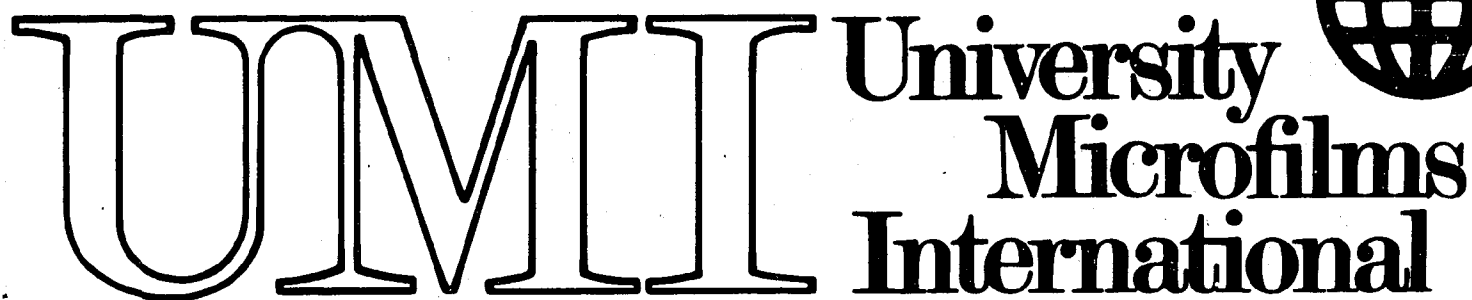


300 N. Zeeb Road, Ann Arbor, MI 48106

INFORMATION TO USERS

This reproduction was made from a copy of a manuscript sent to us for publication and microfilming. While the most advanced technology has been used to photograph and reproduce this manuscript, the quality of the reproduction is heavily dependent upon the quality of the material submitted. Pages in any manuscript may have indistinct print. In all cases the best available copy has been filmed.

The following explanation of techniques is provided to help clarify notations which may appear on this reproduction.

1. Manuscripts may not always be complete. When it is not possible to obtain missing pages, a note appears to indicate this.
2. When copyrighted materials are removed from the manuscript, a note appears to indicate this.
3. Oversize materials (maps, drawings, and charts) are photographed by sectioning the original, beginning at the upper left hand corner and continuing from left to right in equal sections with small overlaps. Each oversize page is also filmed as one exposure and is available, for an additional charge, as a standard 35mm slide or in black and white paper format.*
4. Most photographs reproduce acceptably on positive microfilm or microfiche but lack clarity on xerographic copies made from the microfilm. For an additional charge, all photographs are available in black and white standard 35mm slide format.*

*For more information about black and white slides or enlarged paper reproductions, please contact the Dissertations Customer Services Department.

UMI University
Microfilms
International

8601661

Kallianiotis, Ioannis Nikolaos

EXCHANGE RATES AND RATIONAL EXPECTATIONS

City University of New York

PH.D. 1985

**University
Microfilms
International** 300 N. Zeeb Road, Ann Arbor, MI 48106

Copyright 1985

by

Kallianiotis, Ioannis Nikolaos

All Rights Reserved

EXCHANGE RATES AND RATIONAL EXPECTATIONS

by

IOANNIS N. KALLIANIOTIS

A dissertation submitted to the Graduate Faculty in Economics
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy,
The City University of New York.

1985

COPYRIGHT BY
IOANNIS N. KALLIANIOTIS
1985

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

July 31, 1985

date

Ch. B. Chv

Chairman of Examining Committee

August 5, 1985

date

Michael Grossman

Executive Officer

Professor Harvey Gram

Professor Salih Nertci

Supervisory Committee

The City University of New York.

Abstract

EXCHANGE RATES AND RATIONAL EXPECTATIONS

by

IOANNIS N. KALLIANIOTIS.

Adviser: Professor Thom Thurston.

This dissertation deals with the determinants of exchange rates and develops an asset view of exchange rate determination in the short-run where prices are adjusted gradually (GAP) and Purchasing Power Parity (PPP) does not hold. The role of expectations is emphasized in a model which incorporates the fundamental principles of the monetary approach to the balance of payments under a regime of floating exchange rates. A dynamic version of this approach is considered in which goods market adjustments are not instantaneous (institutional constraints and high cost of acquiring complete information). Exchange rates are strongly influenced by asset holders' expectations of future exchange rates which are influenced by beliefs concerning the future course of monetary policy.

The first Chapter is devoted on the history of exchange rate movement during the transition from fixed to floating exchange rates. The second Chapter deals with the efficiency of foreign exchange markets. In Chapter III, the theoretical model is solved by taking into

account "real" factors, as well as monetary ones, in determining the behavior of exchange rates. Special emphasis is given to the role of expectations in this exchange rate determination and a rational expectations formulation of the model is proposed. Chapter IV shows the empirical results and the tests of the different hypotheses (Price flexibility, PPP, equal elasticities, and equal coefficients of adjustment in both countries). Chapter V examines some alternative formulations of the model by using variables such as long-run interest rates, foreign exchange reserves, the trade balance, etc. Chapter VI is devoted to policy implications. The policy view analyzes the effectiveness of aggregate policies and points out that in the short-run nominal disturbances will tend to be transmitted internationally. The last Chapter presents the conclusion: "The empirical results are shown to be consistent with the GAP hypothesis and the deviation from PPP even though expectations are rational."

To my wife Catherine
and my son Nick
with love.

ACKNOWLEDGMENTS

As I consider the debt of gratitude that I have incurred during my studies and while writing this dissertation, I am overwhelmed by the kindness shown by many people - family, parents, professors, relatives, friends, even virtual strangers. Unfortunately, it simply is not possible to acknowledge all this help - the concern of personal friends who have not slightest interest in Exchange Rate Determination but a good deal of interest in me, say, or the insights graciously shared by many others - on an individual basis.

It gives me great pleasure, however, to single out some of the people who contributed most importantly to arrive at this point and to write my doctorate research, but it is impossible to include all of them. In the process, I built up an intellectual debt to some individuals who provided me with comments on my work and, by so doing, improved it substantially.

Most importantly, I wish to express my gratitude to my dissertation adviser, Dr. Thom Thurston, professor of Economics at Graduate Center and Queens College - CUNY, for his guidance and assistance during the preparation of my dissertation. He read the draft and gave suggestions and invaluable comments throughout this work. I most profoundly appreciate the very constructive criticisms made by him. I would like also to express my thanks to the other two members of my dissertation committee, Dr. Harvey Gram, professor of Economics at Graduate Center

and Queens College - CUNY, and Dr. Salih Neftci, professor of Economics at Graduate Center - CUNY. Their comments, encouragement, and reactions are greatly appreciated. I also benefited from comments at my seminar, where I presented preliminary version of this work, at the Graduate Center-CUNY, in December, 1984. I am glad to have this chance to express my gratitude.

Of course, any errors which remain in this research despite their efforts are due to my own misunderstandings, negligence or stubbornness and time constraints.

Also, during my graduate studies, I and my family have received tremendous financial support and every sort of moral assistance from my parents. In this regard, I particularly wish to acknowledge my debt to them. In addition, I would like to express my appreciation to my uncle Mr. Panayiotis Moutsis for his support and his paternal love with which he surrounded me, and to my friend, colleague, and roommate Mr. Iakovos Arapoglou for his cooperation during our studies and our cohabitation. Of course, I couldn't forget my relatives Mr. and Mrs. Kasdaglis, Mr. and Mrs. Galanis, and Mr. and Mrs. Sarras here in New York for their help that they gave me.

In conclusion, I wish to express my gratitude and my love to my wife and my son for their patience and endurance, and I would like to ask them to forgive me for their abandonment for these six years, for sake of my graduate studies. All this investment in human capital belongs to them. I am deeply grateful for their dedication to the success of my studies.

Besides, I wish to thank all my professors from the University of Thessaloniki - Greece, from Queens College, and those at the Graduate Center and Baruch College - CUNY, for their untiring efforts giving me their wisdom which was very helpful to arrive at the point where I am now.

Lastly, I wish to acknowledge the leave of absence from the General Hellenic Bank and also to thank Miss Athena Photiou and Miss Monica Vittorini who undertook full responsibility for the word processing of the manuscript.

New York

I.N.K.

July 1985

TABLE OF CONTENTS

LIST OF TABLES	xi
I. INTRODUCTION	1
II. EFFICIENCY OF THE FOREIGN EXCHANGE MARKETS	12
II.1 Purchasing Power Parity (PPP).	12
II.2 Interest Rate Parity (IRP).	18
II.3 Fisher Equations.	20
II.4 Rational Expectations (REH).	25
III. MONETARY AND REAL MODELS OF EXCHANGE RATE DETERMINATION	27
III.1 The Model.	33
III.2 Differenced Autoregressive [AR(p)] Process.	50
III.3 Autoregressive - Moving Average [ARMA(p,q)] Process.	67
III.3.1 The Money Supply Process.	70
III.3.2 The Model.	72
IV. EMPIRICAL EVIDENCE	79
IV.1. Ordinary Least Square Estimates (OLS).	80
IV.2. Full Information Maximum Likelihood Estimates (FIML).	106
V. ALTERNATIVE FORMULATIONS OF THE MODEL	113
VI. POLICY IMPLICATIONS	137
VII. CONCLUSION	146
VIII. APPENDIX	153
IX. BIBLIOGRAPHY.	169

LIST OF TABLES

I-1	Cases and Hypotheses Testing	7
II-1	Deviations from PPP (OLS Estimates)	17
II-2	OLS Estimates of IRP	23
II-3	OLS Estimates of IRP	24
IV-1	OLS Estimates of the "monetary-unrestricted" model	84
IV-2	Differenced "monetary-unrestricted" model	86
IV-3	OLS Estimates of the "Monetarist-GAS" model	88
IV-3a	Differenced "Monetarist-GAS" model	90
IV-4	OLS Estimates of the "Monetary-GAP" model	92
IV-4a	Differenced "Monetary-GAP" model	94
IV-5	OLS Estimates of the "Monetarist" model	96
IV-5.1	The "Monetarist" model ($\beta_1 = 1$, $\beta_2 = -1$)	98
IV-5a	Differenced "Monetarist" model	100
IV-5.1a	Differenced "Monetarist" model ($\beta_{12} = 1$)	102
IV-6	Likelihood Ratio Tests for the Models of Tables IV-1 to IV-5	104
IV-7	Likelihood Ratio Test for the Models of Tables IV-2, IV-3a, IV-4a, IV-5a	105
IV.2-1	FIML Estimates of the "Monetarist" model	108
IV.2-2	FIML Estimates of the "Monetarist" model (cont.)	110
IV.2-3	Likelihood Ratio Tests for the FIML Estimates	112
V-1	ARI Estimates of eq. (1)	119
V-2	ARI Estimates of eq. (2)	120
V-3	ARI Estimates of eq.(1) with PPP	122

V-4	LSQ Estimates of the "Monetarist" model	123
V-5	ARI Estimates with GAP	124
V-6	ARI Estimates with GAS	125
V-7	F Statistics Tests for the null hypotheses	126
V-8	Likelihood Ratio Tests for the null hypotheses	127
V-9	OLS Estimates of eq. (3) - "Monetary-unrestricted"	130
V-10	OLS Estimates of eq. (4) - "Monetarist-GAS"	131
V-11	OLS Estimates of eq. (5) - "Monetary-GAP"	132
V-12	OLS Estimates of eq. (6) - "Monetarist"	133
V-13	Likelihood Ratio Tests for the null hypotheses	136

I. INTRODUCTION

Modeling the open economy is not an easy thing. A complexity arises from the fact that for most issues there is an option of at least two regimes. Closed economy models look only at one country, while in the open economy we have the choice to incorporate or neglect interdependence and repercussion effects in our models. Open economy is concerned not only with the level of prices, but with relative prices as well. There are import prices (P^*) and export prices (P) and the distinction between traded goods and nontraded goods, imported intermediates, and final goods. We have also the option of fixed and flexible rates - or dirty floating - in between. Capital may be mobile or immobile, and exchange rate expectations may be there or not, rational or otherwise.

