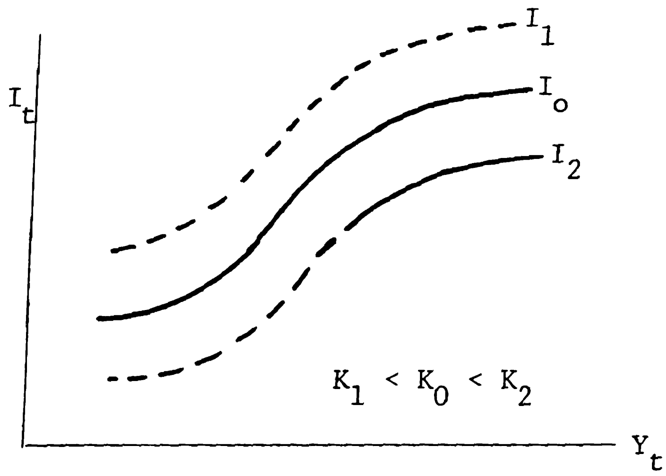

Figure 2.1 (Ichimura's Figure 11.1)

In Evan's terminology, the investment function is likely to be income inelastic at low levels of income because of the existence of excess capacity. Due to high costs of construction and the increased difficulty of borrowing, it is likely that the investment function is also inelastic at very high levels of income.[14]

Kaldor has defended this type of function:

> " ... it is probable that dI/dx (the marginal propensity to invest), will be small, both for low and for high level of X (the level of economic activity), relatively to its "normal" level" Kaldor, 1940, p. 81.

The main differences between Hicks' and Goodwin's models is found in the functional forms of their investment behavior. Considering the acceleration principle: $I=F(\dot{Y})+\beta$, where $F(\dot{Y})$ is the induced investment and β is its autonomous component. Goodwin's (Hicks') investment function can be explained through Figure 2-2, in blue (red), where $y(t)=Y(t)-\bar{Y}$, and $\bar{Y}$ is the equilibrium level of income (Y). denotes the rate of change of the deviation of income (Y) from the equilibrium level ($\bar{Y}$), $\dot{y}=dy/dt$ and t denotes time.

Ichimura (1954, p. 216-218) compares and contrasts these theories of output fluctuation which are put forward by Hicks, Goodwin, and Kaldor. According to Ichimura, the Hicks-Goodwin theory is an accelerator model of investment in a context of "overinvestment

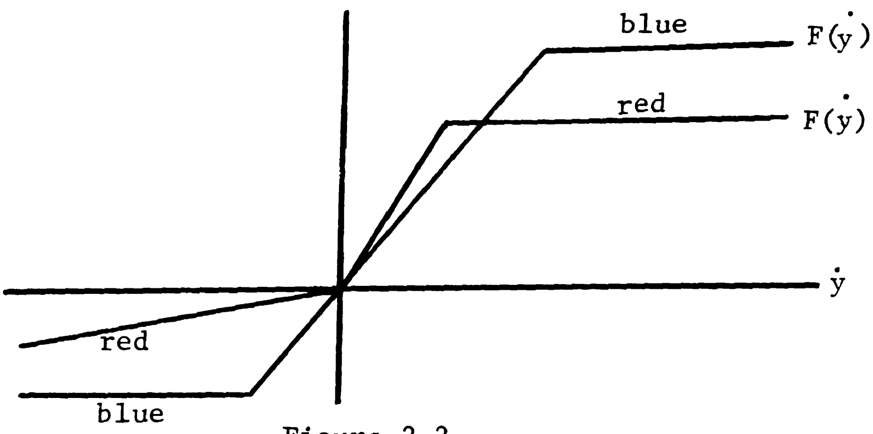

Figure 2.2

theories" framework; while the Kaldorian non-linear investment function is flavored with the color of underconsumption theories, in Ichimura's analysis.

IIb. Monetary Factor in Short Run and Long Run Models of Investment Behavior

In the previous section, I examined the investment function in a real sense. The Goodwin-Kaldorian investment function provided a edium-run explanation of employment fluctuations. Therefore, the imact of monetary factors on the investment function was ignored. In his section my objective is to depict the role of interest rate in he functional behavior of investment.

Short-term fluctuations in employment and output can be exained by distinguishing between investment in inventories (working pital) and investment in fixed plant and equipment. Abramovitz (1950) cognized the importance of inventory investment in business cycle havior. Metzler (1941, 1946, 1947) developed an analysis of ventory behavior within the framework of the multiplier and

accelerator principles. Metzler's theory has been developed and elaborated by Klein (1950), Nurske (1952, 1954), Darling (1959), Fromm (1961), and Lovell (1961). Bryant (1978) supports the hypothesized effect of inventory stock upon output. Blinder (1980:4) develops a macro model in the line with Metzler's model of inventory fluctuations. Blinder (1981) reaffirms the importance of inventory fluctuation in business cycles. But Gordon (1952) criticized the Metzler theory of short term cycles. He argues that:

> " ... the trouble with such a theory is its artificially precise character and its attempt to explain the minor cycle in purely mechanical terms. So far as minor cycle is concerned, Keynes was certainly much closer to the truth, if less precise, in his emphasis on "minor miscalculations" and changes in short run expectations" Gordon (1952), p. 315-316.

In spite of the above argument, it would be a serious theoretical error to ignore the crucial role of the interest rate in explaining investment behavior.[15] The monetary theories of investment and employment changes emphasize the impact of inventories rather than investment of a fixed nature (machinery and equipment). The latter has been largely stressed in real theories of employment fluctuations. Authors of the monetary school correctly recognize the short run phenomenon of the interest rate and its impact on inventory and other non-fixed investment.[16] To be more specific, at lower levels of interest rate, sellers augment their orders for manufactured goods. This leads to higher demand for money and, therefore, higher prices for goods. Sellers continue to increase their orders, which generates more employment, output, money income, higher demand for money, and higher prices for goods. This process continues in a cumulative manner until the capacity of banking system to supply loan decreases. This

creates an upward pressure on the interest rate in the face of ever-increasing demand for loans by sellers and merchants and a declining capacity of the banking system to provide these loans. At this point pure monetary theories explain the downswing of the economy. Money income, demand for money and goods, prices for goods, all decline. The process continues this pattern in a cumulative manner until the liquidity positions of bank improve with their capacity and desire to lend to the merchants. Besides an ever-increasing optimism among merchants and in the industry will have convinced them that the worse has passed. This (i.e., the new lower level of interest rate) would set in motion forces that will turn around the economy toward higher employment. In this theory, the interest rate is considered as the true cause of fluctuations. Once the interest rate activates, it is the economic system itself (the demand for money and the velocity circulation of money) that generates the cumulative process of upward or downward motion.

. The Modified Investment Function and its Mathematical Derivation

I have set the stage for my main theme. In section IIa, I explained the influence of real factors on investment and employment behavior; in section IIb, I presented the monetary side of the story. of these alternative theories explains turning points in investment and output. Individually, they are significant contributions to advancement of the theory. But they fail to provide a complete analysis of the phenomenon.

It is my aim to produce an integrated synthesis of real and monetary theories by applying monetary market disturbances in terms

of interest rate to the real theories of investment and output fluctuations. I choose this model because, first, this model is based on a tractable function which makes mathematical work on it possible; second, Koyck's empirical investigations (the only empirical work) on the time-shape of the reaction of capacity to changes in output led him to believe that:

> " ... the results for the industries investigated are not favorable for the acceleration principle but are much more in accordance with the theory of Kaldor" Koyck, 1954, p. 109.

Thus, I modify the sigmoid-shape investment function in order to accommodate with these matters:[17]

$$I_t = f(Y_t) - mK_t - nr_t \qquad m,n > 0 \qquad (2.2)$$

he first two terms of the right hand side of the above equation explain ovements in fixed part of gross (or net) investment (I), while the ird element (nr_t) explains mainly inventory fluctuations in I.[18] erefore, whereas the Kaldor's sigmoid-shape investment was able to ift upward or downward over time (in the long run, due to the process capital decumulation or accumulation respectively), my investment ction can also shift upward or downward in the short run, Figure 2.3. se short run shifts are the result of monetary disturbances.

The mathematical exposi- of the investment function ased on Allen (1967). He ies the following mathemat- structure (Equation 2.3) to -linear accelerator model.[19]

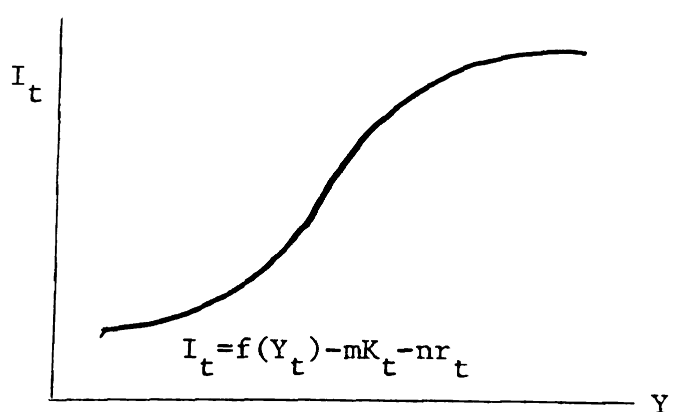

Figure 2.3

$$f(Y) = b((a+b)/(ae^{-vY}+b)) - 1 \quad (2-3)$$

where a denotes the net capacity of the capital goods industries (in Allen's terminology), b denotes the scraping rate of capital equipment, and v denotes the capital output ratio.

Both equation (2-3) and 'igure 2.4 define the investment unction for both positive and egative values of Y.[20] Mathe- atically, $f(Y)+b$ is the same s $f(Y)|b|$ units up if $b > 0$; uation (2-4) and Figure 2.5. other words, I redefine the igin with respect to which e function f(Y) is defined:

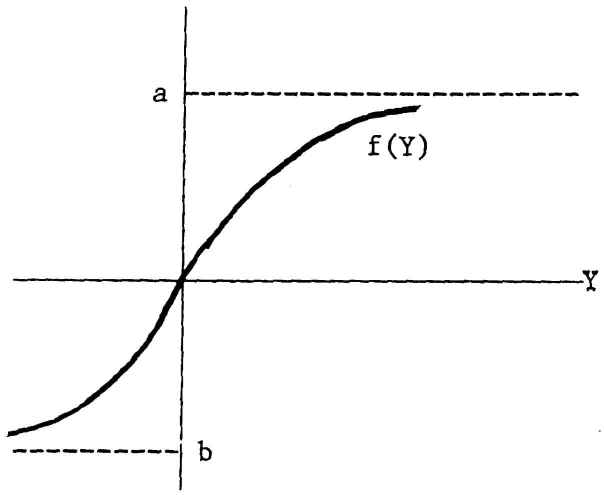

Figure 2.4 (Allen, 1967, p. 379)

$$f(Y)+b=b((a+b)/(ae^{-vY}+b)-b)+b=b(a+b)/(ae^{-vY}+b) \quad (2-4)$$

Again, mathematically ℓ)+b is the same as +b units $|\ell|$ to the right > 0, equation (2-5) and re 2.6.

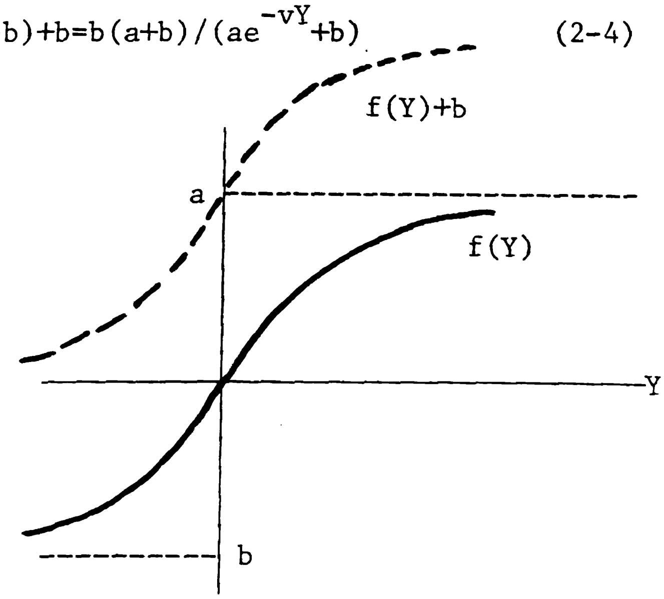

Figure 2.5

$$f(Y-\ell)+b=b\,\frac{a+b}{ae^{-v(Y-\ell)}+b}=\frac{b(a+b)}{(a/b)e^{-vY+v\ell}+b}=\frac{a+b}{\frac{a}{b}e^{-vY}e^{v\ell}+1} \qquad (2\text{-}5)$$

I define:

$q=a+b$

$d=\frac{a}{b}e^{v\ell}$

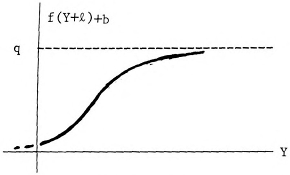

Figure 2.6

Therefore, investment as a function of income could be written as:

$f(Y)=q/(1+de^{-vY}) \qquad q,d > 0$

Thus, investment as a function of income, the stock of capital, and interest rate is rewritten in the form:

$$I=q/(1+de^{-vY})-mk-nr \qquad (2\text{-}6)$$

$q,d,v,m,n > 0$

Based on the shape of investment function, derived in this chapter, goods market equilibrium conditions will be examined in the next chapter.

CHAPTER 2--Footnotes

[1]See, for example, Blinder and Solow (1973, 1974), Tobin and 3uiter (1970), and Tobin (1979).

[2]See Gordon and Klein (1965) Readings in Business Cycles, p. 3.

[3]See Jorgenson (1963), p. 254, Jorgenson and Stephenson (1967), . 192-212, and for individual firms see Meyer and Kuh (1957), p. 91-94.

[4]Jorgenson and Siebert (1968a), p. 683.

[5]For full detail on the neo-classical theory of investment ehavior, see Jorgenson (1963, 1967), Jorgenson and Siebert (1968a, 968b), Jorgenson (1971), and Clark (1979).

[6]For more detail, see Johansen (1959), and Bliss (1968).

[7]Examples of theories based on putty-putty technology are to e found in Jorgenson and Siebert (1968a, 1968b) which are already dis-ussed.

[8]Modigliani cities Ando, Modigliani, Rasche and Turnovsky 1974).

[9]For more detail, see Tobin (1969), Brinard and Tobin (1976), ucas and Prescot (1971), and Ciccolo (1978).

[10]See Fisher (1925).

[11]See General Theory of Employment, Interest and Money, Ch. 22, notes on Trade Cycle," p. 313-332.

[12]Cited in Hansen (1951), p. 348.

[13]Ichimura (1954), p. 200.

[14]Evans, M. (1969).

[15]Hajela, P. D. (1952), Chapters VIII, IX, and X provide a mple version of the impact of interest rate on investment function.

[16]Mass summarized views of the researchers who empirically esti-ted the important role of interest rate:

"Abramovitz recognized that inventory changes accounted for 23 percent of the total change in output during business-cycle expansions and for 47 percent of the change in output during contractions before World War II. ...T. M. Stanback, Jr., found that changes in manufacturers' inventories accounted for 79, 56, and 25 percent, respectively, of the change in gross national product during recessions of 1948/49, 1953/54, and 1957/58. Finally, L. R. Klein and J. Popkin argue that

the business cycle could be virtually eliminated if inventory fluctuations were reduced by 75 percent, ..."
Mass, N. J. (1975), p. 19-20.

[17]Forsake of simplicity, I pursue my investigation of the vestment function, in terms of explanatory variables f(Y), K, and in a linear fashion.

[18]Besides monetary theory (in support of the important role the interest rate in explaining investment behavior), prominent onomists of the past such as Cassel and Fisher believed that interest te plays a major role in explaining the behavior of investment funcon.

"Fisher comes to very much the same conclusion as Wicksell: that the initiating impulses for expansion or contraction have in the past come in large measure from technical progress, discoveries, and inventions, which raise the "rate of return over cost"--Wicksell's natural rate or Keynes' marginal efficiency of capital" Hansen (1951), p. 333.

[19]R. G. Allen (1967) Macroeconomic Theory, p. 379-380.

[20]Recall that Allen (1967) defines investment outlays in terms of the rate of change in income (Y) in an accelerator model, rather than in terms of the level of output or income (Y). Therefore, even though, his diagram holds true for an accelerator model, I need to introduce some modifications. These specifications do not change the mathematical structure of the investment function, but make the investment function both up and to the right so that real level of income could assume positive values only (in the north-east quadrant). This task will be done without disturbing the mathematical structure of the function.

CHAPTER 3

Partial Equilibrium Analysis of Income Determination

uction

This chapter derives the IS and LM curves. I present them ıtely, in section one and two, respectively. A simultaneous sis of real and monetary equilibria will be postponed until er five; and examination of foreign repercusions on domestic ıcial macro-economic policies will be dealt with in the second of this dissertation.

Generally speaking, the IS curve gives the equilibrium pairs ıe interest rate (r) and income (Y) in the product market, where demand for and supply of goods are equal; Figure 3-1:

$$Y = C(Y_d) + I(Y,r,K) + G \qquad (3.1a)$$

$$Y - C = I + G \qquad \text{and} \qquad S = Y_d - C \qquad (3.1b)$$

Y = real income (real gross national product, GNP)

Y_d = real disposable income = Y - T + R

R = transfer payments

r = interest rate on home bonds

K = nominal values of equities issued by firms to finance their investment

C = a consumption function, real consumer expenditure

I = real investment demand (equation (2.6))

G = real government purchases of goods and services

T = real tax revenue as a function of real GNP = tY

$C(Y_d)$ in equation (3.1a) explains consumption as a function of ›osable income.

The investment function I, as explained in the previous chapter, a function of income (Y), interest rate (r), and stock of real capital ds (K). Each element in the above equation is in a planned or ex ante el. Thus, I is the level of planned, fixed and inventory investment, :re $\partial I/\partial Y > 0$, $\partial I/\partial r < 0$, and $\partial I/\partial K < 0$. Government expenditure is con- lered as an exogenous variable. Consumption is related positively to sposable income.

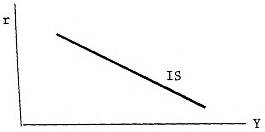

Figure 3.1

The LM curve gives the equilibrium pairs of Y and r in the nancial market--where the supply of money is equal to the demand for ney, Figure 3.2. The demand function for real balances is given by:

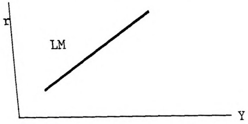

Figure 3.2

$$(M/P)^d = m(Y,r,w) \qquad (3.2)$$

n $\partial m/\partial Y > 0$, $\partial m/\partial r < 0$, $\partial m/\partial w > 0$. Where w denotes real wealth. s the stock of real balances. P is home price level.[1]

Assuming an exogenously fixed supply of money, equilibrium in financial market is realized by:

$$M/P = m(Y,r,w) \tag{3.3}$$

A simultaneous solution of equations (3.2) and 3.3) gives ilibrium in both goods and financial markets and thus in the economy.

The above apparatus is a popular model of income determination. rder to move from a static analysis of economic activity to a dynamic tigation of output fluctuations, we introduce a specific non-linear of investment function, was explained and analyzed in the previous er. This investment function (sometimes called the "sigmoid-shape" tment function) is closely associated with N. Kaldor; other varis of it have been used by Goodwin and Hicks, as discussed in er two.

heories of Income Determination

In this section, I depict the role of the sigmoid-shape investunction in explaining income fluctuations in a simplified economy. ain the relationship between the real theories of income fluctu- and non-linear investment functions.

A starting point is Kaldor's model of the trade cycle (Kaldor His model is a very simplified commodity market which is not ary consistent with a Keynesian or IS model. According to Kaldor, e of change of output is proportional to the difference between ent and saving:

$$Y_{t+1} - Y_t = \gamma(I_t - S_t) \qquad \gamma > 0 \tag{3.4}$$

re γ is constant and is called the "response coefficient" of supply "effective demand." The long run equilibrium is defined where = S_t, and $I_t = (I_r)_t$ where K_t and Y_t do not change and $(I_r)_t$ is the lacement function. Kaldor defines the replacement investment func- n (I_r) as a linear function of Y, as shown in Figure 3.3.

$$I_r = u \cdot Y_t + z, \tag{3.5}$$

e z is a constant depreciation per unit period.

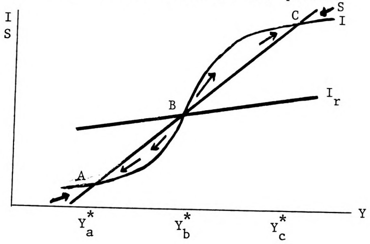

Figure 3.3

At point A and C in Figure 3.3, marginal propensity to invest is less than marginal propensity to save (mpS), the opposite is at B. Therefore A and C are stable equilibria, while B is an un- equilibrium point of this simplified model of income determina- This is true because at A, the saving function cuts investment on from below--mpS > mpI. At point B the investment function he saving function from below--mpI > mpS. If the economy is lly at A (or C), any disturbance which moves the economy beyond

r Y_c^*) is self-correcting. This is true because levels of saving
reater than investment. Aggregate demand is less than aggregate
y. Therefore, output levels shrink. The mechanism works in
se, for disturbances which shift the economy below Y_a^* (or Y_c^*).
point B, if the initial equilibrium condition is disturbed,
is no self-correcting mechanism to restore the initial equili-
Y_b^*. This is true because, beyond Y_b^* the saving level (and
ore, aggregate supply) is less than investment (aggregate demand).
he economy continues the course of expansion beyond Y_b^*. Below Y_b^*,
onomy continues the course of contraction until it reaches Y_a^*,
3.3.

Point B gives a long run equilibrium value of Y_t, Y_b^*. The model
able at this point. Thus, the economy is unlikely to remain
or a prolonged period of time. But at C (or A) gross investment
(is less than) replacement investment. Therefore, over time,
estment curve shifts down and capital accumulates (up and capital
ates). Thus, output declines (increases) toward its long run
Y_b^*. But the long run equilibrium level of output, Y_b^*, is not
and therefore, output tends to move away from it. This produces
cal pattern in output levels.[2]

At this stage I would like to present my own version of income
ation in a Keynesian framework.

In a good market, disposable income is specified as:

$$C + S = Y_d = Y - T + R \quad (3.6)$$

ium is given as:

$$Y = C + I + G \quad (3.7)$$

s is:

$$S = sY_d - f \qquad f > 0 \qquad (3.8)$$

nsumption is:

$$C = Y_d - S = Y_d - sY_d + f = f + cY_d \qquad (3.9)$$

s = marginal propensity to save

c = marginal propensity to consume

f = autonomous consumption.

vestment function, I, is the modified version of sigmoid-shape ment developed in Chapter two. Replacing Y_d in equation (3.9) quation (3.6) we get a conventional consumption function:

$$C = f + c \cdot (Y + R - T) \qquad (3.10)$$

uting C from equation (3.10) and I as the non-conventional func- erived in the previous chapter) into equation (3.7) I get the IS n implicit form.

$$Y = f + c \cdot (Y - T + R) + G + I\left(\frac{q}{1+de^{-vY}}, K, r\right) \qquad (3.11)$$

Following the non-linearity of the investment function, the IS s also non-linear. I can examine and analyze its characteristics graphically or mathematically.

Graphically, equilibrium in the goods market is achieved when G. This is so because:

$Y = Y_d + T\text{-}R = C + I + G$, and $Y_d = C + S$. Therefore,

+ T - R = C + I + G, or S + T - R = I + G, Figure 3.4.

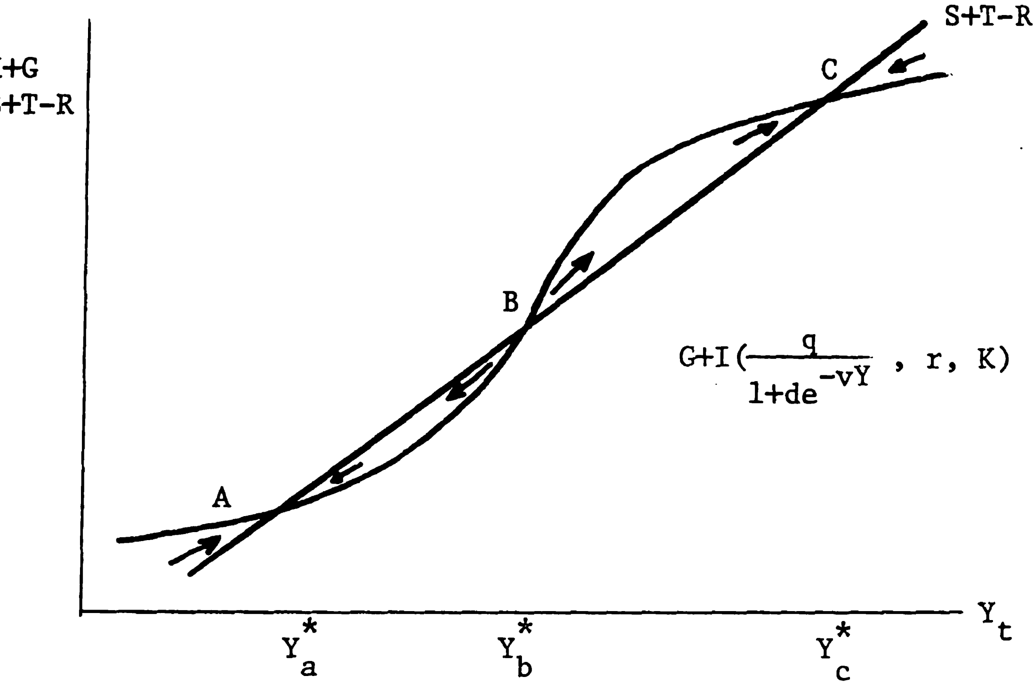

Figure 3.4

A, B, and C, where leakages are equal to injections (aggregate equals aggregate supply) are equilibria. Points A and C are goods market equilibria while point B is an unstable equilibrium.

In order to derive the IS curve, I should trace out equilibrium of Y against different rate of interest. If the real interest uctuates (goes up or down), the investment function and thus the ve will shift (down or up respectively). To derive the IS curve ally, suppose that the economy is represented, initially, by d $G_o+I(Y_t, K_o, r_o)$ in Figure 3.5. Equilibria a_o, b_o, and c_o epresented in Figure 3.6 for the same rate of interest, r_o. he interest rate rises to r_1, the G+I curve would shift down equilibria, a_1, b_1, and c_1, in Figure 3.5. They are redrawn $_1$, and c_1 in Figure 3.6 for interest rate r_1. Suppose r_2 is rest rate at which G+I curve is tangent to the S+T-R curve

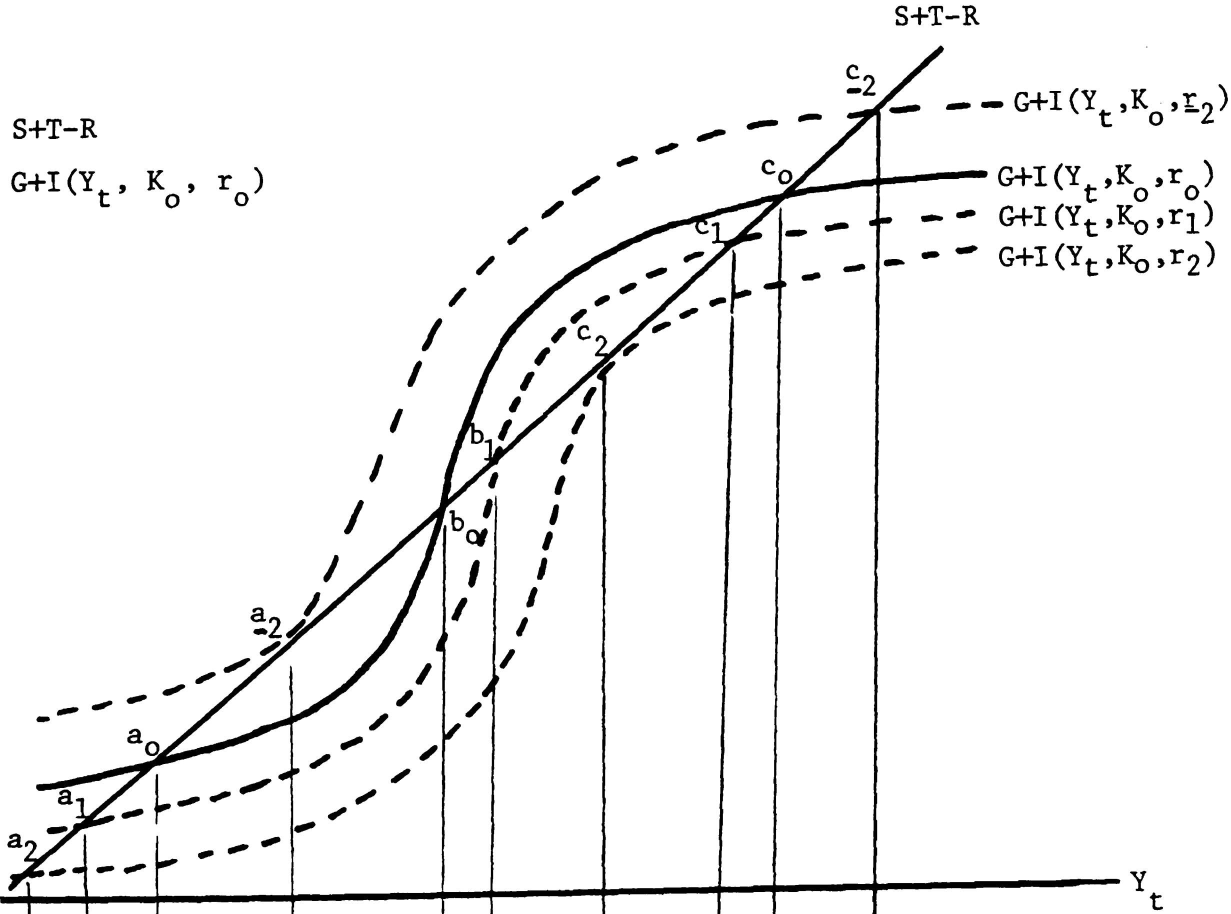

Figure 3-5

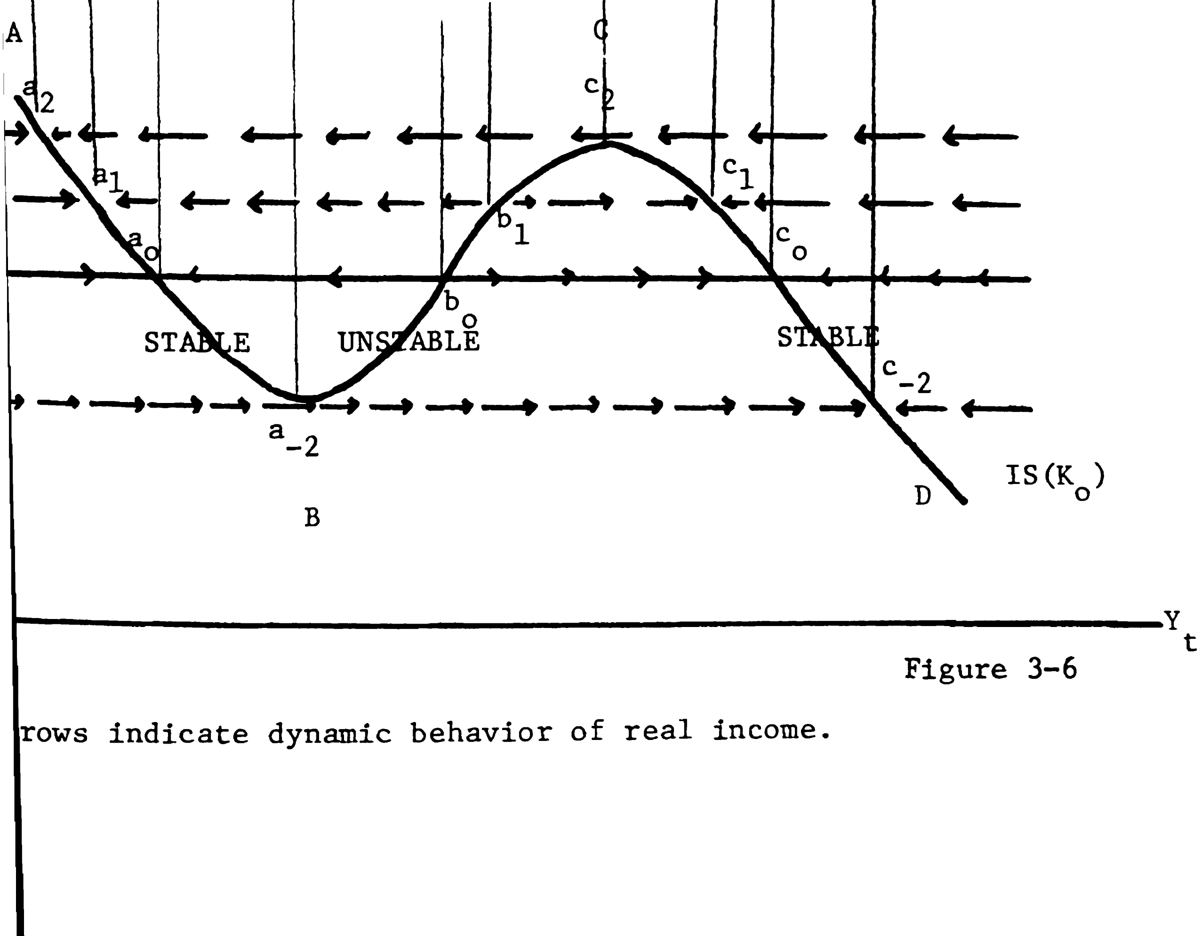

Figure 3-6

rows indicate dynamic behavior of real income.

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nt c_2). Then a_2 and c_2 are the only equilibria at this rate,
3.5 and 3.6. Any increase in interest rate beyond r_2 induces a
downward shift in G+I curve with only one equilibrium level of
(which declines as r rises).

A reduction of interest rate causes an upward shift in G+I curve.
ple, r_{-2} is an interest rate, lower than r_o, which makes G+I
to S+T-R curve at point a_{-2}.

By connecting such points in Figure 3.6 I develop a non-linear
S(K_o). This curve gives the equilibrium pairs of Y and r in
uct market, where the demand for and supply of goods are equal,
ven level of capital stock, K_o.

An interesting characteristic of the IS(K_o) curve, is that it
ivided into three sections, two (conventional) downward sloping
and one (unconventional) upward sloping part. The downward
arms are loci of stable equilibria (such as AB and CD, in
.5). But the upward sloping arm is the locus of unstable
ia (such as BC, in Figure 3.5).

Generally speaking, in a conventional downward sloping IS curve,
t is a function of interest rate alone, I=I(r). This would
he kind of IS curve which appears in most of the literature.
in the rate of interest would cause investment and therefore
urve to shift up. The increase in the level of investment
uce an increase in equilibrium income through the multiplier.
ng (S) and taxes (T) increase. There is again an equilibrium
t market at a lower interest rate and higher income level.
curve depicting equilibrium pairs of Y and r must be negatively
s in Figure 3.1 or downward sloping arms of IS(K_o) in Figure 3.6.

But as seen above, if investment is a function of both the est rate and the output level, then the whole picture changes. lope of the IS curve is greatly changed by making investment d on both Y and r. A decline in the interest rate would lead to crease in investment, and that in turn leads to higher levels of e which leads to higher investment (i.e. I=I(r,Y)). The upward ng section of IS(K_o) is quite plausible if investment, I(r,Y), fficiently responsive to increases in income. A rapid expansion come could lead to a surge in S+T level much higher than the al increase in I+G. To restore equilibrium in the goods market etween G+I and S+T, an increase in r, to cushion the surge of e is needed. Arrows in Figure 3.6 indicate the dynamic behavior al income.