It becomes immediately apparent that the variety of assumptions allows for many permutations and some rather complicated scenarios. Throughout this thesis, I choose a simple monetary model, based on Bilson (1978 a,b) and Dorabusch (1976 a,b), which, however allows prices and exchange rates to adjust gradually. The essential focus is exchange rate determination.

Twelve years have passed since March 1973 when monetary authorities of the major industrialized countries abandoned efforts to maintain the 29 years old Bretton Woods system of fixed exchange rates among the major currencies and established the current exchange rate system known

as the "managed float".¹ Under this system, exchange rates between currencies are largely determined by market forces. This fundamental change in the international monetary system was affirmed by the Rambouillet Summit in 1975 and the Second Amendment of the International Monetary Fund's Articles of Agreement in 1978.

The current regime was established following persistent breakdowns in the previous "adjustable peg" system that had prevailed since 1944 at the Bretton Woods Conference. The adjustable peg system was a "fixed" exchange rate regime under which foreign countries were expected to devalue or revalue their currencies with respect to the U.S. dollar only in the event of a "fundamental disequilibrium". As the dollar price of gold was fixed and official dollar holdings of foreign central banks could be redeemed for gold, this system was effectively a gold-exchange standard.

¹ There were some currencies which had been floating before March 1973: the Canadian dollar since May 1970; the pound sterling since June 1972; and the Japanese yen since February 1973. Also, other floatings were taking place in the later years of the Bretton Woods period but the change in U.S. policy in March 1973 marked the end of those transitional floats. Throughout the floating rate regime we saw countries pegging their currency to the U.S. dollar, or to the currency of a major trading partner, or to a "basket" of major currencies, which is floating against other currencies. Now, the majority of currencies are floating against the highly appreciated U.S. dollar.

During the late 1960's and early 1970's, the system showed increasing signs of stress. Despite widespread capital controls, capital flows and consequent intervention requirements expanded to levels that alarmed policymakers. Imbalances in the current account seemed to be giving off signals of fundamental disequilibrium with growing frequency. Monetary authorities increasingly observed situations in which the monetary policy they believed was appropriate from a domestic standpoint and the policy that would bring about external balance were in conflict. Par value changes and periods during which countries permitted their currencies to float became more common².

Declining growth rates of productivity, large federal budget deficits partly attributable to the Vietnam buildup, and rapid money supply growth in the United States all contributed to higher rates of domestic price inflation during the last half of the 1960's. More modern plant and equipment and lower unit labor costs in Germany and Japan increased competition for the United States in both home and foreign markets. All these factors contributed to an overvaluation of the dollar, to the imposition of balance of payments controls, to subsequent devaluations of the dollar in December 1971 and February 1973, and it was against this background that the decision to float the exchange rate was made in March 1973.

² See footnote 1.

Supporters of the managed float argued prior to March 1973 that price-adjusted or real exchange rates would be maintained at relatively constant values by stabilizing speculation and would change mainly in response to shifts or trends in the equilibrium terms of trade between economies. Also, external balance would be better maintained than under fixed rates. Imbalances in the overall balance of payments - the official settlements balance - would not arise by definition; and current accounts would be kept roughly in line with the fundamental positions of countries as net suppliers or demanders of capital, determined by wealth accumulation and investment potential.

Additionally, economies would be relatively insulated against macroeconomic shocks from abroad, and authorities would enjoy greater independence of monetary policies to pursue domestic stabilization goals. For example, under the purchasing power parity (PPP) view, an overexpansionary monetary policy abroad, causing a rise in foreign prices, would induce a smooth depreciation of the foreign currency, alleviating - if not preventing - the rise in prices at home which would be expected under fixed exchange rates. Furthermore, national policy makers would find it unnecessary to impose restrictions on trade and capital flows for macroeconomic reasons, and existing restrictions could be discarded, thus enhancing the efficiency of resource allocation in the world economy.

There were economists and policymakers, especially outside the United States, who had reservations about the floating exchange rates. They were less confident in the self-equilibrium of markets. They

believed that speculative capital movements would be destabilizing and would lead to wide swings in exchange rates. National policies would be less stable and, on the whole, more inclined to accommodate inflation. Policies, together with frequent speculative disturbances to rates, would tend to result in greater variance and higher average levels of inflation rates. In addition, exchange rates that were not associated with underlying fundamental developments would induce undesirable fluctuations in current accounts, domestic output, employment, and inflation. Moreover false signals from exchange rates and exchange rate uncertainty, per se, were thought to distort and inhibit trade and investment with adverse consequences for the allocation of resources in the world economy. Finally, trade barriers and restrictions on capital flows would proliferate as officials sought to protect their economies from the destabilizing effects of exchange rate changes.

After twelve years of floating exchange rates, the system has not been a panacea. Evidence suggests that the entire period has been marked by great instability in the world economy and relatively poor economic performance when compared with the 1960's and early 1970's. Of course, we cannot blame only the floating exchange rate regime for creating these economic problems because many other economic and political events took place since 1973 and had their effects on the world economies. One of those events was the oil market shocks of 1973-74 and 1979. Also, it is unlikely that growth in the economies of continental Europe and Japan could have been sustained at the rapid pace of the 1950's and 1960's, a period that showed in part a catching up

after the World War II. Besides, the period of floating rates inherited the international disequilibrium and inflationary tendencies that had built up gradually during the 1960's.

Professor Friedman (1953, p.158), in his classic defense of flexible exchange rate regimes, stressed that flexible exchange rates need not be unstable. He wrote: "The ultimate objective is a world in which exchange rates, while free to vary, are in fact highly stable. Instability of exchange rates is a symptom of instability in the underlying economic structure".

The primary object of this dissertation is to examine the empirical validity of a simple asset market model of exchange rate determination. As Table I.1 indicates I would like to test four hypotheses in four different cases. The model is characterized as "monetary" because it is based upon two assumptions associated with the "monetary approach to the balance of payments".³ These assumptions are (1) that the demand for real money is a stable function of a limited number of aggregate economic variables, and (2) that in the absence of transaction costs or capital controls, the domestic and foreign bonds are perfect substitutes - i.e., Uncovered Interest-Parity (UIP). Expectations of future exchange rates are assumed to be formed "rationally" on the average ("REH"). Purchasing power parity ("PPP") will hold in international markets in the long-run. I have also

³ Frenkel and Johnson (1976).

distinguished those four cases into perfect "flexible prices" and into "gradually adjusted prices" (GAP).

TABLE I-1
Cases and Hypotheses Testing

HYPOTHESES CASES	"MONETARY"	"REH"	"L-R PPP"	"S-R PPP"	"FLEXIBLE "PRICES	VALUES OF λ and θ **
1	H	H	H	H	H	$\theta=1$ $\lambda=1$
2	H	H	H	H	DH	$\theta=1$ $\lambda<1$
3	H	H	H	DH	H	$\theta<1$ $\lambda=1$
4	H	H	H	DH	DH	$\theta<1$ $\lambda<1$

H = hypothesis "Holds"

DH = hypothesis "Doesn't Hold"

λ = a parameter showing the speed of price adjustment, and

θ = a parameter showing the speed of adjustment of the spot exchange rate

** coefficients of adjustment (see Chapter III below).

Case 1 is the most restricted one. Here I assume that the speed of price adjustment is infinite, λ is unity (flexible prices) and the speed of adjustment of the spot exchange rate to close the deviation from PPP is infinite, too. ($\theta=1$ and PPP holds even in the short-run). I call this model the "Monetarist" model because there is full flexibility of prices and PPP holds. The reason for these results is that expectations are formed rationally and full and zero cost information is assumed.

Case 2, now, is less restricted than the previous one. I assume that prices adjust with a finite speed, λ is less than unity. This price sluggishness is caused by preexisting two or three periods contracts or by imperfect informations concerning future policies because of the high cost of acquiring complete informations. The speed of adjustment of the spot exchange rate is also infinite here but the agents adjust its changes with the informations that they have from the price level movements. This model can be called the "Monetary-GAP" model because the PPP holds, even though price movements are sluggish, and the spot exchange rate also follows price level movements instead of only monetary and fiscal policy shifts.

Case 3 is a special one. The assumption about prices is that they adjust instantaneously ($\lambda=1$) but the speed of the exchange rate adjustment is relatively small ($\theta < 1$). The spot exchange rate adjusts

gradually (GAS).⁴ Because of the price flexibility and the gradual adjustment of the spot exchange rate, I call this model the "Monetarist-GAS" model.

The last case is the least restricted of all. Prices and the spot exchange rate adjust gradually ($\lambda < 1$) and ($\theta < 1$). This generates a model which I call the "monetary-unrestricted" model because changes in the nominal money supply are also changes in the real money supply through the sluggish price movement, and thus have real effects, especially on the exchange rate.⁵ From this most general case 4, we can test the whole monetary model.

The theory of exchange rate determination has undergone considerable development over the past twelve years as simple models were found to explain current experience poorly and later the lengthening time series revealed new phenomena for theorists to

⁴ We can look at this gradual adjustment of the spot exchange rate through the terms of trade (TOT).
$$TOT = \frac{P_m}{P_x} = \frac{P^* E}{P} \Rightarrow TOT = p_t^* + s_t - p_t.$$
 An

increase in the domestic money supply causes a proportional rise in the price level. The TOT fall and imports are increasing. The country is experiencing a deficit at its current account and devalue the currency (s_t must rise), but there are contracts and goods already in transit which have been made with the lower spot rate. Now, after this devaluation the new transactions start being made under the higher spot rate but this adjustment takes place gradually (GAS).

⁵ See Dornbusch (1976 a).

explain.⁶ The theoretical literature on the "asset market" view of exchange rates has been expanding voluminaously in recent years.⁷

The popularity of this view may be attributed to the compelling realism in today's world of both its theoretical assumptions and its empirical implications.

There are two methods of quotation of the exchange rate. First, quotation in "U.S. terms", where the exchange rate (e) denotes the domestic currency price of foreign exchange, measured in dollars per unit of foreign currency - e.g. $\frac{\$}{\pounds}$. And second, quotation in "European terms" where the exchange rate (e) is the foreign currency price of domestic exchange - e.g. $\frac{\pounds}{\$}$. I use the method of "U.S. terms" to quote the exchange rate throughout this work. Then, a domestic currency devaluation (appreciation) means that the exchange rate increases (decreases) respectively.⁸

⁶ Flexible prices: Frenkel (1976), Mussa (1976), Frenkel (1977), Gorton and Roper (1977), Bilson (1978 a, b), Hodrick (1978), Barro (1978), Frenkel (1979), and Frenkel (1980); Sticky prices: Dornbusch (1976 a, b), Mathieson (1977), Dornbusch (1978), Frankel (1979), Flood (1979), Wilson (1979), Gray and Turnovsky (1979), Kohlhaugen (1979), Bhandari (1981), and Driskill (1981).

⁷ Shafer and Loopesko (1983), Bergstrand (1983), Frenkel (1983), and Frankel (1984).

⁸ For the quotation in "European terms", where $e = \frac{\pounds}{\$}$, an appreciation of the dollar (depreciation of the sterling) means an increase (appreciation) of the exchange rate.

The models will be tested using monthly data for nine⁹ countries over the period from March 1973 to August 1984. The primary object is, therefore, to test some particular hypotheses concerning the determinants of the exchange rate, rather than to provide a detailed description of the behavior of these eight spot exchange rates.¹⁰ Consequently, the specific institutional factors that influence exchange rates and interest rates in the nine countries are ignored. I attempted to create a money and a goods market equilibrium using also time series for making the determinants of the exchange rate endogenous. Despite some limitations, the results may be useful as a foundation for individual country studies and as an indicator of the relationship between monetary policy and the exchange rate.

⁹ U.S.A., Germany, Canada, U.K., Japan, France, Italy, Switzerland, and Greece.

¹⁰ $s_1 = \frac{\$}{DM}$, $s_2 = \frac{\$}{C\$}$, $s_3 = \frac{\$}{f}$, $s_4 = \frac{\$}{Y}$, $s_5 = \frac{\$}{FF}$, $s_6 = \frac{\$}{Lr}$, $s_7 = \frac{\$}{SF}$, and $s_8 = \frac{\$}{Dr}$.

II. EFFICIENCY OF THE FOREIGN EXCHANGE MARKETS

Over the last twenty five years, a substantial research effort has been directed toward developing and testing the efficient-market hypothesis.¹ Stated simply, an efficient market is one "in which prices always 'fully reflect' available information".² Investors collect and process information in order to assess the value of an asset. Trading occurs so that market prices continuously reflect the information set; as a consequence, all opportunities for profit are eliminated, implying, in the absence of transactions costs, that the law of one price (PPP), perfect capital mobility (IRP), and Fisher's equations will hold; and also that market price expectations will be unbiased predictors of actual future prices.

II.1. Purchasing Power Parity (PPP)

The purchasing power parity theory of the exchange rate is one of those empirical regularities that are sufficiently true over long periods of time to deserve our attention but deviations from which are pronounced enough to make all the difference in the short-run. Clearly, purchasing power parity is much like the quantity theory of money and indeed can be viewed as the open economy extension of quantity theory thinking.

¹ By the efficient-market hypothesis, I mean the proposition that the expected rate of return to speculation in, say, the forward foreign exchange market (conditioned on available informations) is zero.

² Fama (1970, 1976), and Levich (1978)

The purchasing power parity doctrine (in its absolute version) states that the equilibrium exchange rate equals the ratio of domestic to foreign prices.³ The relative version of the theory relates changes in the exchange rate to changes in price ratios. Many of the controversies around that doctrine relate to the question of choice of proper indices to be used in computing the parity.⁴

Although the monetary approach to exchange rate determination in the long-run is based upon the theoretical concept of purchasing power parity, monetary models do not typically trace the influence of the exchange rate through conventional price indices like the consumer price index (CPI), the wholesale price index (WPI), or even traded goods price indices (TPI). The belief that conventional price indices are not accurate reflectors of market prices has led to the practice of treating the "true" price index as an unobservable variable whose ratio, for any two countries, is defined by the exchange rate. If, for example, the true U.S. price index measures the number of dollars required to purchase a hypothetical composite good, and the true price index of the U.K. measures the number of pounds required to purchase the same good, then the ratio of the U.S. price index to the U.K. price index yields, by definition, the number of dollars required to purchase one pound, which is, also by definition, the exchange rate between the two

³ PPP condition eliminates opportunities for profit from commodity arbitrage.

⁴ See Frenkel (1976).

countries. The purchasing power parity condition, as represented in equation (1), should be interpreted in this manner:

$$S = \frac{P}{P^*} \quad (1)$$

where, S = the current spot rate (\$ per unit of £)

P = the U.S. price index

P^* = the U.K. price index

In my model, the price index which would perform best in estimating PPP would be the one most accurately representing the implicit price index which deflates the nominal money supply in the aggregate demand function for real balances. If the demand for money is determined by households, one would expect that the consumer price index would be best.

In the case of some countries, many of the prices entering the index were pegged by the government during a large part of the sample period. These recorded prices cannot measure the true value of money in a country, and consequently their use would lead to poor statistical results.⁵

⁵ See Hodrick (1978) for an estimate of equation (1) and other tests of PPP during this period. Magee (1978) has demonstrated, even the traded goods indices reflect contracts that may have been made up to 18 months previously and that will consequently appear to adjust slowly to the exchange rate. He examines a model in which PPP holds ex ante (at the time contracts are made), but unanticipated shocks to the exchange rate, or to one price, cause serially correlated deviations from PPP, ex post, due to the existence of these long-term contracts. Isard (1977) demonstrates that at the most disaggregated level of product classification for which price data are available, the tradable goods prices exhibit large and persistent changes in their common-currency prices.

What ever the price index used for computation of parities, the question remains of distinguishing between an equilibrium relationship and a causal relationship. Most authors recognized that prices and exchange rates are determined simultaneously. A minority, however, argued that there exists a causal relationship between prices and exchange rates. Some claimed that the causality goes from prices to the exchange rate, others claimed the opposite.

Indeed, the economics profession now seems to be reaching consensus that while PPP is a viable description of the long-run relation between the exchange rate and national price levels, short-run deviations from PPP are a fact of life in this world of floating exchange rates.⁶

Kimbrough (1983) shows that even in a world without non-traded goods, and where both goods and asset markets clear continuously, short-run deviations from PPP will occur if "effective" information travels more rapidly in asset markets than in goods markets.⁷

The asset market approach to exchange rates, which I am testing in this thesis, implies that exchange rates, if free to move, mainly reflect expectations about future events whereas national price levels reflect

⁶ Recent studies by Isard (1977), Kravis and Lipsey (1978), and Frenkel (1981) all support this view.

⁷ By "effective" information it is meant information which influences individual behavior. Information is "ineffective" if it is received by an individual after he has already committed himself to a certain course of action. The source of the differential speed with which effective information travels is, for purposes of illustration, assumed to be the existence of nominal wage contracts along the lines suggested by Fisher (1977) and also other institutional constraints.

more strongly present and past events that are embedded in existing contracts. I therefore adopted an equation which assumes that PPP does not hold at all times. I introduced different time lags with which new information affects prices and exchange rates. Equation (2) below represents deviations from PPP.

$$s_t - s_{t-1} = \theta(p_t - p_t^* - s_{t-1}) + u_t \quad (2)^8$$

where s_t = the spot exchange rate in period t ,

θ = coefficient of adjustment,

p_t = domestic price index,

p_t^* = foreign price index, and

u_t = error term.⁹

It follows from equation (2) that only if $\theta = 1$ will PPP be expected to prevail. We can then test PPP by testing the hypothesis $\theta = 1$. This is done in Chapter IV below. Here, I also estimate equation (2) using OLS and the results are shown in Table II-1. We see that θ is a very small number for all countries. Thus PPP does not hold in the short-run.

⁸ All the variables in equation (2) are in natural logarithm forms. (Lower case letters in the text denote natural logarithms of their upper case counterparts).

⁹ The economic interpretation of changes in u_t is that they are changes in the price of domestic relative to foreign goods on world markets.

TABLE II-1

OLS Estimates of equation (2): $\Delta S_t = \alpha + \theta(p_t - p_t^* - s_{t-1}) + u_t$

Deviations from PPP

VARIABLES	COEFFICIENTS							
Δs_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
C	.1468	.0652	.0351	-.0085	-.0244	-.0209	.0356	-.0201
	(.1204)	(.0691)	(.0934)	(.0191)	(.0525)	(.0498)	(.0874)	(.0144)
$(p_t - p_t^* - s_{t-1})$	.0379	.0148	.0077	.0105	-.0066	.0055	.0085	-.0137
	(.0310)	(.0152)	(.0180)	(.0213)	(.0176)	(.0216)	(.0221)	(.0189)
R^2	.0184	.0069	.0013	.0018	.0010	.0005	.0011	.0039
DW	2.327	2.158	1.871	1.880	2.114	1.952	1.854	2.100

Note: standard errors in parentheses.

Data come from O.E.C.D's, Main Economic Indicators

The Data are monthly from March 1973 until August 1984

* significant at the 10 percent level

** significant at the 5 percent level

*** significant at the 2 percent level

**** significant at the 1 percent level

II.2 Interest Rate Parity (IRP)

The Interest Rate Parity (IRP)¹⁰ theory maintains that in equilibrium the premium (or discount) on a forward contract for foreign exchange is (approximately) related to the interest rate differential according to the following equation.

$$\Delta E = \frac{F - S}{S} = i - i^* \quad (3)$$

where, ΔE = the forward premium or discount (change in the exchange rate),

F = the forward exchange rate,

S = the spot exchange rate,

i = the domestic rate of interest, and

i^* = the foreign rate of interest on comparable securities
for the same maturity.