The mathematical investigation of the IS curve, equation (3.11), rms the nature of IS curve derived graphically, in Figure 3.5 and

Rewrite the IS curve, equation (3.11), in a linear form in terms nd K, if T=ty.

$$Y = f + c\ (Y - tY + R) + G + \frac{q}{1+de^{-vY}} - mK - nr \qquad (3.12)$$

$$(1-c(1-t))Y = q/(1 + de^{-vY}) - mK - nr + G + f + cR \qquad (3.13)$$

ome rearrangement, we derive an equation for the IS curve:

$$r = (1/n)\ \{q/(1+de^{-vY}) - (1-c(1-t))Y-mK + G + f + cR\} \qquad (3.14)$$

In order to verify the nature of the extrema of the above equa- ve take a partial differentiation of (3.14) with respect to Y:

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$\partial r/\partial Y = (1/n)\ \{(qdve^{-vY})/(1+de^{-vY})^2 - (1-c(1-t))\}$

set $1-c(1-t) \equiv \ell$, then

$\partial r/\partial Y = (1/n)\ \{(qdve^{-vY})/[(e^{vY}+d)/(e^{vY})]^2 - \ell\}$

$$= (1/n)\ \{(qdve^{vY})/(d+e^{vY})^2 - \ell\} \qquad (3.15)$$

$$\frac{\partial r}{\partial Y} = 0$$

$- \ \{- qdve^{vY} + \ell(d+e^{vY})^2\} = 0$

$- \ \{\ell\ (d+e^{vY})^2 - qdve^{vY}\} = 0$

$- \ \{\ell\ d^2+2\ell de^{vY}+\ell\cdot e^{2vY}-qdve^{vY}\} = 0$

$- \ \{\ell\ e^{2vY}+(2\ell d-qdv)e^{vY}+\ell d^2\} = 0$

licity we define $e^{vY}=X$ (3.16)

e,

$- \ \{\ell\ X^2+(2\ell d-qdv)X+\ell d^2\} = 0$ (3.17)

he roots:

$X_1, X_2 = \{qdv-2\ell d\pm[(2d-qdv)^2-4\ell^2d^2]^{\frac{1}{2}}\}\ /(2\ell)$

$$= \{qdv-2\ell d\pm[qv(qv-4\ell)]^{\frac{1}{2}}\}\ /(2\ell) \qquad (3.18)$$

, the necessary condition for the existence of extrema is that:

$v > 4\ell$ (3.19)

of the partial derivative equation $(\partial r/\partial Y)$ is the same as

of the equation $-(X-X_1)(X-X_2)$. Where X_1 and X_2 are roots of eq

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n (3.17) and suppose $X_1 < X_2$. To determine if X_1, X_2 are ve) maximum or minimum of the above equation I construct table

TABLE 3.1

	0		X_1		X_2	∞
		----	0	+++	+++	++++
		----	----	-----	0	++++
$-X_2)$		++++	0	------	0	++++
$-X_2)=(\partial r/\partial Y)$		----	0	++++++	0	----

row shows that $(X-X_1)$ is zero at $X=X_1$, positive (negative) at X greater than (less than) X_1. The second row shows values of l to, greater than or less than zero as X is equal to, greater less than X_2. The third row shows different values of $(X-X_1)\cdot$ different levels of X_1 and X_2. These values are derived by ation of the first and second rows. As is indicated in the w, the partial derivative $\partial r/\partial Y$ values at different level of n opposite to $(X-X_1)(X-X_2)$.

ntitutively, the fourth row indicates that the partial deriva-he IS curve is zero at X_1 and X_2 (extrema points), negative) at values of X less than X_1 and greater than X_2 (between). In other words the IS curve is sloping downward (upward) at X less than X_1 and greater than X_2 (between X_1 and X_2). $X_1(X_2)$ is a relative minimum (maximum) point of the IS curve.

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he discussion can be extended from values of X to income, Y. to equation (3.16), $e^{vY_1}=X_1$ and $e^{vY_2}=X_2$. There is a one-to-ionship between X and Y. Therefore, the IS curve (3.14) has minimum at Y_1 and relative maximum at Y_2, while $Y_1 < Y_2$. herefore, the IS curve, r(Y), behaves something like the graph Figure 3.7.

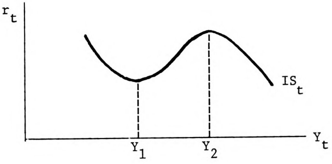

Figure 3.7

above mathematical investigation confirms the graphical of the IS curve.

ad

CHAPTER 3--Footnotes

[1] Real wealth is defined as:

$$w = \frac{M}{P} + \frac{B^P}{P} + \frac{EF^P}{P}$$

where

w = real wealth

$\frac{M}{P}$ = real money balances held by home private citizens

$\frac{B^P}{P}$ = real home bonds held by home private citizens

$\frac{EF^P}{P}$ = real foreign bonds held by home private citizens and denominated in home currency

E = Exchange rate, home currency price of foreign currency

P = Home price level.

[2] Readers interested in following the Kaldorian model on an level are advised to consult Ichimura (1954).

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CHAPTER 4

Catastrophe Theory

My objective, in this thesis, is to build economic models are capable of explaining large swings and oscillatory fluc-ns of economic variables. Catastrophe theory (CT) provides a complex mathematical framework in achieving this objective. r, I stress the economic rationale, rather than mathematical urations per se, to explain the equilibrium path of real , exchange rate, and interest rate.[1] Therefore, this chapter ended to provide only the essentials of catastrophe theory. terials explained in this chapter will not be dealt with tly in the rest of the dissertation. However, I believe that k of mastery in CT may damage this dissertation's effort in ing equilibrium behavior of economic variables.

Varian (1979) describes catastrophe theoretic models as para-ed dynamical system, described explicitly by a system of dif-al equations:

$$\dot{x} = f(x,a)$$

is an n-vestor of state variables (endogenous variables in models), $\dot{x}$ is the n-vector of their time derivatives, and a vector of parameters. In these models, parameters may change e, but at a much slower rate than the state (endogenous) variab

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The exposition of the theory is pursued through a macro-ic model, similar to the one developed in Chapter three.

Suppose there are n commodities, real and financial, ed 1, ..., n. The equilibrium conditions, E, make excess for each commodity zero:[2]

$$\text{(E)}: \begin{aligned} e_1(a_1, \ldots, a_m, x_1, \ldots, x_n) &= 0 \\ e_2(a_1, \ldots, a_m, x_1, \ldots, x_n) &= 0 \\ &\vdots \\ e_n(a_1, \ldots, a_m, x_1, \ldots, x_n) &= 0 \end{aligned}$$

$(x_1, \ldots, x_n)$ is a n-vector of endogenous variables (interest d income in Chapter three) "a" is an m-vector of exogenous es (i.e., financial policies).

S denotes the set of solution $a_1, \ldots, a_m; x_1, \ldots, x_n$ of (E) called the equilibrium surface (manifold) or stationary sur- point (a_o,x_o) in the surface S is singular if:

$$\det(\partial e_i/\partial x_j) = 0$$

$_o$), given e_is are continuously differentiable. a_o is defined astrophe if there are x_o such that (a_o,x_o) is a singular

Sussman (1975), Lu (1976), Golubitsky (1978), Poston and (1978), and Sussman and Zahler (1978) all use the following to depict the simplest type of catastrophe: <u>the fold catas-</u> Suppose the equilibrium equation is:

Then,

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$$e(a,x) = a-x^2 = 0$$

Then, the equilibrium surface is the parabola $a=x^2$ in the a,x plane, Figure 4.1. As shown in Figure 4.1, there exists no solution to the left of a=0, but two solutions, given a value of a, to the right of a=0. Therefore, qualitative characteristics of solution change for values of a greater and less than zero. Then, a=0 is a catastrophe point.

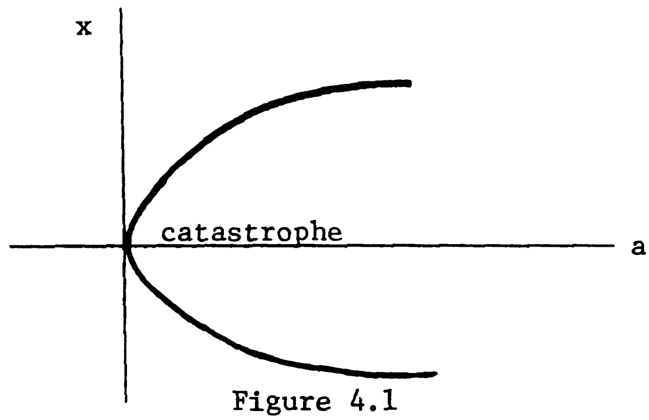

Figure 4.1

The second type of catastrophe is the <u>cusp</u>. This type of catastrophe has widespread applications in both natural and social sciences.[3]

The cusp equilibrium surface, S, is equivalent to:

$$x^3-a_1x-a_2 = 0$$

hich is the first derivative, at extrema, of a function called energy unction, G.[4]

$$(\partial G/\partial x) = x^3-a_1x-a_2 = 0$$

here one dependent variable, x, is explained by two independent variables (parameters), a_1 and a_2, Figure 4.2.

The equilibrium surface (stationary surface), S, in Figure 4.2, nsists of two qualitatively different parts. The intermediate part which lies between the fold curves, F_1 and F_2, is called repellor

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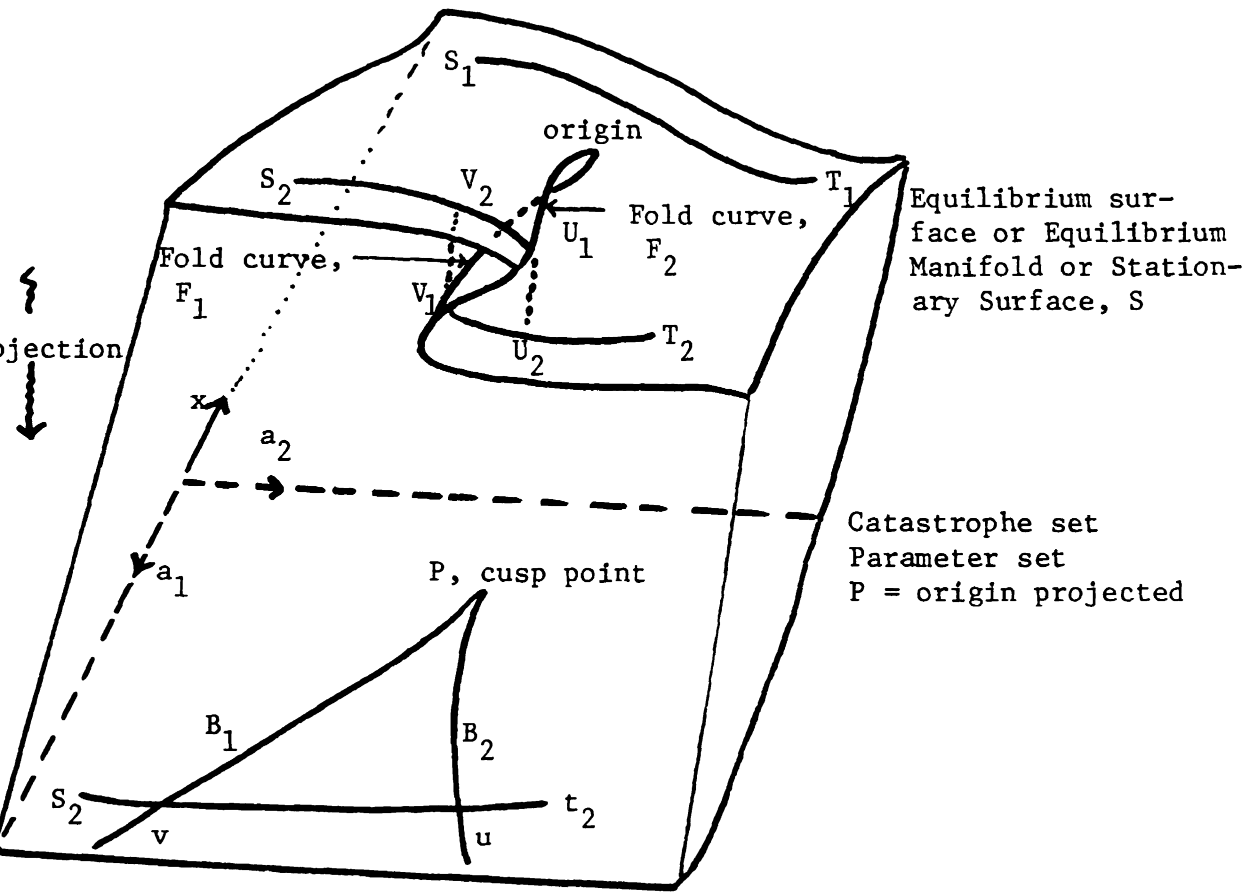

Figure 4.2

urface where $(\partial^2 G/\partial x^2)=3x^2-a_1<0$ so that G is at maximum.[5] The emaining $S-\bar{S}$ of equilibrium surface, is called attractor surface, iere $(\partial^2 G/\partial x^2)=3x^2-a_1>0$ so that the energy G is at a minimum.[6] The oundary between the attractor and repellor surfaces is the fold irve depicted by F_1 and F_2, where $(\partial^2 G/\partial x^2)=3x^2-a_1=0$. Projections fold curves from the equilibrium surface onto the catastrophe set ve a cusp-shape bifurcation set depicted by B_1PB_2. They are loci- catastrophes.

The significance of a cusp in explaining the behavior of a del (system) can be studied further. Suppose s_1, t_1 (or s_2, t_2) om the parameter set correspond to S_1,T_1 (or S_2, T_2) of the beha

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or set (equilibrium set), in Figure 4.2. By changing parameters you could change the value of the endogenous variable from S_1 The transition occurs in a continuous and smooth manner. The olds true if by changing parameters, the system moves from S_1 to T_1 to T_2, on the equilibrium surface. The picture is quite ent if by changing parameters you wish to move the system from T_2. The system moves smoothly from S_2 to U_1 and back, T_2 to V_1 k. If at U_1 you increase the value of parameter (beyond U_1), tem has no choice but to jump from a stable state at U_1 to stable state at U_2 (point u on B_2 curve, in catastrophe set). ement of the system from U_1 to U_2 is fast. The transition from ble equilibrium to another stable equilibrium, through an un- equilibrium, is defined as catastrophe. The same phenomenon when the system reaches the lip of the pleat at V_1 from T_2 to

An important characteristic of the catastrophe theory is the nce of the so called "delay rule." In the jargon of CT, the lay rule means that the system stays in the original stable rium surface as long as it can. Suppose the system was at S_2 in the equilibrium surface S in Figure 4.2. By changing para- a_1, a_2 you can change the equilibrium value of the endogenous from S_2 to T_2. The catastrophe occurs at point U_1. However, economy was at point T_2 in the equilibrium surface S of Figure picture is different as far as the occurrence of catastrophe rned. In this case the system moves from T_2 to S_2 and the phe occurs at point V_1 (v) in the equilibrium surface S ophe set P) rather than at U_1 (u).

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The fold and the cusp are two of the seven catastrophes :lassified by Rene Thom. He proved that these seven (elementary) :atastrophes depict all possible discontinuities in a paradigm con- :rolled by no more than four parameters. Interested readers are :eferred to Lu (1976), Golubitsky (1978), and Poston and Stewart (1978) for a complete exposition of the seven elementary catastrophes, V.I. Arnol'd has classified catastrophes up to at least 25 dimen- sions.[7] However, natural and social phenomena can best be explained by the seven elementary catastrophes.

The mathematical structure of catastrophe theory has been explained by Lu (1976), Golubitsky (1978), and Poston and Steward (1978). To avoid confusion and for the sake of simplicity, the theory could be defined in non-technical terminology. It asserts that while there are an infinite number of ways for a system to change continuously (i.e., moving from S_1 to T_1, Figure 4.2); there are only seven struc- turally stable ways for it to change discontinuously (passing through an unstable state).[8] The nature of the catastrophe depends on the number of exogenous variables in the model.

Debreu (1976) argues that an economy that has an equilibrium such that in any neighborhood of e, there are infinitely many equilib- ia, is unstable and "... the explanation of the equilibrium is essenti- lly indeterminate ..."[9] He continues that "... the economic system s unstable in the sense that arbitrary small perturbations from e to neighboring equilibrium induce no tendency for the state of economy o return to e."[10] Therefore, through an elaborate mathematical expo- .tion he shows that unique equilibria is not necessarily considered : a good assumption. Furthermore, equilibria are not continuous in the par

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parameter of the paradigm at all time. Thus, catastrophe theory useful technique to explain discontinuous changes in the equilib- values of a system.

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CHAPTER 4--Footnotes

[1]For a mathematical treatment of the theory, see Lu (1976), tsky (1978), and Poston and Stewart (1978).

[2]Sussman and Zahler (1978), p. 141.

[3]See Sussman and Zahler (1978).

[4]In economics, behavioral functions such as demand functions ibrium in a portfolio-balance model) are derived from the rele- energy) objective function of utility maximization subject to ints (risk minimization subject to wealth constraint).

[5]A locus of unstable equilibria is defined as repellor surface.

[6]A locus of stable equilibria is defined as attractor surface.

[7]Arnold (1972, 1974, 1976) cited in Golubitsky (1978), p. 353.

[8]Woodcock and Davis (1978), p. 42.

[9]Debreu (1976), p. 281.

[10]Ibid.

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CHAPTER 5

Macroeconomics and Catastrophe Theory

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The economic analysis of this chapter is based on the theoreti-
ndations that were derived in the previous chapters. In this
I end the theoretical investigation of discontinuity in a
economy. The building blocks developed for a closed economy
used as a spring board into theoretical investigation of an
onomy's interactions and foreign exchange market.

This introduction presents a formal discussion of conventional
te demand and supply models. In section one, I develop further
LM framework of Chapter three. It will incorporate that frame-
to a catastrophe-theoretical model. In section two, I derive
ernative (unconventional) aggregate demand curve, and discuss
c equilibrium within an aggregate demand-supply framework.

The macroeconomics of aggregate demand and supply presented
section is based on Sargent (1979) and Dornbusch and Fischer
They are developed here in order to set the stage ready for
ventional analysis of aggregate demand and supply to be
d in section two.

As far as aggregate demand model building is concerned,
classical nor Keynesian economists have any disagreement
ng the structural equations. The introduction to Chapter

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three reviewed aggregate demand in terms of IS and LM curves; equations (3-1) and (3-3). For convenience, these IS and LM curves are shown in Figure 5-1.

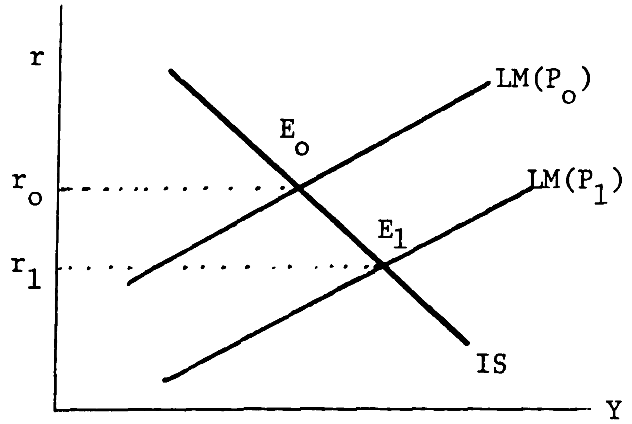

Figure 5-1

I now use Figure 5-1 to derive the standard aggregate demand curve. Suppose the economy is in an initial equilibrium, depicted by E_o. A price reduction from P_o to P_1 implies an increase in real balances, holding other things constant. LM curve shifts to the right to $LM(P_1)$. Thus, a decrease in price level leads to higher level of real income, Figure 5-2.

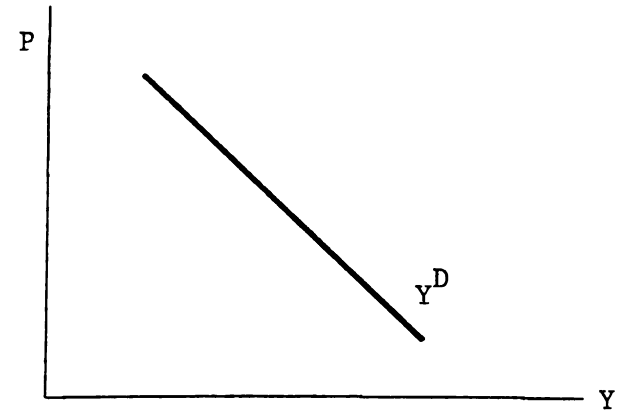

Figure 5-2

The Hicksian interpretation of income determination, presented in IS-LM framework, leaves the economic system with two equations and three unknowns, Y, r, and P. The Keynesian approach to this problem is to assume P to be exogenous. Therefore, for an economy at a lower level of employment than full employment, aggregate demand determines the equilibrium level of real income. Monetarist might respond to the same problem by assuming Y to be fixed at full employment level (so that P is determined endogenously).

Generally speaking, the limitation of an exogenous price is remedied by amending this model with an aggregate supply function that relates

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relates real income and price level:

$$Y = F(K,N) \tag{5-1}$$

$$(W/P) = (\partial F(K,N)/\partial N) = F_N(K,N) \tag{5-2}$$

$$N^S = N = N(W/P) \tag{5-3}$$

Equation (5-1) represents the aggregate production function as a function of capital K and labor N. K is considered constant in the short run. Equation (5-2) which depicts the firms' demand for labor, generates the equality between real wage rate (W/P) and marginal physical product of labor, $F_N(K,N)$.

Equations (5-1) and (5-2) in conjunction with the IS-LM framework constitute the structural equations of a general Keynesian macroeconomic model. This model determines six endogenous variables Y, N, C, I, P, and r. The money wage rate, W, is viewed as exogenous at a point in time. However, in the classical model the money wage rate W is treated as an endogenous variable.

The subsequent need for an extra equation in the classical model is met by the inclusion of labor market equilibrium condition, equation (5-3), into the system.

The mathematical and economic counterparts of classical and Keynesian models of macroeconomics lead to qualitatively different aggregate supply curves. Classical economists perceive a vertical aggregate supply curve at full employment level of output because of the flexibility of nominal wage rate and prices, Figure 5.3. The equilibrium level of output is determined through the interaction of labor market and the production function, independent of the price level

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level and aggregate demand repercussions. If the price level rises, due to an increase in aggregate demand, firms' profit rises and thus creates incentive for higher production and demand for labor.

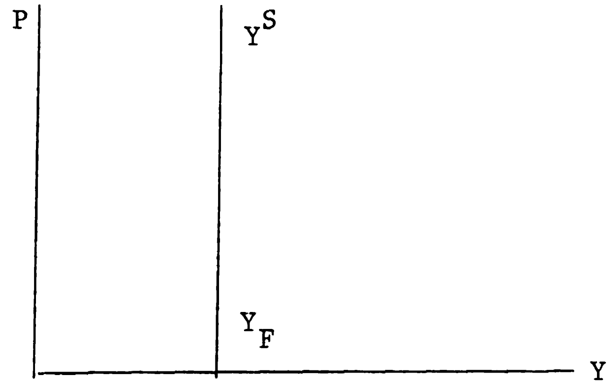

Figure 5-3

Firms' competitive drive to hire more labor implies a higher money wage rate. The nominal wage rate will increase in proportion to the price rise and therefore, leaves the real wage rate, employment, and output all unchanged.

However, the classical full employment equilibrium condition is a long-run phenomenon. In the short run, transaction costs, stickiness of wages and prices, among a variety of other reasons, affect the adjustment process. These factors imply transitory disequilibrium in labor and output markets and hence explain an upward sloping short run, Keynesian supply curve, Figure 5-4. The Keynesian model of aggregate supply and demand differs from classical in the sense that the former does not depend on classical labor supply curve for achieving equilibrium in labor and output markets. In a Keynesian model, the money

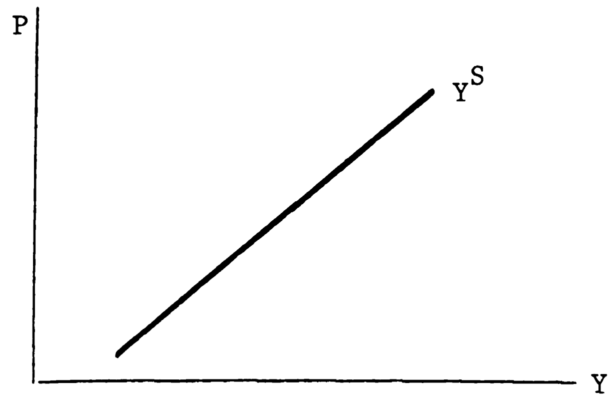

Figure 5-4

wage rate is considered as an exogenous variable while the model determines the equilibrium values of the endogenous variables Y, N, C, I, r, and P.[1] Thus, the structural equations of the supply side of the

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Keynesian model are:

$$Y = F(K,N) \qquad (5\text{-}1)'$$

$$(W/P) = F_N \qquad (5\text{-}2)'$$

where F_N denotes the marginal physical product of labor, N.

I. IS-LM Again

In Chapter three, I derived a non-linear IS curve with distinctive characteristics (equation (3-12), Figure 3-6). My objective in this section is to use this IS curve, in conjunction with LM curve, to develop a catastrophe-theoretical model. I will use this model for explaining and investigating discontinuous changes in the equilibrium behavior of a closed economy. This effort is carried on in a model with the assumption of fixed prices in the short run. Thus, I brush aside the economic repercussions of output-employment side of the economy. In section two, I will incorporate the supply side of the economy into the mainstream of the investigation.

The IS curve gives the equilibrium pairs of interest rate (r) and real income (Y) in the product market, where the demand for and supply of goods are equal; equation (5-4) (which is equation (3-12) of Chapter three):

$$Y = f+c(Y-tY+R)+G+(q/(1+de^{-vY}))-mK-nr \qquad (5\text{-}4)$$

Graphically, the equilibrium is shown in Figure 5-5 which is a representation of Figure 3-6 of Chapter three. Arrows denote dynamic behavior of income, as a function of excess demand (or supply).

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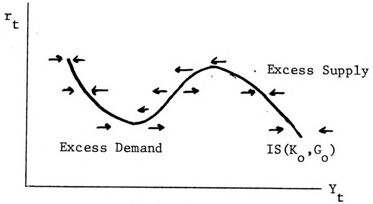

Figure 5-5

IS curve in equation (5-4), or Figure 5-5 is investigated under the assumption that the capital stock remains constant in the short run. However, in the long run, the IS curve shifts up (down) as capital decumulate (accumulates). As capital decumulates (K_o ---> K_1) investment outlays increase and the investment curve shifts up, for each level of interest rate, Figure 5-6.

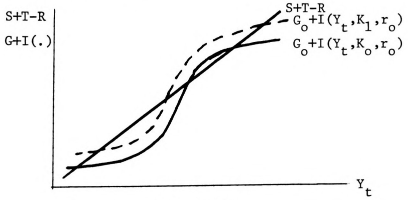

Figure 5-6

Assume that there are two economies which are exactly alike except in their level of capital stock (K_1<K_o). Following the procedures outlined in Figure 3-5 and 3-6 of Chapter three I recognize the fact that the economy with a lower level of capital stock (K_1) has a higher IS curve, Figure 5-7.

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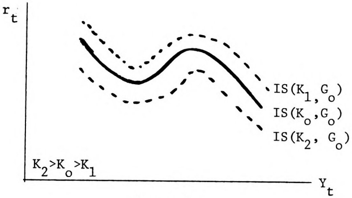

Figure 5-7

The converse is true for capital accumulation (K_o ---> K_2).

I can add further insight to our understanding of this economic model by investigating fiscal policy. An increase in government spending, G, (revenue, T), implies an upward (upward) shift of G+I (S+T-R) curve. This adjustment is reflected in an upward (downward) shift of IS curve, respectively.

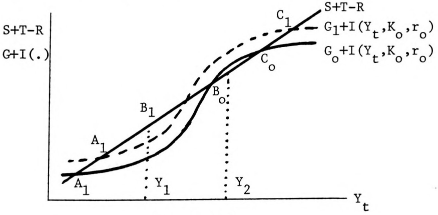

Figure 5-8

The $IS(K_o,G_o)$ curve, in Figure 5-9 is derived by tracing out equilibrium levels of output (in Figure 5-8) as the interest rate changes. As the interest rate rises, the investment curve and thus, the whole $G_o+I(Y_t,K_o,r_t)$ curve shifts down, holding G_o and K_o constant. The critical point Y_1 (Y_2) of the $IS(K_o,G_o)$ curve in Figure 5-9 corresponds to the tangency of S+T-R and $G_o+I(Y_t,K_o,r_t)$ curves as interest rate decl

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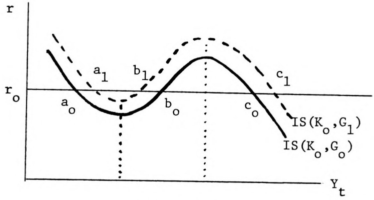

Figure 5-9

declines (increases) and $G_o+I(Y_t,K_o,r_t)$ shifts up (down). Suppose that the initial conditions of this economy are changed by an expansionary fiscal policy. The $G_o+I(Y_t,K_o,r_o)$ curve would shift upward to $G_1+I(Y_t,K_o,r_o)$. In order to derive the new IS curve I trace out the equilibrium level of output as interest rate is changing, Figure 5-8. Points a_i, b_i, c_i in Figure 5-9 correspond to points A_i, B_i, and C_i in Figure 5-8 respectively, which in turn corresponds to G_i fiscal policy for a given r_j. Figure 5-8 and 5-9 clearly show that a smaller (greater) reduction of interest rate would bring our system to the critical point Y_1 (Y_2) after the expansionary fiscal policy is executed than before the expansionary fiscal policy. Thus, our new IS curve, IS (K_o,G_1) lies above the initial one IS(K_o,G_o), Figure 5-9.

Ignoring the unstable arm of the IS curve temporarily, I see that the stable arm shifts rightward (leftward) as capital decumulates (accumulates) and investment increases (decreases). This is true when government spending, G, increases, or its revenue, T, decreases. This phenomenon is in complete harmony with the conventional applications of IS curve. Conventional IS curves shift to the right as investment and/or government outlays rises or government revenue net of tr

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of transfer (T-R) declines.

Now I turn to LM curve. I assume a normal-shape (conventional) LM curve. Appendix A presents an additional source of catastrophes, using a non-conventional LM curve. However, this thesis is not concerned with this second source of catastrophes.

The LM curve gives the equilibrium pairs of r and Y in the asset market--where a portfolio equilibrium is achieved; equation (5-5).

$$\bar{M}/P = m(r,Y) \tag{5-5}$$

Graphically, portfolio equilibrium in the asset market is shown by an upward sloping LM curve in Figure 5-1.

A simultaneous solution of these two (equations) curves--IS and LM--gives equilibrium in both markets and thus in the economy, with fixed prices. We can find the pair (r,Y), that gives equilibrium in both markets by these two curves (IS&LM) in the same quadrant, that is solving equations (5-4) and (5-5) simultaneously. This is shown in equations (5-6) and Figure 5-10.

$$r_t = \frac{1}{n}\left(\frac{q}{1+de^{-vY}} - Y+c\cdot(Y-tY+R)+G-m.k+f\right) \tag{5-6a}$$

$$r_t = \frac{1}{\lambda}\left(\theta Y_t-(\bar{M}/P)\right) \qquad \lambda < 0 \qquad 0<\theta<1 \tag{5-6b}$$

θ and λ are interest and income sensitivies of demand for money.

Due to the non-linear nature of our model, we have a multiple equilibria. Points M and T are stable equilibria, while N is an unstable one, Figure 5-10. Whether the economy remains at M or T depends on the initial conditions of the system.

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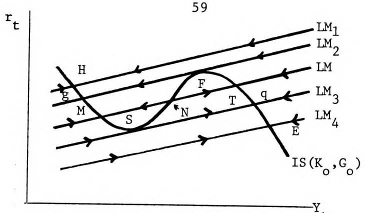

Figure 5-10

At this point we develop our theory in two fronts. The first is a short run discussion of the model. The second is the long-run analysis of the theory.

ɪa. Short Run

The theoretical model is represented by the equations (5-6) nd Figure 5-10. The stock of capital remains unchanged at K_o. The S and/or LM curves may shift either upward or downward. The only ynamic changes in this model come through fiscal and monetary disurbances.

Suppose the economy is initially at the equilibrium point M, igure 5-10. A monetary expansion pursued by monetary authorities given G_o) produces a rightward shift in the LM curve. The economy races out an equilibrium path on the LM curve along the IS (K_o,G_o) urve. The interest rate declines, employment and production inrease. The smooth expansion of the output level which comes about ue to a continuous expansion in the supply of money continues until ne economy reaches point S on the $IS(K_o,G_o)$ curve. If the monetary uthorities continue the process of monetary expansion beyond LM_3, the uilibrium system would shift suddenly from point S to q. Both the equi

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equilibrium level of interest rate and output experience a sudden and discontinuous change (jump) when monetary authorities pursue their objective continuously.

An expansionary (contractionary) fiscal policy causes an upward (downward) shift of the $IS(K_o)$ curve, given money supply, Figure 5-11.

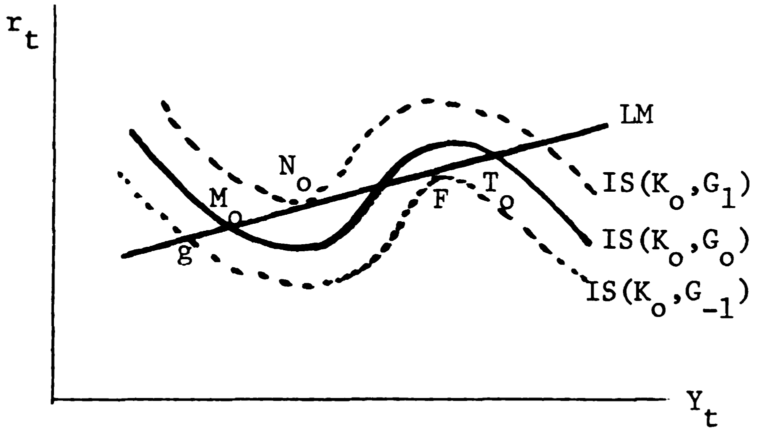

Figure 5-11

Thus, fiscal policies are capable of creating a change of catastrophic nature, if their changes pass through certain levels of aggregate spending. Suppose the economy is initially at the equilibrium point T_o, corresponding to a given fiscal policy, G_o, Figure 5-11. A contractionary fiscal policy shifts the IS curve downward, along the LM curve. The economy contracts smoothly and continuously until it reaches point F on the LM curve, as government outlays shrink. A further reduction in the government expenditure would produce still a downward shift of the IS curve and a rapid jump (catastrophe) of the economy from point F on the LM curve to the point g on the same curve. Further continuation of fiscal policy reduction makes the economy contract smoothly and continuously after it passes the point on the LM curve.

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Ib. Long Run

The long-run equilibrium path of the economy is influenced by the change in the stock of capital and is depicted by Figure 5-12 or equation (5-6).

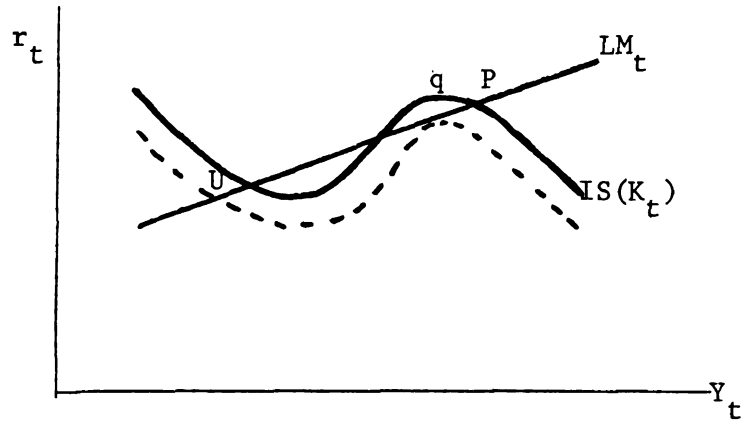

Figure 5-12

Suppose the economy is initially at the equilibrium point P, in Figure 5-12, which corresponds to the equilibrium point C in Figure 3-3 of Chapter three. At point C gross investment exceeds replacement investment (i.e., positive net investment), Figure 5-13. Therefore, due to capital accumulation, investment curve shifts downward, and output and employment decline. Thus, the IS curve is pressured downward (see Chapter three, Figures 3-5 and 3-6). For the moment I assume a stable (fixed) monetary policy. As the curve shifts downward, the economy moves along the stable LM curve until the economy reaches the point q in Figure 5-12. Point q corresponds to the point c_2, in Figure 3-5 of Chapter three (where the equilibrium points B and C of Figure 3-4 in Chapter three coincide with each other). Since q is not a stable equilibrium point, a small perturbation would shift the economy to the point U in Figure 5-12.

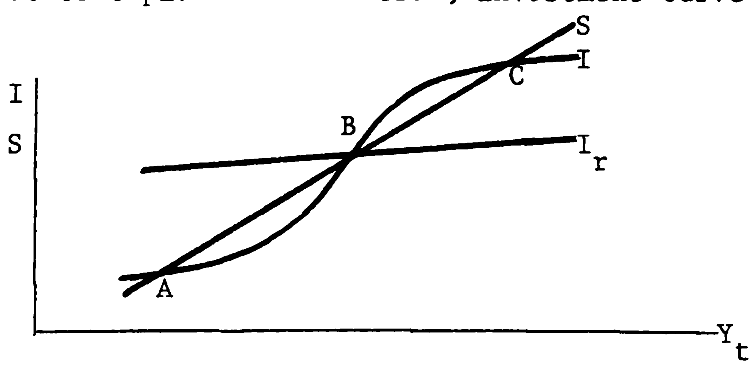

Figure 5-13

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The converse is true when the economy is in a recession.