$F - S$ = the swap rate

If $\Delta E > 0 \Rightarrow F > S \Rightarrow \$$ (domestic currency) is at a discount $\Rightarrow$

$\Rightarrow \$$ will depreciate ($e \uparrow$)

If $\Delta E < 0 \Rightarrow S > F \Rightarrow \$$ is at a premium $\Rightarrow \$$ will appreciate ($e \downarrow$)

The spot exchange rate is almost dominated by the course the public expects it to take in the near future. These expectations, of course, are influenced by the structure of the economy and institutional features such as indexing or systematic policy responses.

¹⁰ The IRP is associated with efficient markets in which the bonds of different countries are perfect substitutes. This condition eliminates opportunities for profit from asset arbitrage.

From equation (3) we have:

$$\Delta e = i - i^* = f - s \quad (4)$$

and $s = f - (i - i^*) \quad (5)$

Equation (5) is central to a correct interpretation of exchange rate movements. It says that movements in the spot rate are due either to changes in interest differentials or to changes in expectations over the future course of exchange rates. Specifically, an increase in the domestic interest rate widens the interest differential, the spot rate falls, and this leads to an appreciation of the domestic currency. On the other hand, the anticipation of depreciation (forward rate increases), given interest rates, will lead to an immediate depreciation of the currency (spot rate increases) in the same proportion.

Also, equation (4) is a statement of Covered Interest Parity (CIP) if Δe is considered to be the forward discount. Under perfect capital mobility, that is, in the absence of capital controls and transactions costs, CIP must hold exactly, since its failure would imply unexploited opportunities for certain profits. If Δe is defined as the expected rate of depreciation, then (4) represents the stronger condition of Uncovered Interest Parity (UIP). Of course if there is no uncertainty, as in a perfect foresight economy, then the forward discount is equal to the expected rate of depreciation, and (4) follows directly.¹¹

¹¹ See Frankel (1979) and Frenkel and Levich (1975, 1977).

Freakel (1977) has examined the efficiency of the market by regressing the following equations:

$$s_t = a + bf_{t-1} + u_1 \quad (6)$$

and
$$s_t = a + bf_{t-1} + cf_{t-2} + u_2 \quad (7)$$

He found a and c close to zero and b equal to unity. These results support the efficient market hypothesis. Estimating equations (6) and (7) I found results which support this hypothesis. These results are reporting in Tables II-2 and II-3.

II.3 Fisher Equations

One of the basic points to be discerned is the distinction that exists between nominal and real interest rates in an inflationary environment.

$$i_t = r_t + E_t(p_{t+1} - p_t) \quad (8)$$

$$i_t^* = r_t^* + E_t(p_{t+1}^* - p_t^*) \quad (9)$$

where, i_t = the domestic nominal interest rate,

i_t^* = the foreign nominal interest rate,

r_t = the domestic real interest rate,

r_t^* = the foreign real interest rate,

$E_t(p_{t+1} - p_t)$ = the expected rate of inflation in the domestic economy, and

$E_t(p_{t+1}^* - p_t^*)$ = the foreign expected rate of inflation.

As we see from the above equations, the nominal rate of interest will be equal to the real rate of interest plus the expected rate of inflation. In general, however, when evaluating an investment opportunity, you do not know what the rate of inflation will be in the future and cannot therefore calculate the real rate of interest beforehand. It is necessary to make an estimate of the future inflation rate. Consequently, the domestic anticipated (ex ante) real interest rate, r , can be defined as

$$r_t = i_t - E_t(p_{t+1} - p_t) \quad (10)$$

and the foreign, r^* , as

$$r_t^* = i_t^* - E_t(p_{t+1}^* - p_t^*) \quad (11)$$

By substituting equation (4) into (10) and (11), we obtain the following expressions for the (ex ante) real interest rates:

$$r_t = i_t - E_t(p_{t+1} - p_t) = (i_t^* + E_t \Delta e_t) - E_t(p_{t+1} - p_t) \quad (12)$$

and

$$r_t^* = i_t^* - E_t(p_{t+1}^* - p_t^*) = (i_t^* + E_t \Delta e_t) - E_t(p_{t+1}^* - p_t^*) \quad (13)$$

Assuming that the foreign interest rate is fixed and cannot be significantly influenced by domestic forces, the domestic real interest rate will vary in response to expected exchange rate changes and anticipated inflation. The larger the expected devaluation of the

domestic currency, the higher the domestic real interest rate will have to be to equillize domestic and foreign expected rates of return. The higher the anticipated domestic inflation rate, on the other hand, the lower the real interest rate, since the value of the return on domestic assets in terms of their purchasing power declines.

TABLE II-2

OLS Estimates of IRP, equation (6): $s_t = \alpha + bf_{t-1} + u_1$

VARIABLES s_t	COEFFICIENTS							
	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
C	.2800*** (.1095)	-.0021 (.0588)	.0150 (.0972)	- -	-.0048 (.0384)	- -	.1798**** (.0576)	- -
f_{t-1}	.9241**** (.0289)	1.000**** (.0131)	.9975**** (.0184)	- -	1.000**** (.0128)	- -	.9497**** (.0150)	- -
R^2	.8820	.9770	.9580	-	.9779	-	.9671	-
DW	1.470	1.908	1.560	-	1.955	-	1.744	-

Note: See Table II-1

Data from U.K. are from March 1973 until December 1983

TABLE II-3

OLS Estimates of IRP, equation (7): $s_t = \alpha + bf_{t-1} + cf_{t-2} + u_2$

VARIABLES		COEFFICIENTS							
s_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr	
C	.3072**** (.1068)	-.0094 (.0592)	.0286 (.0984)	- -	-.0083 (.0396)	- -	.1789**** (.0579)	- -	
f_{t-1}	1.2635**** (.1156)	.9051**** (.0921)	1.0829**** (.0942)	- -	.9682**** (.0862)	- -	1.0052**** (.0845)	- -	
f_{t-2}	-.3466**** (.1145)	.0968 (.0926)	-.8804 (.0951)	- -	.0336 (.0882)	- -	-.0554 (.0829)	- -	
R^2	.889	.977	.959	-	.978	-	.967	-	
DW	1.895	1.773	1.717	-	1.890	-	1.859	-	

Note: See Table II-1

Data for U.K. are from March 1973 until December 1983

II.4 Rational Expectations (REH)

The Rational Expectations Revolution in Economics throughout the last decade has been a major theme of research. Its proponents claim that the hypothesis represents a vital breakthrough in the methodology of Economics, with profound implications for all theoretical and empirical work. This hypothesis simply asserts that individuals do not make systematic mistakes in forecasting the future.¹² That is a good optimizing principle on which the REH is based. It is not appealing to assume that individuals make predictable errors yet take no action to revise their rule for forming expectations.¹³

Under the REH, the expected rate of inflation does not reflect past rates of inflation but is a rational forecast of future inflation, based upon all currently available information. Under these conditions, a monetary expansion not only triggers a depreciation of the currency directly but it may also induce a further depreciation by creating expectations of future monetary growth. Bilson (1978) and Mussa (1976) have extended the Sargent and Wallace (1973) model to the problem of exchange rate determination.

The basic implication of the asset approach is the special role expectations play in determining the exchange rate. The demand for domestic and foreign monies depends, like the demand for any other asset, on the expected rates of return. Thus it may be expected that

¹² Muth (1961).

¹³ The RE assumptions as a condition for efficient markets eliminate profit opportunities from exchange speculation and the sale of informations.

current values of exchange rates incorporate the expectations of market participants concerning the future course of events. This notion can account therefore, for large changes in prices resulting from large changes in expectations.

If the foreign exchange market is efficient, as many other asset markets appear to be, then current prices should reflect all available information. Therefore, an expectation of monetary expansion should be reflected in the current spot exchange rate since asset holders will incorporate the anticipated reduction in the real rate of return on the currency in their pricing of the existing stocks. The only difficulty in incorporating the role of expectations, in empirical work, has been the lack of an observable variable measuring expectations.

While the central idea of RE is extremely simple, the technical analysis often seems forbidding to the theorist since the solution procedure typically requires the consideration of the whole future path of the economy. The impact of the hypothesis of RE has not been confined to theoretical models. Empirical econometricians have constructed models of open-economy Macroeconomics to be used both for forecasting and for policy evaluation, in which the simulation of hypothetical policies allows a better understanding of the likely consequences of adopting the policy.¹⁴ The hypothesis of RE not only exposes a problem which had previously gone unnoticed, but also provides a framework in which to predict the probable revision of expectations when a new policy is adopted.

¹⁴ Isard (1980), Hansen and Hodrick (1980), Hartley (1983).

III. MONETARY AND REAL MODELS OF EXCHANGE RATE DETERMINATION

Recently, asset market models have dominated the discussion of exchange rate determination. These approaches presume that the exchange rate is determined in the same manner in which other asset prices are determined. Thus, relative prices adjust to determine the allocation of the total stock of assets - Frenkel (1976), and Bilson (1978). An important property of the asset models is the role given to the market expectations of future exchange rates. In fact, it is argued that changes in the market view of future exchange rates will alter that current exchange rate. This notion has been employed here to explain the recently observed volatility of exchange rates.

Throughout this work, I assume two markets and two countries, first the asset market (money and capital markets), and second, the goods market. I also assume that my two countries are roughly of equal economic size in relative volume of trade and their exports and imports are a small fraction of their total spending (two large countries). Finally, I assume that expectations are rational and the money market is clearing faster than the goods market.

My main point in this dissertation is that an asset market model of exchange rate determination must incorporate not only the effects of the secular monetary and real income growth, as in Frenkel (1976), Mussa (1976), and Bilson (1978 b), but also the effects of the inflation rate which was high at the late '70s and early '80s. When we want to be more

realistic we must take into account deviations from PPP due to sticky prices in the short-run, as in Dorabusch (1976, 1978) and to estimate the speed of adjustment in goods market which gradually move to close the gap between the current spot rate and an equilibrium (hypothetical) exchange rate.

My four models determine equilibrium in the asset markets and in the goods markets, domestic and foreign. To accomplish this I use a complete supply and demand proceeding. I use a time series approach - Differenced Autoregressive [AR(p)] process - as a monetary rule for generating the money supply which is exogenous.¹

In this section I lay out a general equilibrium framework for the discussion of exchange rates from a short-run perspective - "monetary - unrestricted" approach. The critical assumptions of this theory are that PPP does not hold between the two countries and that price levels adjust gradually after a monetary shock. The other three cases are tested later because they are subcases of this general one.

Since the exchange rate is determined as part of the general, real, and monetary equilibrium of the system, there is no relevant sense in which one would want to assert that the exchange rate is an exclusively monetary phenomenon. Indeed, the equilibrium exchange rate can change

¹ I derive here a complete aggregate demand function and an equation showing the goods market equilibrium (IS) in this work, similar to those that we see in the recent closed economy rational expectations papers.

without any accompanying change in the money supply or the real money demand. Such would, for example, be the case if there were a change in the real income. This is the reason why I have named my models "Monetary and Real".

One particular asset model that has received substantial attention in the literature is the flexible prices monetary model. As with other asset models, expectations of future exchange rates play a dominant role in the determination of the current exchange rate. Usually these expectations are assumed to be formed "rationally".² The policy conclusions summarized in RE models have not been generally accepted in the profession. One of the major reasons is the widespread belief that the speed of price-level adjustment, required in these models is greater than is observed in actual economies. The conventional interpretation of the price adjustment lag was suggested by Gordon (1982) - "Natural

² The REH asserts that the market's subjective probability distribution of any variable is identical to the objective probability distribution of the variable, conditional on all the available past information. Following Muth's definition - Muth (1961) - expectations are said to be rational when they are "essentially the same as the predictions of the relevant economic theory". The public forms unbiased predictions of an event conditional on the information available when the expectations are formed. This concludes the policies of the Central Bank for my model: the public eventually learns the monetary authority's systematic response to economic data and is able to form unbiased estimates of future values of monetary instruments. Not all market participants need be rational for a market to display rational expectations. The behavior of a market (foreign exchange market, here) is not necessarily the same as the behavior of the average individual. As long as unexploited profit opportunities are eliminated by some participants in a market, then the market will behave as though expectations are rational despite irrational participants in the market. See Barro (1978), Hodrick (1978), Bilson (1979 a, b), Mussa (1979), and Hoffman and Schlagenhauf (1983).

Rate Hypothesis and Gradual Adjustment of Prices (NRH - GAP)".

According to this theory, price sluggishness is caused by imperfect information (concerning future policies) associated with the high cost of acquiring complete information.³

Even though price expectations play a central role in the monetary model and evidence suggests that prices move "sluggishly" toward their eventual long-run values, to date there has been no attempt to empirically estimate a complete asset model with rational expectations and gradually adjusted prices and spot exchange rates. By estimating such a model, the appropriateness of the REH, the GAP and the GAS hypotheses in a model of exchange rate determination may be formally tested. Procedures for testing the restrictions implied by REH have been outlined by Sargent (1978), Revankar (1980), Leiderman (1980), Wogin (1980), Hoffman and Schmidt (1981), Hoffman and Schlagenhauf (1983), and Miskin (1983).

As mentioned in Chapter I, PPP may be a good approximation in the long-run, but large deviations appear in the short-run, empirically.⁴ The existence of the long-term contracts, imperfect information, decentralization of decision making (institutional constraints), and inertia in consumer habits means that prices do not change instantaneously but adjust gradually during a short time, with a speed

³ See Thurston (1983).

⁴ See Officer (1976), Isard (1977), Genberg (1978), and Krugman (1978).

of adjustment much smaller than the long-run one. This gives me a class of models in which changes in the nominal money supply are also changes in the real money supply because prices are "sticky", and thus have real effects, especially on the exchange rate ("undershooting" or "overshooting")⁵ and on real income.

In my model PPP does hold in the long-run, so that a given increase in the money supply raises the exchange rate proportionately only in the long-run. In the short-run, because prices are sticky, an increase in the nominal money supply will create an initial excess supply of real money that portfolio owners will seek to eliminate by buying bonds. These bonds purchases will result in not only a decline in the domestic interest rate but also an incipient capital outflow, which causes the currency to depreciate instantaneously more than it will in the long-run; it depreciates just enough so that the rationality expected rate of future appreciation precisely cancels out the interest differential. This phenomenon is known as "overshooting" of the spot rate.

Over time the exchange rate is determined by the interaction between goods markets and asset markets. This is so because the price level will rise to match the expansion in the nominal quantity of money until, in the long-run, the monetary expansion is exactly matched by a price increase so that real balances and interest rates are unchanged and the spot and forward rate increase (currency depreciate) in the same

⁵ See Dornbusch (1976 b)

proportion as the increase in the nominal quantity of money. The exact dynamics of that adjustment process will depend on the speed with which prices respond as compared to expectations.

Thus, the adjustment process under rational expectations will be characterized by an initial increase of the exchange rate (currency depreciation) coupled with no change in the price of the domestic good, and then a decline of the exchange rate (currency depreciation) with a rising price of the domestic good. PPP relationships will therefore not be maintained during the adjustment process as Figure III-1 shows.

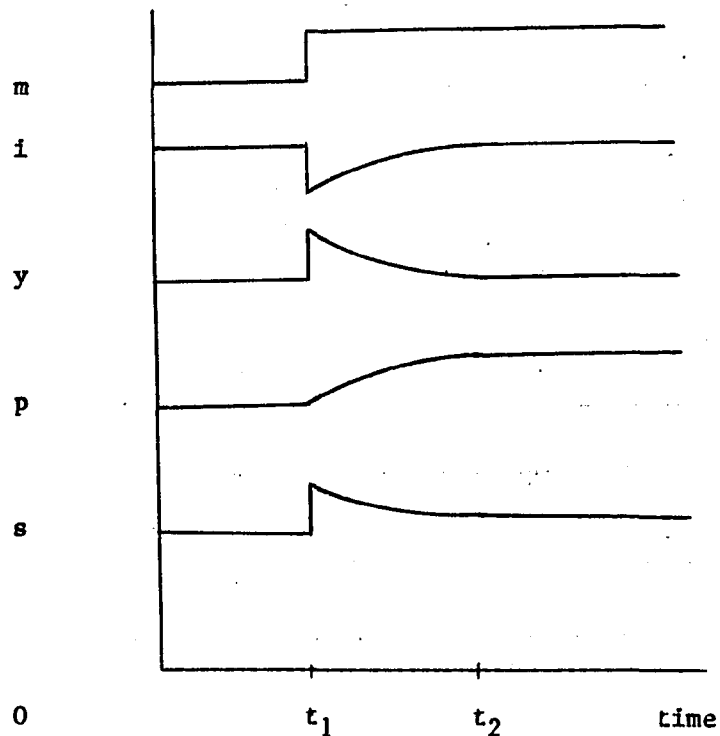


Figure III-1

Overshooting under rational expectations and sticky prices.

Effects of increase in money supply:

- | | |
|-------------------------|---|
| (1) Initial impact: | (i) Price of domestic good (none) |
| | (ii) Interest rate (decline) |
| | (iii) Real income (increase) |
| | (iv) Exchange rate (increase) |
| | |
| (2) Medium-term impact: | (i) Price of domestic good (gradual rise) |
| | (ii) Interest rate (gradual rise) |
| | (iii) Real income (gradual decline) |
| | (iv) Exchange rate (gradual decline) |

III.1 The Model

The assumption that I use for this general "monetary-unrestricted" model are as follows:

1. There are no barriers (such as transactions costs or capital controls) segmenting international capital markets, and the only interest bearing assets are identical bonds. It implies Uncovered Interest Parity (UIP): The Interest rate on a domestic bond is equal to the interest rate on a foreign bond plus the expected rate of change of the exchange rate.
2. Expectations are Rational on the average (REH)
3. Prices respond gradually to nominal aggregate demand disturbances (GAPH), and
4. Exchange rate deviates from its long-run equilibrium value due to price sluggishness and PPP does not hold (GASH).

Now, the behavioral (structural) equations of the model that specify the basic determinants of the exchange rate will be set forth. I express all the variables in natural logarithms with the only exceptions the nominal and real interest rates i , i^* and r , r^*

respectively.

The domestic demand for real balances depend on real income and on the rate of interest.

$$m_t^d - p_t = k + \alpha y_t - b i_t + \varepsilon_t \quad (1)$$

where, m_t^d = the domestic demand for nominal money balances,

p_t = the price level,⁶

y_t = the level of real income,

i_t = the nominal rate of interest,

k = a parameter (constant),

α = the income elasticity of the demand for money,

$b i_t$ = the interest rate elasticity of the demand for money, or

b = the semilogarithmic interest response of real balances, and

ε_t = the disturbance term or innovations.

The foreign demand for real balances, equation (2), depends on the same variables as domestic demand, the difference between countries being denoted by an asterik.

⁶ I don't use any small country assumption here, then both countries are large and the amount of imports and exports is just a small fraction of the domestic demand and production, then the prices of traded goods (P_T and P_T^*) do not affect the general price level (P and P^*) which are price indices.

$$m_t^{*d} - p_t^* = k^* + \alpha y_t^* - b i_t^* + \varepsilon_t^* \quad (2)$$

For convenience and for the time being, the parameters α and b are assumed to be the same in both countries.⁷

I assume equations (3) and (4) to denote domestic and foreign money market equilibrium. I assume at the moment that the money supply is exogenously determined by the respective governments.

$$m_t^d = m_t^s = m_t \quad (3)$$

$$m_t^{*d} = m_t^{*s} = m_t^* \quad (4)$$

where, m_t^s = the supply of nominally money balances,

m_t = the stock of nominal money balances.

An IS-type expenditure function for the domestic and foreign countries relates the quantity of output demanded for consumption and investment to the real rate of interest.

⁷ Later, I relax this assumption and I test the hypothesis of different parameters in each country.

$$y_t^d = c_0 - c_1 [i_t - E_t(p_{t+1} - p_t)] + \xi_t \quad (5)$$

$$y_t^{*d} = c_0^* - c_1 [i_t^* - E_t(p_{t+1}^* - p_t^*)] + \xi_t^* \quad (6)$$

where, y_t^d = the aggregate expenditure or domestic demand,

y_t^{*d} = the foreign demand,

$E_t(p_{t+1} - p_t)$ = the expected inflation rate, and

ξ_t = the disturbance term.

The aggregate supply at the point where the market clears is as follows:

$$\tilde{y}_t = y_{n,t} + \alpha_1 (y_{t-1} - y_{n,t-1}) + \alpha_2 (y_{t-2} - y_{n,t-2}) + \varepsilon_{st} \quad (7)$$

$$\tilde{y}_t^* = y_{n,t}^* + \alpha_1 (y_{t-1}^* - y_{n,t-1}^*) + \alpha_2 (y_{t-2}^* - y_{n,t-2}^*) + \varepsilon_{st}^* \quad (8)$$

where, $\tilde{y}_t$ = the market clearing value of real output,

$y_{n,t}$ = the natural level of output, and

ε_{st} = the disturbance term.

Equations (7) and (8) show the equilibrium level of real output depending on its natural level and on the gap between natural and actual output at the period (t-1) and (t-2). By introducing these two equations the real incomes (y_t) and (y_t^*) become endogenous variables. Due to this endogeneity we do not observe the current value of those two

variables.⁸ We observe only lagged values of real income.