Another factor must be considered. In the above diagram (5-12), the equilibrium interest rate declines along the Pq line, as the IS curve shifts down. This produces a resistance against the falling investment curve and IS curve. Thus, whether the economy passes through the critical point of q and produces a catastrophe (as indicated by Kaldor, Ichimura, and Varian) or not, all depends on the investment sensitivities to interest rate and capital. Besides, supportive (expansionary financial) policies if diagnosed and pursued correctly could postpone or even eliminate the occurrence of the turning points and sudden jumps. Ill-planned financial policies could quicken the occurrence of downswings or prolong it.

In terms of catastrophe theoretical concepts, the model can be discussed as follows. Two endogenous (state) economic variables Y and r are explained by financial policies in the short run and long run. A continuous change in these policies leads to a smooth and continuous change in the economy. Nevertheless, at certain levels of these policies (i.e., LM_3) the state of equilibrium undergoes a discontinuous jump (from S to q in Figure 5-10 or q to U in Figure 5-12). Figure 5-10 depicts different LM curves associated with different level of nominal (or real with fixed prices) balances, given a fixed fiscal policy ($IS(K_o,G_o)$). Figure 5-14 shows the equilibrium path for real income, Y^e, as the supply of money is changing, $M_4>M_3>M>M_2>M_1$. Arrows above the ACT curve depict the equilibrium path of real income due to an expansionary monetary policy, given G_o. Arrows underneath the curve depict the equilibrium path of real income due to a contractionary monetary policy, given G_o. Points H, g, S, F, q, and E of Figure 5-14 corres

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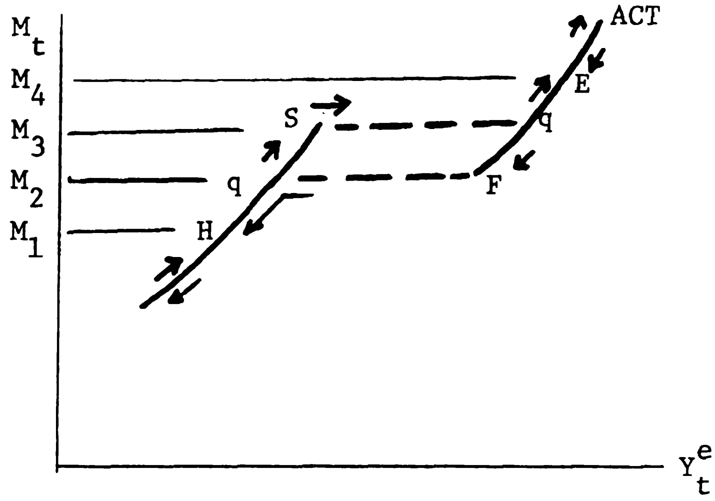

Figure 5-14

corresponds to the same points in Figure 5-10, as far as real income is concerned. If the economy is initially at H, a continuous expansionary monetary policy, leads to a rightward shift of the LM curve. Therefore, the economy traces out an equilibrium path until it reaches point S. At S a further pursuit of expansionary monetary policy causes a discontinuous jump of the system to point q, Figure 5-10 and 5-14. Then, after this sudden jump, the system behaves smoothly and continuously as money supply expands. However, as the system contracts due to contractionary monetary policy, a qualitatively different characteristic develops. The economy contracts, starting from E, smoothly and continuously until it reaches point F as money supply shrinks. A further reduction in the supply of money makes the economy to jump to g from F, Figure 5-10 and 5-14. After this sudden jump, the system contracts again smoothly and continuously as money supply declines. The economy is not contracting along the path it followed while expanding. While contracting, the economy postpones the occurrence of catastrophe until it reaches point F rather than q, Figure 5-14. This phenomenon, which is called the "delay rule," is explained and predicted by catastrophe theory (see Chapter four).

The dynamic analysis of equilibrium in the economic system is, in a sense, limited by the assumption of a fixed fiscal policy, G_o.

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could embark a more complicated analysis of equilibrium and catastrophe by taking both fiscal and monetary policies into account. However, the main purpose of this chapter is the construction of solid fundamental building blocks for a theory of exchange rate determination. This chapter and the previous chapter provide a framework for the application of catastrophe theory to models of exchange rate determination.

II. Aggregate Demand-Aggregate Supply

In this section I take the analysis of income determination one step further. First a non-linear (non-conventional) aggregate demand curve that follows from the non-linear investment is derived. Then, I will use this demand curve, in conjunction with an aggregate supply curve, to build a macroeconomic model. The purpose, thus, is to shed some more light on the theory of catastrophe in a closed economy. But I always believe in the law of diminishing marginal returns. As a result, this section is short and brief. It may answer some theoretical curosity of the application of catastrophe theory to an aggregate demand concept. The rest is left to readers' imagination.

Equations (5-6) and Figure 5-15 present the structural equations of the aggregate demand curve. Interest rate and real income are assumed to be endogenous variables. Price level was assumed constant. Now suppose the economy is initially at the equilibrium point of T in Figure 5-15. Given a nominal supply of money, an increase in the price level reduces real balances. In order for the public to hold a lesser quantity of real balances, income would have to decline or interest rate to rise. Therefore, LM curve shifts to the left.

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we trace out the equilibria, given a fiscal policy, we derive an gregate demand curve of the type depicted in Figure 5-16. In gure 5-15 I assume initially that the LM curve is flatter than the ward sloping part of IS curve.

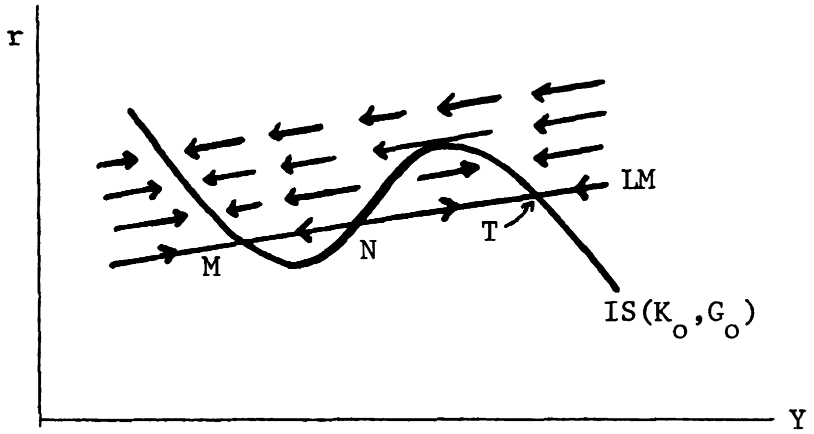

Figure 5-15

Expansionary Fiscal and monetary policies imply an upward ift of the aggregate demand curve. A contractionary financial licy causes a downward shift of the curve.

The full equilibrium condition of the system is achieved by mbining aggregate demand and supply schedules, Figure 5-16. Here (Y^F) depicts a short-run (long-run) aggregate supply curve. Its sitive (zero) slope reflects the sluggish (rapid) adjustment of ices and wages to output.

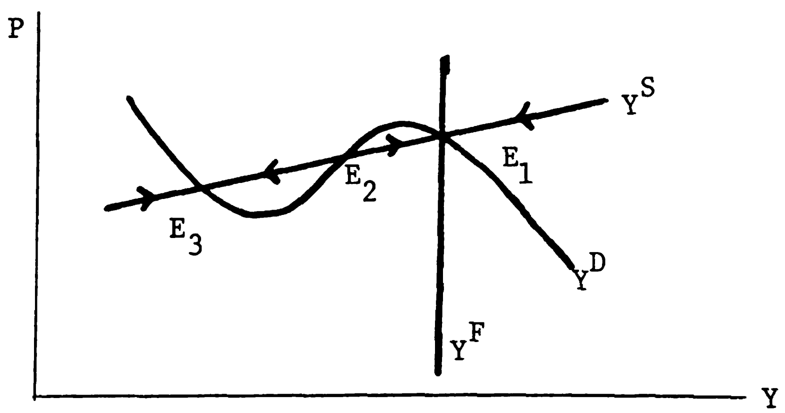

Figure 5-16

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Arrows in Figure 5-15 indicate the stability (unstability) of equilibrium for a conventional (unconventional) downward (upward) sloping IS curve.

A conventional aggregate demand curve is sloping downward. This can be explained in economic terms. Suppose that the goods and money markets are initially at equilibrium. Thus, the economy is at a point on the aggregate demand curve. A lower price level leads to higher real balances and therefore creates an excess supply of real balances at the given level of income. The excess supply of real balances reduces interest rates in return. The decline in interest rates cause a surge in real spending by encouraging investment. Equilibrium level of income rises as a result of this surge in investment. Therefore, I can conclude that aggregate demand curve is negatively sloped.

But the aggregate demand curve derived in Figure 5-16 is nonlinear. It comprises two conventional downward sloping and one unconventional upward sloping sections. I know that the aggregate demand curve is a combination of price level and real income where both goods and money markets are at equilibrium. The money market clearing conditions are met along the upward sloping section of aggregate demand. The goods market equilibrium conditions are also met, but are unstable. This is true because along the upward section of aggregate demand curve households' marginal propensity to save is less than their marginal propensity to spend (i.e., point B in Figure 3-4 of Chapter three). Therefore, points E_1 and E_3 (E_2) are stable (unstable) equilibria.

Suppose the economy was initially at equilibrium point E_3

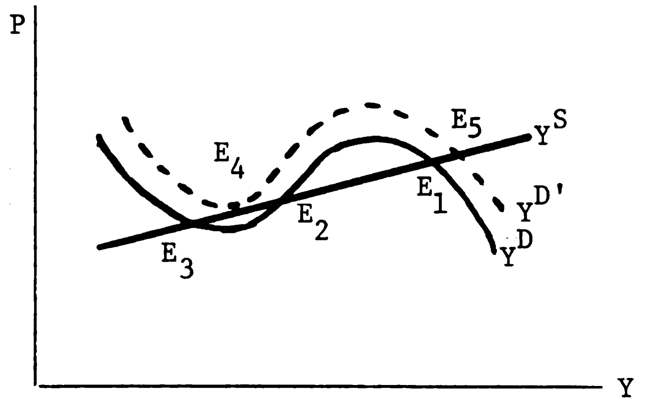

Figure 5-17

in Figure 5-17. Expansionary financial policies shift Y^D upward. Equilibrium point E_3 moves upward as expansionary financial policies continues. If the course of financial expansionary policies are continued beyond the ones associated with aggregate demand $Y^{D'}$ and equilibrium point E_4, the economy suddenly jumps from equilibrium point E_4 to E_5,

The catastrophe nature of the model is better explained through Figure 5-18.

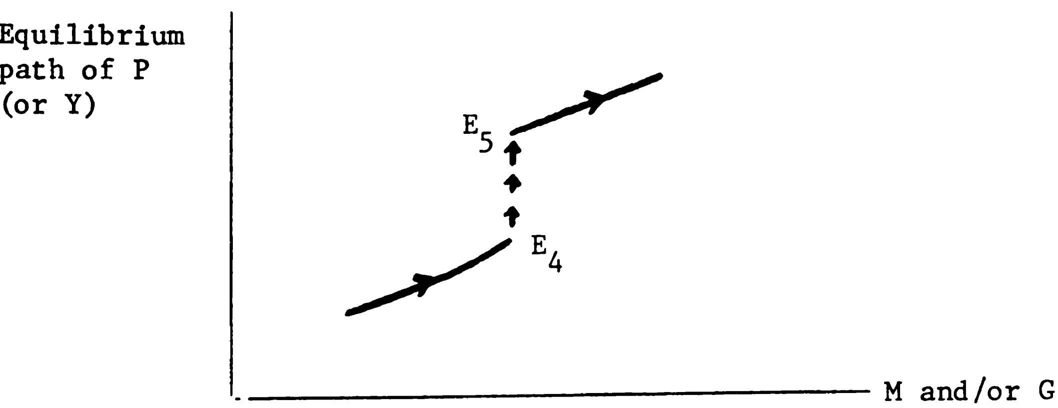

Figure 5-18

Fiscal (monetary) policies

In the long run the picture changes. The level of real income is fixed in the long run. As a result of expansionary financial policies Y^D shifts upward. Real income does not change. However price level rises, Figure 5-19.

In Figure 5-15 the LM curve was flatter than the upward sloping part of IS curve. In this part, I reverse that assumption.

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As in Figure 5-20, I assume that the LM curve is steeper than the upward sloping section of the IS curve. The derivation mechanism of aggregate demand curve is the same as explained before.

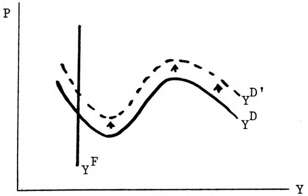

Figure 5-19

As prices rise, the supply of real balances declines. Interest rates rise and hence discourages the real spending on investment. Real income declines.

A rise in price level is indicated by an upward (leftward) shift of LM curve, Figure 5-20. To derive the aggregate demand curve, I trace out the equilibrium level of income correspondent to changing price levels, Figure 5-21.

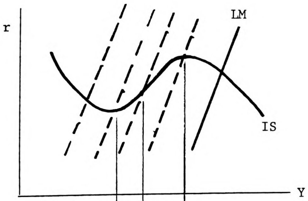

Figure 5-20

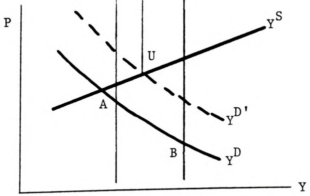

Figure 5-21

Aggregate demand curve, Y^D, derived in Figure 5-21 looks like a conventional downward sloping demand curve. However, the AB portion of aggregate demand curve in Figure 5-21 which corresponds to upward sloping part of IS cu

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curve is unstable. Along AB section of Y^D marginal propensity to save is less than marginal propensity to spend (i.e., point B in Figure 3-4 of Chapter three).[2]

The equilibrium path of real income and price level are clear as long as the economy lays outside of AB portion of aggregate demand curve, Figure 5-21. Expansionary financial policies shift Y^D curve up. Both price level and real income rise. However, equilibria are unstable if aggregate demand and supply curve on the AB portion of Y^D curve, Figure 5-21.

Figures (5-22 and 23) specify the dynamic behavior of economy in such a case. Suppose aggregate demand and supply curves intersect at point U on the unstable part of aggregate demand curve in Figure 5-23.

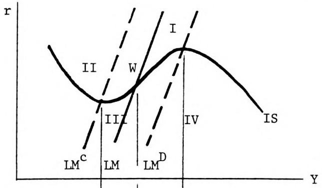

Figure 5-22

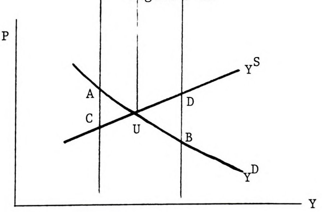

Figure 5-23

Point W, in Figure 5-22 is the intersection of IS and LM curves which corresponds to point U in Figure 5-23. By disturbing the system, the economy moves to region I, II, III, or IV in Figure 5-22. The economy could not remain in regions I and III. In these regions both goods and money markets clearing conditions are disturbed. Therefore, economy moves from regi

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region I (III) into II (IV) or lays on LM curve. If the economy moved to region II (IV) excess supply (demand) in goods market causes the real income to decline (rise). To keep the money market in equilibrium as income declines in region II (increases in region IV) price level should rise (fall). LM curve shifts up (down) in region II (IV) and the economy moves away from point U in Figure 5-23 toward point C (D).

The equilibrium path of real income or price level is explained through Figure 5-24.

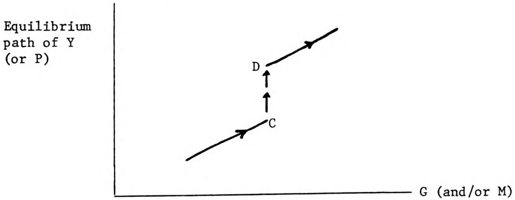

Figure 5-24

Fiscal (monetary) policies

CHAPTER 5--Footnotes

[1]Patinkin, Don. 1956.

[2]As we know, an economic model which is comprised of both a (conventional) downward sloping demand curve and an upward sloping supply curve is stable in both Marshallian and Walrasian sense, Figure 5F-1.

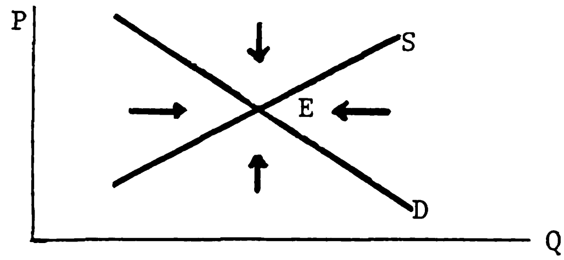

Figure 5F-1

Point E in Figure 5F-1 is a stable equilibrium point. Therefore, the economy remains there as long as structural changes in supply and/or demand curve is assumed.

But as readers notice, the economy is unstable in the AB portion of the aggregate demand curve, Y^D, even though this demand curve is downward sloping, Figure 5-21. This apparent paradox may be explained in a static-dynamic dichotomy. The stability of equilibrium of Figure 5F-1 is explained within a static framework. However, this is not true for my model, Figure 5F-2. In this model, the dynamic equilibrium behavior of real income and prices are studied.

Beside, the equilibrium instability is an inherent characteristic of my model. Both aggregate demand curves derived in Figure 5-16 and 5-21 are reproduced in Figures 5F-2 and 5F-3. These aggregate demand curves show identical stability characteristics. The economy would be stable at levels of real income below Y_c (Y_a) or above Y_d (Y_b), in Figure 5F-2 (5F-3). The economy is unstable in the Y_c-Y_d (Y_a-Y_b) range of real income in Figure 5F-2 (5F-3). Y^D is sloping upward in Figure 5F-3 since LM curve is assumed flatter than the upward sloping (unstable) section of IS curve in Figure 5-15. While, Y^D is sloping downward, because LM curve is assumed steeper than the upward sloping (unstable) section of IS curve in Figure 5-20. In either case, marginal propensity to save is less than marginal propensity to spend, CD (AB) in Figure 5F-2 (5F-3).

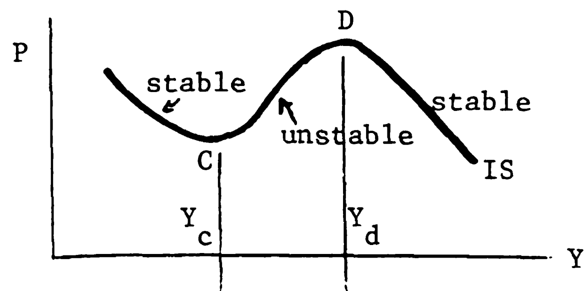

Figure 5F-2

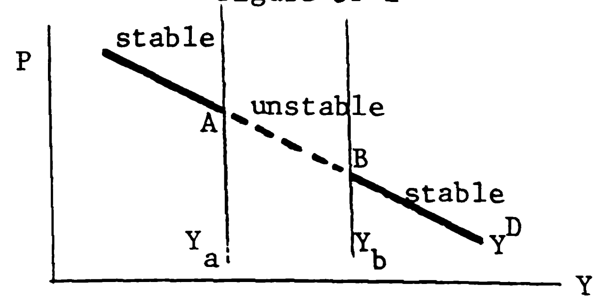

Figure 5F-3

CHAPTER 6

Theories of Exchange-Rate Determination

Introduction

Chapter two through five developed a non-conventional closed economy model. In this second part of the dissertation the non-conventional macroeconomic model is extended to allow for international economic repercussions. In Chapter seven a (non-conventional) macroeconomic model of an open economy will be developed. Once this model has been developed, it will then be applied to explore the short run and long run effects of macropolicies on both home and international (i.e., exchange rate) economic variables. It will be argued that no single theory completely explains the foreign exchange rate, the price or value associated with a currency being acquired or bought in terms of another currency.[1]

The main objective of this chapter is to review the various theories of exchange-rate determination. This task will be accomplished in a concise and brief manner, since there are numerous authoritative and critical surveys in the literature.[2] This chapter lays a foundation for the next ones. The theoretical building blocks of exchange-rate behavior, to be developed in the next two chapters are based on the concept that these theories are supplementary rather than mutually exclusive.

In the nineteenth century there were two views on the theory

of the flexible exchange rate. One view was the monetary approach to exchange rates. This view asserted that foreign exchange rates are determined only by the money supply (Ricardo) or mainly by the money supply (Christiernin, Thornton). The other view was the balance of payments (BOP) theory. According to this view, exchange rate fluctuations are explained in terms of the demands for and supplies of currencies in the foreign exchange market. International trade flows lead to demands for and supplies of foreign exchange in these models.

This dichotomy (stock vs flow) of theories of exchange-rate behavior has been an enduring characteristic of this area of international economics. The hypothesized relationship between capital and current accounts (stock vs flow) has changed considerably over time. After World War II, due to the obstruction of the free flow of funds and other international financial barriers, the emphasis of exchange-rate determination models was on the current account. As a result the flow BOP theories of exchange-rate behavior were developed and applied. However, in contemporary and modern international financial system, the core of prevailing exchange-rate determination models originates from the portfolio equilibria selection and monetary considerations. This led to the development of a vast theoretical and empirical pool of literature on (stock) asset models of exchange-rate movements. One branch of asset models, called the monetary approach, describes exchange-rate behavior mainly in terms of changes in demands for and supplies of money stocks. The other asset model, the portfolio-balance model, is a more generalized version of the monetary approach. As wealth holders realign their wealth among different financial assets, exchange and interest rates are determined imultaneously.

In section one of this chapter I explore the flow market (BOP) odel of exchange-rate determination. In section two, I will briefly iscuss the external and internal balance theory of BOP adjustment nd exchange-rate determination. This model is based on an IS-LM odel extended to an open economy. In section three I examine the sset market models of exchange-rate behavior.

. Flow Market Models of Exchange-Rate Determination

The flow market model of exchange-rate (or traditional textook analysis of foreign exchange market) uses a Marshallian demand nd supply analysis. The foreign exchange rate like any other price, s determined by the demand for and supply of foreign exchanges (currencies). Several different approaches have been posed to explain he effects of exchange rate movements upon the BOP and international conomic phenomena. Perhaps the most widely discussed approaches are lasticities and absorption approaches.

a. Elasticity Approach

The essence of this approach is the relation between the slope f the demand and supply curves of foreign exchange and various emand and supply elasticities of tradable commodities. This model ttempts to link the effects of exchange rate changes in the foreign xchange market to i) the relative price effect, ii) the internal rice effect, iii) the income effect and iv) the distribution effect. he analysis is limited to the current account portion of the BOP. he main question that this approach seeks to answer is: "what are he necessary and sufficient conditions for devaluation to achieve an mprovement in the current account balance?"

The elasticities condition to improve the BOP has been speci- ied in many writings and may be repeated here as:

$$d(TB)/dE = \frac{\eta_x - 1}{1+\eta_x/e_x} + \frac{\eta_m + \eta_m/e_m}{1+\eta_m/e_m} \qquad (6\text{-}1)$$

here

$d(TB)$ = the change in the home country's trade balances, denominated in home currency

$\eta_x(\eta_m)$ = foreign (home) demand elasticity for its export (import)

$e_x(e_m)$ = foreign (home) elasticity of export supply.

The famous Marshall-Lerner condition is derived if $e_x = e_m = \infty$. he size of elasticities is very important in the stability analysis f this approach.[3]

In response to the critiques, the elasticity approach has been xtended to include secondary income effects. These effects are rought on as the multiplier works through the economy because of the xpansion of income generated by an increase in net export (i.e., X = xports minus imports). These secondary effects are offsetting in the ense that an increase in income implies an expansion in imports. Thus, he Keynesian revolution served as an extension of the domestic income ultiplier (developed basically by J. Robinson and R. Harrod) to the rade section.

b. Absorption Approach

The restrictive nature of traditional elasticities models led o the further modification and consideration of income/price interactions by Sohmen (1957), Harberger (1950), Vanek (1962), and Clement, Pfister, and Rothwell (1967).[4] While the proposed modifications made the above approach more complex, it failed to provide remedies for its limitations. Thus, Alexander's absorption approach was a response in eliminating the complexity of proposed modified elasticities approach by focusing on the macroeconomic view of the problem. This approach begins with national income accounting which can be expressed as:

$$Y = C+I+G+X \tag{6-2}$$

where the left (right) hand-side of the above equation implies aggregate supply (demand).

Y = the value of real aggregate output,
C = the value of real aggregate consumption outlays,
I = the value of real investment expenditure,
G = the value of real government expenditure,
X = the value of real net export expenditure.

Equation (6-2) can be rewritten as:

$$Y = A + X \tag{6-3}$$

where A=C+I+G is defined as the national expenditure on domestic goods and services, or absorption. The current account balance, B, is defined as export of goods and services minus their imports, X, which is also equal to Y-A.

$$X = Y-A \tag{6-4}$$

It can be easily deduced from equation (6-4) that if domestic absorption, A, exceeds output then more goods are being consumed than produced and thus $B<0$.

The absorption approach expands upon the elasticities approach in its emphasis upon appropriate policy measures, and its inclusion of national income. That is, this approach suggests that if B is to improve then Y-A should rise, equation (6-4). This is easily done, through income policies, for economies at less than full employment while holding down the growth of A. Otherwise, through pricing policies (i.e., interest rate rise), absorption must be depressed in order to improve the current account balance. This approach ascribes surplus in countries' current account balances largely to their high propensities to save and appropriate government policies.

II. Internal and External Balance Approach

The Keynesian revolution not only changed the monetary and macro theories of the closed economy, it also introduced a fundamentally different approach to the BOP adjustment problem. During this era, classical theories took a back seat for about three decades until they were discovered again. This rediscovery and reformulation were performed energetically by Robert Mundell and Harry Johnson. In a series of articles in the 1960's, they examined macroeconomic implications of monetary policies for an open economy. The essence of the model used by Mundell and Johnson was an ordinary IS-LM model extended to an open economy with capital account and the BOP. This model may be written as:

$$Y = C(Y) + I(Y,r,K) + G + X(Y,E) \qquad (6\text{-}5)$$

$$\bar{M} = m(r,Y) \qquad (6\text{-}6)$$

$$B = X(Y,E) + CA(r,E) \qquad (6\text{-}7)$$

where

r = interest rate,
K = the (fixed) stock of real capital goods,
X = exports net of imports of goods and services,
E = foreign exchange rate, defined as the home currency price of foreign currency,
B = balance of payments,
CA = net capital inflow, capital account.

Equations (6-5) and (6-6) give equilibrium conditions for the goods and asset markets respectively. Equation (6-7) is the BOP equation which is an equilibrium condition for the foreign exchange market under a flexible rate B=0. Equations (6-5) and (6-6) are structural equations of the model, while equation (6-7) is an identity (except under free float: 0=X+CA). They can be solved for equilibrium values of Y, r, E, or B.[5]

III. Asset Market Models of Exchange-Rate Determination

The traditional flow market models determine the equilibrium values of the exchange rate through the balancing forces of flow demands and flow supplies of foreign exchanges. In contrast, equilibrium conditions in asset market models are spelled out by the stock-equilibrium conditions in each country's financial markets. There are two types of theories in asset market models which try to explain exchange-rate behavior. One theory is called the monetary model and the other is called the portfolio-balance model. Both these theories will be discussed in the following subsections. However, the monetary model of exchange-rate determination rests basically on purchasing power parity theory (PPPT). Thus, PPPT will be explained first.

IIa. Purchasing Power Parity Theory (PPPT)

Gustav Cassel rediscovered and reformulated Ricardo's theory as the so-called purchasing power parity theory. Later, this theory was developed to a higher level of sophistication by Officer (1976, 1982). Generally speaking, the PPP between two countries is defined as either the rate of countries' price level (i.e., absolute PPP) or the product of the exchange rate in a base period and the ratio of the countries' price indices (i.e., relative PPP). It could be re-written as:

$$PPP_t^{abs} = P_t^B / P_t^A \quad (6\text{-}8)$$

$$PPP_t^{rel} = (p_t^B / p_t^A) E_o \quad (6\text{-}9)$$

where

P = price level
p = price index
Subscripts "t" and "o" denote the values of a variable in period t and base period respectively.
Superscript "abs", "rel", B, and A denote absolute, relative, countries B and A respectively.

The short run equilibrium exchange rate is defined as the rate that would exist under a freely floating exchange-rate system. The long run exchange rate is defined as the fixed exchange rate that would yield BOP equilibrium over a time period incorporating any cyclical fluctuations in the BOP. The PPPT presupposes that a) the short run equilibrium exchange rate is a function of the long run equilibrium exchange rate in the sense that the former variable tends to approach the latter, and b) the PPP is either the long run equilibrium exchange rate or the principal determinant of it.[6]

IIIb. Monetary Model

Generally speaking, the monetary model of exchange-rate determination asserts that exchange-rate fluctuations can be explained by changes in the demand for and supply of monies in different countries. Even though there are many variations of this approach all share some common and important assumptions. Most models of monetary approach assume strict purchasing power parity,

$$e = P-P^{*} \tag{6-10}$$

where

e = logarithm of exchange rate
P = logarithm of home prices
Superscript "*" denotes foreign counterpart of a home variable.

Domestic and foreign financial assets are taken as perfect substitutes. Thus, interest rates (r, r^{*}) are equal in the absence of inflationary expectations.

$$r = r^{*} \tag{6-11}$$

Or with inflationary expectations, interest rate differentials in favor of home country implies expected exchange-rate depreciation of home currency, π.

$$r-r^{*} = \pi \tag{6-12}$$

Furthermore, the demand for money is a stable function of interest rate and real income.

$$M_d = ky-hr \tag{6-13a}$$

$$M_d^{*} = k^{*}y^{*}-h^{*}r^{*} \tag{6-13b}$$

where

y = logarithm of real income

M_d = logarithm of demand for real balances

k = income elasticity of real money demand

r = nominal interest rate

h = semilogarithmic interest response of real balances

Finally, to restore equilibrium, money markets adjust rapidly through prices.

$$P = M-M_d \tag{6-14a}$$

$$P^* = M^*-M_d^* \tag{6-14b}$$

where M denotes logarithm of nominal money stock. I substitute (6-13) into (6-14) to get:

$$P = M-ky+hr \tag{6-15a}$$

$$P^* = M^*-k^*y^*+h^*r^* \tag{6-15b}$$

Thus, an exchange-rate determination equation in this model is derived by substituting equations (6-15) into equation (6-10):

$$e = M-M^*+h(r-r^*)-k(y-y^*) \tag{6-16}$$

The above equation is the one which is derived in Dornbusch (1980). Nothing makes this equation qualitatively different from the other versions found in the textbooks. However, the logarithmic form of equation (6-16) clearly indicates the relationship between the exchange rate and relative changes in money supply, interest rate, and real income.

The classical authors, incorporating asset market equilibrium condition with purchasing power parity, were interested mainly on the effects of monetary changes on the BOP adjustment and exchange-rate movements through domestic commodity prices. But the modern versions of this approach have a tendency to accentuate the direct effects of money, at given prices and interest rates, on the BOP and exchange rates. The main reason for this, as explained by Lindbeck is that:

> "external commodity and asset prices (interest rates) in contemporary monetarist models are usually assumed to be parametrically given for the individual country, and therefore that domestic excess supply for money is reflected either in excess demand for commodities, which spills over into the current account or excess demand for financial claims which spills over into the capital account. The classical economists, by contrast, usually assumed that domestic excess supply of money also influences domestic commodity and asset prices, with indirect effects on the BOP and/or the exchange rate."[7]

Kreinin and Officer's (1978) survey of the monetary approach to the BOP furnishes an excellent and thorough inquiry into theoretical and empirical implications of this approach.

As a final note on this approach I should add that a considerable investigation has shown that changes in relative stocks of monies explain a large part of the behavior of exchange rates (Frenkel (1976, 1977, 1978), Girton and Roper (1977), Hodrick (1978), and Bilson (1978a, 1978b)). But other investigations, Dornbusch (1980) and Pearce (1983), argue that in the light of empirical findings on PPP and its relation with exchange rate, monetary models fail to explain exchange-rate behavior adequately. This and other reservations lead to the other asset market model (i.e., portfolio balance model) of exchange-rate determination.

IIIc. Portfolio-Balance Model of Exchange-Rate Determination

The portfolio-balance model of exchange-rate determination is an extension of monetary macroeconomics of Tobin-Brainard and Markowitz models of portfolio selection and market clearing to an international economy. Indeed, this theory, based on the distinction between stock and flow equilibria, has been put forward by a series of models built by Johnson, Mckinnon and Oates (1966), Swoboda, Ott and Ott (1965, 1968), Oates (1966), and Mckinnon (1969). The extension of this approach to an open economy is enriched in one way or another by Black (1973), Hewson and Sakakibara (1975), Branson (1974), Girton and Henderson (1977), Dooley and Isard (1979), Driskill (1980), Mason (1980), and Turnovsky (1981).

There are many versions of this model. However there is a common presumption that wealth holders, in diversifying their wealth among money and other financial instruments (both home and foreign) determine exchange and interest rates simultaneously. Foreign and domestic financial instruments are considered imperfect substitutes. Generally speaking there are three financial instruments among which private citizens may allocate their wealth. These assets are real cash balances, M; home bonds, B; and foreign bonds, F; assuming currency substitution is ruled out.[8]

$$w = \frac{M+B^P+EF^P}{P} \qquad (6\text{-}17)$$

where

w = real wealth

M = stock of home real balances

B^P = stock of home bonds denominated in home currency and held by home private citizens

B^s = outstanding stock of home bonds

B^c = stock of home bonds denominated in home currency and held by home central bank

E = foreign exchange rate

F^p = stock of foreign bonds denominated in foreign currency and held by home private citizens

he rate of return of home real balances, home bonds, foreign bonds re zero, r, and r^* respectively when prices are given.

The stock demand for these financial assets are expressed as:

$$M^d = m(\overset{-}{r},\overset{-}{r}^*,\overset{+}{Y})\overset{+}{w} \tag{6-18}$$

$$F^d = b^*(\overset{-}{r},\overset{+}{r}^*.\overset{+}{Y})\overset{+}{w} \tag{6-19}$$

$$B^d = b(\overset{+}{r},\overset{-}{r}^*,\overset{+}{Y})\overset{+}{w} \tag{6-20}$$

uperscripts "+" ("-") above an explanatory variable indicate how that ariable is related to stock demand functions. These demands are estrained by the wealth budget constraints, equations (6-17) and 6-21).

$$m(.)+b(.)+b^*(.) = 1 \tag{6-21}$$

In a financial portfolio-balance model, equilibrium is chieved when the desired stock demand for these assets equal their upplies. The price level and real income are assumed given. The quilibrium values of exchange and interest rates are determined imultaneously:

$$\frac{\bar{M}}{P} = m(r,r^*,Y)w \tag{6-22}$$

$$\frac{\bar{B}^p}{P} = b(r,r^*,Y)w \tag{6-23}$$

$$\frac{\bar{EF}}{P} = b^*(r, r^*, Y)w \tag{6-24}$$

The left-hand side of equations (6-22), (6-23) and (6-24) denotes stock supplies of real money balances, home bonds and foreign bonds respectively. By implication of the wealth definition (equation 6-17)) equilibrium condition for home cash balances is dropped, equation (6-22). Thus, equations (6-23, 24) determine r and E simultaneously. Yield on foreign bonds, r^*, is given by invoking a small country assumption.

As noted by Pearce (1983), the model is concerned with the allocation of the net wealth of all private home wealth holders. Thus, the monetary base rather than the supply of money enters into this model. This is true because demand deposits are the liabilities of commercial banks.

The outstanding stock supplies of financial assets are held constant in a time period. Thus, in the short run, exchange and interest rates move to equalize desired demand and stock supplies of these assets. However, through a positive net investment, government deficit spending, and current account imbalances, stocks of these assets change over time.

A money-financed deficit would increase the domestic monetary base and home wealth. In realigning their wealth, wealth holders would like to redistribute their wealth increase toward home and foreign bonds. The exchange rate goes up (home currency depreciates), while home interest rate drops. The foreign interest rate is assumed constant. A current account surplus would increase wealth and disturb portfolio selection. To readjust their portfolio, home wealth holders would like to realign their wealth toward home assets. Exchange rate declines (home currency appreciates) and home interest rate falls.