The natural level of output for the domestic and foreign country is represented by the simplest extrapolation model, the linear trend model. The series $y_{n,t}$ and $y_{n,t}^*$ will increase in constant absolute amounts each time period and their predictions in the future are the fitted trend lines.

$$y_{n,t} = \alpha_0 + b_0 t \quad (9)$$

$$y_{n,t}^* = \alpha_0^* + b_0^* t \quad (10)$$

where, t = time ($t = 1, 2, \dots, 152$)⁹

The domestic and foreign goods market equilibrium is denoted by equations (11) and (12).

$$y_t^d = y_t^s = y_t \quad (11)$$

$$y_t^{*d} = y_t^{*s} = y_t^* \quad (12)$$

⁸ Even though the current values of real outputs do not appear in eqs. (7) and (8), they show up in the final equation of the spot exchange rate determination because there we extend j to the future ($j = 0, 1, 2, \dots, \infty$), and when $j = 1$, the y_t and y_t^* give the information needed to estimate the parameters of this regression.

⁹ t takes the values 1, 2, ..., 152 because I have 152 observations.

where, y_t^d = the demand for real output, and
 y_t^s = the real production for the country.

This model is a short-run monetary model of exchange rate determination where prices adjust sluggishly to any demand shock. Let's say that at time t_1 we have once-and-for-all increase in the domestic money supply. Prices of domestic goods adjust (start increase) slowly, but the spot exchange rate instantaneously increases by more than its long-run level ("overshoots").¹⁰ Now prices of domestic goods in terms of foreign currency are below the foreign price and this price arbitrage could induce some people to make an arbitrage profit. They can buy the good in question from the domestic country and sell it abroad. If this can take place very fast the increased demand for the domestic good and the increased supply of the foreign will cause the domestic price to increase and the foreign price to fall but arbitrage profits can still be made before this price equilibration takes place. On the other hand, for these transactions there is a shipping cost and a transaction cost which might exceed the price difference, in which case PPP will appear to be violated. Also, for these transactions the demand for domestic currency will increase and the spot exchange rate will fall reducing the price arbitrage any further. For those reasons in the short-run and during this price adjustment period the PPP does not hold. The coefficient of adjustment of the spot exchange rate (θ) below shows this shipping and transactions cost.

¹⁰ See the overshooting argument above, $(p_t < p_t^* + s_t)$.

Equation (13) represents deviations from PPP.¹¹

$$s_t - s_{t-1} = \theta(p_t - p_t^* - s_{t-1}) + u_t \quad (13)$$

$$0 \leq \theta \leq 1$$

where, s_t = the spot exchange rate, expressed in units of domestic currency per unit of foreign currency (e.g. $\frac{\$}{\pounds}$),

θ = coefficient of adjustment of the spot exchange rate, and

u_t = the error term.

Now, I introduce a simple scheme of price inertia¹², equations (14) and (15), in which agents manage to change the price level a constant fraction λ of the gap between the new market clearing price level and the price level that extend in the previous period. I assume that λ is the same for both countries.

¹¹ Because of this deviation from PPP we have a commodity price arbitrage between the two countries and an arbitrageur trying to make some profit equalizes the P and P^* . But due to the high cost of transportation and other transaction cost in the short-term, an arbitrageur does not enter these two different markets to equilibrate the domestic and foreign commodity prices.

¹² See McCallum (1978).

$$p_t - p_{t-1} = \lambda(p_t^c - p_{t-1}) + v_t \quad (14)$$

$$p_t^* - p_{t-1}^* = \lambda(p_t^{*c} - p_{t-1}^*) + v_t^* \quad (15)$$

$$0 \leq \lambda \leq 1$$

where, p_t^c = the market clearing value of the domestic price level,

λ = the speed of price adjustment, and

v_t = the disturbance term.

As is well known, from extensive use of formulas like (14) and (15) in theoretical and empirical studies, small values of λ imply slow adjustments. Thus, (14) and (15) provide a formulation in which the price levels may adjust either slowly or rapidly, but in which market clearing prevails only in the extreme case, $\lambda = 1$, when the monetarist assumption holds.

The Uncovered Interest rate Parity (UIP) or Uncovered Interest Arbitrage (UIA) is the next equation (16) which is associated with efficient markets, in which the bonds of different countries are perfect substitutes.

$$i_t - i_t^* = (\Delta s_t)^e \quad (16)^{13}$$

¹³ If the domestic currency is expected to depreciate, interest rates on assets denominated in terms of domestic currency will exceed those abroad by the expected rate of depreciation.

where, $i_t - i_t^* =$ the short-term interest rate differential, and

$(\Delta s_t)^e =$ expected rate of change of the spot exchange rate.

Equation (17) and (18) show the Fisher conditions for the two countries.

$$i_t = r_t + (p_{t+1}^e - p_t) \quad (17)$$

$$i_t^* = r_t^* + (p_{t+1}^{*e} - p_t^*) \quad (18)$$

where, $r_t =$ the real rate of interest, and

$p_{t+1}^e =$ the expected price level in period $(t+1)$.

In addition to the above behavioral equations, my system contains three more equations to give expression to the rational expectations hypothesis. They are the following:

$$(\Delta s_t)^e = E [\Delta s_t | I(t)] = E [s_{t+1} - s_t | I(t)] = E_t s_{t+1} - s_t \quad (19)$$

$$p_{t+1}^e = E [p_{t+1} | I(t)] = E_t p_{t+1} \quad (20)$$

$$p_{t+1}^{*e} = E [p_{t+1}^* | I(t)] = E_t p_{t+1}^* \quad (21)$$

where, $E[Z | I(t)] =$ the conditional expectation of the variable Z , given the information available at time t .

An asterisk on a variable denotes the foreign country. Superscripts "d", "s", and "e" denote demand, supply, and market expectations respectively. Subscripts "t" and "t+1" indicate the current and the following period respectively.

The theoretical assumption that all asset-market models share is the absence of substantial transaction costs, capital controls, or other impediments to the flow of capital between countries, an assumption which will here be referred to as perfect capital mobility.

In the case, where the market clearing prices are the equilibrium prices ($\lambda = 1$) and PPP also holds ($\theta = 1$), the spot exchange rate is determined as follows.¹⁴

I solve equations (1) and (2) for p_t and p_t^* and I have the market clearing price levels for the domestic and foreign countries. Those prices are also the equilibrium prices.

$$p_t^c = -k + m_t - \alpha y_t + b i_t - \epsilon_t \quad (1')$$

$$p_t^{*c} = -k^* + m_t^* - \alpha y_t^* + b i_t^* - \epsilon_t^* \quad (2')$$

Substituting now equations (1') and (2') in equation (13) I get the equilibrium spot exchange rate.

$$s_t = - (k - k^*) + (m_t - m_t^*) - \alpha (y_t - y_t^*) + b (i_t - i_t^*) - (\epsilon_t - \epsilon_t^*) \quad (22)$$

¹⁴ Output is at the natural level, too.

In equation (22) we see that the real money demand terms constitute one of the links between the exchange rate, the monetary sector, and the real sector. The term $(y_t - y_t^*)$ also helps explain how changes in productivity, get reflected in exchange rate changes.

This equation establishes that relative changes in money supply, interest rate, and real income affect the exchange rate. An increase in the money supply at home leads to an equiproportionate depreciation. An increase in domestic real income raises the demand for real balances and thus leads to a fall in domestic prices, this induces an offsetting currency appreciation. Relatively higher domestic interest rates, by contrast, reduce the demand for real balances, raise prices, and therefore bring about a currency depreciation.

By taking now into consideration the GAP hypothesis - equations (14) and (15), and the deviation from PPP - equation (13), we have the following solution of the above system.

First, I substitute $y_{n,t}$ and $y_{n,t}^*$ in equations (7) and (8) from equation (9) and (10) and I get the equilibrium output (aggregate supply) of the two countries.

$$\begin{aligned} \tilde{y}_t^s &= \alpha_0(1-\alpha_1-\alpha_2) + b_0(\alpha_1+2\alpha_2) + (\alpha_1 y_{t-1} + \alpha_2 y_{t-2} \\ &\quad + b_0(1-\alpha_1-\alpha_2)t + \varepsilon_{st} \end{aligned} \quad (23)$$

$$\tilde{y}_t^{*s} = \alpha_0^*(1-\alpha_1-\alpha_2) + b_0^*(\alpha_1+2\alpha_2) + \alpha_1 y_{t-1}^* + \alpha_2 y_{t-2}^*$$

$$+ b_0^*(1-\alpha_1-\alpha_2)t + \epsilon_{st}^* \quad (24)$$

Equalizing the demand equations (5) and (6) with the supply ones (23) and (24) I have the following IS curves (equilibrium in the goods markets).

$$\begin{aligned} i_t = \text{const.} - \frac{\alpha_1}{c_1} y_{t-1} - \frac{\alpha_2}{c_1} y_{t-2} + E_t(p_{t+1} - p_t) - \\ - \frac{b_0}{c_1}(1-\alpha_1-\alpha_2)t + \frac{1}{c_1}(\xi_t - \epsilon_{st}) \end{aligned} \quad (25)$$

$$\begin{aligned} i_t^* = \text{const.}^* - \frac{\alpha_1}{c_1} y_{t-1}^* - \frac{\alpha_2}{c_1} y_{t-2}^* + E_t(p_{t+1}^* - p_t^*) - \\ - \frac{b_0^*}{c_1}(1-\alpha_1-\alpha_2)t + \frac{1}{c_1}(\xi_t^* - \epsilon_{st}^*) \end{aligned} \quad (26)$$

Substituting equations (25) and (26) into the money markets equilibrium (LM) equations (3) and (4), I get the market clearing price levels (hypothetical price at which the economy is tending to) at the point of intersection of the IS and LM curves.

$$\begin{aligned} p_t^c = \text{const.} + m_t - \alpha y_t - \frac{\alpha_1 b}{c_1} y_{t-1} - \frac{\alpha_2 b}{c_1} y_{t-2} + bE_t(p_{t+1} - p_t) - \\ - \frac{b_0 b(1-\alpha_1-\alpha_2)}{c_1} t + \frac{b}{c_1} (\xi_t - \epsilon_{st}) - \epsilon_t \end{aligned} \quad (27)$$

$$p_t^{*c} = \text{const.}^* + m_t^* - \alpha y_t^* - \frac{\alpha_1 b}{c_1} y_{t-1}^* - \frac{\alpha_2 b}{c_1} y_{t-2}^* + bE_t(p_{t+1}^* - p_t^*) -$$

$$- \frac{b_0^* b(1-\alpha_1 - \alpha_2)}{c_1} t + \frac{b}{c_1} (\xi_t^* - \varepsilon_{st}^*) - \varepsilon_t^* \quad (28)$$