A bond financed deficit would increase the outstanding supply of home bonds and thus private citizens wealth. This government policy has two offsetting impact on exchange rate. On the one hand, wealth holders realign their wealth in favor of foreign assets. This would lead to an increase in the exchange rate (depreciation of home currency). At the same time, a bond financed deficit increases home interest rate and thus makes foreign assets less appealing. Thus, the outcome of a bond financed deficit on exchange rate is ambiguous and depends on whether the wealth effect or the substitution effect is dominant.

This finishes the survey of different models of exchange-rate determination. Traditional flow models gave their way to asset models. This was mainly due to a stronger forecasting capability of the latter models. Both Murphy and Duyne (1980) and Pearce (1983) indicate the superiority of portfolio-balance model in explaining exchange-rate behavior. Monetary models can be considered a special case of portfolio-balance models where financial assets are perfect substitutes and the wealth effect is ruled out. At the same time, portfolio-balance models includes elements of flow models by allowing current account imbalances to affect wealth and hence exchange and interest rates.

CHAPTER 6--Footnotes

[1]Pearce (1983), p. 16.

[2]For a comprehensive and authoritative survey on theories of exchange-rate determination see Whitman (1975), Dornbusch (1980), Murphy and Duyne (1980), and Pearce (1983).

[3]For more detail see Grubel (1981) Chapter 14; Vanek (1962), p. 56-65; Kreinin (1983); G. Orcut (1968); and Yeager (1976), Chapters 8, 10-11.

[4]For critic of the elasticities approach, see Yeager (1976), p. 172-178.

[5]For further detail see Meade (1951); Johnson (1958); Mundell (1968); and Willett and Forte (1969).

[6]There has been a major empirical concern about the validity of PPPT in the short run. For further detail on this matter see Kohlhagen (1978).

[7]Lindbeck, A. Scand. J. Ec., 1976, Vol. 78, No. 2

[8]Private citizens are not holding other countries' currencies.

CHAPTER 7

Theories of Exchange-Rate and Real Income Determination

My objective in this chapter is to construct a real and financial model of income and exchange-rate determination. This model is based on equilibrium conditions in both goods and financial markets. In the previous chapter both the traditional flow and asset market models of exchange-rate determination were explored. It was shown that real economic variables (i.e., real income) were the major factors in explaining exchange-rate behavior in flow models. In the asset market models, monetary and portfolio-selection considerations mainly explained exchange-rate movements. The portfolio-balance model of asset market models emerged as a theory capable of explaining exchange-rate changes. This model includes some elements of the traditional flow market models, by allowing current account imbalances to change wealth and hence interest rates and exchange rates.

In this chapter, in contrast to a restricted financial portfolio-balance model of the exchange rate, real income is assumed to be an endogenous variable.[1] Its equilibrium value is determined when the demand for and supply of goods and services are equal (i.e., IS curve). In Chapter three I discussed and developed equilibrium conditions for the goods market in a closed economy. In this introduction, the equilibrium condition for the goods market is extended to an open economy.

Then, the goods market clearing condition, in conjunction with the portfolio-selection equilibria condition (developed in Chapter six), will be used to construct an income and exchange-rate determination model.

To derive conclusive results about exchange-rate behavior I explore in section two a simplified version of this model. The equilibrium solution, stability conditions, and comparative statics of the (simplified) model are presented in section three. Extended versions of this model will be discussed in the next chapter. Links between exchange rate and real income on the one hand and expectations, inflation, and growth (dynamic), on the other hand will be discussed in section four, five, and six respectively.

Ia. Goods Market

This section presents a general examination of the goods market. In Chapter three I presented my version of income determination in a Keynesian framework. Here, I extend this model to the open economy.

Real disposable income in the goods market is given as:

$$C + S = Y_d = Y - T + R + r\ (B^P/P) + Er^*\ (F^P/P) \qquad (7\text{-}1)$$

where

C = real consumption expenditure

S = real saving

Y_d = real disposable income

Y = real income

$T = tY$ = government revenue as a function of real income

R = government transfer payments

r = interest rate on home bonds

$r(B^P/P)$ = real interest payment received on home bonds held by home private wealth holders

$Er^*(F^p/P)$ = interest payments (real) received on foreign bonds held by home wealth holders in home currency.

r^* = interest rate on foreign bonds

E = exchange rate, home currency price of foreign currency

Furthermore, the equilibrium condition for the goods market is:

$$Y = C + I + G + X \tag{7-2}$$

where

I = real investment expenditure

G = real government expenditure

X = real net export expenditure

We know that saving is:

$$S = sY_d - f \qquad f > 0 \tag{7-3}$$

and consumption is:

$$C = Y_d - S = Y_d - sY_d + f = f + cY_d \tag{7-4}$$

where

s = marginal propensity to save

c = marginal propensity to consume

f = autonomous consumption

The investment function, I, is the modified version of the sigmoid-shape investment function developed in Chapter two:

$$I = (q/(1+de^{-vY})) - mK - nr \tag{7-5}$$

n, q, m, d, and v are parameters.

Replacing Y_d in equation (7-4) from equation (7-1) I get a consumption function:

$$C = f + c\cdot[Y + R - T + r\ (B^p/P) + Er^*\cdot(F^p/P)] \tag{7-6}$$

Replacing C from equation (7-6) and I from equation (7-5) in equation (7-2) I get the IS curve for an open economy:

$$Y = f + c\cdot[Y + R - T + r\,(B^P/P) + Er^{*}\cdot(F^P/P)] + (q/(1 + de^{-vY})) - mk - nr + G + X \qquad (7\text{-}7)$$

Net exports, X, are a function of both real income and the exchange rate:

$$X = x(Y,E) \qquad x_Y < 0, \qquad x_E > 0 \qquad (7\text{-}8)$$

The equilibrium condition for the goods market in an open economy may be rewritten as:

$$(n - c(B^P/P))r = (q/(1 + de^{-vY})) - (1 - c\,(1 - t))\,Y - mK + G + x(Y,E) + f + cR + cEr^{*}\,(F^P/P) \qquad (7\text{-}9)$$

where tax revenue, T, is a simple proportional function of real income, T = tY.

The equilibrium condition for the goods market in the open economy version, equation (7-9), can be graphically represented in a 3-dimensional diagram. Real income, Y, real interest rate, r, (with given prices), and exchange rate, E, all are depicted by this equilibrium surface. However, for the sake of simplicity, I take a cross section of this equilibrium surface, once with respect to r and Y, and once with respect to E and Y. This leads us to the goods market equilibrium condition (i.e., IS curve) in r-Y and E-Y planes which will be examined.

First, I totally differentiate equation (7-9):

$$(n - c(B^P/P))dr - (rc/P)db^P = ((qdve^{-vY}) \,/\, (1 + de^{-vY})^2 - (1 - c\,(1 - t)) + x_Y)dy + x_E dE + (cr^{*}F^P/P)\cdot dE + (cEr^{*}/P)dF^P + dG \qquad (7\text{-}10)$$

The slope of the IS curve in a r-Y plane is:

$$(\partial r/\partial Y)\big|_{IS} = ((qdve^{-vY})/(1 + de^{-vY})^2 - (1 - c(1 - t)) + x_Y) \;/\; (n - c(B^P/P)) \qquad (7\text{-}11)$$

The slope of the same IS curve in an E-Y plane is:

$$(\partial E/\partial Y)\big|_{IS} = -((qdve^{-vY})/(1 + de^{-vY})^2 - (1 - c\;(1 - tY)) + x_Y) \;/\; (x_E + cr^{*}\;(F^P/P)) \qquad (7\text{-}12)$$

The term, $(n - c(B^P/P))$, of the denominator in equation (7-11), is constant and positive. Therefore, the sign of the slope $(\partial r/\partial Y)_{IS}$ depends on the sign of nominator and is denoted by Z:[2]

$$Z = (qdve^{-vY}) \;/\; (1 + de^{-vY})^2 - (1 - c(1 - t) + x_Y \qquad (7\text{-}13)$$

Chapter three examined both mathematically and graphically, the characteristics of Z in equation (7-13).

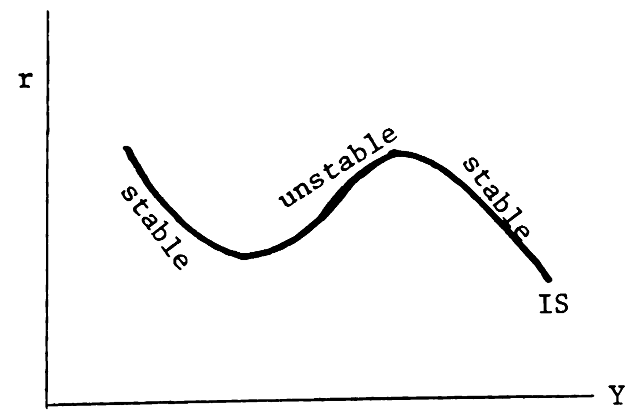

Figure 7-1

In a r-Y plane, Figure 7-1, the goods market equilibrium curve, IS, shows combination of interest rates (on home bonds) and levels of income for which the goods market clear, holding everything else particularly exchange rate constant. The (conventional) downward sloping sections of this IS curve represent locus of stable equilibria. But the upward (unconventional) sloping section of the IS curve (Figure 7-1) is a locus of unstable equilibria. The upward sloping section of the IS curve is quite plausible if investment, I(r,Y,K), is sufficiently sponsible to increases in income. A rapid expansion of income could ad to a surge in S+T-R level much higher than the initial increase in G+X. To restore equilibrium in the goods market and between G+I+X d S+T-R, we need an increase in home interest rate, r, to cushion the rge of income.

In an E-Y plane, Figure 7-2, the goods market equilibrium nedule, IS curve, shows the locus of the exchange rate and levels of come for which the goods market clears, holding everything else articularly the interest rate) constant. However, the relationship tween the exchange rate, E, d real income, Y, needs some aboration. For a conven- nal IS curve, as E in- eases (i.e., home currency preciates) so does the nand for goods (through net ports). To restore equilib-

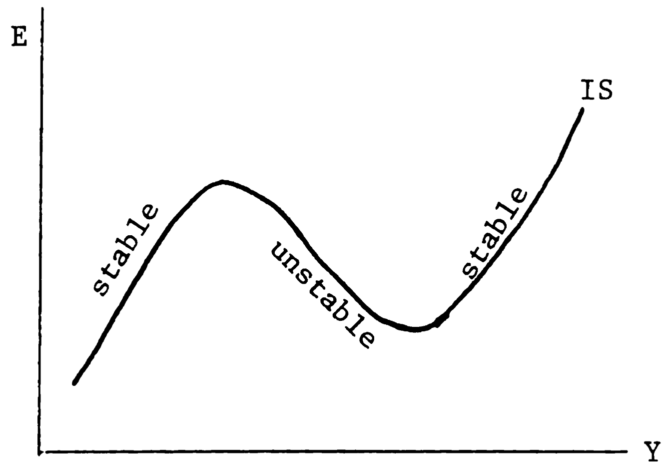

Figure 7-2

um in the goods market, a rise in real income, and thus imports, is uired. This is clearly shown by the upward sloping sections of the curve in Figure 7-2.

The downward (unconventional) sloping sections of the IS curve, ure 7-2, is a locus of unstable equilibria. The downward sloping tion of the IS curve is quite plausible if investment, I(r,Y,K), is ficiently responsive to increases in real income. A rapid expansion income could lead to a surge in S+T-R level much higher than the tial increase in I+G+X. To restore equilibrium in the goods market between G+I+X and S+T-R, there must be a decrease in exchange rate

., home currency appreciates) to cushion the surge of income.

Mathematically the slope of IS curve in E-Y plane is a nega- multiplication of the same IS curve in r-Y plane (equations 7-11 7-12). Thus, for the same level of real income, while the IS e is an increasing function of real income in r-Y plane, it also decreasing function of Y in E-Y plane, Figures 7-1 and 7-2.

A Model of Real Income and
Exchange-Rate Determination

In this section, I summon up the theoretical building blocks loped in section IIIc of Chapter six and section one of this chapter.

A portfolio-selection equilibrium requires that home stock nds for home real balances, home and foreign bonds be equal to r stock supplies, equations (6-22, 23, and 24). At the same time ibrium in the goods market requires that the supply of goods be l to their demand, equation (7-9). Thus, I have a total of four ets in this model. They are rewritten as:

$$(M/P) = m(r,r^*,Y)w \quad (7\text{-}14)$$

$$(B^p/P) = b(r,r^*,Y)w \quad (7\text{-}15)$$

$$(EF^p/P) = b^*(r,r^*,Y)w \quad (7\text{-}16)$$

ASSETS MARKETS (7-14)–(7-16)

$$(n-c(B^p/P))r = (q/(1+de^{-vY})) - (1-c(1-t))Y - mK + G + x(Y,E) + cR + f + cEr^*(F^p/P) \quad (7\text{-}9)$$

GOODS MARKET

erscript "p" above B (F) denotes stock supply of home (foreign) denominated in home (foreign) currency and held by home private ens.

Equilibrium in any two of the asset markets (stocks) insures ibrium in the third asset market. However, equilibrium in the three asset (stock) markets does not guarantee equilibrium in the flow, goods market.[2] By implication of the wealth definition, equation (6-17), I drop the equilibrium condition for home real balances market, equation (7-14). Thus, I rewrite the model as:

$$(B^p/P) = b(r,r^*,Y)w \tag{7-15}$$

$$(EF^p/P) = b^*(r,r^*,Y)w \tag{7-16}$$

$$(n-c(B^p/P)) = (q/(1+de^{-vY})) - (1-c(1-t))Y - mk + G + x(Y,E) + cR + f + cEr^*(F^p/P) \tag{7-9}$$

The above set of equations determined the equilibrium values of the rates of return on home bonds, r, exchange rate, E, and real income, Y, respectively and simultaneously. The policy determined variables are the stock supplies of real money balances, M/P; home and foreign bonds held by central bank, B^c/P and F^c/P. Where superscript "c" denote central bank's holding of a variable.

II. Exchange-Rate Behavior and Perfect Substitution

To derive conclusive results about exchange-rate behavior, this section explores a simplified version of the former model (i.e., equations 7-15, 7-16, and 7-9). The simplifying assumption will be relaxed in the next chapter.

In this chapter, I assume that home and foreign bonds are perfect substitutes. Therefore, in the financial markets, home citizens face the choice between two assets: money and bonds. The demands depend on rates of return, income, and wealth:

$$(M/P)^d = h(r,r^*,Y)w \tag{7-17}$$

$$(\tilde{B}^p/P)^d = g(r,r^*,Y)^w \tag{7-18}$$

where $(\tilde{B}^p/P)$ denotes home citizens desired demand for home and foreign bonds. Due to perfect substitution assumption, the domestic interest rate, r, equals the given world rate of interest, r^*:[3]

$$r = r^* = \text{constant} \qquad (7\text{-}19)$$

Real wealth, w, equals real money balances, M/P, and financial assets (bonds), $\tilde{B}^p/P$:

$$w = (M + \tilde{B}^p)/P \qquad (7\text{-}20a)$$

where

$$(\tilde{B}^p/P) = (B^p + EF^p)/P \qquad (7\text{-}20b)$$

I next turn to the real sector of the model, to examine the market clearing condition for goods. In section Ia of this chapter, I examined this issue. Thus, the market equilibrium condition for the goods market is rewritten as:

$$(n-c(B^p/P))r = (q/(1+de^{-vY})) - (1-c(1-t))Y - mK + G + cR + x(Y,E) + f + cEr^*(F^p/P) \qquad (7\text{-}21)$$

III. Equilibrium Solution

With home price level, P, given, equilibrium in the asset market requires that the existing stock of financial assets be equal to their respective stock demands. By the implication of the wealth constraint (equation 7-20a), I dropped the market clearing condition for real money balances in the previous section. Thus, equilibrium in this model requires equilibrium in bonds and goods markets. These conditions are rewritten as:

$$g(r,r^*,Y)w = (B^P + EF^P)/P \qquad \underline{\tilde{B}B \text{ curve}} \qquad (7\text{-}22)$$

$$(n-c(B^P/P))r = (q/(1+de^{-vY})) - (1-c(1-t))Y - mK + G + x(Y,E) + cR + f + cEr^*(F^P/P) \qquad (7\text{-}23)$$

market clearing conditions, equations (7-22) and (7-23), determine librium values of E and Y simultaneously, given the price level, th, and interest rate.

The market clearing condition for the bonds market, equation), indicates a positive relationship between real income (Y) and exchange rate (E). Stock demand for bonds increases when real in- rises. To restore equilibrium in the bond market, exchange rate d rise and thus increase the supply of bonds values in home currency B^P+EF^P), Figure (7-3). Mathematically, this relationship can be ined by totally differentiating equation (7-22):

$$wg_Y dY + gdw = (1/P)(dB^P + EdF^P + F^P dE) \qquad (7\text{-}24a)$$

eplacing for change in wealth, I find:

$$(F^P/P)(1-g)dE = wg_Y dY + (g/P)dM-(1-g)(1/P)dB^P - E(1-g)(1/P)dF^P$$

$$dE = (wg_Y)/(1-g)(F^P/P)dY + (1/(1-g)(F^P/P))((g/P)dM - (1-g)(1/P)dB^P - E(1-g)(1/P)dF^P) \qquad (724b)$$

slope of $\tilde{B}B$ curve is given as:

$$(\partial E/\partial Y) = (wg_Y)/(1-g)(F^P/P) > 0 \qquad (7\text{-}25)$$

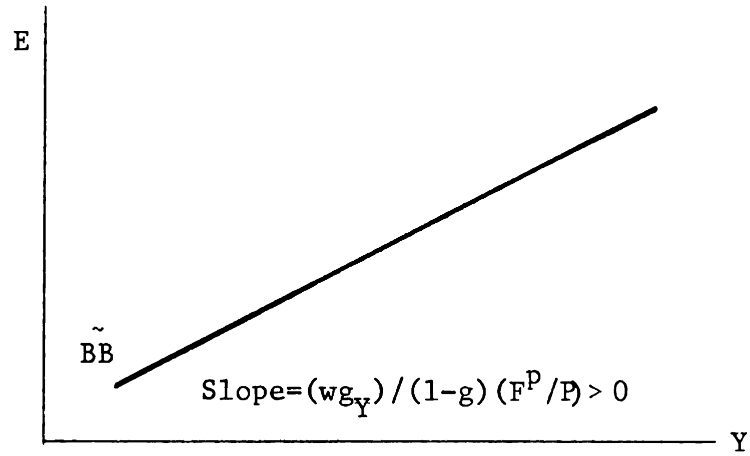

Figure 7-3

The goods market equilibrium curve, equation (7-23), which was examined in section one of this chapter, is illustrated in Figure 7-4.

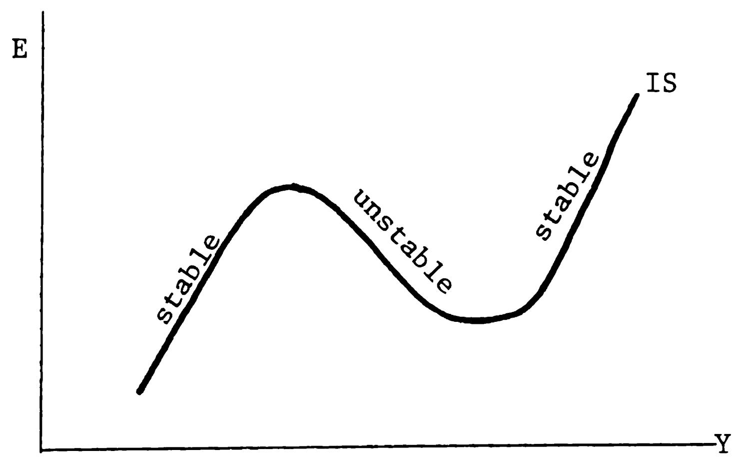

Figure 7-4

Since home interest rate is assumed constant, examination of the model will be continued in an EY plane in the rest of this chapter. To examine stability of equilibrium, a disequilibrium behavior model for exchange rate and real income is given as:

$$\dot{E} = \alpha[g(r,r^*,Y)w - (B^p/P) - (EF^p/P)],\ \alpha>0 \tag{7-26a}$$

$$\dot{Y} = \beta[c(Y-tY + R + r(B^p/P) + Er^*(F^p/P)) + I(Y,r,K) + G + x(Y,E) - Y],\ \beta>0 \tag{7-26b}$$

where α and β are adjustment coefficients. Equation (7-26a) indicates that the rate of change in exchange rate is proportionally related to excess demand for bonds. There are two sources for the supply of bonds (i.e., home and foreign bonds). One is a government bond-financed deficit which leads to an increase in stock supply of outstanding home bonds. The second source is a current account surplus which increases home supply of foreign bonds. If the excess demand for bonds (in equation (7-26a)) is not met by either sources, then private wealth holders will realign their portfolio by supplying their real money balances for bonds in foreign exchange market. Home currency depreciates and E rises.

Equation (7-26b) is an excess demand equation for goods. The basic underlying premise for this equation is the producers response to unexpected inventory changes. As the firms find their inventories are decreasing, because demand exceeds their production, they increase their output to meet the demand for goods.

A linearized version of (7-26), in the neighborhood of equilibrium is given as:

$$\begin{pmatrix} \dot{E} \\ \dot{Y} \end{pmatrix} = \begin{bmatrix} -\alpha(F^P/P)(1-g) & g_Y w \\ \beta(x_E + cr^*)(F^P/P) & (c(1-t) + (qdve^{-vY})/(1+de^{-vY})2 - 1) + x_Y \end{bmatrix} \begin{pmatrix} E-\bar{E} \\ Y-\bar{Y} \end{pmatrix} \quad (7\text{-}27)$$

where $\bar{E}$ and $\bar{Y}$ are equilibrium values for E and Y. Change in real wealth is substituted from equations (7-20).

The necessary and sufficient conditions for the stability of the system requires that trace of the coefficient matrix J, on the right hand-side of (7-27) be negative and its determinant positive.[4]

$$J = [j_{ij}] = \begin{pmatrix} \alpha & 0 \\ 0 & \beta \end{pmatrix} \begin{bmatrix} -(F_P/P)(1-g) & g_Y w \\ (x_E + cr^*(F^P/P) & (qdve^{-vY})/(1-de^{-vY})^2 - (1-c(1-t)) + x_Y \end{bmatrix}$$

The trace and determinant of J are:

$$\text{Trace}(J) = -\alpha(F^P/P) + \beta[(qdve^{-vY})/(1+de^{-vY})^2 -$$

$$(1-c(1-t) + X_Y] \qquad (7\text{-}28a)$$

$$\det(J) = \alpha\beta[-(F^P/P)((qdve^{-vY})/(1+de^{-vY})^2 -$$

$$(1-c(1-t)) + x_Y - (x_E + (cr^* F^P)/P)g_Y w] \qquad (7\text{-}28b)$$

The (2,2) element of matrix J, $(qdve^{-vY})/(1+de^{-VY})^2-(1-c(1-t)+x_Y=Z$ determines the slope sign of the IS curve. This was examined in section one of this chapter, equations (7-11, 7-12, and 7-13). For the IS curve to slope upward, $(\partial E/\partial Y)|_{IS} > 0$, Z must be negative. Otherwise, IS curve slopes downward, $(\partial E/\partial Y)|_{IS} < 0$.

Therefore, along the upward sloping sections of the IS curve, where $(\partial E/\partial Y)|_{IS}$ is positive and $Z=(qdve^{-vY})/(1+de^{-VY})^2-(1-c(1-t))+x_Y$ is negative, trace(J) is negative. To meet the sufficient condition for stability, it is required that det(J) should be positive. In other words:

$\det(J) > 0$ if:

$$\det(J) = -(F^P/P)Z - g_Y w(x_E + cr^*(F^P/P)) > 0 \qquad (7\text{-}29a)$$

where

$$Z = (qdve^{-vY})/(1+de^{-vY})^2 - (1-c(1-t)) + x_Y$$

or

$$-(Z)/(x_E + cr^*(F^P/P) > (wg_Y)/(F^P/P) \qquad (7\text{-}29b)$$

The left-hand side of inequality (7-29b) is the slope of IS curve, $(\partial E/\partial Y)|_{IS}$, equation (7-12). The right-hand side of inequaity (7-29b)

is the slope of bond market equilibrium condition, equation (7-25).

Thus, I conclude that both necessary and sufficient conditions are met when our IS curve intersects $\tilde{BB}$ curve (i.e., bond market) from below, Figure 7-5.

By considering the downward sloping section of the IS curve, I realize that the trace(J) $\lessgtr 0$, while the det(J)<0, so the system is unstable.

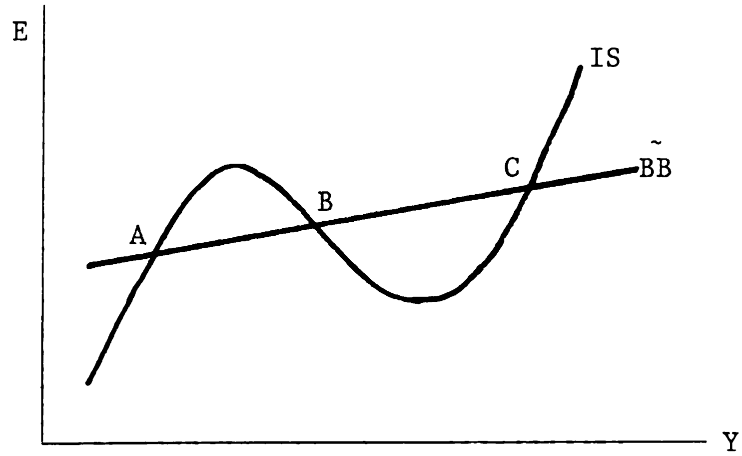

Figure 7-5

Comparative Statics

To examine comparative statics, total differentiation of equations (7-22) and (7-23) provides:

$$wg_Y dY + gdw = (dB^P + EdF^P + F^P dE)/P \tag{7-30a}$$

$$((-crdB^P)/P) = ((qdve^{-vY})/(1+de^{-vT})^2 - (1-c(1-t)) + x_Y)dY + dG + x_E dE + cr^*(F^P/P)dE + cr^*E(dF^P/P) \tag{7-30b}$$

where the change in wealth is substituted from equations (7-20). In equations (7-30), the change in the home country's rate of interest is zero, by invoking the small country assumption. In the set of equations (7-30) the term $dB-dB^C$ $(dF-dF^C)$ can be substituted for its equivalent values $dB^P(dF^P)$. The set of equations (7-30) could be rewritten in a matrix format:

$$[a_{ij}]\begin{pmatrix} dE \\ dY \end{pmatrix} = \left[b_{ij}\right]\begin{pmatrix} dM \\ dB^c \\ dF^c \\ dG \end{pmatrix} \qquad (731a)$$

where

$$A = [a_{ij}] = \begin{bmatrix} -(F^p/P)(1-g) & g_Y w \\ (x_E + cr*(F^p/P) & Z \end{bmatrix}$$

$$B = [b_{ij}] = \begin{bmatrix} -(g/P) & -((1-g)/P) & -E(1-g)/P & 0 \\ 0 & cr/P & cEr^*/P & -1 \end{bmatrix}$$

The determinant of matrix A is written as:

$$\det(A) = Z(F^p/P)(1-g) - g_Y w(x_E + cr^*(F^p/P)) \qquad (7\text{-}31b)$$

Along the downward sloping section of the IS curve (i.e., when $Z > 0 \Longrightarrow (\partial E/\partial Y)|_{IS} < 0$), $\det(A) < 0$. But along the (conventional) upward sloping IS curve (i.e., $Z<0$, $\Longrightarrow (\partial E/\partial Y)|_{is} > 0$), we have the following circumstances for the determinant of matrix A.

$$\det(A) > 0 \text{ if } |Z(F^p/P)(1-g)| > |g_Y w(x_E + cr^*(F^p/P)|$$

$$\det(A) < 0 \text{ if } |Z(F^p/P)(1-g)| < |g_Y w(x_E + cr^*(F^p/P)|$$

these are the same conditions that I derived and discussed for stability conditions.

The sign pattern of $\partial Y/\partial M$, $\partial Y/\partial B^c$, $\partial Y/\partial F^c$, $\partial Y/\partial G$, $\partial E/\partial M$, $\partial E/\partial B^c$, $\partial E/\partial F^c$, and $\partial E/\partial G$ is given by the following partial derivatives and table one.

$$(\partial Y/\partial M) = (1/\det(A)) \begin{vmatrix} -(F^P/P)(1-g) & -(g/P) \\ x_E+cr^*(F^P/P) & 0 \end{vmatrix} = (+)/(\det(A))$$

$$(\partial Y/\partial B^c) = (1/\det(A)) \begin{vmatrix} -(F^P/P)(1-g) & -(1/P) \\ x_E+cr^*(F^P/P) & cr/P \end{vmatrix} =$$

$$(1/\det(A))(1/P)(-cr(F^P/P) + g(F^P/P)(cr/P) +$$

$$x_E+cr^*(F^P/P)) = (1/\det(A))(1/P)(x_E+gcr(F^P/P) =$$

$$(+)/(\det(A))$$

$cr(F^P/P)$ and $cr^*(F^P/P)$ are cancelled out because r and r^* are equal (and fixed) in this model (i.e., due to perfect substitution between home and foreign bonds).

$$(\partial Y/\partial F^c) = (1/\det(A)) \begin{vmatrix} -(F^P/P)(1-g) & -E/P \\ x_E+cr^*(F^P/P) & cEr^*/P \end{vmatrix} =$$

$$(1/\det(A))(E/P)(-cr^*(F^P/P) + gcr^*(E/P)(F^P/P +$$

$$x_E+cr^*(F^P/P) = (1/\det(A))(x_E E/P+gcr^*(E/P)(F^P/P)) =$$

$$(+)/(\det(A))$$

$$(\partial Y/\partial G)=(1/\det(A)) \begin{vmatrix} -(F^P/P)(1-g) & 0 \\ x_E-cr^*(F^P/P) & -1 \end{vmatrix} = (+)/(\det(A))$$

$$(\partial E/\partial M)=(1/\det(A)) \begin{vmatrix} -(g/P) & g_Y w \\ 0 & Z \end{vmatrix} = (1/\det(A))(-Zg/P)$$

$$(\partial E/\partial B^c)=(1/\det(A)) \begin{vmatrix} -(1/P)(1-g) & g_Y w \\ cr/P & Z \end{vmatrix} =$$

$$(1/\det(A))(-Z/P)(1-g)-crwg_Y P = (?)/(\det(A))$$

To find the sign of nominator for the above partial derivative, $\partial E/\partial B^{c}$, two cases should be examined (a) determinant of A is positive, (b) determinant of A is negative.

If det(A) > 0, I know from (7-29b) that:

$$-Z > (1/(F^{p}/P)(1-g))(g_{Y}w(x_{E}+cr^{*}(F^{p}/P)))$$

or

$$Z < -g_{Y}wcr^{*}-((g_{Y}w)(x_{E}+cr^{*}g(F^{p}/P))/(F^{p}/P))$$

or

$$Z+g_{Y}wcr^{*} < -(1/(F^{p}/P))(g_{Y}w(x_{E}+cr^{*}g(F^{p}/P)))$$

Since $g_{Y}wx_{E}/(F^{p}/P) > 0$ then I can write:

$$Z+g_{Y}wcr^{*} < 0$$

Thus, as long as det(A) > 0 partial derivative, $\partial E/\partial B^{c}$, has a positive sign for its nominator:

$$\partial E/\partial B^{c} = (+)/\det(A) \qquad (7\text{-}32a)$$

However, if det(A) < 0 (i.e., when the system is unstable) then the sign of the denominator of partial derivative $\partial E/\partial B^{c}$ can be either negative or positive.

If det(A) < 0, then

$$-Z < (1/(F^{p}/P)(1-g)(g_{Y}w(x_{E}+cr^{*}(F^{p}/P)))$$

or

$$Z > -g_{Y}wcr^{*}-(1/(F^{p}/P))(g_{Y}w(x_{E}+cr^{*}g(F^{p}/P)))$$

or

$$Z+g_Y wcr^* > -(1/(F^P/P))(g_Y w(x_E+cr^* g(F^P/P)))$$

$$(\partial E/\partial F^C)=(1/\det(A)) \begin{vmatrix} -E/P & wg_Y \\ cEr^*/P & Z \end{vmatrix} =$$

$$(1/\det(A))(-E/P)(Z+g_Y cr^* w) = (?)/\det(A)$$

The only difference between the sign of $\partial E/\partial F^C$ and $\partial E/\partial B^C$ is that the former is multiplied by a positive term (i.e., E/P). Thus, as far as the sign of $\partial E/\partial F^C$ is concerned, the argument made for the partial derivative $\partial E/\partial B^C$ is applicable to partial derivative $\partial E/\partial F^C$.

Thus, when $\det(A) > 0$ and the system is stable, I have:

$$(\partial E/\partial F^C) = (+)/\det(A) \qquad (7\text{-}32b)$$

But when $\det(A) < 0$ and the system is unstable, I have:

$$(\partial E/\partial F^C) = (?)/\det(A)$$

For the partial derivative $\partial E/\partial G$, I have:

$$(\partial E/\partial G)=(1/\det(A)) \begin{vmatrix} 0 & wg_Y \\ -1 & Z \end{vmatrix} = (+)/\det(A)$$

The result of monetary and open market purchase of bonds ($+dB^C$=dM or EdF^C=dM) and expenditure generating policies are recorded in Table one.[5] This table depicts all possible influences (sign patterns) on equilibrium values of real income and exchange rate as a result of government financial policies when the system is stable. Rows two and three describe the system in unstable positions.

TABLE 1

EFFECTS OF MONETARY, OPEN MARKET OPERATIONS, AND BUDGETARY POLICIES ON REAL INCOME AND EXCHANGE RATE IN A SHORT-RUN MODEL

			M	B^c	F^c	G	
:) $Z<0 \Longrightarrow (\partial E/\partial Y)\|_{IS} > 0$	det(A) > 0	Y	+	+	+	+	1
		E	+	+	+	+	
	det(A) < 0	Y	-	-	-	-	2
		E	-	±	±	-	
:I) $Z>0 \Longrightarrow (\partial E/\partial Y)\|_{IS}<0$ & det(A) < 0		Y	-	-	-	-	3
		E	-	±	±	-	

$-dB^D=dB^c=dM$ or $-EdF^P=EdF^c=dM$

At this stage, to supplement the comparative static analysis depicted by table one), I apply some geometrical tools.

quilibrium Behavior of Exchange Rate

Short run equilibrium solution of this model is indicated in igures 7-5 and 7-6. There exist a multiple equilibria, A, B, and C. hile the model is unstable at equilibrium point B (i.e., trace(J)$\lessgtr$ 0, et(J)<0), it could be stable either at equilibrium point A or C depends on the initial conditions of the system).

Central bank intervention in the foreign exchange market and pen market operations in the domestic bond market have the same impact in this model as long as the perfect substitution assumption is eld.[6]

Let suppose that he economy is initially t equilibrium point A. n open market purchase f bonds shifts the $\tilde{BB}$ urve upward.

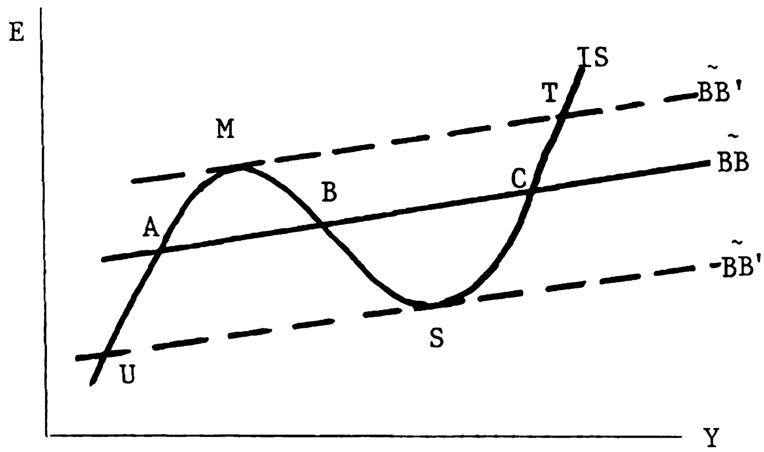

Figure 7-6

ome and exchange rate ise. An expansionary iscal policy leads to a downward shifting of the IS curve, equation 7-30b). Equilibrium values of both real income and exchange rate ise. These results confirm our conclusions derived in the first ow of table one.

We have a clear case of fold catastrophe in this model. xpansionary monetary policies (open market purchase of bonds) shift he $\tilde{BB}$ curve upward in Figure 7-6. If the central bank pursues this olicy beyond the level indicated by the $\tilde{BB}'$, the economy would uddenly experience a discontinuous shift from point M to point T in igures 7-6 and 7-7. urther expansionary onetary policy implies smooth transition of he economy on the IS urve from point T.

However, suppose he economy was initial- y at equilibrium point

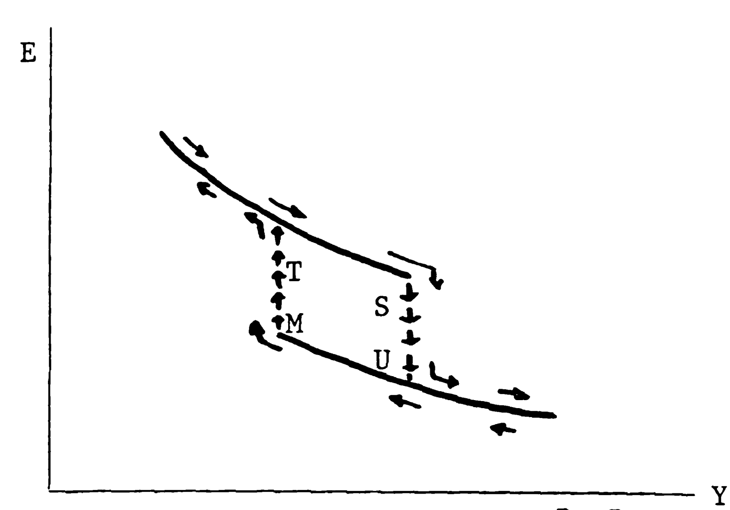

Figure 7-7 $B^P = B^P + EF^P$

C (in Figure 7-6). If central bank conduct an open market sale of bonds, the B̃B curve could shift down. The economy slides smoothly down along the IS curve until it reaches point S. Further conduct of contractionary monetary policy shifts the system from point S to point U in Figure 7-6.

Figure 7-7 shows exchange rate behavior as a result of central bank's monetary policies. The impact of government budgetary policies is depicted by Figure 7-8.

A deficit spending financed by issuing new bonds implies a downward shift of both IS and B̃B curves. The exchange rate declines (home currency appreciates). The direction of change in real income is ambigous. Real income may either increase or decrease. It depends on whether IS curve shifts down more than B̃B curve or not, and whether the economy is on the stable or unstable part of the IS curve, Figure 7-9. As supplies of bonds rise, wealth holders realign their increase in their wealth toward home real balances away from home and foreign bonds. Demand for home currency rises. This

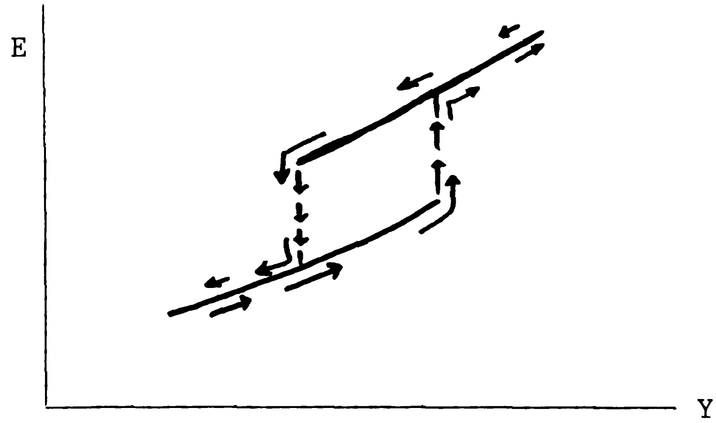

Figure 7-8

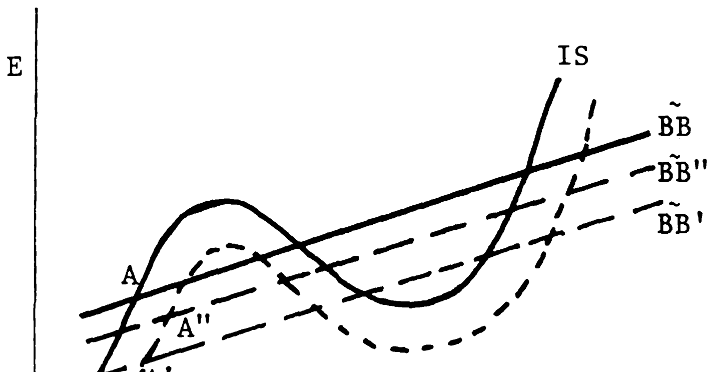

Figure 7-9

leads to an appreciation of home currency (i.e., E declines).

A deficit spending leads through the multiplier, to an expansion in the level of real income. However, if deficit is financed by issuing new bonds, the expansionary impact of increases in government spending is crowded out by contractionary effects of selling new bonds and the reduction in real balances. In this case, the expansionary effect of deficit would be exactly offset by contractionary effect of bond financing, Figure 7-9 (i.e., economy moves from point A to point A'). However, if $\widetilde{BB}$ curve shifts down proportionally less than IS curve (i.e., to $\widetilde{BB}''$) the real income will rise (i.e., point A").

At this stage I would like to examine the status of the home and world interest rate in my model. In section I of this chapter, I treated the home interest rate as an endogenous variable. However, beginning with section II, I assumed that home and foreign bonds are perfect substitution. This assumption leads to the interest parity condition and the equality of home and foreign interest rates. I further assumed that world interest rates are given. Thus, a major underlying assumption through out this chapter is the equality of home and a given world interest rate. Later in Chapter eight the interest parity condition will be dropped and the equilibrium values of home interest rates will be examined. In this part of the section, I shall examine the foreign repercusions of changes in foreign interest rate on the home economy.

To examine the effects of exogenous changes in foreign interest rate on the home economy, I totally differentiate equation (7-22) and (7-23). Previously in this chapter, I equalized the changes in home and foreign interest rates to zero. This was based

on the assumptions of interest parity condition and a given foreign interest rate. However, in the following, the changes in home and foreign interest rates are not equalized to zero, even though they are equal to each other (interest parity condition still hold). Therefore, with some rearrangement, I get:

$$wg_Y dY-(1-g)(F^P/P)dE = -(g/P)dM-((1-g)/P)dB^C - (E(1-g)/P)dF^C - w(g_r + g_r*)dr^*$$

Bond Market (7-30a)'

$$(n-c(B^P/P)-cE(F^P/P)dr^* + (cr/P)dB^C = ZdY+dG+(x_E+cr^*(F^P/P))dE - (cEr^*/P)dF^C$$

Goods Market (7-30b)'

An exogenous increase in the foreign interest rate, r^*, would shift the $\tilde{B}B$ curve up in Figure 7-6. Here, home private wealth holders demand for bonds increase as r^* rises. This increase in the stock demand for bonds causes an excess demand for bonds. Home private wealth holders, then, realign their portfolio composition in favor of home and foreign bonds. As a result, the exchange rate goes up as private citizens demand more foreign bonds. However, this rise in the exchange rate increases the supply of foreign bonds denominated in home currency. Thus, excess demand for bonds will be eliminated as E rises and the asset market is restored to its equilibrium.

The impact of a foreign interest rate increase on the goods market is ambiguous. An exogenous increase in the foreign interest rate influences the goods market by influencing consumption and investment

outlays. This is true, because, changes in foreign interest rates cause fluctuations in the home private wealth holders interest earnings on foreign bonds (and home bonds due to interest parity condition). This implies changes in real disposable income and hence induced changes in consumption expenditure.

An exogenous increase in foreign interest rate is likely to put a curb on investment expenditure at home. This is true, because, home and foreign interest rates are equal due to interest parity condition by assumption.

Therefore, an exogenous increase in foreign interest rate shifts the IS curve up as a result of expanding consumption outlays at home. However, the same exogenous increase in foreign interest rate shifts the IS curve down as a result of contracting investment outlays at home. The final outcome depends on the relative sensitivity of home consumption and investment expenditures to the exogenous changes in foreign interest rate. However, the consumption sector's responses tends to be relatively weak and offset by contracting investment sector. Therefore, the goods market contracts as a result of an exogenous rise in foreign interest rate, and the IS curve shifts up in Figure 7-6.

I, therefore, can conclude that an exogenous increase (decrease) in the foreign interest rate causes the exchange rate to rise (decline) in the home economy in this model. The real income effect of such changes, as it was explained before, is not clear. The economy contracts because of contracting investment sector. However, I should make this clear that the foreign sector (net exports) will expand as a result of depreciating home currency (i.e., E is rising).

IV. Exchange Rate and Rational Expectation

Through the application of perfect substitutability and capital mobility, I obtained interest rate (nominal and real with given prices) equality across countries, equation (7-19). However, private wealth holders will be indifferent between financial assets (bonds) denominated in different currencies if interest rate differential in favor of the home country is exactly offset by the expected rate of home currency depreciation, e.

$$r - r^{*} = e \qquad (7\text{-}33a)$$

or

$$r = r^{*} + e \qquad (7\text{-}33b)$$

where e denotes expected rate of home currency depreciation.

In this section, by invoking perfect foresight version of rational expectation, the expected rate of exchange-rate depreciation, e, is equalized to the actual rate of exchange-rate depreciation, $\dot{E}/E$.[7] However, Dornbusch (1976) argues that the actual rate of exchange rate depreciation is a function of exchange rate deviation from its steady state value:

$$(\dot{E}/E) = \theta(\bar{E} - E) \qquad (7\text{-}34)$$

A bar above a variable indicates its long run (steady state) value. By substituting equation (7-34) into equation (7-33b), I can rewrite the home interest rate as:

$$r = r^{*} + \theta(\bar{E} - E) \qquad (7\text{-}35)$$

To derive the market clearing condition for the bond market with exchange rate expectations, I substitute equation (7-35) into equation (7-22) and obtain the bond market clearing condition:

$$(1/P)(B^p+EF^p) = g(r^*+\theta(\bar{E}-E), r^*, Y)w \tag{7-36}$$

The long run equilibrium condition of the asset market is given by equation (7-37):

$$(B^p+\bar{E}F^p)/P = g(r^*, \bar{Y})w \tag{7-37}$$

By substituting equation (7-37) from equation (7-36), I get a general form for the market clearing condition over time:

$$(E-\bar{E})(F^p/P) = h(E-\bar{E}, Y-\bar{Y})w \tag{7-38}$$

To get (7-38), I linearize g in equation (7-36) as:

$$g = (\alpha r+\beta r^*+\lambda Y)w \tag{7-39a}$$

By substituting (7-35) into (7-39a), I get:

$$g = (\alpha(r^*+\theta(\bar{E}-E)+\beta r^*+\lambda Y)w \tag{7-39b}$$

Thus, a linearized asset market clearing condition is obtained by substituting (7-39b) into (7-36)

$$(B^p+EF^p)/P = ((\alpha+\beta)r^*+\theta(\bar{E}-E)+\lambda Y)w \tag{7-39c}$$

The linearized long run equilibrium condition of the asset market is given as:

$$(B^p+\bar{E}F^p)/P = ((\alpha+\beta)r^*+\lambda\bar{Y})w \tag{7-40}$$

The asset market clearing condition over time is derived by subtracting equation (7-40) from equation (7-40) from equation (7-39c):

$$(\alpha\theta(\bar{E}-E)-\lambda(\bar{Y}-Y))w = -(1/P)(\bar{E}-E)F^{P} \quad (7\text{-}41a)$$

or

$$(\alpha\theta w+(F^{P}/P))(E-\bar{E}) = w(Y-\bar{Y}) \quad (7\text{-}41b)$$

or

$$E = \bar{E} + ((\lambda w)/(\alpha\theta w+(F^{P}/P)))(Y-\bar{Y}) \quad (7\text{-}41c)$$

Goods market equilibrium is explained by equation (7-23). The structural foundations of the model and market conditions are not changed by introduction of exchange rate expectations. The equilibrium condition of this model can be presented as Figure 7-6.

An increase in the expected long run equilibrium values of exchange rate, $\bar{E}$, would lead to an upward shift of the $\tilde{BB}$ curve in Figure 7-6. Thus, the equilibrium values of exchange rate and real income would rise. Indeed, a surge in the expected long run equilibrium value of exchange rate will be reflected in the spot value of foreign exchange rate, in this model, as a result of rational expectation formation theorem. As the home currency depreciates and net exports rise, this leads to higher equilibrium levels of real income. An increase in the expected long run equilibrium values of real income, $\bar{Y}$, would lead to downward shifts of the $\tilde{BB}$ curve in Figure 7-6. An increase in $\bar{Y}$ reduces the real income deviation from its expected long run equilibrium values, $\bar{Y}$, and hence reduces the demand for bonds (home and foreign), equation (7-38). To restore equilibrium in the asset market and eliminate the excess supply in the bond

market, the exchange rate, E, should decline. Thus, home currency appreciates and net exports decline, and hence the equilibrium level of real income declines.

V. Exchange-Rate Behavior and Inflation

In this section, I relax the assumption of a fixed domestic price level. I bring inflation into the model.

To take inflation into account, the market clearing conditions for bonds market is modified as:

$$g(r-\pi,\ r^*-\pi^*, Y)w = (1/P)(B^P+EF^P) \qquad (7\text{-}42)$$

Equation (7-42) is an inflation ridden version of equation (7-22) where

π = expected overall rate of home inflation
π^* = expected overall rate of foreign inflation
P = overall home price level which is a weighted average of prices of home and foreign goods

The goods market equilibrium conditions, derived as equation (7-23), is also modified to consider inflation:

$$(n-c(B^P/P))(r-\pi) = q/(1+de^{-vY}) - (1-c(1-t))Y+G+x(Y,(EP^*/P_h)) \qquad (7\text{-}43)$$

All variables but P_h are defined. P_h denotes market prices of home produced goods.

Equation (7-42 and 7-43) comprise the structural equations of the model. However, this set of equations is supposed to determine equilibrium values of real income, exchange rate, and price level simultaneously. To complete the model a third equation (i.e., one

which specifies price structure) should be added to the set of equations (7-42 and 7-43). The following subsection (i.e., price structure) adopts and develops the necessary equation for home price level and inflation rate.

Price (Inflation) Structure

My starting point to develop an inflationary building block for our model is the following equation:

$$P_h = \alpha_o + \alpha_1(Y-\bar{Y}) + \alpha_2 W + \alpha_3 P^* \qquad (7\text{-}44)$$

$$\alpha_1 > 0, \qquad 0 \leq \alpha_2 \leq 1, \qquad 0 \leq \alpha_3 \leq 1, \qquad 0 \leq \alpha_2 + \alpha_3 \leq 1$$

where P^* denotes foreign produced goods price level. Equation (7-44) is a modification of mark up pricing models.[8] It has been used as the building blocks of many empirical studies explaining price determination in open economies.[9] In equation (7-44), Y is the actual level of output and $\bar{Y}$ is the full employment level of output. W is the home money wage which measures percentage change in unit labor costs in the absence of any change in labor productivity.

Equation (7-44) states that the price level of home produced goods is a function of income deviation from its steady level, costs (i.e., W), the price level of foreign produced goods (i.e., P^*). As P^* increases, home producers have more room to raise their price.

Turnovsky uses the following "extended Phillips curve" to explain home money wage inflation rate:

$$W = \beta_0 + \beta_1 U + \beta_2 \pi , \qquad \beta_1 < 0, \qquad 0 \leq \beta_2 \leq 1 \qquad (7\text{-}45)$$

where

U = rate of unemployment

π = expected overall rate of home inflation

Unemployment could be explained as

$$U = \lambda_0 + \lambda_1(Y-\bar{Y}) \tag{7-46}$$

I substitute (7-45 and 7-46) into equation (7-44) to get:

$$P_h = a_0+a_1(Y-\bar{Y})+a_2EP^*+a_3\pi \tag{7-47}$$

$$a_1 > 0, \quad 0 \leq a_2 \leq 1, \quad 0 \leq a_2+a_3 \leq 1$$

To relate home produced goods price level, P_h, to overall home price leve, P, Turnovsky (1977) assumes the following equation:

$$P = \Psi(P_h, EP^*) \tag{7-48}$$

This equation asserts that overall home price level, P, is a function (Ψ) of home produced goods price level, P_h, and price of foreign produced goods expressed in home currency, EP^*.

The Complete Model and Its Solution

In this subsection, I, first, put the whole model together:

$$g(r-\pi, r^*-\pi^*, Y)w = (B^p+EF^p)(1/P) \tag{7-49a}$$

$$(n-c(B^p/P))(r-\pi) = q/(1+de^{-vY}) -$$
$$(1-c(1-t))Y-mK+G+f+cR+x(Y,(EP^*/P_h)) +$$
$$cr^*E(F^p/P) \tag{7-49b}$$

$$P_h = a_0 + a_1(Y-\bar{Y}) + a_2EP^* + a_3\pi \qquad (7\text{-}47)$$

$$P = \Psi(P_h, EP^*) \qquad (7\text{-}48)$$

Equation (7-49a) is market clearing condition for bonds (i.e., equation 7-42).

Equation (7-49b) is the goods market equilibrium condition.

Net exports, X, is value of exports (EX) minus value of imports (IM):

$$im_Y > 0, \quad im_{(EP^*/P_h)} < 0, \; x_Y < 0, \quad x_{(EP^*/P_h)} > 0 \qquad (7\text{-}50)$$

At this point I continue the investigation of this model on two fronts. First, I take overall and home price levels (P, P_h) as exogenous variables. This would allow me to measure and explore real income and exchange rate responses to changes in inflation rates and price levels. Then, in the second approach, price levels are taken as endogenous variables as specified by equations (7-47) and (7-48).

Va. Exchange Rate and Inflationary Shocks

In this subsection, price levels are considered exogenous. I totally differentiate equations (7-42 and 7-43) respectively:

$$wg_\pi d\pi + wg_Y dY + gdw + (B^P + EF^P)(1/P^2)dP = (1/P)(dB^P + F^P dE + EdF^P) \qquad (7\text{-}51a)$$

$$[c(B^P/P^2)dP - (c/P)dB^P](r-\pi) - (n - c(B^P/P))d\pi =$$

$$[qdve^{-vY}/(1+de^{-vY})^2 - (1-c(1-t)) + x_Y]dY + dG + x_E\cdot(P^*/P_h)dE$$

$$+ x_{P_h}\cdot dP_h + cr^*(F^P/P)dE - (cEr^*/P^2)F^P dP + (cEr^*/P)dF^P$$

(7-51b)

or

$$wg_Y dY-(F^P/P)(1-g)dE = [(-B^P+EF^P+g(M+B^P+EF^P)/P^2-g]dP -$$

$$(g/P)dM+(1/P)(1-g)dB^P + (E/P(1-g)dF^P \qquad (7\text{-}52a)$$

where the change in wealth is substituted from equation (7-20).

$$[(qdve^{-vY})/(1+de^{-vY})^2 - (1-c(1-t)+x_Y]dY+[x_E(P^*/P_h) +$$

$$cr^*(F^P/P)]dE = (((cB^P/P^2)(r-\pi) - (n-(cB^P/P)) -$$

$$(Er^*c/P^2))dP-x_{P_h} dP_h - (c(r-\pi)/P)dB^P - (cEr^*/P)dF^P-dG$$

$$(7\text{-}52b)$$

The expected overall home rate of inflation, π, is considered as a function of overall home price level, P:

$$d\pi = \theta(P) \qquad (7\text{-}53)$$

θ could be a function which measures the deviation of the overall home price level, P, from its steady state value, an equation like (7-34). Thus:

$$d\pi = \theta_P dP \qquad \theta_P<0 \qquad (7\text{-}54)$$

In the above set of equations (7-52) the term $\theta_P dP$ is substituted for $d\pi$.

The solution for changes in exchange rate and real income is given as:

$$A\binom{dE}{dY} = B\begin{pmatrix} dP \\ dP_h \\ dM_c \\ dB_c \\ dF \end{pmatrix} \qquad (7\text{-}55)$$

where

$$A = \begin{bmatrix} -(F^P/P)(1-g) & g_Y w \\ x_E(P^*/P_h)+cr^*(F^P/P) & a_{22} \end{bmatrix} = \begin{bmatrix} - & + \\ + & \pm \end{bmatrix}$$

The jacobain matrix of this section is identical to the one derived in the previous sections.

$$B = \begin{bmatrix} -(g_\pi-(B^P+EF^P)/(P^2))+gw/P^2 & 0 & -g/P & 0 & -(1-g)/P & -(E/P)(1-g)/P \\ ((cB^P/P^2)(r-\pi)-(n-c(B^P/P)-(cEr^*/P^2)F^P) & -x_{P_h} & 0 & -1 & c(r-\pi)/P & cEr^*/P \end{bmatrix}$$

The element a_{22} determines the sign pattern of the slope of IS curve, derived in section Ia of this chapter (i.e., Z in equation 7-13).

The sign pattern of changes in exchange rate and real income with respect to financial and inflationary shocks are given by the following partial derivatives and table two.

$$(\partial Y/\partial P)=(1/\det(A))\begin{vmatrix} - & \pm \\ + & + \end{vmatrix}=(\pm)/\det(A)$$

$$(\partial Y/\partial P_h)=(1/\det(A))\begin{vmatrix} - & 0 \\ + & + \end{vmatrix}=(-)/\det(A)$$

$$(\partial Y/\partial M)=(1/\det(A))\begin{vmatrix} - & - \\ + & 0 \end{vmatrix}=(+)/\det(A)$$

$$(\partial Y/\partial B^c)=(1/\det(A))\begin{vmatrix} - & - \\ + & - \end{vmatrix}=(+)/\det(A)$$

$$(\partial Y/\partial F^c)=(1/\det(A))\begin{vmatrix} - & - \\ + & - \end{vmatrix}=(+)/\det(A)$$

$$(\partial Y/\partial G)=(1/\det(A))\begin{vmatrix} - & 0 \\ + & - \end{vmatrix}=(+)/\det(A)$$

$$(\partial E/\partial P)=(1/\det(A))\begin{vmatrix} \pm & + \\ \pm & \pm \end{vmatrix}=(\pm)/\det(A)$$

$$(\partial E/\partial P_h)=(1/\det(A))\begin{vmatrix} 0 & + \\ + & \pm \end{vmatrix}=(-)/\det(A)$$

$$(\partial E/\partial M)=(1/\det(A))\begin{vmatrix} - & + \\ 0 & \pm \end{vmatrix}=(\pm)/\det(A)$$ + for the stable economy; − for the unstable economy

$$(\partial E/\partial B^c)=(1/\det(A))\begin{vmatrix} - & + \\ - & \pm \end{vmatrix}=(\pm)/\det(A)$$ + for the stable economy; ± for the unstable economy

$$(\partial E/\partial F^c)=(1/\det(A))\begin{vmatrix} - & + \\ - & \pm \end{vmatrix}=(\pm)/\det(A)$$ + for the stable economy; ± for the unstable economy

$$(\partial E/\partial G)=(1/\det(A))\begin{vmatrix} 0 & + \\ - & \pm \end{vmatrix}=(+)/\det(A)$$

Partial derivatives of real income and exchange rate with respect to financial policies in this section are exactly identical to those derived in static models (section three). Thus, from now on, I continue my discussion by focusing on inflationary impacts on real income and exchange rate.

$$(\partial Y/\partial P)=(\pm)/\det(A), \qquad (\partial Y/\partial P_h)=(-)/\det(A)$$

$$(\partial E/\partial P)=(\pm)/\det(A), \qquad (\partial E/\partial P_h)=(-)/\det(A)$$

TABLE 2

EFFECTS OF FINANCIAL AND INFLATIONARY SHOCKS ON REAL INCOME AND EXCHANGE RATE IN AN INFLATIONARY MODEL

			P	P_h	M	B^c	F^c	G	
I) $a_{22}<0 \Rightarrow (\partial E/\partial Y)\|_{IS}>0$	det(A) > 0	Y	±	-	+	+	+	+	1
		E	±	-	+	+	+	+	
	det(A) < 0	Y	±	+	-	-	-	-	2
		E	±	+	-	±	±	-	
II) $a_{22}>0 \Rightarrow (\partial E/\partial Y)\|_{IS}<0$ & det(A) < 0		Y	±	+	-	-	-	-	3
		E	±	+	+	±	±	-	

The sign patterns of partial derivatives of real income and exchange rate with respect to inflationary shocks are ambiguous (table two, column one). However, this makes my analysis more interesting. An inflationary shock (P↑) would reduce the real supply of bonds and creates an excess demand for bonds. At the same time the demand for bonds declines through rational expectation assumption, $d\pi=\theta_p dP$. Therefore, the direction of change in E depends on the relative strength of these two factors. If private wealth holders have a very elastic price expectations (i.e., as price, P, rises so does π) then demand for bonds falls faster than their supply. Wealth holders re-align their portfolio toward home real balances and therefore, price of home currency in terms of foreign currency increases (i.e., home currency appreciates) and E declines. E rises if home wealth holders have a very inelastic price expectations.

Whether real income rises or declines as P changes all depends on price elasticities of demand for investment and net exports. Prices increases lead to an increase in investment outlays (i.e., through price expectations π) and a decrease in net exports. If price elasticity of demand for investment is greater than price elasticity of demand for net exports, then income should rise.

As far as home produced goods inflation rate, P_h, is concerned, we should bear the following fact in mind. Changes in P_h have two significant fallouts: one is the impact on inflation rate (P) and the other is the impact on price expectations. The former leads to a reduction of real supply of bonds while the latter contributes to a surge in demand for bonds, equation (7-49a). Thus, in row one of table two, price expectations are very inelastic (weak). Demand for bonds declines drastically and hence private citizens realign their portfolio toward home currency. Home currency appreciates and E declines. But row two has a different story. Here, price expectations are very elastic (strong) and that leads to a great surge in demand for bonds. Private wealth holders realign their portfolio toward bonds away from real balances. Home currency depreciates and E rises.

Vb. Price Level as an Endogenous Variable

In this subsection, I assume that home overall price level, P, and home produced goods price level, P_h, are endogenous variables. They are given by equations (7-47) and 7-48).

I can rewrite my model, in this context, as:

$$g(r-\pi, r^{*}-\pi^{*}, Y)w = (B^{P}+EF^{P})/P \qquad (7\text{-}49a)$$

$$(n-c(B^P/P))(r-\pi) = [q/(1+de^{-vY}) - (1-c(1-t)]Y-mK+G+cR+x(Y,EP^*/P_h) + cEr^*(F^P/P)+f \quad (7\text{-}49b)$$

$$P = \Psi(P_h, EP^*) \quad (7\text{-}48)$$

$$P_h = a_0+a_1(Y-\bar{Y})+a_2P^*+a_3\pi \quad (7\text{-}47)$$

I totally differentiate the above set of equations to get:

$$wg_Y dY-(F^P/P)(1-g)dE+(\theta_P g_\pi+(B^P+EF^P)/P^2 - g(M+B^P+EF^P)/p^2)dP = ((1-g)/P)(dB-dB^c) + (E/P)(1-g)(dF-dF^c) - (g/P)dM \quad (7\text{-}56a)$$

$$((qdve^{-vY})/(1+de^{-vY})^2 - (1-c(1-t)) + x_Y+a_1x_{P_h})dY + (x_E(P^*/P_h) + (cr^*/P)F^P dE - ((cB^P/P)(r-\pi) - (n-c(B^P/P))\theta_P - (cEr^*/P^2)F^P-a_3x_{P_h})dP = - (c(r-\pi)/P)(dB - dB^c) - (cEr^*/P)(dF-dF^c) \quad (7\text{-}56b)$$

$$dP = \Psi_{P_h}\cdot dP_h + \Psi_E dE \quad (7\text{-}56c)$$

$$dP_h = a_1dY+a_3d\pi+a_2P^*dE \quad (7\text{-}56d)$$

I substitute (7-56d) into (7-56c) to get:

$$-a_1\Psi_{P_h}\cdot dY-(\Psi_{P_h}\cdot a_2P^*+\Psi_E)dE+(1-\theta_P\Psi_{P_h}\cdot a_3)dP = 0 \quad (7\text{-}56e)$$

where dP_h from (7-56d) is substituted into equation (7-56b) and (7-56c).

The solution for changes in exchange rate, real income, and overall home price level is given as:

$$A\begin{pmatrix} dE \\ dY \\ dP \end{pmatrix} = B \begin{pmatrix} dG \\ dM \\ dB^c \\ dF^c \end{pmatrix} \tag{7-57}$$

where

$$A = \begin{bmatrix} -(1-g)(F^P/P) & wg_Y & \theta_P g_\pi w + (B^P + EF^P)/P^2 \\ x_E(P^*/P_h) + cr^*(F^P/P) & Z + a_1 x_{P_h} & -((cB^P/P)(r-\pi) - (n - (cB^P/P)\theta_P - (cEr^*/P^2)F^P - a_3 x_{P_h}) \\ -\Psi_E - a_2 P^* \Psi_{P_h} & -a_1 \Psi_{P_h} & (1 - a_3 \theta_P \Psi_{P_h}) \end{bmatrix} = \begin{bmatrix} - & + & + \\ + & \pm & \pm \\ - & - & + \end{bmatrix}$$

The jacobian matrix A, in this section differs from its counterpart in the previous sections only by the introduction of price level as the third endogenous variable. If $a_{22} = Z + a_1 x_{P_h}$ is negative then the IS curve is sloping upward (stable) in an EY plane. This is true because the slope of IS curve in an EY plane is $-(Z+a_1 x_{P_h})/(x_E(P^*/P_h) + cr^*(F^P/P))$. The denominator is positive. Thus, the sign of the slope depends on the sign of $a_{22} = Z + a_1 x_{P_h}$. If Z is negative, then the slope of IS curve, $(\partial E/\partial Y)|_{IS} = -(Z+a_1 x_{P_h})/(x_E(P^*/P_h) + cr^*(F^P/P))$, is positive and IS curve is sloping upward in an EY plane, Figures 7-5 and 7-6. I proved, in section three, that the system is stable when the IS curve is sloping upward and cuts BB curve (bonds market equilibrium) from below in an EY plane.

$$B = \begin{bmatrix} 0 & -(g/P) & -(1-g)/P & -(E/P)(1-g) \\ -1 & 0 & c(r-\pi)/P & cEr^*/P \\ 0 & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & - & - & - \\ - & 0 & + & + \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

In the jacobian matrix A, the element a_{22} is $Z+a_1 x_{P_h}$. I know that $x_{P_h} < 0$, as home produced goods price level increases net exports declines. Thus:

$$a_{22} = Z+a_1 x_{P_h} < 0 \quad \text{if } Z < 0$$

In that case, the IS curve is sloping downward (upward) in an r-Y (E-Y) plane, Figure 7-1 (7-5).

$$a_{22} = (\partial r/\partial Y)|_{IS}+a_1 x_{P_h} \lesseqgtr 0 \qquad \text{if} (\partial r/\partial Y)|_{IS} > 0$$

In other words, the element a_{22} or the sign pattern of the slope of IS curve may be either positive or negative and the system is unstable.

Thus, I continue the discussion by focusing on the stability conditions of the system (i.e., $Z+a_1 x_{P_h} < 0$).

The sign pattern of determinant of jacobian matrix A depends on the sign pattern of element a_{23}.

If $a_{23} > 0$, I can write matrix A determinant in an expanded form as:

$$\begin{aligned}&-(1-g)(F^P/P)[(Z+a_1 x_{P_h})(1-a_3\theta_P\Psi_{P_h}) + a_1\Psi_{P_H}\cdot(c(B^P/P)(r-\pi) - \\ &\quad (n-c(B^P/P)\theta_P-cEr^*(F^P/P^2) - a_3 x_{P_h})] - (x_E(P^*/P_h)+cr^*(F^P/P) \\ &\quad [wg_Y(1-a_3\theta_P\psi_{P_h})+a_1\Psi_{P_h}) + a_1\Psi_{P_h}\cdot(\theta_P g_\pi w + (B^P+EF^P)/P^2)] + \\ &\quad (-\Psi_E-a_2P^*\Psi_{P_h})[wg_Y(-c(B^P/P)(r-\pi)- (n-c(B^P/P)\theta_P - \\ &\quad cEr^*(F^P/P^2) - a_3 x_{P_h}) - (\theta_p g_\pi w+(B^P+EF^P)/P^2)(-Z+a_1 x_{P_h})\end{aligned} \tag{7-58}$$

But if $a_{23} < 0$, then det(A) is rewritten as:

$$-(1-g)(F^P/P)[(Z+a_1x_{P_h})(1-a_3\theta_P\Psi_{P_h}) + a_1\Psi_{P_h}\cdot(-c(B^P/P)(r-\pi) - (n-c(B^P/P))\theta_P - cEr^*(F^P/P^2) - a_3x_{P_h})] - (x_E(P^*/P_h)+cr^*(F^P/P))[wg_Y(1-a_3\theta_P\Psi_{P_h}) + a_1\Psi_{P_h}\cdot(\theta_P g_\pi w+(B^P+EF^P)/P^2)] + (-\Psi_E-a_2P^*\Psi_{P_h})[wg_Y(-c(B^P/P)(r-\pi) - (n-cB^P/P)\theta_P-cEr^*(F^P/P) - a_3x_{P_h}) - (Z+a_1x_{P_h})(\theta_P g_\pi w+(B^P+EF^P)/P^2)$$

(7-59)

By comparing equations (7-58) and 7-59) I realize that in the latter equation all expanded elements have identical signs except the second and fourth ones which are positive. Thus, in order to have the system in a stable position (i.e., det(A) >0) we need to have a_{23} to be negative. This is true because the determinant of the jacobian matrix A is greater when $a_{23}<0$, equation (7-59) than when $a_{23}>0$, equation (7-58).

The partial derivatives of changes in real income, exchange rate, and overall home price level can be given as:

$$(\partial Y/\partial M)=(1/\det(A)) \begin{vmatrix} - & 0 & + \\ + & - & - \\ - & 0 & + \end{vmatrix} = (\pm)/(\det(A))$$

$$(\partial Y/\partial B^C)=(1/\det(A)) \begin{vmatrix} - & - & + \\ + & - & - \\ - & 0 & + \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial Y/\partial F^C)=(1/\det(A)) \begin{vmatrix} - & - & + \\ + & + & - \\ - & 0 & + \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial Y/\partial G)=(1/\det(A)) \cdot \begin{vmatrix} - & 0 & + \\ + & - & - \\ - & 0 & + \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial E/\partial M)=(1/\det(A)) \begin{vmatrix} - & + & + \\ 0 & - & - \\ 0 & - & + \end{vmatrix} = (+)/\det(A)$$

$$(\partial E/\partial B^{C})=(1/\det(A) \begin{vmatrix} - & + & + \\ + & - & - \\ 0 & - & + \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial E/\partial F^{C})=(1/\det(A)) \begin{vmatrix} - & + & + \\ + & - & - \\ 0 & - & + \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial E/\partial G)=(1/\det(A)) \begin{vmatrix} 0 & + & + \\ - & - & - \\ - & 0 & + \end{vmatrix} = (+)/\det(A)$$

$$(\partial P/\partial M)=(1/\det(A)) \begin{vmatrix} - & + & - \\ + & - & 0 \\ - & - & 0 \end{vmatrix} = (+)/\det(A)$$

$$(\partial P/\partial B^{C})=(1/\det(A)) \begin{vmatrix} - & + & - \\ + & - & + \\ - & - & 0 \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial P/\partial F^{C})=(1/\det(A)) \begin{vmatrix} - & + & - \\ + & - & + \\ - & - & 0 \end{vmatrix} = (\pm)/\det(A)$$

$$(\partial P/\partial G)=(1/\det(A)) \begin{vmatrix} - & + & 0 \\ + & - & - \\ - & - & 0 \end{vmatrix} = (+)/\det(A)$$

TABLE 3

EFFECTS OF OPEN MARKET OPERATIONS AND BUDGETARY POLICIES ON REAL INCOME, EXCHANGE RATE, AND OVERALL PRICE LEVEL

		M	B^c	F^c	G
	Y	±	±	±	±
$a_{22} < 0 \Longrightarrow det(A) > 0$	E	+	±	±	+
	P	+	±	±	+

Stable Economy $-dB^p = dB^c = dM, \quad -EdF = dF^c = dM$

The results obtained from table three do not predict, in a determinate manner, the direction of change in real income, exchange rate, and overall price level as a result of financial policy changes. Part of this ambiguity could be explained by complications in estimating sign patterns of coefficient matrix in partial derivative equations. It could be also explained by certain assumptions regarding speed of adjustment in real and financial markets.

For example, as far as real income is concerned, expansionary fiscal policy leads to a higher income. But having assumed price level a function of real income (i.e., equations 7-47 and 48), overall price level increases in the home economy. This increase in price level leads to an excess demand for bonds, equation (7-49a). To restore asset in market equilibrium condition, Y should decline or price level expectation, should rise. The outcome depends on the speed of adjustment as far as price expectations are concerned. If price expectations are elastic, then there is no need for Y to decline. And

therefore, Y would rise as G rises. Otherwise, real income, Y, declines as G rises.