The clearing prices of eqs. (27) and (28) may not be the equilibrium prices because of the price inertia. To find the equilibrium prices I substitute eqs. (27) and (28) into eqs. (14) and (15), and I have:

$$p_t = \text{const.} + \lambda m_t - \alpha \lambda y_t - \frac{\alpha_1 b \lambda}{c_1} y_{t-1} - \frac{\alpha_2 b \lambda}{c_1} y_{t-2} + (1-\lambda) p_{t-1} + \\ + b \lambda E_t(p_{t+1} - p_t) - \frac{b_0 b \lambda (1-\alpha_1 - \alpha_2)}{c_1} t + \frac{b \lambda}{c_1} (\xi_t - \varepsilon_{st}) - \lambda \varepsilon_t + v_t \quad (29)$$

$$p_t^* = \text{const}^* + \lambda m_t^* - \alpha \lambda_t^* - \frac{\alpha_1 b \lambda}{c_1} y_{t-1}^* - \frac{\alpha_2 b \lambda}{c_1} y_{t-2}^* + (1-\lambda) p_{t-1}^* + \\ + b \lambda E_t(p_{t+1}^* - p_t^*) - \frac{b_0^* b \lambda (1-\alpha_1 - \alpha_2)}{c_1} t + \frac{b \lambda}{c_1} (\xi_t^* - \varepsilon_{st}^*) - \lambda \varepsilon_t^* + v_t^* \quad (30)$$

Equation (13), the deviation from PPP, through eqs. (29) and (30) becomes:

$$s_t = \text{const} + \theta \lambda (m_t - m_t^*) - \alpha \theta \lambda (y_t - y_t^*) - \frac{\alpha_1 b \theta \lambda}{c_1} (y_{t-1} - y_{t-1}^*) - \\ - \frac{\alpha_2 b \theta \lambda}{c_1} (y_{t-2} - y_{t-2}^*) + \theta (1-\lambda) (p_{t-1} - p_{t-1}^*) + b \theta \lambda [E_t(p_{t+1} - p_t) - \\ - E_t(p_{t+1}^* - p_t^*)] - \frac{b \theta \lambda (1-\alpha_1 - \alpha_2) (b_0 - b_0^*)}{c_1} t + (1-\theta) s_{t-1} + \frac{b \theta \lambda}{c_1} (\xi_t - \xi_t^*) - \\ - \frac{b \theta \lambda}{c_1} (\varepsilon_{st} - \varepsilon_{st}^*) - \theta \lambda (\varepsilon_t - \varepsilon_t^*) + \theta (v_t - v_t^*) + u_t \quad (31)$$

Equation (31) is similar to eq. (22). The only difference is the extra terms in (31) which correspond to inertia in price adjustment and the deviation from PPP. This equation through eqs. (5), (6), (16), and (19) becomes:

$$\begin{aligned}
 s_t = & \text{const} + \theta\lambda(m_t - m_t^*) - \frac{\theta\lambda(\alpha c_1 - b)}{c_1} (y_t - y_t^*) - \frac{\alpha_1 b\theta\lambda}{c_1} (y_{t-1} - y_{t-1}^*) - \\
 & - \frac{\alpha_2 b\theta\lambda}{c_1} (y_{t-2} - y_{t-2}^*) + \theta(1-\lambda)(p_{t-1} - p_{t-1}^*) - \frac{b\theta\lambda(1-\alpha_1-\alpha_2)(b_0 - b_0^*)}{c_1} t + \\
 & + (1-\theta)s_{t-1} + b\theta\lambda(E_t s_{t+1} - s_t) - \frac{b\theta\lambda}{c_1} (\varepsilon_{st} - \varepsilon_{st}^*) - \\
 & - \theta\lambda (\varepsilon_t - \varepsilon_t^*) + \theta(v_t - v_t^*) + u_t
 \end{aligned} \tag{32}$$

I define:

$$\begin{aligned}
 Z_t \equiv & \{ \text{const} + \theta\lambda(m_t - m_t^*) - \frac{\theta\lambda(\alpha c_1 - b)}{c_1} (y_t - y_t^*) - \frac{\alpha_1 b\theta\lambda}{c_1} (y_{t-1} - y_{t-1}^*) - \\
 & - \frac{\alpha_2 b\theta\lambda}{c_1} (y_{t-2} - y_{t-2}^*) + \theta(1-\lambda)(p_{t-1} - p_{t-1}^*) - \frac{b\theta\lambda(1-\alpha_1-\alpha_2)(b_0 - b_0^*)}{c_1} t + \\
 & + (1-\theta)s_{t-1} \}
 \end{aligned} \tag{33}$$

The last relationship of the spot exchange rate, eq. (32), becomes:

$$\begin{aligned}
 s_t = & (1+b\theta\lambda)^{-1} Z_t + \frac{b\theta\lambda}{1+b\theta\lambda} E_t s_{t+1} - \frac{b\theta\lambda}{c_1} (\varepsilon_{st} - \varepsilon_{st}^*) - \\
 & - \theta\lambda (\varepsilon_t - \varepsilon_t^*) + \theta(v_t - v_t^*) + u_t
 \end{aligned} \tag{34}$$

I also define: $BZ_t \equiv Z_{t+1}$ and $B^2 Z_t \equiv Z_{t+2}$

(35)¹⁵

$$\frac{b\theta\lambda}{1+b\theta\lambda} \equiv \phi, \quad 0 < \phi < 1$$

Substituting (35) into (34) and taking the expected value we have:

$$E_t s_t = \frac{(1+b\theta\lambda)^{-1}}{(1-\phi B)} E_t Z_t \quad (36)^{16}$$

Equation (36) can be written as

$$s_t = (1+b\theta\lambda)^{-1} [1 + \phi B + \phi^2 B^2 + \dots] E_t Z_t \quad (37)$$

and

$$s_t = (1+b\theta\lambda)^{-1} [Z_t + \phi E_t Z_{t+1} + \phi^2 E_t Z_{t+2} + \dots] \quad (37')$$

or

$$s_t = (1+b\theta\lambda)^{-1} \sum_{j=0}^{\infty} \phi^j E_t Z_{t+j} \quad (37'')$$

Now, I replace Z_{t+j} with the terms which are including in it, and I have the final equation.

$$\begin{aligned} s_t = & \text{const} + \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t m_{t+j} - \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t m_{t+j}^* \\ & - \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t+j} + \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t+j}^* \\ & - \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t-1+j} + \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t-1+j}^* \end{aligned}$$

¹⁵ B is called the forward operator (or $B \equiv L^{-1}$)

¹⁶ $1-\phi B > 0 \Rightarrow \phi B < 1$. This is true because ϕ is a very small positive number.

$$\begin{aligned}
& - \frac{\alpha_2 b \theta \lambda / c_1}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j E_t y_{t-2+j} + \frac{\alpha_2 b \theta \lambda / c_1}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j E_t y_{t-2+j}^* \\
& + \frac{\theta(1-\lambda)}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j E_t p_{t-1+j} - \frac{\theta(1-\lambda)}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j E_t p_{t-1+j}^* \\
& + \frac{b \theta \lambda (1 - \alpha_1 - \alpha_2) (b_0 - b_0^*)}{c_1} t + \frac{(1-\theta)}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j E_t s_{t-1+j} \quad (38)
\end{aligned}$$

Equation (38) illustrates the monetary-unrestricted theory of the exchange rate, according to which the exchange rate is determined by the relative supply of (first two terms), demand for (the third until the eight terms), lagged prices of (the other two terms), and lagged spot rate of (last term) the two currencies.

Suppose now that money increase. The public immediately recognizes, that the long-run equilibrium price level and exchange rate will rise in the same proportion - in the long-run money is neutral even though without the rationality assumption. The economy cannot instantaneously jump to the new long-run equilibrium because, by assumption prices are sluggish, they can only move gradually. In the short-run, the level of prices is given and an increase in nominal money therefore is an increase in real money. The equilibrium interest rate will fall. What happens to the exchange rate?

The short-run exchange rate will rise (currency depreciate) because there is the recognition of an increase in both the long-run equilibrium exchange rate and the long-run price level. The exchange rate in the

short-run overshoots or rises by more than the increase in the long-run equilibrium rate. Overshooting results from the requirement that the interest differential be equal to the anticipated rate of depreciation. Thus, the spot rate has to go beyond the long-run equilibrium rate to yield an expectation of appreciation.

This equation clearly illustrates the point that exchange rates depend upon current and expected future values of exogenous variables and observable endogenous variables specified in the model. In practice, it is extremely difficult to predict the future path of the money supply and real income. Exchange market participants may look at a wide variety of possible indicators - elections, unemployment and inflation statistics, union wage agreements, past values of exchange rates and forward rates, current account balance, budget deficit or surplus, GNP growth, foreign reserves, real wealth, short and long-term interest rates, the announced policy targets of the monetary authority, official intervention in the foreign exchange market, and even the political situation in the country.¹⁷

Now in order to express eq. (38) in terms of observable data, the processes generating the exogenous variables and the functions of the endogenous ones must be specified. I use two different procedures to identify the processes of the exogenous variables. First, I adopt the differenced Autoregressive [AR(p)] forecasting process, and then the

¹⁷ See Chapter V below for estimation with a few of those variables.

Autoregressive-Moving Average [ARMA(p,q)] process. Finally, I use an Instrumental Variable (IV) procedure to express the endogenous variables as functions of the exogenous and lagged endogenous variables.

III.2 Differenced Autoregressive [AR(p)] Process

I assume that the two independent exogenous variables (m_t and m_t^*) of equation (38) follow a differenced AR(1) process. The four independent endogenous variables (y_t , y_t^* , p_t and p_t^*) are functions of the exogenous and lagged endogenous; they can be substituted by some Instrumental Variables (IV).¹⁸ Then, these six independent variables are expressed explicitly as follows:

$$m_t = m_{t-1} + \rho_m \Delta m_{t-1} + u_{t1}$$

$$m_t^* = m_{t-1}^* + \rho_{m^*} \Delta m_{t-1}^* + u_{t2}$$

$$\begin{aligned} y_t = & \text{const} + \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} m_t + \frac{a_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1} + \frac{a_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-2} \\ & - \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1} + \frac{bc_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} i_t + \frac{b_0 b\lambda(1-a_1-a_2)}{ac_1 - ac_1\lambda + b\lambda} t + u_{t3} \end{aligned} \quad (39)$$

¹⁸ See Appendix 1.

$$\begin{aligned}
y^* &= \text{const.}^* + \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} m_t^* + \frac{\alpha_1 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1}^* + \frac{\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2}^* \\
&\quad - \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1}^* + \frac{b c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t^* + \frac{b_0^* b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} t + u_{t4} \\
p_t &= \text{const.}^* + \frac{b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} m_t + \frac{\alpha \alpha_1 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1} + \frac{\alpha b_2 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2} \\
&\quad + \frac{\alpha c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1} + \frac{b^2 \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t - \frac{\alpha b_0 b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} t + u_{t5} \\
p_t^* &= \text{const.}^{*'} + \frac{b\lambda}{\alpha c_1 - \alpha_1 \beta + b\lambda} m_t^* - \frac{\alpha \alpha_1 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1}^* - \frac{\alpha \alpha_2 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2}^* \\
&\quad + \frac{\alpha c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1}^* + \frac{b^2 \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t^* - \frac{\alpha b_0^* b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} t + u_{t6}
\end{aligned}$$

where, AR(1) = autoregressive process of order 1,

ρ = the autoregressive parameter

Δ = the difference operator,¹⁹

u_t 's = the forecast errors or innovations (independently distributed random variables with zero mean and variance σ_u^2).