An Open market purchase of home bonds (i.e., $B^p\downarrow$, $B^c\uparrow$) leads to an excess supply for real balances. To restore equilibrium in money market, either interest rate (r) should decline or real income, Y, should rise. But in this model, r is fixed. Therefore, Y would rise. Meanwhile, this open market purchase of bonds reduces supply of bonds and creates an excess demand for bonds. To restore equilibrium in the asset market either P or Y should decline. Again the speed of adjustment is very critical.

The same could be argued for the effect of open market operation of foreign bonds on real income.

VI. Exchange-Rate Movement in a Dynamic Model

To close in the model in a dynamic sense, I need to specify the nature of wealth over time and the role of central bank and government over monetary and fiscal policies.

In the equilibrium analysis of section III, the change in wealth was taken into account. Usually the stock of real wealth is considered constant in a very short run and long run model.

The change in real wealth, $\dot{w}$, which is equal to saving is given as:

$$\dot{w}=S=Y_d-C \qquad (7\text{-}60)$$

where

Y_d = real disposable income

C = real consumption expenditure

S = real saving expenditure

w = real wealth

real consumption is:

$$C = cY_d+f \tag{7-61}$$

where

c = marginal propensity to consumer

f = autonomous consumption

I substitute (7-61) in equation (7-60) to get:

$$w = Y_d-cY_d-f \tag{7-62}$$

with some rearrangement I get:

$$\dot{w} = (1-c)Y_d-f \tag{7-63}$$

Real disposable income is:

$$Y_d = Y-tY+R+(r-\pi)(B^P/P)+E(R^*-\pi)(F^P/P) \tag{7-64}$$

where

Y = real income

T = tY = simple proportional tax

R = transfer payments

$(r-\pi)(B^P/P)$ = interest earnings on home bonds held by home private citizens

$E(r^*-\pi)(F^P/P)$ = interest earnings on foreign bonds held by home private citizens and denominated in home currency

E = exchange rate, home currency price of foreign currency

To get an equation for the change in real wealth, I substitute equation (7-64) into (7-63). I get:

$$\dot{w} = (1-c)[(1-t)Y + (r-\pi)(B^P/P) + E(r^*-\pi)(F^P/P)] - f \tag{7-65}$$

A balance on official settlement is defined as:

$$BOP = x(E,Y)-E\dot{F} \tag{7-66}$$

under a flexible exchange rate regime, BOP=0. Therefore, current account imbalances, x(E,Y), are equal to foreign asset flow, $\dot{F}$.

$$x(E,Y) = E\dot{F} = E(\dot{F}^p + \dot{F}^c) \tag{7-67}$$

$$(E\dot{F}^p/P) = x(E,Y) - (E\dot{F}^c/P) \tag{7-68}$$

The central bank's asset include home bonds, B^c, and foreign reserves, F^c. Central banks usually do not hold currencies of other countries. Their liabilities are the banking system reserve deposits with the central bank,

$$((B^c + EF^c)/P) = M/P \tag{7-69}$$

where M denotes the monetary base. Changes in central bank stock of bonds depend both on its monetary and foreign exchange objectives.

The government deficit, D, is defined as:

$$D = G - (T - R - r(B^p/P)) \tag{7-70}$$

where

D = government deficit

G = real government expenditure

T = real government revenue as a function of real income

R = government transfer payments to private citizens

Deficits are defined either by printing money and/or issuing new bonds:

$$D = G + R - T + r(B^p/P) = \dot{M} + \dot{\tilde{B}}^p \tag{7-71}$$

where $(\tilde{B}/P)$ denotes real stock supply of both home and foreign bonds held by home private citizens. If γ_m (γ_b) denotes the fraction of

deficit financed by printing money (issuing new bonds) by government, then I have:

$$\dot{M} = \gamma_m(G+R-tY+r(B^P/P))+Q_m \tag{7-72}$$

$$\dot{B}^P = \gamma_b(G+R-TY+r(B^P/P))-B^c \tag{7-73}$$

where Q_m denotes open market operation by central bank with either home real bonds (B^c/P) and/or foreign real bonds (EF^c/P).

$$Q_m = -(\dot{B}^c+E\dot{F}^c) \tag{7-74}$$

where

$r(B^P/P)$ = real interest payment on home bonds held by home citizens

$r^*(F^P/P)$ = real interest payment on foreing bonds held by home citizens

$\gamma_m + \gamma_b = 1$

Stability

A disequilibrium behavior model for exchange rate, real income, and wealth is given as:

$$\dot{E} = \alpha[g(r-\pi,r^*-\pi,Y)w-((B^P+EF^P)/P)] \tag{7-75}$$

$$\dot{Y} = \beta[c(Y-tY+R+(r-\pi)(B^P/P)+E(r^*-\pi)(B^P/P)) + I(Y,r,K)+G+x(Y,EP^*/P_h)-Y] \tag{7-76}$$

$$\dot{w} = (1-c)[(1-t)Y+(r-\pi)(B^P/P)+E(r^*-\pi)(F^P/P)] - f \tag{7-65}$$

where α and β are adjustment coefficients. Equations (7-75) and (7-76) describe the same disequilibrium behavior as equations (7-26a and b).

A linearized version of (7-75, 76, and 65) in the neighborhood

of equilibrium is:

$$\begin{pmatrix} \dot{E} \\ \dot{Y} \\ \dot{W} \end{pmatrix} = \begin{bmatrix} \alpha & 0 & 0 \\ 0 & \beta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -(F^p/P) & g_Y w & g \\ x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & 0 \\ (r^*-\pi)(F^p/P) & (1-c)(1-t) & 0 \end{bmatrix} \begin{matrix} E-\bar{E} \\ Y-\bar{Y} \\ w-\bar{w} \end{matrix} \tag{7-77}$$

where $Z=qdve^{-vY}/(1+de^{-vY})^2-(1-c(1-t))+x_Y$ and $\bar{E}$, $\bar{Y}$, and $\bar{w}$ are equilibrium values for E, Y, and w in the long run.

The necessary and sufficient conditions for the stability of the system require that trace of coefficient matrix, J, on the right-hand side of (7-77) be negative and its determinant positive:

$$J=[j_{ij}]= \begin{bmatrix} \alpha & 0 & 0 & -(F^p/P) & g_Y w & g \\ 0 & \beta & 0 & x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & 0 \\ 0 & 0 & 1 & (r^*-\pi)(F^p/P) & (1-c)(1-t) & 0 \end{bmatrix}$$

The trace and determinant of J are:

$$\text{Trace}(J) = -(F^p/P)+Z$$

If $Z<0$, then trace$(J)<0$

If $Z>0$, then trace$(J) \lesseqgtr 0$

Thus, the first condition of stability should be met if IS curve were sloping upward in an E-Y plane.

$$\det(J) = g[(x_E(P^*/P_h)+c(r^*-\pi)(F^p/P)(1-c)(1-t)-Z(r^*-\pi)(F^p/P)]$$

For det(J) to be positive, I need the following inequality to hold:

$$(x_E(P^*/P_h)+c(r^*-\pi)(F^p/P)(1-c)(1-t)-Z(r^*-\pi)(F^p/P)>0$$

or

$$-Z/[x_E(P^*/P_h)+c(r^*-\pi)(F^p/P)] > -(1-c)(1-t)/(r^*-\pi)(F^p/P)$$

The above inequality holds for an upward sloping IS curve in an E-Y plane. Therefore, both necessary and sufficient conditions of dynamic stability are met if IS curve slopes up in an E-Y plane.

Steady State and Comparative Statics

The rates of growth of real income, the exchange rate, and wealth declines to zero in a long run stationary state (i.e., equilibrium). Thus, the equilibrium solution of this dynamic model is given by the following equations.

$$g(r-\pi,r^*-\pi,Y)w = (B-B^c+E(F-F^c))/P \qquad (7\text{-}78)$$

$$(n-c((B-B^c)/P)(r-\pi) = q/(1+de^{-vY}) - (1-c\cdot(1-t))Y-mK+G+f+cR+x(Y,EP^*/P_h) + cEr^*((F-F^c)/P) \qquad (7\text{-}79)$$

$$(1-c)[(1-t)Y+c(r-\pi)(B^p/P)+E(r^*-\pi)(F^p/P)] - f \qquad (7\text{-}80)$$

where equations (7-78 and 79) are market clearing conditions for bonds and goods respectively. Equation (7-80) states saving (i.e., change in wealth) equals zero. These equations determine long run equilibrium values of E, Y, and w simultaneously.

I totally differentiate equations (7-78, 79 and 80) to get:

$$wg_Y dY-(F^p/P)dE+gdw = (-dB^c-EdF^c)/P \qquad (7\text{-}81)$$

$$ZdY+(x_E(P^*/P_h)+c(r^*-\pi)(F^p/P))dE = (cr/P)dB^c+(cEr^*/P)dF^c-dG \qquad (7\text{-}82)$$

$$(1-c)(1-t)dY+[(r^*-\pi)(F^p/P)]dE = (r/P)dB^c+(E(r^*-\pi)/P)dF^c \qquad (7\text{-}83)$$

The solution for changes in exchange rate, real income, and

real wealth is given as:

$$A \begin{pmatrix} dE \\ dY \\ dw \end{pmatrix} = B \begin{pmatrix} dB^c \\ dF^c \\ dG \end{pmatrix} \qquad (7\text{-}84)$$

$$A = \begin{bmatrix} -(F^p/P) & wg_Y & g \\ x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & -1 \\ (r^*-\pi)(F^p/P) & (1-c)(1-t) & 0 \end{bmatrix} = \begin{bmatrix} - & + & + \\ + & \pm & 0 \\ + & - & 0 \end{bmatrix}$$

$$B = \begin{bmatrix} -(1/P) & -(E/P) & 0 \\ c(r-\pi)/P & cE(r^*-\pi)/P & -1 \\ (r-\pi)/P & E(r^*-\pi)/P & 0 \end{bmatrix}$$

The jacobian matrix, A, in this section, differs from its counterpart in previous sections only by the introduction of wealth as the third endogenous variable. It has a positive determinant (proved in the stability section), if the IS curve slopes upward, in an E-Y plane.

The partial derivatives may be written as:

$$(\partial E/\partial B^c) = (1/\det(A)) \begin{vmatrix} -(1/P) & wg_Y & g \\ c(r-\pi)/P & Z & 0 \\ (r-\pi)/P & (1-c)(1-t) & 0 \end{vmatrix} =$$

$$g[c((r-\pi)/P)(1-c)(1-t) - Z(r-\pi)/P]/\det(A) > 0$$

$$(\partial E/\partial F^c) = (1/\det(A)) \begin{vmatrix} -E/P & wg_Y & g \\ c(r^*-\pi)E/P & Z & 0 \\ E(r^*-\pi)/P & (1-c)(1-t) & 0 \end{vmatrix} =$$

$$(E/\det(A))[g(c(r^*-\pi)/P)(1-c)(1-t)-Z(r^*-\pi)/P]$$

The partial derivative $(\partial E/\partial F^{c})$ is equal to $E(\partial E/\partial B^{c})$. Therefore, it has the sign pattern of $(\partial E/\partial B^{c})$:

$$(\partial E/\partial F^{c}) = (+)/\det(A)$$

$$(\partial E/\partial G)=(1/\det(A)) \begin{vmatrix} 0 & wg_Y & g \\ -1 & Z & 0 \\ 0 & (1-c)(1-t) & 0 \end{vmatrix} =$$

$$(1/\det(A))g[-(1-c)(1-t)] = (-)/\det(A)$$

$$(\partial Y/\partial B^{c})=(1/\det(A)) \begin{vmatrix} -(F^{p}/P) & -1/P & g \\ x_E(P^{*}/P_h)+c(r^{*}-\pi)(F^{p}/P) & c(r-\pi)/P & 0 \\ (r^{*}-\pi)(F^{p}/P) & (r-\pi)/P & 0 \end{vmatrix} =$$

$$(+)/\det(A)$$

$$(\partial Y/\partial F^{c})=(1/\det(A)) \begin{vmatrix} -F^{p}/P & -E/P & g \\ x_E(P^{*}/P_h)+ c(r^{*}-\pi)(F^{p}/P) & Ec(r^{*}-\pi)/P & 0 \\ (r^{*}-\pi)(F^{p}/P) & E(r^{*}-\pi)/P & 0 \end{vmatrix} =$$

$$(+)/\det(A)$$

$$(\partial Y/\partial G)=(1/\det(A)) \begin{vmatrix} -F^{p}/P & 0 & g \\ x_E(P^{*}/P_h)+c(r^{*}-\pi)(F^{p}/P) & -1 & 0 \\ (r^{*}-\pi)(F^{p}/P) & 0 & 0 \end{vmatrix} =$$

$$(1/\det(A))[(r^{*}-\pi)(F^{p}/P)] = (+)/\det(A)$$

$$(\partial w/\partial B^c)=(1/\det(A))\begin{vmatrix} -F^p/P & wg_Y & -1/P \\ x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & cr/P \\ (r^*-\pi)(F^p/P) & (1-c)(1-t) & r/F \end{vmatrix}$$

To find the sign pattern of $\partial w/\partial B^c$, I need to know the sign of the following matrix:

$$\begin{vmatrix} -F^p/P & wg_Y & -1/P \\ x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & rc/P \\ (r^*-\pi)(F^p/P) & (1-c)(1-t) & r/P \end{vmatrix}$$

I multiply row three of the above matrix by -c and then add it to row two. I get:

$$\begin{vmatrix} -F^p/P & wg_Y & -1/P \\ x_E(P^*/P_h) & Z-c(1-t)(1-c) & 0 \\ (r^*-\pi)(F^p/P) & (1-c)(1-t) & r/P \end{vmatrix}$$

Again, I multiply row one of the above matrix by r and then add it tc row three to get:

$$\begin{vmatrix} -F^p/P & wg_Y & -1/P \\ x_E(P^*/P_h) & Z-c(1-t)(1-t) & 0 \\ 0 & wrg_Y+(1-c)(1-t) & 0 \end{vmatrix} =$$

$$-(1/P)[x_E(P^*/P_h)(wrg_Y+(1-c)(1-t))]<0$$

Therefore, the sign pattern of $\partial w/\partial B^c$ can be given as:

$$(\partial w/\partial B^c)=(-)/\det(A)<0$$

The sign pattern of partial derivative, $\partial w/\partial F^{c}$, is given as:

$$(\partial w/\partial F^{c})=E(\partial w/\partial B^{c}) < 0$$

And finally:

$$(\partial w/\partial G)=(1/\det(A))\begin{vmatrix} -F^{p}/P & wg_{Y} & 0 \\ x_{E}(P^{*}/P_{h})+c(r^{*}-\pi) & Z & -1 \\ (r^{*}-\pi)(F^{p}/P) & (1-c)(1-t) & 0 \end{vmatrix} =$$

$$(1/\det(A))[-(F^{p}/P)(1-c)(1-t)-wg_{Y}(r^{*}-\pi)(F^{p}/P)] < 0$$

TABLE 4

EFFECT OF FINANCIAL POLICIES ON REAL INCOME, EXCHANGE RATE, AND WEALTH IN A DYNAMIC MODEL IN THE LONG RUN

		B^{c}	F^{c}	G
Stable Economy	Y	+	+	+
trace(A) < 0 det(A) > 0	E	+	+	-
	w	±	±	-

The sign patterns of partial derivatives of real income and exchange rate with respect to financial policies are the same as predicted by previous sections.

CHAPTER 7--Footnotes

[1]Restricted in the sense that only financial and monetary variables (to the exclusion of real economic variables) are treated as endogenous variables.

[2]Foley (1975).

[3]At this stage, I assume the world interest rate is given. This assumption will be relaxed later in this chapter. I will examine the impact of exogenous changes in world interest rate on the equilibrium values of real income and exchange rate.

[4]Let (a_{ii}) denotes a square matrix. Then, trace(A)=$\sum_i a_{ii}$, where a_{ii} are the diagonal elements of matrix A.

[5]The interdependency between monetary and open market operations is taken into account in this chapter. However, section four of chapter eight takes the interdependency between these policies into account.

[6]Kreinin and Officer (1978), p. 11.

[7]Turnovsky and Kingston (1977).

[8]For more detail see Bodkin, Bond, Rewuber and Robinson (1966), Pitchford (1968), Lipsey and Parkin (1970).

[9]Turnovsky (1977), p. 220.

CHAPTER 8

Extended Model: A Theory of Exchange Rate, Real Income, and Interest Rate Determination

This chapter examines and develops model of exchange rate, real income, and interest rate behavior in a broader context. The assumption of perfect substitution between home and foreign bonds (i.e., interest parity) will be relaxed.

Ia. Imperfect Substitution Among Financial Assets

In Chapter seven I developed a real and financial model of real income and exchange rate determination. It was shown that both budgetary policies and open market operations could cause sudden jumps (i.e., catastrophes) in the equilibrium values of real income and exchange rate. The cyclical behavior of economic variables was examined under the assumption of perfect substitution between home and foreign bonds. Private home wealth holders faced a portfolio-selection problem of choosing between home real balances and bonds. Equation (7-18 and 19) simultaneously determined equilibrium values of real income, Y, and the exchange rate, E. In this section, I relax the assumption that home and foreign bonds are perfect substitutes.

Ib. Asset Market

In a financial portfolio-balance model, equilibrium is achieved when the desired stock demands for these (financial) assets

equal their supplies

$$M(\overset{-}{r}-\pi,\overset{-}{r^{*}}-\pi,\overset{+}{Y})\overset{+}{w} = M/P \qquad (8\text{-}1)$$

$$b(\overset{+}{r}-\pi,\overset{-}{r^{*}}-\pi,\overset{+}{Y})\overset{+}{w} = B^{P}/P \qquad (8\text{-}2)$$

$$b^{*}(\overset{-}{r}-\pi,\overset{+}{r^{*}}-\pi,\overset{+}{Y})\overset{+}{w} = EF^{P}/P \qquad (8\text{-}3)$$

where

w = real wealth

M/P = stock of real cash balances

B^{P}/P = stock of home bonds held by home private citizens

F^{P}/P = stock of foreign bonds denominated in foreign currency and held by home private citizens

E = foreign exchange rate, home currency price of foreign currency

π = expected overall rate of home inflation, assumed given

P = overall home price level, assumed given

Superscript "+" ("-") depicts the nature of relations an economic variable has with respect to demand for financial assets.

The nominal rates of return on home real balances, home bonds, and foreign bonds are zero, r, and r^{*} respectively. The left (right) hand sides of equations (8-1, 2, and 3) indicate stock demand for (supply of) financial assets. Demands must satisfy the wealth constraints:

$$w = M/P + B^{P}/P + EF^{P}/P \qquad (8\text{-}4)$$

$$m(r-\pi,r^{*}-\pi,Y) + b(r-\pi,r^{*}-\pi,Y)+b^{*}(r-\pi,r^{*}-\pi,Y) = 1 \qquad (8\text{-}5)$$

Ic. Goods Market

In Chapter three, I presented my own version of income determination in a Keynesian framework in a closed economy. In section I of Chapter seven, I derived a model of income determination for an

open economy. This issue will be examined again in this section.

In goods market equilibrium I have:

$$C+S=Y_d = Y-T+R+(r-\pi)(B^p/P)+E(r^*-\pi)(F^p/P) \qquad (8\text{-}6)$$

where

C = real consumption expenditure

S = real saving

Y_d = real disposable income

$T=tY$ = real government revenue as a function of real income

R = government transfer payments

$(r-\pi)(B^p/P)$ = real interest payment received on home bonds held by home citizens

$E(r^*-\pi)(F^p/P)$ = real interest payment received on foreign bonds held by home citizens denominated in home currency

π = expected overall rate of home inflation, assumed given

The equilibrium condition for the goods market is given as:

$$Y = C+I+G+X \qquad (8\text{-}7)$$

where

I = real investment expenditure
G = real government expenditure
X = real net export expenditure

Saving is:

$$S = sY-f \qquad f>0 \qquad (8\text{-}8)$$

and consumption is:

$$C=Y_d-S=Y_d-sY+f=f+cY_d \qquad (8\text{-}9)$$

where

s = marginal propensity to save
c = marginal propensity to consume

The investment function, I, is the modified version of sigmoid-shape investment function developed in Chapter two:

$$I = q/(1+de^{-vY}) - mK - n(r-\pi) \qquad (8\text{-}10)$$

where, q, d, v, m, and n are parameters. Replacing Y_d in equation (8-9) from equation (8-6) we get a consumption function:

$$C=f+c[Y+R-tY+(r-\pi)(B^P/P)+E(r^*-\pi)(F^P/P)] \qquad (8\text{-}11)$$

substituting C from equation (8-11) and I from equation (8-10) into equation (8-7) I get IS curve for an open economy:

$$Y=f+c[Y+R-tY+(r-\pi)(B^P/P)+E(r^*-\pi)(F^P/P)]+q/(1+de^{-vY}) -mk-n(r-\pi)+G+X \qquad (8\text{-}12)$$

Net exports, X, are a function of real income, Y, and the ratio of overall foreign and home price levels, EP^*/P_h:

$$X = x(Y,EP^*/P_h) \qquad x_Y < 0, \quad x_{EP^*/P_h} > 0 \qquad (8\text{-}13)$$

where

P^* = overall foreign price leval
P_h = home goods price level

The equilibrium condition for the goods market in an open economy can be written as:

$$(n-c(B^P/P))(r-\pi)=q/(1+de^{-vY}) - (1-c(1-t))Y-mK+x(Y,EP^*/P_h) + G+f+cR+cE(r^*-\pi)(F^P/P) \qquad (8\text{-}14)$$

The relationships between E, Y, and r need some elaboration. In a r-Y plane, the downward sloping sections of IS curve shows combinations of interest rate (r) and levels of real income (Y) for which the goods market clears, holding E and everything else constant, Figure 8-1.

However, the (unconventional) upward sloping part of the IS curve, in the same r-Y plane, is a locus of unstable equilibria, Figure 8-1 as shown in Chapter seven, section one.

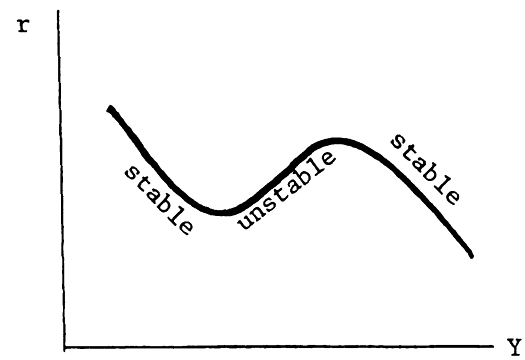

Figure 8-1

In an E-Y plane, the curve slopes in an opposite direction as compared to the direction of IS curve in a r-Y plane, Figure 8-2 as shown in Chapter seven, section one.

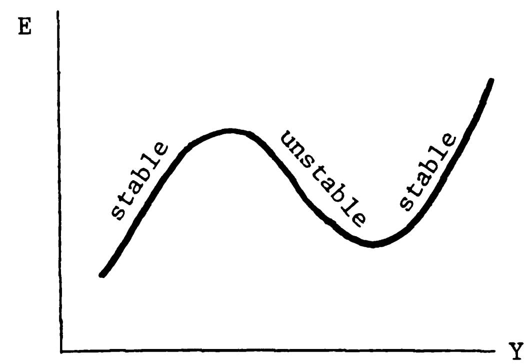

Figure 8-2

The upward sloping sections of the IS curve in an E-Y plane can be explained, first, mathematically. A total differentiation of equation (8-14) is given as:

$$(x_E(P^*/P_h)+c(r^*-\pi)(F^P/P))dE+(Z)dY-(n-c(B^P/P))dr =$$

$$-c(r-\pi)(1/P)dB^P-cE(r^*-\pi)(1/P)dF^P-dG \qquad (8\text{-}15)$$

where

$$Z = (qdve^{-vY})/(1+de^{-vY})^2-(1-c(1-t)+x_Y$$

In a r-Y plane, the slope of IS curve is given as:

$$(\partial r/\partial Y)\Big|_{IS} = Z/(n-c(B^P/P)) \qquad (8\text{-}16)$$

The denominator, $n-c(B^P/P)$, is constant. Thus, the sign pattern of the slopes depends on the sign of Z term.

In an E-Y plane, the slope of the IS curve is given as:

$$(\partial E/\partial Y)\Big|_{IS} \text{ is } -Z/[(x_E(P^*/P_h)+c(r^*-\pi)(F^P/P)]$$

The denominator, in equation (8-17), is constant and positive. Thus, the sign pattern of the slope, depends on the sign pattern of -Z term.

From the economic point of view, the (conventional) IS curve slopes upward in an E-Y plane. This is true because as E rises, so do net exports. An increase in real income would raise imports and hence offset the surge in net exports and equilibrium would be restored in the goods market. This requires that the term $-Z/[(x_E(P^*/P_h+c(r^*-\pi)(F^P/P)]$ (or the slope of IS curve) be positive for a conventional upward sloping IS curve. The denominator is positive. Thus, the term Z should be negative to guarantee a (conventional) upward sloping IS curve.

Equation (8-16) is the slope of IS curve in a r-Y plane. It must be negative for a conventional downward sloping IS curve (in r-Y plane).

From the previous discussion, the term Z is negative. This is true in order to guarantee a conventional upward sloping IS curve in an E-Y plane. For equation (8-16) to be negative, having the term Z already negative, requires that the term $(n-c(B^P/P))$ be positive.

Thus, it can be concluded that (conventional) IS curve slopes downward (upward) in r-Y plane, Figure 8-1 (8-2). Unconventional IS curve sloped upward (downward) in r-Y (E-Y) plane, Figure 8-1 (8-2).

II. Equilibrium Solution

With a given home price level, P, equilibrium in asset market requires that the existing stock of financial asset be equal to their stock demands, equation (8-1, 2, and 3). Equilibrium in any two of the asset markets (stock) insures equilibrium in the third asset market. However, equilibrium in the three asset (stock) markets does not guarantee equilibrium in the flow, goods market.[1] By applying the asset constraint to the asset markets, I drop the equilibrium condition for the home real balances, equation (8-1). Thus, I rewrite the model as:

$$b(r-\pi, r^{*}-\pi, Y)w = B^{P}/P \qquad (8\text{-}2)$$

$$b^{*}(r-\pi, r^{*}-\pi, Y)w = EF^{P}/P \qquad (8\text{-}3)$$

$$(n-c(B^{P}/P))(r-\pi) = q/(1+de^{-vY}) - (1-c(1-t))Y-mK+x(Y,EP^{*}/P_{h})+G+cR+f+$$

$$cE(r^{*}-\pi)(F^{P}/P) \qquad (8\text{-}14)$$

The above set of equations determine the equilibrium values of the rates of return on home bonds, r; exchange rate, E; and real income, Y; respectively and simultaneously. By invoking a small country assumption, r^{*} and P^{*} are considered constant. The policy determined variables are M, B^{C}, F^{C}, and G. B^{C} and F^{C} denote central bank's holdings of home and foreign bonds.

III. Stability Analysis

A disequilibrium behavior for exchange rate, real income, and interest rate is given as:

$$\dot{E} = \alpha[b^*(r-\pi, r^*-\pi, Y)w - (EF^P/P)] \qquad \alpha > 0 \qquad (8\text{-}18)$$

$$\dot{Y} = \beta[c(Y-tY+R+(r-\pi)(B^P/P)+E(r^*-\pi)(F^P/P))+I(Y,r-\pi,K)+G+x(Y,EP^*/P_h)+ f-Y] \qquad \beta > 0 \qquad (8\text{-}19)$$

$$\dot{r} = \lambda[(B^P/P)-b(r-\pi, r^*-\pi, Y)w] \qquad \lambda > 0 \qquad (8\text{-}20)$$

where α, β, and λ are adjustment coefficients.

Equation (8-18) indicates that the rate of change in the exchange rate is proportional to excess demand for foreign bonds. This causes home private wealth holders to realign their portfolio by supplying their real cash balances and/or home bonds for foreign bonds in foreign exchange market. Home currency depreciates and E rises.

Equation (8-19) is a goods market adjustment equation. The basic underlying hypothesis for this equation is producers' response to unexpected inventory changes. As firms find their inventories are decreasing unexpectedly, they increase their output to meet the demand for goods.

Equation (8-20) states that the rate of change in home interest rate, r, is proportional to excess supply of home bonds. If the stock of home bonds held by home private wealth holders, B^P/P, rises relative to its demand, $b(r-\pi, r^*-\pi, Y)w$, the treasury must offer higher interest rate (r) to borrow from private wealth holders.

A linearized version of (8-18, 19, and 20) in the neighborhood of equilibrium is:

$$\begin{pmatrix} \dot{E} \\ \dot{Y} \\ \dot{r} \end{pmatrix} = \begin{bmatrix} \alpha & 0 & 0 \\ 0 & \beta & 0 \\ 0 & 0 & \lambda \end{bmatrix} \begin{bmatrix} -(F^P/P)(1-b^*) & wb^*_Y & wb^*_r \\ x_E(P^*/P_h)+c(r^*-\pi)(F^P/P) & Z & -(n-c(B^P/P)) \\ -b(F^P/P) & -wb_Y & -wb_r \end{bmatrix} \begin{pmatrix} E-\bar{E} \\ Y-\bar{Y} \\ r-\bar{r} \end{pmatrix} \qquad (8\text{-}21)$$

where $\bar{E}$, $\bar{Y}$, and $\bar{r}$ are the long-run equilibrium values for E, Y, and r respectively. To derive the coefficient matrix, the change in wealth, dw, is replaced by differentiating equation (8-4).

The necessary and sufficient conditions for the stability of the system are that the trace of coefficient matrix J be negative and its determinant positive:

$$J=[j_{ij}]\begin{bmatrix}\alpha & 0 & 0\\ 0 & \beta & 0\\ 0 & 0 & \lambda\end{bmatrix}\begin{bmatrix}-(F^p/P)(1-b^*) & wb_Y^* & wb_r^*\\ x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & -(n-c(B^p/P))\\ -b(F^p/P) & -wb_Y & -wb_r\end{bmatrix}$$

The trace and determinant of J are:

$$\text{trace}(J) = -\alpha(F^p/P)(1-b^*)+\beta Z-\lambda wb_r, \qquad \alpha,\ \beta,\ \lambda>0$$

If $Z<0$, then $\text{trace}(J) < 0$

If $Z>0$, then $\text{trace}(J) \lesseqgtr 0$

Therefore, the necessary condition for stability would be met if the IS curve was sloping downward in a r-Y plane, Figure 8-1. The above statement is equivalent to the following one. The necessary condition of stability is met if the IS curve was sloping upward in an E-Y plane, Figure 8-2.

$$\det(J) = \alpha\beta\lambda[(-F^p/P)(-Zwb_r)-w(n-c(B^p/P))wb_Y)-(x_E(P^*/P_h)+ c(r^*-\pi)(F^p/P)(-wb_Y^*b_r+w^2b_r^*b_Y)-b(F^p/P)(-w\cdot(n-c(B^p/P)b_Y^*-Zwb_r^*]$$

(8-22)

Under the necessary conditions (i.e., $Z<0$), all the terms but the first one in equation (8-22) are positive. However, I cannot draw a

clear cut conclusion with respect to the sufficient condition of stability. At this point, I therefore, intend to use some geometry in order to examine the sufficient and hence stability conditions further.

IIIa. Dynamics of the Model in an E-Y Plane

The dynamic behavior of exchange rate was explained by equation (8-18). This equation is an excess demand for foreign bonds.

The curve FF, in Figure 8-3, is the locus of equilibrium points where demand for foreign bonds equal their supplies, equation (8-3). The FF curve has a positive slope. An increase in real income causes an excess demand for foreign bonds. The exchange rate should rise to restore equilibrium in this market. The increase in exchange rate would increase the home currency value of foreign bonds held by home citizens. The slope of the FF curve can be derived by taking a total differentiation of equation (8-3):

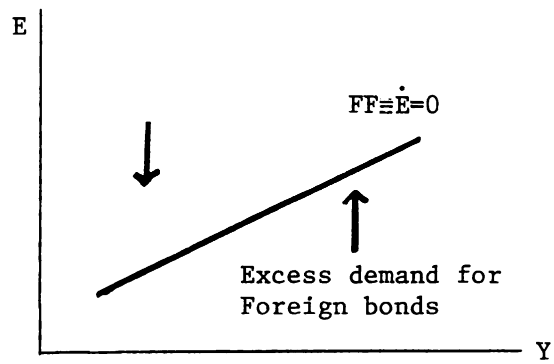

Figure 8-3

$$-(F^P/P(1-b^*)dE + wb^*_Y dY + wb^*_r dr = -(b^*/P)dM - (b^*/P)(dB - dB^C) + (E/P)(1-b^*)(dF - dF^C) \quad (8\text{-}23)$$

The slope of the FF curve is given as:

$$(dE/dY) = (wb^*_Y)/(F^P/P)(1-b^*)>0 \quad (8\text{-}24)$$

On the FF curve, in Figure 8-3, the rate of change in exchange rate is zero, $\dot{E}=0$. All points below the FF curve depict excess demand for foreign bonds. Points above the FF curve depict excess supply of foreign bonds. Therefore, exchange rate tends to rise (decline) for points below (above) the FF curve.

The dynamic behavior of real income was specified by equation (8-19) and Figure (8-2). Figure (8-2) is represented here as Figure 8-4.

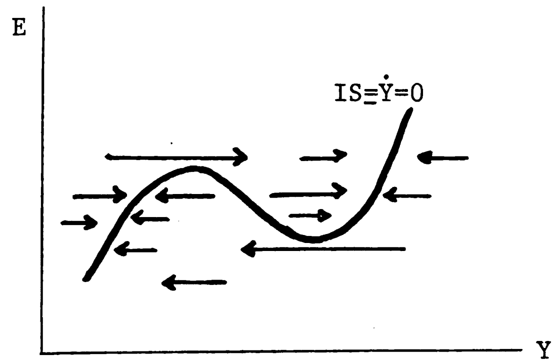

Figure 8-4

The IS curve, in Figure 8-4, depicts combinations of E and Y, where the rate of change in real income is zero, (i.e., $\dot{Y}=0$) and demand for goods equal their supply. The sign pattern of the slope of the IS curve were explained in Chapter three. All points above the IS curve depict excess demand for goods. Thus, the real income tends to rise (decline) for points above (below) the IS curve, Figure 8-4.

The dynamic behavior of home interest rate was explained by equation (8-20). This equation is an excess supply of home bonds. The BB curve, in Figure 8-5, depicts combinations of exchange rate and real income where demand for bonds equal their supply for given r^*. The BB curve has a negative slope. An increase in real income causes an excess demand for home bonds.

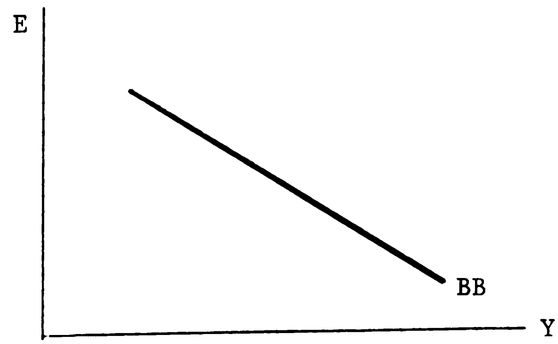

Figure 8-5

Exchange rate should decline to restore equilibrium in this market. A decline in exchange rate would reduce the home currency valuation of foreign bonds and thus real wealth. The demand for home bonds decline as wealth declines. The slope of the BB curve can be derived by taking a total differentiation of equation (8-2):

$$-(F^P/P)bdE-wb_YdY-wb_rdr = (b/P)dM-((1-b)/P)(dB-dB^c) + (Eb/P)(dF-dF^c) \quad (8\text{-}25)$$

The slope of the BB curve is given as:

$$(dE/dY) = (-wb_Y)/((F^P/P)b) < 0 \quad (8\text{-}26)$$

To make the understanding of stability conditions clearer, I superimpose Figures (8-3, 4, and 5).

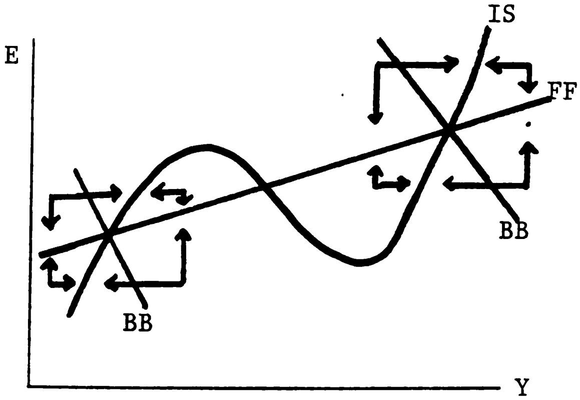

Figure 8-6

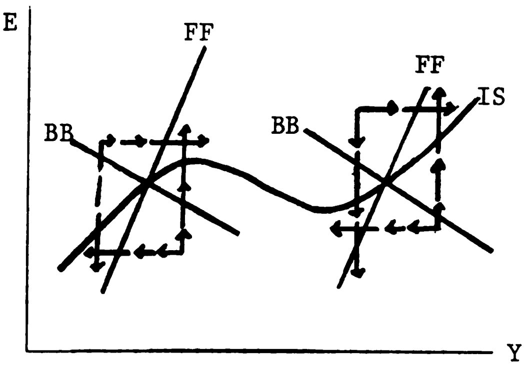

Figure 8-8

Arrows in Figures (8-6 and 7) indicate the direction of change in real income, Y, and exchange, E. Equilibrium is indicated by the intersections of the IS and FF curves, on the upward sloping sections of the IS curve (i.e., where the necessary condition of stability is met, Z<0).[2]

Figure (8-7), where the FF curve is steeper than the IS curve, shows a clear picture of unstable dynamics for exchange rate and real income. But when the IS curve is steeper than the FF curve, our economy behaves in a stable manner, Figure 8-6.

The stability condition of Figure (8-6) can be written in terms of respective slopes:

$$-Z/(x_E(P^*/P_h)+c(r^*-\pi)(F^p/P)) > ((wb_Y^*)/(F^p/P(1-b^*)) \qquad (8\text{-}27)$$

as long as Z is negative. The left (right) hand side of inequality (8-27) denotes the slope of the IS (FF) curve.

The stability condition of (8-27) denotes the fact that home foreign bonds market is more responsive to a given change in exchange rate than home goods market. In other words, the real income must rise more in home foreign bonds market than in the home goods market for a given change in the exchange rate in order to restore the equilibrium in both markets.

IIIb. <u>Dynamics of the Model in an r-Y Plane</u>

The dynamic behavior of home interest rate was explained by the equation (8-20) and Figure (8-8).

The BB curve, in Figure 8-8, depicts combinations of the home interest rate and real income where the rate of change in interest rate is zero (i.e., $\dot{r}=0$). All point above the BB curve are characterized by an excess demand for home

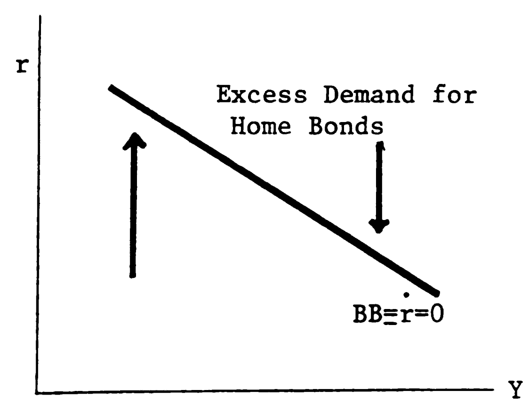

Figure 8-8

bonds. As a result, interest rate is rising. The slope of the BB curve can be derived from equation (8-25):

$$(dr/dY) = -(b_Y)/(b_r) < 0 \qquad (8\text{-}28)$$

The dynamics of real income can be represented by equation (8-19) in Figure 8-9. At point again I assume that the first (necessary) condition of stability is met and the IS curve is sloping downward. Points below the IS curve indicate an excess demand for goods.

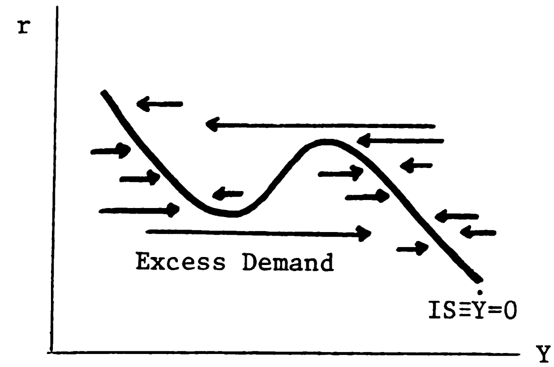

Figure 8-9

Points above the IS curve represents an excess supply of goods. Thus, real income tends to rise (fall) for points below (above) the IS curve in Figure 8-9.

The dynamic behavior of exchange rate was explained by equation (8-18). This equation was an excess demand for foreign bonds.

The FF curve in Figure 8-10, depicts combinations of interest rates and real incomes where demand for home bonds equal their supply.

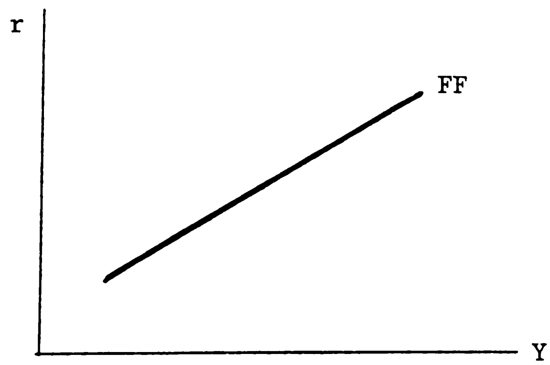

Figure 8-10

The FF curve has a positive slope. An increase in real income causes the excess demand for foreign bonds. Interest rates should rise to restore equilibrium in the market, holding everything else constant. A rise in the home rate of interest reduce demand

for foreign bonds.

The slope of the FF curve is derived from equation (8-23):

$$(dr/dY) = -(b^*_Y/b^*_r) > 0$$

To determine the stability conditions, I superimpose Figures (8-8, 9, and 10).[3] In Figure 8-11 (8-12) the IS curve slopes down steeper (flatter) than the BB curve.

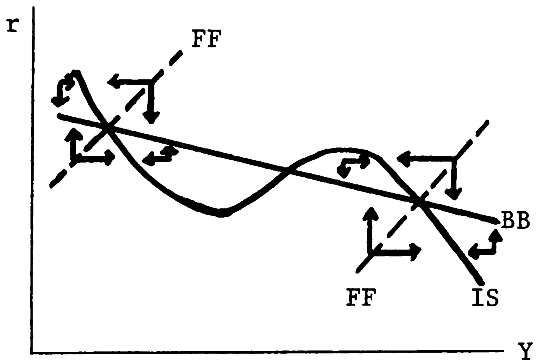

Figure 8-11

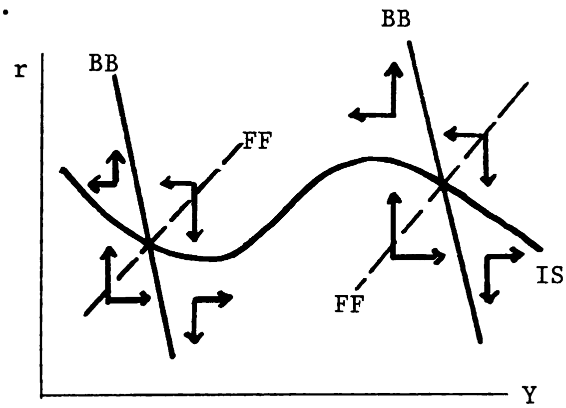

Figure 8-12

Arrows in Figures (8-11 and 12) indicate the direction of change in real income, Y, and interest rate, r.

Figure 8-12, where the BB curve is sloping downward and steeper than the IS curve, depicts a clear picture of unstable dynamics for interest rate and real income. But when the IS curve slopes down steeper than the BB curve, our economy behaves in a stable manner, Figure 8-11.

The stability condition of Figure 8-11 can be written in terms of respective slopes:

$$Z/(n-c(b^P/P)) < -(b_Y/b_r) \qquad (8\text{-}30)$$

as long as the necessary condition of stability (i.e., $Z < 0$) is met. The left (right) hand side of inequality (8-30) denotes the slope of

the IS (BB) curve.

The stability condition of (8-30) denotes the fact that the home bonds market is more responsive than home goods market to a given change in interest rate. In other words to restore equilibrium in both markets, real income rises more in the home bonds market than in home goods market for a given rise in interest rate.

IV. Comparative Statics

To examine the comparative statics, I take the total differentiation of equations (8-2, 3, and 14), with the change for real wealth can be derived equation (8-4):

$$wb_r dr + wb_Y dY + (b/P)(dM + dB^p + EdF^p + F^p dE) = (1/P)dB^p \qquad (8\text{-}31a)$$

$$wb_r^* dr + wb_Y^* dY + (b/P)(dM + dB^p + EdF^p + F^p dE) = (E/P)dF^p + (F^p/P)dE \qquad (8\text{-}31b)$$

$$(x_E(P^*/P_h) + c(r^* - \pi)(F^p/P))dE + (Z)dY - (n - c(B^p/P))dr =$$
$$-c(r-\pi)(1/P)dB^p - cE(r^* - \pi)\cdot(1/P)dF^p - dG \qquad (8\text{-}31c)$$

The set of equations (8-31) can be rearranged as:

$$-(F^p/P)(1-b^*)dE + wb_Y^* dY + wb_r^* dr = -(b^*/P)dM - (b^*/P)dB - dB^c) +$$
$$(E/P(1-b^*)(dF - dF^c) \qquad (8\text{-}32a)$$

$$(x_E(P^*/P_h) + c(r^* - \pi)(F^p/P))dE + (Z)dY - (n - c(B^p/P))dr - c(r-\pi)(1/P(dB - db^c) +$$
$$(Ec(r^* - \pi)/P)(dF - dF^c) - dG \qquad (8\text{-}32b)$$

$$-(F^p/P)bdE - wb_Y dY - wb_r dr = (b/P)dM - ((1-b)/P)(dB - dB^c) +$$
$$(Eb/P)(dF - dF^c) \qquad (8\text{-}32c)$$

The solution for changes in exchange rate, real income, and interest rate is given as:

$$-A \begin{pmatrix} dE \\ dY \\ dr \end{pmatrix} = \begin{pmatrix} dM \\ dB^c \\ dF^c \\ dG \end{pmatrix}$$

where

$$A = \begin{bmatrix} -(F^p/P)(1-b^*) & wb^*_Y & wb^*_r \\ x_E(P^*/P_h)+c(r^*-\pi)(F^p/P) & Z & -(n-c(B^p/P)) \\ -(b/P)(F^p/P) & -wb_Y & -wb_r \end{bmatrix}$$

and

$$B = \begin{bmatrix} -(b^*/P) & b^*/P & -(E/P)(1-b^*) & 0 \\ 0 & c(r-\pi)/P & cE(r^*-\pi)/P & -1 \\ b/P & & (1-b)/P & 0 \end{bmatrix}$$

The jacobian matrix A is identical to coefficient matrix J (derived for stability analysis) except for the positive parameters α, β, and λ. However, since it was not possible to prove the sign of coefficient matrix A, the comparative analysis of partial derivatives is pursued geometrically rather than mathematically.

The graphical investigation of comparative analysis will be based on three building blocks. These building blocks are the equilibrium conditions of the goods, home bonds, and foreign bonds markets. The comparative statics of each market will be examined independently from the other markets, in the following subsections. In other words, the impact of financial policies on each market is examined independently from the others. However, the theoretical

implications of these analysis will be combined in order to give us an overall view of the economy's response to changing policies.

Goods Market

Equilibrium in the goods market is depicted by Figure 8-13 and 14.

Monetary policies leave both IS curves undisturbed.

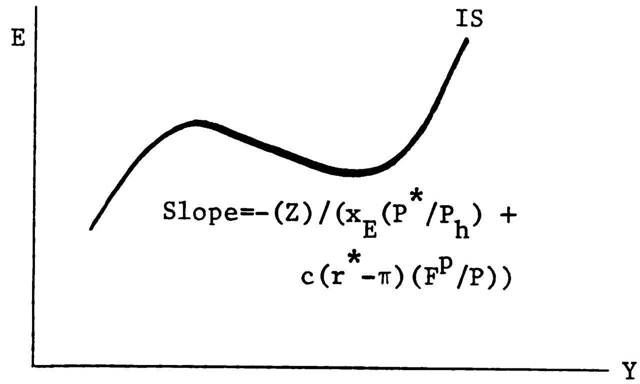

Figure 8-13

But open market operations and budgetary policies have reverse effects on the IS curves in Figures 8-13 and 14.

An open market purchase of home and/or foreign bonds (i.e., $B^c\uparrow$, $F^c\uparrow$) reduces home citizens interest earnings and hence their disposable income and aggregate demand holding everything else constant (including GNP). Exchange rate should rise to restore equilibrium in goods market through a surge in net exports. Therefore, a purchase of bonds would shift the IS curve in Figure 8-13. But as we will see this effect is not very strong.

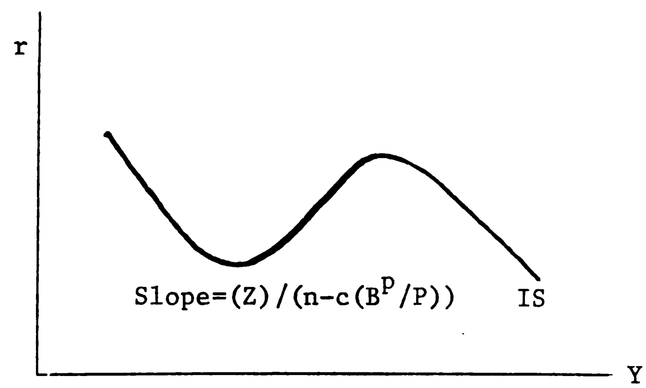

Figure 8-14

Holding everything else (including real income and exchange rate) constant, the contractionary impact of bond purchase could be offset through a reduction in home interest rate. Therefore, the IS

curve would shift downward in Figure 8-14 as a result of bond purchase (i.e., $B^c\uparrow$, $F^c\uparrow$). This effect is not strong either as we will see in the open market operation subsection (Vb) of section V.

An expansionary fiscal policy disturbs equilibrium in goods market. Either the exchange rate should decline or home interest rate should rise to restore the equilibrium in that market. Therefore, the IS curve shifts down (up) in Figure 8-13 (8-14) as a result of expansionary fiscal policy.

Foreign Bonds Market

Equilibrium in the foreign bonds market is depicted by Figures 8-15 and 8-16.

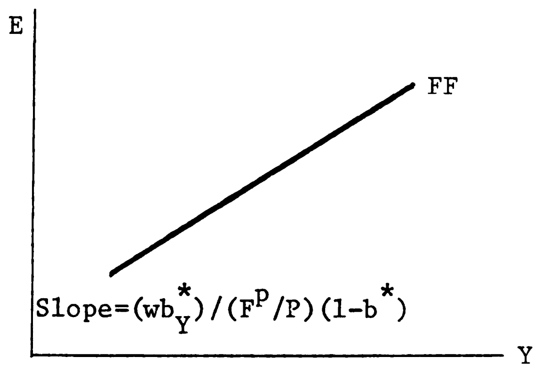

Figure 8-15

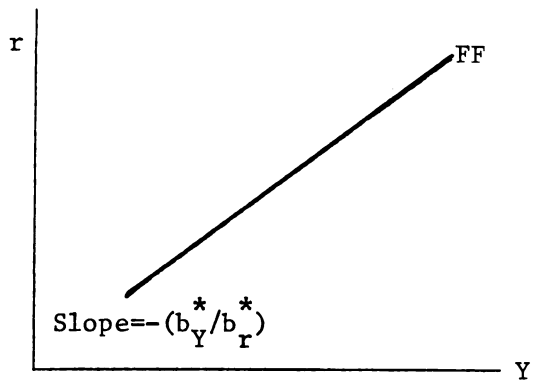

Figure 8-16

An expansionary monetary policy (i.e., printing money) disturbs equilibrium in this market by increasing wealth and hence demand for all financial assets including foreign bonds. In the foreign bonds market either E and/or r should rise to restore equilibrium. An increase in exchange rate would increase the home currency value of foreign bonds held by home citizens. An increase in home interest rate would reduce the home demand for foreign bonds. Thus, the IS curve shifts upward in Figures 8-15 and 8-16.

An open foreign bond purchase (i.e., $F^C\uparrow$) disturbs the market by reducing the outstanding supply of foreign bonds. As the case of monetary expansion, either E and/or r should rise to restore equilibrium in the market.

An open home bond purchase (i.e., $B^C\uparrow$) disturbs the market by decreasing wealth and hence the demand for foreign bonds. To restore equilibrium E and/or r should decline. Therefore, the FF curve shifts down in Figures 8-15 and 8-16.

A fiscal policy by itself has no effect on the location of the FF curve.

Home Bonds Market

Equilibrium in the home bonds market is depicted in Figures 8-17 and 8-18.

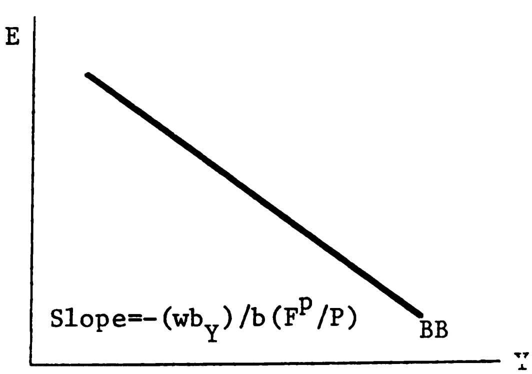

Figure 8-17

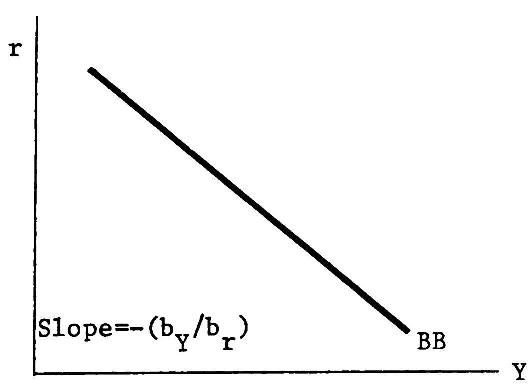

Figure 8-18

An expansionary monetary policy (i.e., $M\uparrow$) disturbs this market by increasing real wealth and hence demand for home bonds. Either E and/or r should rise to restore equilibrium in this market. A reduction in r reduces demand for home bonds directly. A reduction in E reduces home currency values of foreign bonds and therefore the total wealth. Thus, a reduction in E reduces demand for bonds

indirectly through a change in wealth. In both cases the BB curve shifts down in Figures 8-17 and 8-18.

An open foreign bond purchases (i.e., $F^{c\uparrow}$) affects the market indirectly through wealth. Real wealth declines so the demand for home bonds. Either E and/or r should rise. Thus, the IS curve would shift up in Figures 8-17 and 8-18.

An open purchase of home bonds (i.e., $B^{c\uparrow}$) reduces the outstanding supply of home bonds. Either E and/or r should decline. The BB curve shifts down in Figures 8-17 and 8-18.

Table one sums up the conclusion of our discussion.

TABLE 1

SHIFTS IN REAL AND FINANCIAL MARKETS AS A RESULT OF FINANCIAL POLICIES (MARKETS ARE EXAMINED INDEPENDENTLY FROM EACH OTHER)

		M	B^c	F^c	G
IS curve	EY Plane	-	up	up	down
	rY plane	-	down	down	up
FF curve	EY Plane	up*	down*	up	-
	rY Plane	up*	down*	up	-
BB curve	EY Plane	down* *	down *	up* *	-
	rY Plane	down*	down	up*	-

V. <u>Comparative Statics: Effects of Financial Policies on Exchange Rate, Real Income, and Interest Rate; Combined Effects</u>

The effects of financial policies on real and financial markets were examined independently in each market. This section

examines such effects (interdependently) on all markets. I make the following assumptions about real and financial markets' speed of adjustment. I assume that financial markets respond faster than the real sector to government policies. This is a standard assumption made in the literature.

Va. Monetary Policy: Discount Rate and Reserve Requirement Fluctuations

An application of an expansionary monetary policy to the economic system can be explained by a decrease in discount rate, reserve requirement ratios and/or government purchase of home bonds. In this section, I examine the impact of an expansionary monetary policy, through discount rate and reserve requirement ratio manipulations, on the economy. Any change in the supply of home bonds held by private citizens is sterilized.

As explained in Table one, the IS curve does not respond to an expansionary monetary policy.

Expansionary monetary policy shift the equilibrium locus (FF curve) up. Home bonds market equilibrium conditions (BB curve) shifts down, Figure 8-19.

Suppose the economy was initially at point E_0 in Figure 8-19. With an expansionary monetary policy, the financial markets would be at equilibrium point E_1. But at E_1 the goods market (i.e., IS curve) is out of equilibrium condition. There is an excess demand for goods. This

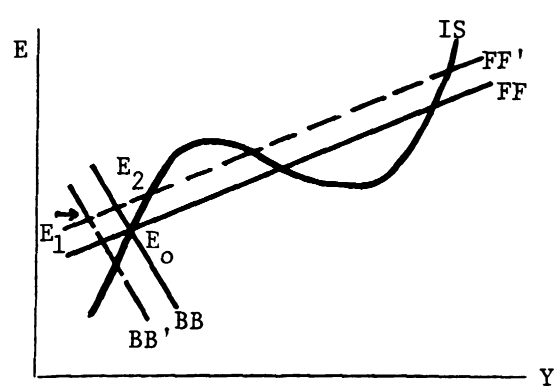

Figure 8-19

is based on the assumption that financial markets respond faster than real markets to financial policies. However, because of an excess demand for goods at E_1, real income starts to rise. E_1 starts to move to the right.

At equilibrium point E_1, demand for foreign bonds equals their supply. However, this demand for foreign bonds rises as real income rises. The exchange rate rises and home currency depreciates. The supply of foreign bonds declines as net exports (as a function of real income) declines.[4] Exchange rate surge keeps rising. But this rise is partially dampened by the very effect of rise in E on supply of foreign bonds denominated in home currency.

As far as home bonds market is concerned, a rise in real income requires a decline in exchange rate in order to remain in equilibrium. However, exchange rate equilibrium value is determined in the foreign bonds market. Home bonds respond to this circumstances by shifting to the right. This happens as supply of foreign bonds decline through a surge in imports.

Thus, the economy starts to move away from E_1 along the FF curve toward E_2. But the economy can stop short of E_2 as the IS curve starts to shift upward. An upward shift in the IS curve can be explained by a reduction in interest earning of private citizens on foreign bonds. However, this shift is not likely to be a major one as this interest earnings makes a small fraction of real income.

The large swings and cyclical behavior of exchange rate and real income might become reality if an expansionary monetary policy passes certain levels.

Suppose the economy is initially at poine E_3 in Figure 8-20.

A further expansionary monetary policy can cause a sudden jump (large swing or catastrophe) in equilibrium values of real income and exchange rate. As explained before, at E_4, real income will rise and the BB' curve shifts upward along the FF' curve. However, the economy will move from E_4 to another equilibrium point, E_5, on the other stable arm of the IS curve in Figure 8-20.

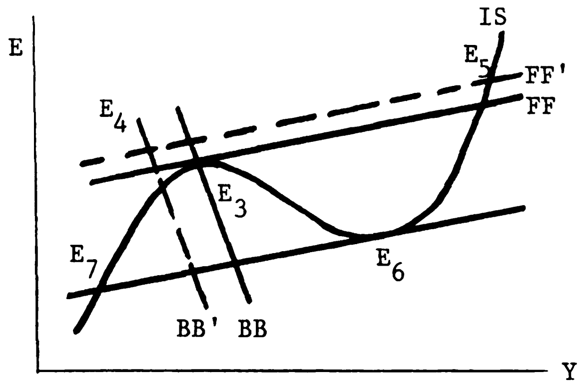

Figure 8-20

The cyclical behavior of exchange rate (real income) might become more clear by the use of picture (8-21). E (or Y) curve, in Figure 8-21, shows the equilibrium path of exchange rate (or real income) as a result of continuous change in monetary policy. Arrows in Figure 8-21 depict the direction of equilibria as a function of monetary policy.

The interest rate impact of monetary policy can be illustrated by the use of Figure 8-22.

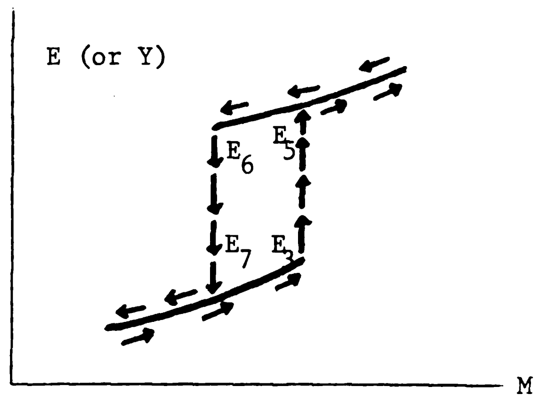

Figure 8-21

As a result of expansionary monetary policy, the economy will move to equilibrium point E_1 (for financial markets only) if it was initially at E_0. At E_1 financial markets are in equilibrium but goods market is not. At E_1, because of excess demand for goods, real income rises. Demand for home bonds rises and therefore, interest rate declines.

Net exports decline as real income goes up. Supply of foreign bonds decline. This leads to a downward shift in the FF curve.

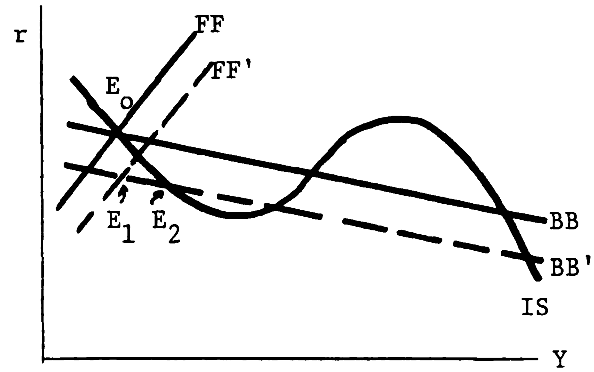

Figure 8-22

Therefore, the economy moves away from E_1, along BB' curve toward E_2. However, the economy can stop short of equilibrium point E_2 as the IS curve shifts down. The shift in the IS curve is caused by the reduction of interest earnings of private wealth holders on home bonds.

The cyclical behavior of interest rate and real income can become clear by the use of Figure 8-23 similar to Figure 8-20.

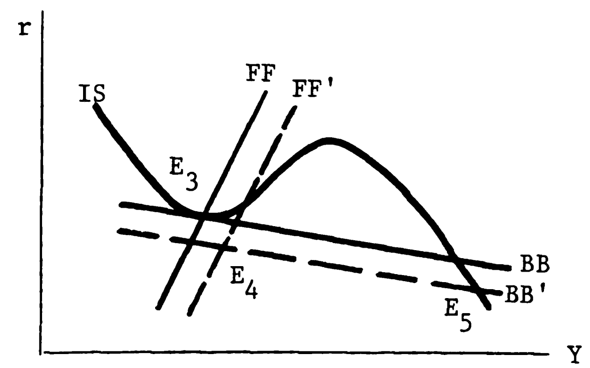

Figure 8-23

Suppose the economy was initially at equilibrium point E_3. An expansionary monetary policy insures equilibrium for financial markets first. But at E_4 the real income starts to rise and economy moves to an equilibrium point such as E_5 in Figures 8-23 and 24.

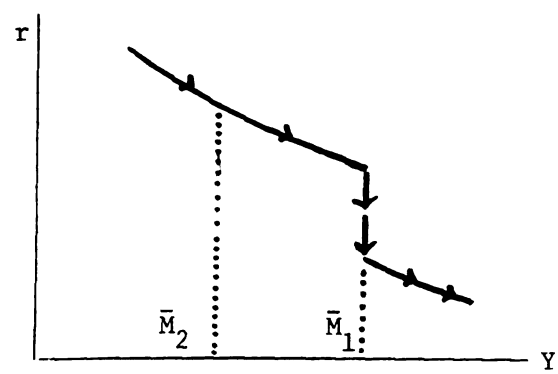

Figure 8-24

At $\bar{M}_1$ level, the economy experiences a sudden jump (i.e., catastrophe), as money supply rises continuously.

But the economy does not experience large swings

(i.e., catastrophes) at the same level of money supply (i.e., $\bar{M}_1$) as money supply shrinks. This has been explained by the "delay rule" in theory of catastrophe.

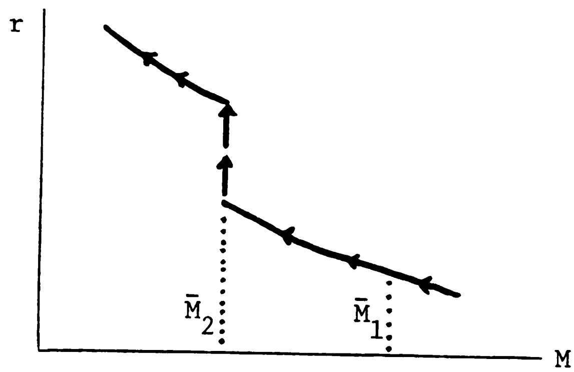

Figure 8-25

Vb. <u>Monetary Policy: Open Market Operations in Home Bonds Market</u>

Government open market purchase of home bonds leads to a reduction of outstanding supply of home bonds held by home private wealth holders and an expansion in the supply of cash balances.

The effects of open market operations (in home bond) on the economy are summarized in Table two. Information, given in Table two, is obtained from Table one. This table provides information about the economy in both E-Y and r-Y planes.

TABLE 2

EFFECTS OF OPEN MARKET PURCHASE OF BONDS
ON REAL AND FINANCIAL MARKETS

	E-Y Plane		r-Y Plane	
	$B^c\uparrow$==========> $M\uparrow$		$B^c\uparrow$==========> $M\uparrow$	
IS curve	shifts up	no change	shifts down	No change
FF curve	shifts down*	shifts up*	shifts down*	shifts up*
BB curve	shifts down*	shifts down**	shifts down	shifts down*

The comparative statics of exchange rate and real income can be illustrated by Figure 8-26.

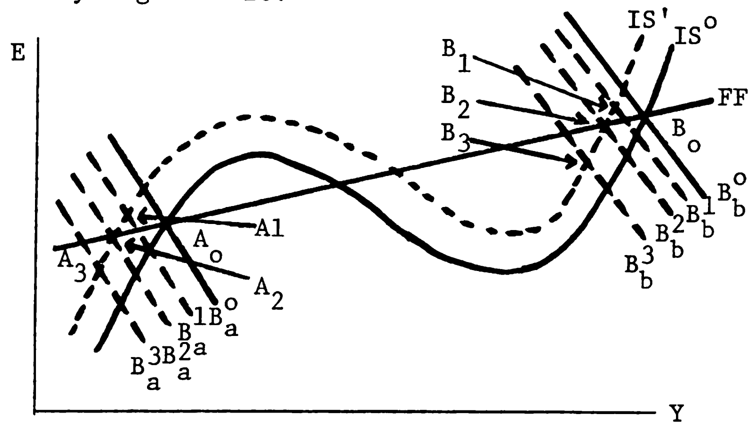

Figure 8-26

An open market purchase of home bonds does not cause any shift in the foreign bond equilibrium condition. The FF curve shifts up and down by $(b^*/P)/((F^P/P)(1-b^*))$ amount (equation 8-23). BB curve shifts down by $(1/bF^P)$ (equation 8-25). The IS curve shifts up by $(c(r-\pi)/P)/(x_E(p^*/P_h)+c(r^*-\pi)(F^P/P))$ amount (equation 8-32b).

Suppose the economy was initially at equilibrium point A_o (B_o), in Figure 8-26. An open market purchase of home bonds causes the IS curve to shift up and the BB curve down. Since the absolute amount of change in location of curves can not be determined, I drew three different shifts for the BB curve, B_a^1, B_a^2, and B_a^3 (or B_b^1, B_b^2, and B_b^3). Equilibrium conditions in financial markets would be achieved at points A^1, A^2, and A^3 (or B^1, B^2, and B^3) respectively. At equilibrium point A^1 (or B^1) the goods market is in disequilibrium. The supply of goods exceeds their demand at equilibrium point A^1 (or B^1). Real income declines. The B_a^1 (or B_b^1) curve shifts down along the FF curve until it reaches point A_2 (or B_2). If the initial open market purchase of home bonds implied a financial equilibrium

condition of point A_3 (or B_3), demand for goods would exceed their supply. Real income would rise and the B_a^3 (or B_b^3) curve would shift upward. The economy would settle at equilibrium point B^2 (or A^2).

The catastrophic nature (large swings) of real income and exchange rate can be illustrated by the use of Figure 8-27.

Suppose the economy was initially at point E_o. An open purchase of home bonds leads to an upward (downward shift of the IS (BB) curve from IS^o (BB^o) to IS^1 (BB^1) in Figure 8-27. Financial markets

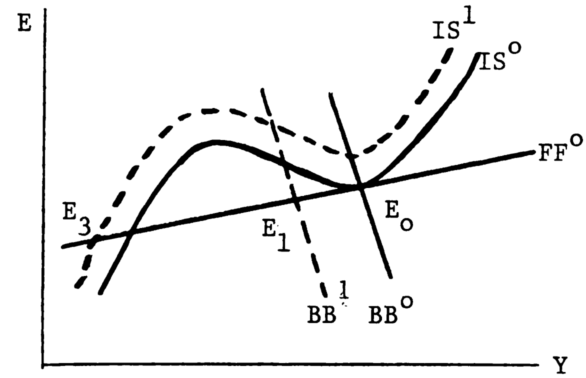

Figure 8-27

will be in equilibrium at point E_1. However, at E_1, excess supply of goods is positive. Real income would decline. The BB curve would shift down along the FF curve until it reaches point E_3. At E_3, all markets are in equilibrium.

Equilibrium path of exchange rate (or real income) and the occurrence of catastrophe is depicted in Figure 8-28.

The effects of an open market purchase of home bonds on the interest rate can be illustrated by Figure 8-29. Suppose that the economy was initially at point A_o (or B_o). An open market purchase of home bonds does not cause

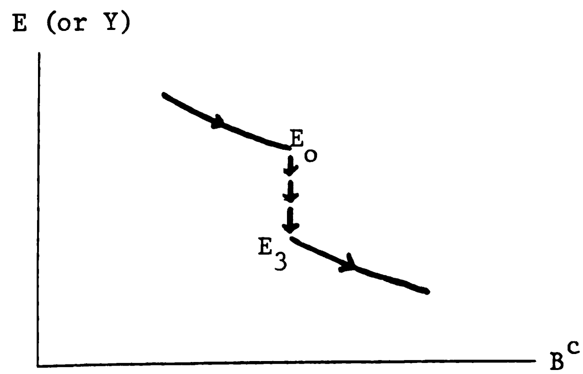

Figure 8-28

any shift in foreign bond markets. The FF curve shifts up as shown

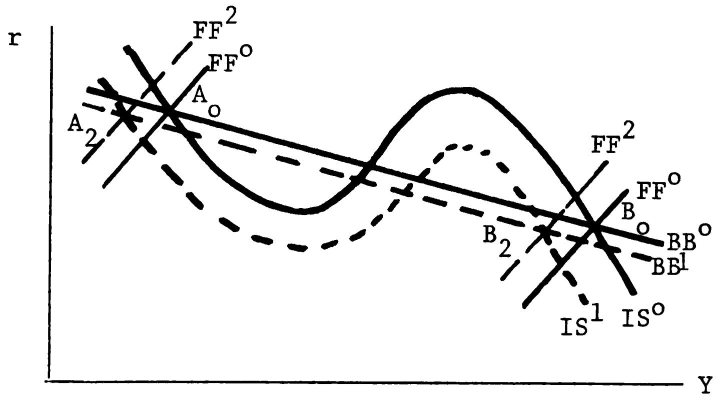

Figure 8-29

by $(b^*/P)/(wb^*_r)$ amount (equation 8-23). The BB curve shifts down by $1/Pwb_r$ amount (equation 8-25). The IS curve shifts down by $(c(r-\pi))/(n-c(B^P/P))$ amount (equation 8-32b). An open market purchase of home bonds causes the IS and BB curves to shift down. The analysis is similar to the one discussed for Figure 8-25. The economy will move from equilibrium point A_o (B_o) to A_2 (or B_2). Interest rate and real income decline. At this stage I skip the dynamics of the economy in moving from the initial equilibrium point A_o (or B_o) to A_2 (or B_2). The argument is similar to the one given for E-Y model (i.e., Figure 8-26).

The catastrophic nature of interest rate is illustrated by Figure 8-30.

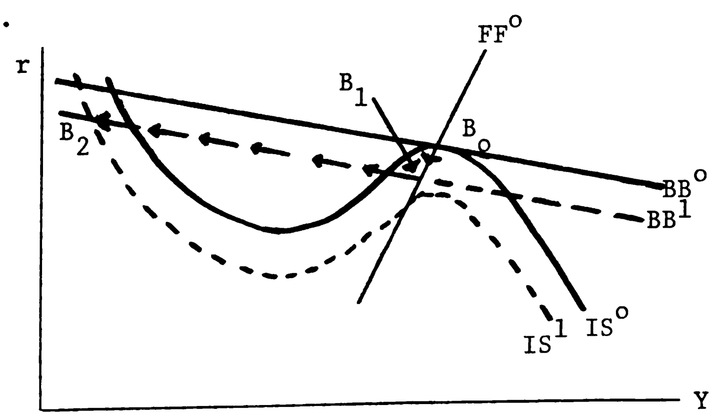

Figure 8-30

The economy was initially at B_o. An open purchase of home bonds leads to downward shifts of both the IS and BB curves. Point B_1 would be a financial equilibrium if the IS curve shifts down further than the BB curve. The economy can not sustain itself at point B_1. It moves further westward as a result of excess supply of goods and leftward shift of the FF curve until it reaches point B_2. Interest rate declines initially as a result of open market purchase of home bonds. However, at point B_1 real income starts to rise. Demand for home bonds declines and thus, its price falls. As price of home bonds declines interest rate shoots up.

Indeterminate behavior of interest rate is more visible when the BB curve happens to be tangent to the IS curve at extrema, Figure 8-31. Even then the occurrence of the catastrophe (or large swings), in this case only, depends on the sensitivity of real and financial markets to changes in open market operations.

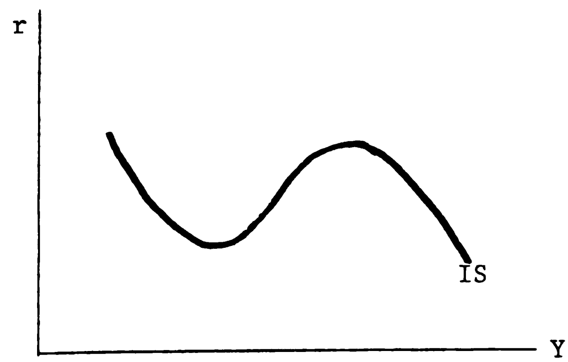

Figure 8-31

Vc. Intervention in Foreign Bond Market

A government open market purchase of foreign bonds leads to a reduction of outstanding supply of foreign bonds held by home wealth holders and an expansion in the supply of real cash balances.

Table three summarizes the effects of open market purchase of foreign bonds by government on the economy.

TABLE 3

EFFECTS OF OPEN MARKET PURCHASE OF FOREIGN BONDS
ON REAL AND FINANCIAL MARKETS

	E-Y Plane		r-Y Plane	
	$F^c\uparrow$==========> $M\uparrow$		$B^c\uparrow$==========> $M\uparrow$	
IS curve	shifts up	no change	shifts down	no change
FF curve	shifts up	shifts up*	shifts up	shifts up
BB curve	shifts up*	shifts down*	shifts up*	shifts down*

Information, given in Table three, is obtained from Table one. Table three provides the necessary information about the economy in both E-Y and r-Y planes.

The comparative statics of exchange rate and real income can be illustrated in Figure 8-32.

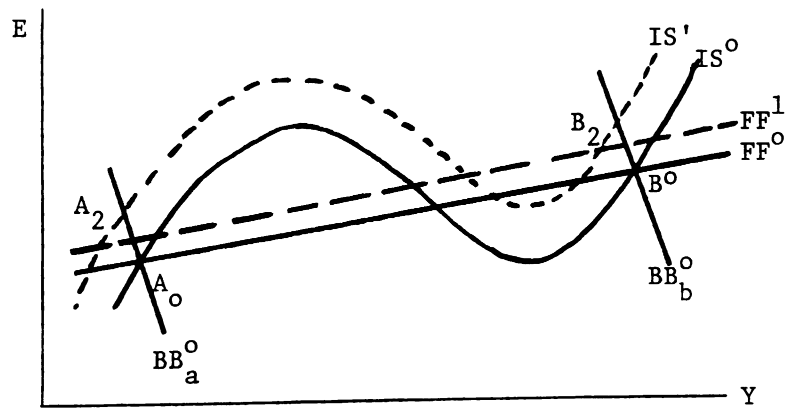

Figure 8-32

An open market purchase of foreign bonds does not cause shift in the BB curve initially. The home bond market shifts up and down by $1/F^p$ (or $(b/P)/(wb_r)$) in E-Y (or r-Y) plane, (equation 8-25). The foreign bonds market shifts up by the amount of $((b^*/P)+(E/P)(1-b^*))/$

$((F^p/P)(1-b^*))$, (or $((b^*/P) + (E/P)(1-b^*))/wb_r)$, in an E-Y, (or r-Y), plane. The IS curve shifts up (down) by the amount of $(cE(r^*-\pi))/(x_E(P^*/P_h)+(c(r^*-\pi)(F^p/P))$, (or $(cE(r^*-\pi))/(n-c(B^p/P)))$ in an E-Y (or r-Y) plane.

An open market purchase of foreign bonds causes the economy to move from the equilibrium point A_o (or B_o) to A_2 (or B_2). I skip the explanation of the equilibrium path from A_o (or B_o) to A_2 (or B_2) since it is similar to the accounts given earlier. Thus, as a result of this operation exchange rate rises. But the direction of change in real income depends on real and foreign bonds markets sensitivity to open market operational policies of government. The flatter (i.e., the more elastic) the curves are, the more likely that real income would rise. Furthermore, the higher (lesser) the FF (IS) curve shifts up the more likely that real income would rise.

The occurrence of catastrophe can be illustrated by Figure 8-33.

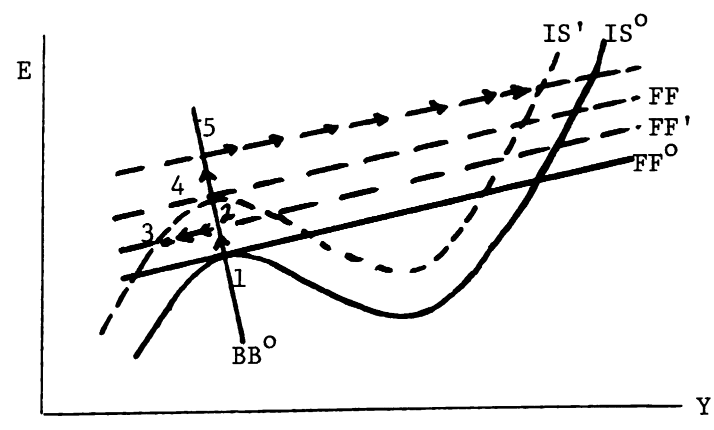

Figure 8-33

Here, in this figure, open market purchase of bonds implies different responses by foreign bonds market.

Suppose the economy was initially at point 1 in Figure 8-33. If the FF curve shifts up less than (equal to) the IS curve, E would

rise and real income would decline (real income would remain the same). The economy would move from point 1 to 3 (4). But if the FF curve shifts up more than the IS curve, the economy would move from equilibrium point 1 to 6. Both E and Y would rise suddenly.

The comparative statics of interest rate is illustrated by Figure 8-34.

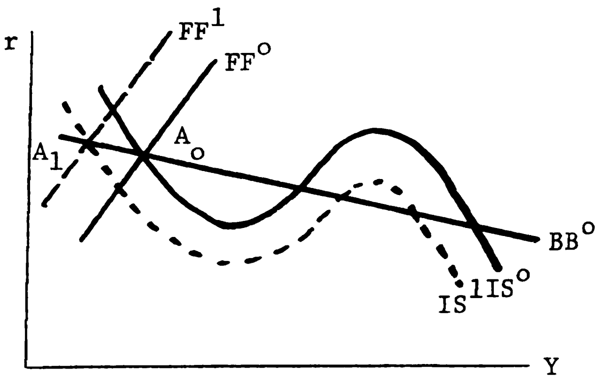

Figure 8-34

An open market purchase of foreign bonds leaves the BB curve unchanged. The FF curve shifts up and the IS curve shifts down. Thus, the economy moves from the equilibrium point A_0 to A_1 in Figure 8-34. Interest rate (real income) would rise (declines) as a result of open market purchase of foreign bonds.

Vd. Fiscal Policy

Government fiscal policy can either be bond or money financed. Table four depicts a money financed fiscal policy effects on real and financial markets.

TABLE 4

EFFECTS OF MONEY FINANCED FISCAL POLICY

	E-Y Plane		r-Y Plane	
	G↑ ==========>	M↑	G↑ ==========>	M↑
IS curve	shifts down	no change	shifts up	no change
FF curve	no change	shifts up*	no change	shifts up*
BB curve	no change	shifts down**	no change	shifts down*

The equilibrium conditions of real and financial markets are illustrated by points e_o in Figures 8-36 and 37. According to Table four, money financed fiscal policy causes the FF (or BB) curve to shift up (down) in both planes. The IS curve shifts up (down) in r-Y (E-Y) plane, Figure 8-37 and 36 respectively.

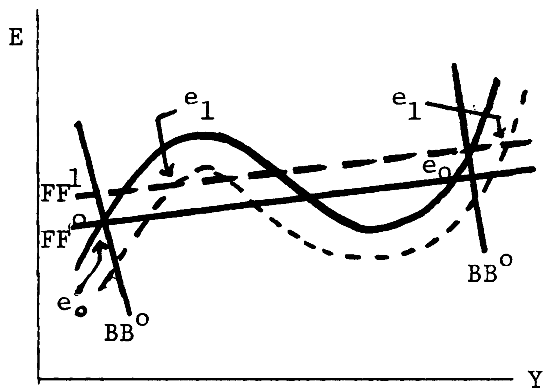

Figure 8-36

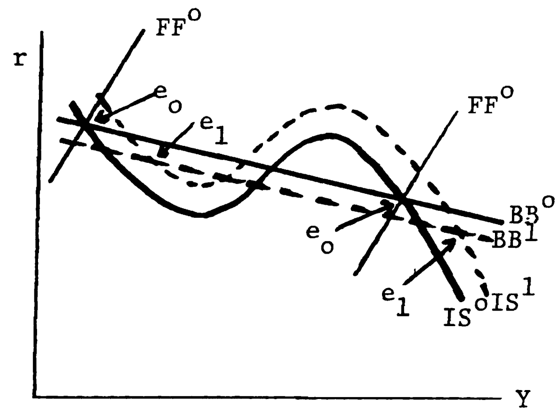

Figure 8-37

These figures clearly indicate that real income and exchange rate rise. But interest rate declines.

An important point is that the equilibrium point e_1 was basically determined by real and foreign (home) bonds markets in E-Y (r-Y) plane, Figure 8-36 (8-37).

The catastrophe nature of the model (large swings in the economic variables) can be illustrated by Figures 8-38 and 39.

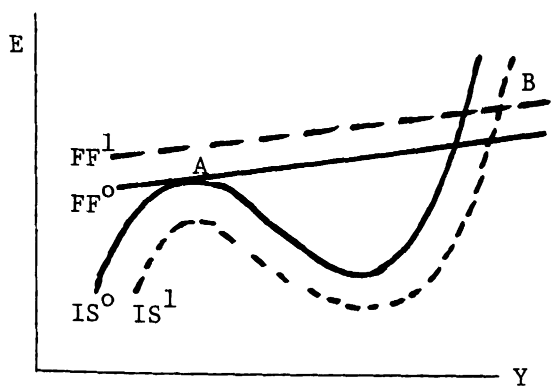

Figure 8-38

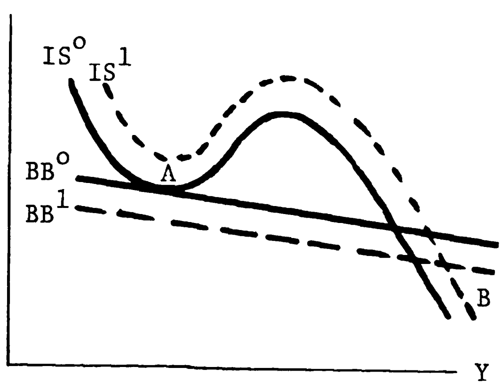

Figure 8-39

Suppose the economy is initially at equilibrium point A in Figures 8-38 and 39. An expansionary fiscal policy financed by printing money leads to changes in the original locations of the IS, FF, and BB curves. As explained before, the IS curve shifts down (or up) in the E-Y (or r-Y) plane, Figure 8-38 (or 39). The FF curve shifts up in both E-Y and r-Y planes. The BB curve shifts down in both E-Y and r-Y planes. Therefore, the economy jumps suddenly from the equilibrium point A to B in Figures 8-38 and 39. Figures 8-40 and 41 trace out the equilibrium path of exchange rate, real income, and interest rate as a result of continuous fiscal policy changes.

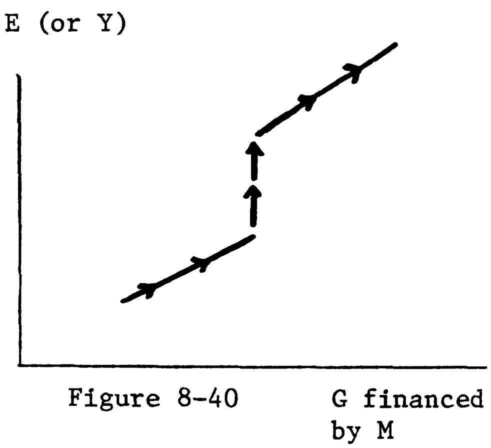

Figure 8-40

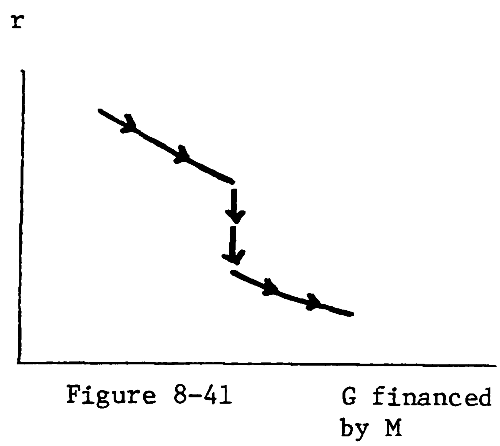

Figure 8-41

Table five depicts the effects of a bond financed fiscal policy on the economy.

TABLE 5

EFFECTS OF BOND FINANCED FISCAL POLICY

	E-Y Plane		r-Y Plane	
	$G\uparrow$ ==========>	$B^c\downarrow$ or $B\uparrow$	$G\uparrow$ =========>	$B^c\downarrow$ or $B\uparrow$
IS curve	shifts down	shifts down	shifts up	shifts up
FF curve	no change	shifts up*	no change	shifts up*
BB curve	no change	shifts up*	no change	shifts up

Again I assume that the necessary condition of stability is met (i.e., $Z < 0$) and consider a down (up)-ward sloping IS curve in a r-Y (E-Y) plane.

Equilibrium conditions of the economy are specified by points e_o in Figure 8-43.

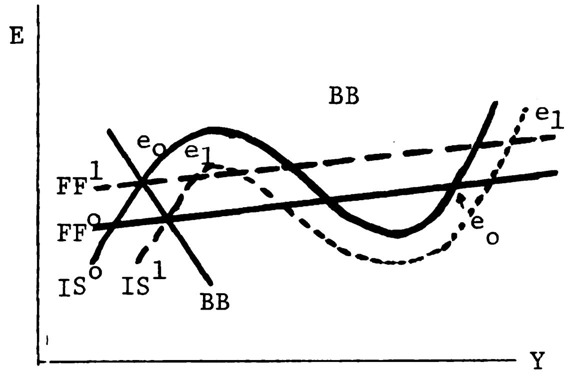

Figure 8-42

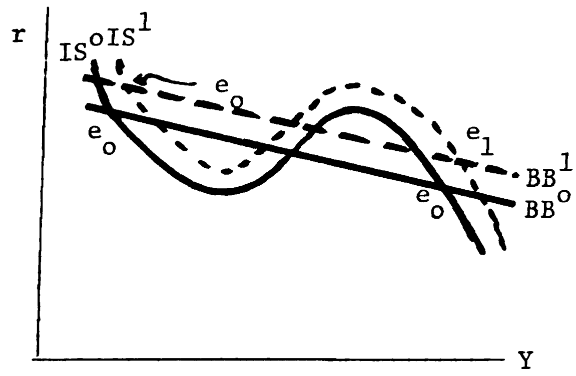

Figure 8-43

According to Table five, bond financed fiscal policy causes both the BB and FF curves to shift up. The IS curve shifts down (up) in E-Y (r-Y) plane.

Figures 8-42 and 43 clearly indicate that bond financed deficit would raise exchange rate, real income and reduce interest rate.

The catastrophe nature of the model can be illustrated by Figures 8-44 and 8-45.

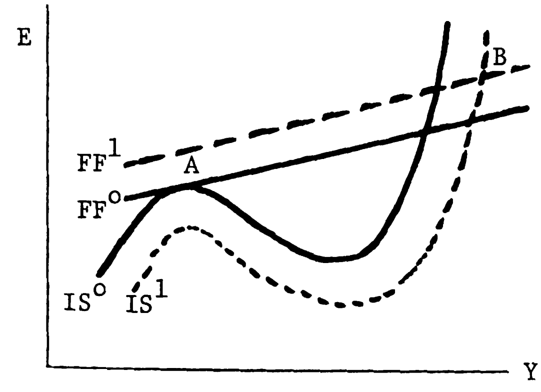

Figure 8-44

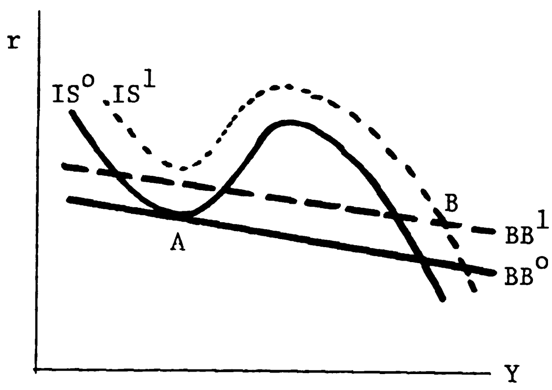

Figure 8-45

Suppose the economy is initially at the equilibrium point A in Figures 8-44 and 45. An expansionary fiscal policy financed by open market operations in the home bonds market leads to changes in the original locations of the IS, FF, and BB curves. As explained by Table five, the IS curve shifts down (up) in an E-Y (r-Y) plane. The FF curve shifts up in both E-Y and r-Y planes. The BB curve shifts up in both the E-Y and r-Y planes. A continuous bond financed fiscal policy leads to the occurrence of a large swings in the equilibrium values of exchange rate, real income, and interest rate, Figures 8-44 and 8-45.

The equilibrium path of exchange rate, real income, and interest rate can be illustrated by Figures 8-46 and 8-47.

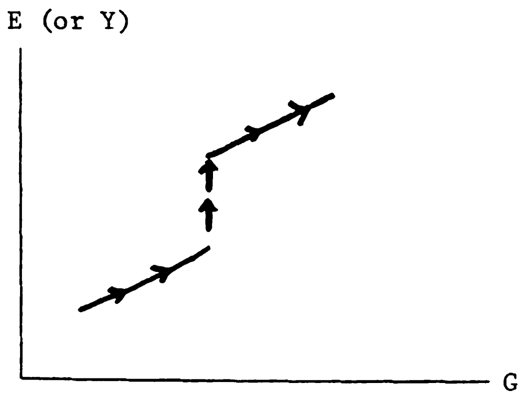

Figure 8-46 Financed by bond ($B^c\downarrow$)

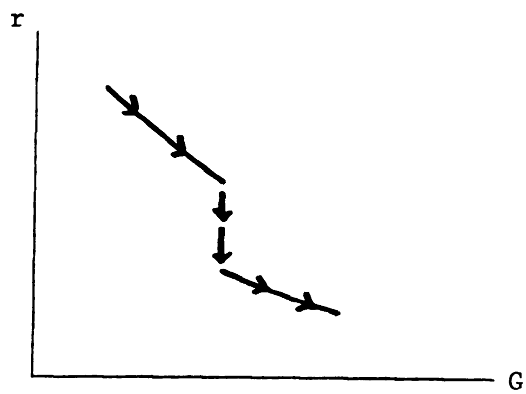

Figure 8-47 Financed by bond ($B^c\downarrow$)

CHAPTER 8--Footnotes

[1]Foley (1975).

[2]In an E-Y plane, the dynamic behavior of exchange rate and real income are explicitly depicted by equations (8-18 and 19) and Figures 8-3 and 4. The dynamic behavior of interest rate is not explicitly examined in such a plane. This is due to the fact that interest rate can not be presented in such a plane, Figure 8-6. As a result, the dynamic behavior of the model is primarily dictated by the IS and FF curves. The BB curve is reacting passively to the rest of the model. This issue will be examined further in section V of this chapter.

[3]The picture changes as the economy is represented by a r-Y plane. The dynamic behavior of real income and interest rate rather than the exchange rate can only be shown in a r-Y plane. This can be accomplished through equations (8-19 and 20) and Figures 8-9 and 8. The dynamic behavior of exchange rate is not explicitly examined in such a plane, Figure 8-11, even though a market clearing condition for foreign bonds is derived in Figure 8-10. As a result, the dynamic behavior of the model is dictated primarily by the IS and BB curves. The foreign bonds market is reacting passively to the rest of the economy. I examine this issue further in section V.

[4]Under a flexible exchange rate regime, the balance of payments (BOP) is zero. The current account imbalances, $x(Y,P^*/P_h)$, are equal to foreign asset flows, $\dot{F}$, equation (7-67):

$$x(Y,EP^*/P_h) = E\dot{F}=E(\dot{F}^p+\dot{F}^c) \qquad (7\text{-}67)$$

In a BOP (flow) theory of exchange-rate determination, the equilibrium values of exchange rate is determined by the BOP constraint, equation (7-67). But in a portfolio-balance model of exchange-rate determination (applied in this chapter), the equilibrium value of exchange rate is determined when stock demand for foreign bonds equal their (stock) supply, equation (8-3):

$$b^*(r-\pi,r^*-\pi,Y)w = EF^p/P \qquad (8\text{-}3)$$

To use the BOP constraint, equation (7-67) as a structural equation for our model leads to the overdetermination of exchange rate.

CHAPTER 9

Conclusion

In this thesis, I develop and examine a real and financial model of real income, exchange rate, and interest rate determination. Different versions of this model have been investigated. The purpose of such models were to deal with the subject of exchange rate and other variables' fluctuations within the mathematical framework of catastrophe theory. It was basically the existence of large swings and sudden jumps in the equilibrium values of exchange rate that warrant this dissertation.

I searched the real sector of the economy rather than expectations formation (as explained by De Grauwe 1983) and/or monetary sector (as explained by Tobin 1979) of the economy as a major contributing factor in explaining the catastrophic nature of the exchange rate.

Tobin (1979) can be a starting point in building a monetary model of catastrophe theory. Appendix A examines this case briefly.

De Grauwe (1983) develops an expectational formation model of catastrophe theory. Appendix B discusses such a model. The characteristics of this model were examined in Chapter one. Therefore, I restrain myself on this issue and pay closer attention to the consequences of this thesis.

First of all, catastrophes are defined as sudden or

discontinuous jumps (or swings) in the equilibrium values of a dynamic system when the parameters of such a system are changing continuously.

Probably real income and interest rate are the two major factors among many, which can explain the equilibrium values of exchange rate. Any factor (or factors) that can cause catastrophes in real income and interest rate could do the same for exchange rate. Therefore, I searched the real sector of the economy and theories of income fluctuations in order to pinpoint the sources of catastrophes. The sigmoid-shape investment function developed and modified in Chapter two was treated as the major source in the development of income fluctuations and turning points. This has been confirmed by Ichimura (1954, 1955) and Varian (1977, 1979). The sigmoid-shape investment function was originally developed by Kaldor and applied by Ichimura and varian to catastrophe theory in a closed economy. This investment function was considered as a function of real income and the stock of capital. Chapter two provided the theoretical groundwork to modify this investment function. The interest rate was added to the sigmoid-shape investment function as an additional variable in the line of existing literature on investment theory.

In Chapter three, in line with the modified version of sigmoid-shape investment function, I derived a non-linear IS curve. Chapter four explained the essentials of catastrophe theory.

A Keynesian macroeconomic analysis of a closed economy was presented in Chapter five. The equilibrium values of real income and interest rates were explained in an IS-LM model. It was shown there that continuous changing financial policies could lead to the

occurrence of catastrophes in this model. This was a significant departure from the existing literature on the application of catastrophe theory to a closed economy model. Both Ichimura and Varian could explain the catastrophes of real income through a continuous change in the stock of capital. But in my model, I was able to explain large swings in the equilibrium values of real income in terms of continuous fiscal and monetary policy changes. The stock of capital was a third source of catastrophe. Besides, in my model, not only the equilibrium values of real income, but also that of the interest rate was explained. With the brief examination of aggregate demand and supply I finished the first part of the thesis (i.e., closed economy).

In the second part of the thesis, I examined catastrophes in an open economy. Chapter six presented a brief review of the existing literature on alternative theories of exchange rate determination. It was concluded that the portfolio-balance theory has superiority in explaining exchange-rate behavior.

At this stage, I had built two major building blocks in order to examine consequences of financial policy changes in an open economy. The first building block was the IS and LM model that I developed in Chapter three. The second building block was the portfolio-balance model of exchange-rate determination which was specified in Chapter six.

In Chapter seven, I used these two building blocks to construct a real and financial model of income and exchange-rate determination. The goods market clearing condition in conjunction with the portfolio-selection equilibrium condition determined the

equilibrium values of real income and exchange rate. Interest parity condition was assumed throughout this chapter. As a result of this assumption and in conjunction with small country assumption home interest rate was constant and equal to foreign interest rate (corrected for inflationary expectations).

I examined the equilibrium behavior of exchange rate and real income in this model with a static, rational expectations, inflationary, and dynamic framework. The stability conditions of these models were carefully examined. It was proved that as long as the economy remained on the conventional down (up)-ward sloping parts of the IS curve in a r-Y (E-Y) plane, the system is stable. As a result of any small perturbation the system returned to its original position. However, the system displayed unstable behavior on the unconventional upward (down)-ward sloping part of the IS curve in a r-Y (E-Y) plane.

The displays of both stable and unstable behavior in my model are the major keys enabling me to explain discontinuous changes (i.e., catastrophes) in the equilibrium values of exchange rate and real income. It was shown that continuous changing financial policies can move the system from one set of stable equilibrium positions (surface) to another set of stable equilibrium positions (surface) suddenly and rapidly. There exists a locus (surface) of unstable equilibria between the two stable surfaces in which the economy could not sustain itself.

This was the crux of this thesis. The occurrence of catastrophes in exchange rate is beyond any doubts. Exchange-rates fluctuate continuously in small amplitude daily. This has been explained

by the existing literature in the field. However, along this small amplitude, there sometimes happens sudden discontinuous changes in the values of exchange rate. This thesis was bent to explain such changes in the framework of dynamic theory of catastrophe.

Catastrophes happened when our model moved from one stable equilibrium surface to another stable surface as a result of continuous financial policy changes. However, the result obtained when the system did not change its stable equilibrium surface did not contradict the results obtained from the existing literature on exchange-rate behavior.

The same can be argued about Chapter eight. In this chapter I relaxed the assumption of interest parity condition. As a result, home and foreign bonds were no longer perfect substitutes. This made me able to study the behavior of interest rate side by side with real income and exchange rate.

Due to the mathematical intractability, the case of stability analysis was harder in Chapter eight. However, the general conclusions of this chapter inspired the same results as Chapter seven.

The last issue which is probably the first question raised by an intelligrant critic is the extent of the truth of this thesis in a world of empirical investigation. I do not believe, at this stage, that the lack of empirical investigation can harm the significant theoretical contributions of this thesis. Catastrophes (or discontinuities) are very, very new phenomenon in the foreign exchange market (exchange rate) literature. When I started this research, there was no work on this area. Only recently De Grauwe (1983) attempted to explain exchange-rate behavior within a catastrophic

framework. My dissertation is the first full-scaled effort in building theoretical grounds of such a model. I do not assert that this work has developed and finished the whole picture of an exchange-rate behavior analysis within a catastrophe theory framework. Rather it can be the beginnings of new efforts and researches to contest and test the theoretical derivations of this thesis.

APPENDIX A

An investigation of equilibrium in a financial market was depicted in the beginning of Chapter three, where Figure 3-2 showed an upward sloping LM curve. Our objective in this appendix is not to elaborate further this issue, rather to clarify the condition under which the sign of the slope of the LM curve may change. By showing out that at certain levels of income the slope of LM curve changes, we may have an additional case for application of catastrophe theory, even though it is not explained in the main body of the thesis.

The theoretical groundwork of this appendix is based on pioneering works developed by Blinder, Solow, and Tobin.[1]

Following Tobin (1979),

The LM curve is given by equation (A-1):

$$\bar{M}/P = m(r,Y,w) \tag{A-1}$$

where $(\partial m/\partial r) = m_r < 0$, $(\partial m/\partial Y) = m_y > 0$, and $(\partial m/\partial w) = m_w > 0$.

w denotes the demand for wealth, which is equal to its supply.

$$\bar{w} = w(r,Y) \tag{A-2}$$

where $(\partial w/\partial r) = w_r > 0$, and $(\partial w/\partial Y) = w_y > 0$. Wealth changes by saving and by government budgetary policies. If w=B/P+M/P+K, then

$S=\dot{w}=\dot{B}/P+\dot{M}/P+\dot{K}=D+I$

or

$$S = \dot{w}=\dot{B}/P+\dot{M}/P+\dot{K}=D+(I-\delta K) \tag{A-3}$$

where δ denotes depreciation per unit time
S denotes saving
D denotes government deficit
B denotes the proportion of government deficit financed by selling bonds
M denotes the proportion of government deficit financed by printing high powered money

To derive the slope of the LM curve I substitute (A-2) into (A-1) and differentiate totally:

$$0 = m_r(\partial r/\partial Y)+m_y+m_w(w_y(\partial r/\partial Y)+w_r) \quad \text{(A-4)}$$

Rearranging (A-4) yields

$$-(m_y+m_w m_y) = (m_r+m_w m_r)(\partial r/\partial Y) \quad \text{(A-5a)}$$

or

$$(\partial r/\partial Y) = -(\overset{+}{m}_y+\overset{+}{m}_w\overset{+}{m}_y)/(\overset{-}{m}_r+\overset{+}{m}_w\overset{+}{m}_r) \quad \text{(A-5b)}$$

The numerator of the right-hand side fraction is negative, while the denominator is of ambiguous sign. (where m_y, m_w, w_y, and w_r are all greater than zero, while m_r is less than zero).

The sign of the slope of LM curve (A-5) depends on the sign of the denominator. We have a standard LM curve if the denominator, $\overset{-}{m}_r+\overset{+}{m}_w\overset{+}{w}_r$ is negative. This may hold if $\overset{+}{m}_w\overset{+}{w}_r < -\overset{-}{m}_r$. The LM curve might possess a non-conventional down sloping curve, $(\partial r/\partial Y < 0)$ if

$$\overset{-}{m}_r+\overset{+}{m}_w\overset{+}{w}_r > 0, \text{ or } \overset{+}{m}_w\overset{+}{w}_r > -\overset{-}{m}_r \quad \text{(A-6)}$$

After an extensive mathematical calculations, Tobin argues that for this condition to be met:

> ". . . the elasticity of wealth with respect to the interest rate would have to be much larger than the substitution elasticity of demand for money."[2]

Tobins's belief in this condition grow thinner as he considers capital accumulation in his model.

I became interested in the outcome of Tobin's paper even though he himself had some reservations about the empirical validity of his theory. This paper is the only attempt in the investigation of a downward sloping LM curve. As it was mentioned before, the possibility of changing signs in the slope of LM curve can contribute to our own investigation of discontinuous changes in an economic system when parameters are changing slowly and continuously. However, the explained IS curve is sufficient to generate catastrophes.

APPENDIX A--Footnotes

[1]See Blinder and Solow (1973, 1974), Tobin and Buiter (1976) and Tobin (1979).

[2]Tobin (1979), p. 224.

APPENDIX B

In this appendix I present an exposition of De Grauwe (1983).

The first building block in De Grauwe (1983) is the following equilibrium condition in domestic money market:

$$h-p = -\lambda r+\theta y \qquad \text{(B-1)}$$

where all variables are indicated as logarithms:

h = logarithm of the nomial money stock
p = logarithm of the home price level
y = logarithm of real income

De Grauwe assumes further two restrictive assumptions of interest parity and purchasing power parity conditions. The interest parity condition is given as:

$$r = r^{*} + \mu \qquad \text{(B-2)}$$

where

r = the log of one plus the domestic interest rate
r^{*} = the log of one plus the foreign interest rate
μ = the expected rate of depreciation of the home currency

The purchasing power parity condition can be given as:

$$\bar{e} = \bar{p}-p^{*} \qquad \text{(B-3)}$$

where

$\bar{e}$ = the equilibrium value of exchange rate in the long run, expressed in logarithm
$\bar{p}$ = the equilibrium value of home price level in the long run, expressed in logarithm
p^{*} = the log of foreign price level

De Grauwe assumes further that when the current exchange rate surpasses its long run value ($e>\bar{e}$) an "expansionary" process is set in motion in the goods market. Real income rises above its long run value and the rate of price increases hastens. The reverse holds true when $e<\bar{e}$.

The second major building block in De Grauwe (1983) is the development of expectation formations. Expectation formulation is formed according to both regressive and extrapolative expectations behavior:

$$\mu = \theta(\bar{e}-e)+\varepsilon(e-\bar{e})+\bar{\pi}-\pi^{*} \qquad \text{(B-4)}$$

Figure B-1 provides a graphical presentation of expectation formulation of equation (B-4)

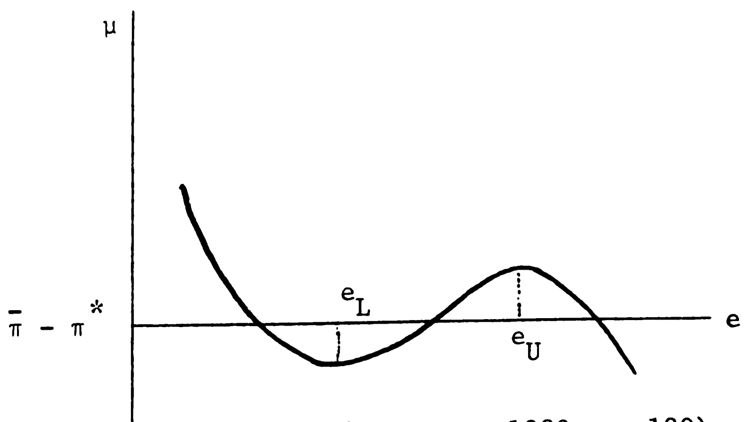

Figure B-1 (De Grauwe 1983, p. 189)

Regressive expectations behavior is assumed non-linear and is represented by the non-linear downward sloping parts of the cuve in Figure B-1. Extrapolative expectations behavior is represented by the upward sloping part of the curve in Figure B-1. Below e_L and above e_U level of exchange rate, the regressive part of expectations formation dominates. Thus, an increase in exchange rate leads to further

expected depreciation of the home currency. In Figure B-1, exchange rate moves away from $\bar{e}$ until regressive expectations become dominant (e_L or e_U).

De Grauwe (1983) imposes the expectation formulation of equation (B-4) on the asset market equilibrium, equation (B-1). He, therefore, derives a non-linear asset market equilibrium curve (aa) illustrated by Figure B-2.

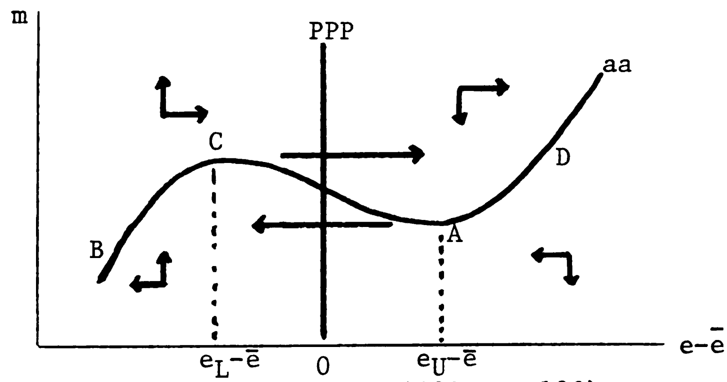

Figure B-2 (De Grauwe 1983, p. 189)

where

m = h-p-θy = real money stock per unit of putput

$e-\bar{e}$ = real exchange rate

PPP = purchasing power parity condition

The occurrence of catastrophes in such a model is explained as the following. Suppose the economy is in the short run equilibrium point A. A contractionary monetary policy leads to a surge in the home rate of interest. A depreciation of home currency should be expected in order to restore the interest parity condition. A sudden jump of exchange rate (catastrophe) from equilibrium point A to B can make such an expectation possible.

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