From equations (39), I estimate ρ_m and ρ_{m^*} . I also estimate the other structural parameters of the system (α , α_1 , α_2 , b , b_0 , b_0^* , c_1 , and λ). Forecasts for monetary aggregates may be formed from the specification depicted in eqs. (39). If I base these predictions on a period- t information set I can express arbitrary, j -period conditional forecasts as

$$E_t m_{t+j} = m_t + \sum_{i=1}^j \rho_m^i \Delta m_t$$

$$E_t m_{t+j}^* = m_t^* + \sum_{i=1}^j \rho_{m^*}^i \Delta m_t^*$$

¹⁹ The difference in ln form is the rate of growth of the variable.

$$E_t y_{t+j} = y_t = f_1(m_t, y_{t-1}, y_{t-2}, p_{t-1}, i_t, t)$$

$$E_t y_{t+j}^* = y_t^* = f_2(m_t^*, y_{t-1}^*, y_{t-2}^*, p_{t-1}^*, i_t^*, t)$$

$$E_t y_{t-1+j} = y_t = f_3(m_t, y_{t-1}, y_{t-2}, p_{t-1}, i_t, t)$$

$$E_t y_{t-1+j}^* = y_t^* = f_4(m_t^*, y_{t-1}^*, y_{t-2}^*, p_{t-1}^*, i_t^*, t) \quad (40)^{20}$$

$$E_t y_{t-2+j} = y_t = f_5(m_t, y_{t-1}, y_{t-2}, p_{t-1}, i_t, t)$$

$$E_t y_{t-2+j}^* = y_t^* = f_6(m_t^*, y_{t-1}^*, y_{t-2}^*, p_{t-1}^*, i_t^*, t)$$

$$E_t p_{t-1+j} = p_t = f_7(m_t, y_{t-1}, y_{t-2}, p_{t-1}, i_t, t)$$

$$E_t p_{t-1+j}^* = p_t^* = f_8(m_t^*, y_{t-1}^*, y_{t-2}^*, p_{t-1}^*, i_t^*, t)$$

and $E_t s_{t-1+j} = s_t + j\Delta s_t$

The j -period forecasts in (40) can be used to replace the unobservable expected values in eq. (38) to obtain:

²⁰ See Appendix 2 for the intermediate steps.

$$\begin{aligned}
s_t = & \text{const} + \theta\lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2) - \alpha c_1] (1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \right] m_t \\
& - \theta\lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2) - \alpha c_1] (1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \right] m_t^* \\
& - \frac{\alpha_1 b \theta \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1} \\
& + \frac{\alpha_1 b \theta \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1}^* \\
& - \frac{\alpha_2 b \theta \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2} \\
& + \frac{\alpha_2 b \theta \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2}^* \\
& + \frac{\theta(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} [\alpha c_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1} \\
& - \frac{\theta(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} [\alpha c_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1}^* \\
& + \frac{b\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} [b(2-\alpha_1-\alpha_2) - \alpha c_1] i_t \\
& - \frac{b\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} [b(2-\alpha_1-\alpha_2) - \alpha c_1] i_t^* \\
& - b\theta\lambda(1-\alpha_1-\alpha_2)(b_0 - b_0^*) \left[\frac{\lambda[\alpha c_1 - b(1-\alpha_1-\alpha_2)]}{c_1(\alpha c_1 - \alpha c_1 \lambda + b\lambda)} + \frac{\alpha(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} + \frac{1}{c_1} \right] t \\
& + (1-\theta)s_{t-1} + b\theta\lambda(1-\theta)\Delta s_{t-1}
\end{aligned}$$

$$\begin{aligned}
& + \frac{b\theta^2 \lambda^2 \rho_m}{1+b\theta\lambda-b\theta\lambda\rho_m} \Delta m_t \\
& - \frac{b\theta^2 \lambda^2 \rho_{m^*}}{1+b\theta\lambda-b\theta\lambda\rho_{m^*}} \Delta m_t^* \\
& + u_t
\end{aligned} \tag{41}$$

The resulting spot exchange rate, equation (41), is directly estimable since all variables are now observable. The appropriate way of estimating this "monetary-unrestricted"²¹ model with rational expectations is to estimate eqs. (39) and eq. (41) as a system to account for the implicit cross-equation parameter restrictions.

The estimates from this "monetary-unrestricted" model with rational expectations depends upon the validity of the rational expectations hypothesis, the GAP hypothesis, the GAS hypothesis, the appropriateness of the "monetarist" model itself, and the suitability of the processes presumably used by market participants to forecast future money growth. There are similar procedures for conducting tests of hypothesis in models with rational expectations, done by Sargent (1978), Revanker (1980), Hoffman and Schmidt (1981), and Hoffman and Schlagenhauf (1983). A test of the empirical validity of these hypotheses will allow me to determine whether the theoretical "monetary-unrestricted" model which incorporates rational expectations is indeed justified.

²¹ This is case 4 in Table I-1 (The least restricted model), and it is just identified - number of parameters is equal to the number of variables.

An unconstrained version of eq. (41) can be written as follows:

$$\begin{aligned}
s_t = & \text{const} + \theta\lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2)-\alpha c_1](1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \right] m_t \\
& - \theta\lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2) - \alpha c_1](1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \right] m_t^* \\
& - \frac{\alpha_1 b\theta\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1} \\
& + \frac{\alpha_1 b\theta\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1}^* \\
& - \frac{\alpha_2 b\theta\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2} \\
& + \frac{\alpha_2 b\theta\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2}^* \\
& + \frac{\theta(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} [\alpha c_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1} \\
& - \frac{\theta(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} [\alpha c_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1}^* \\
& + \frac{b\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} [b(2-\alpha_1-\alpha_2)-\alpha c_1] i_t \\
& - \frac{b\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} [b(2-\alpha_1-\alpha_2)-\alpha c_1] i_t^* \\
& - b\theta\lambda(1-\alpha_1-\alpha_2)(b_0 - b_0^*) \left[\frac{\lambda[\alpha c_1 - b(1-\alpha_1-\alpha_2)]}{c_1(\alpha c_1 - \alpha c_1\lambda + b\lambda)} + \frac{\alpha(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} + \frac{1}{c_1} \right] t \\
& + (1-\theta)s_{t-1}
\end{aligned}$$

$$\begin{aligned}
& + J_1 \Delta s_{t-1} \\
& + J_2 \Delta m_t \\
& + J_3 \Delta m^*_t \\
& + u_t
\end{aligned} \tag{42}$$

Equation (42) incorporates the assumptions:

- (1) Prices adjust gradually with a speed λ to nominal demand changes,
- (2) Exchange rate adjust gradually with a speed θ ,
- (3) Equal elasticities in both countries, and
- (4) Equal coefficients for the domestic and foreign country.

However, it fails to capture the precise functional form of the coefficients for Δs_{t-1} , Δm_t , and Δm^*_t depicted in eq. (41). These variables enter the observable structure eq.(41) when the rational expectations hypothesis is incorporated into the model. Equating coefficients in eqs.(41) and (42) reveal that (41) expresses three coefficients - the J's - in terms of one parameter - b. This suggests two restrictions which may be represented in terms of unconstrained parameters as:

$$J_1 = b\theta\lambda(1-\theta) \tag{43}$$

$$J_2(\theta\lambda J_3 - \theta\lambda\rho_m J_3 + \theta^2\lambda^2\rho_m^*) = J_3(\theta\lambda J_2 - \theta\lambda\rho_m J_2 - \theta^2\lambda^2\rho_m)$$

This type of restriction is attributed to the rational expectations hypothesis since it is implied by the functional form of the solution obtained by replacing expected spot rates with predictions from the relevant theory. However, it is clear that if either the original structure eq. (38) or the forecasting eqs. (39), are misspecified the restrictions may not apply. Hence a test of this restriction might more appropriately be viewed as a test of the internal consistency of the "monetary-overshooting" model with rational expectations.

It is also possible to conduct a specification test of the joint assumptions of rationality, the GAP hypothesis, the GAS hypothesis, equal elasticities, and equal coefficients. A spot exchange rate equation free of these assumptions may be written as:

$$\begin{aligned}
 s_t = & \text{const} + J_4 m_t + J_5 m_t^* + J_6 y_{t-1} + J_7 y_{t-1}^* + J_8 y_{t-2} + J_9 y_{t-2}^* \\
 & + J_{10} p_{t-1} + J_{11} p_{t-1}^* + J_{12} i_t + J_{13} i_t^* + J_{14} \tau + J_{15} s_{t-1} + J_{16} \Delta s_{t-1} \\
 & + J_2 \Delta m_t + J_3 \Delta m_t^* + u_t
 \end{aligned} \tag{44}$$

Two available test statistics may be employed in testing the restrictions outlined above. A likelihood ratio test may be formulated by generating Full-Information-Maximum-Likelihood (FIML) estimates from both the constrained and unconstrained systems. In conducting the rational expectation specification tests, the constrained likelihood is obtained by estimating (41) and (39) as a system, while the unrestricted likelihood may

be similarly obtained from (42) and (39). A joint test of rationality restrictions, GAP hypothesis, GAS hypothesis, and the elasticity restrictions embedded in the "monetary-unrestricted" model may be accomplished in a similar comparison of likelihoods from (41) and (39); and (44) and (39).

Now, I use the same procedure for case 3 (Table I-1) model which I have called the "Monetarist-GAS" model, because prices adjust instantaneously ($\lambda=1$) but the speed of spot exchange rate adjustment is relatively small ($\theta < 1$).

With $\lambda=1$, equation (41) is as follows:

$$\begin{aligned}
 s_t = & \text{const.} + \theta m_t - \theta m_t^* \\
 & - \alpha_1 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-1} + \alpha_1 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-1}^* \\
 & - \alpha_2 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-2} + \alpha_2 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-2}^* \\
 & - b \theta (1 - \alpha_1 - \alpha_2) (b_0 - b_0^*) \left[\frac{1}{c_1} (\alpha_1 + \alpha_2) + \frac{\alpha}{b} \right] t \\
 & + (1 - \theta) s_{t-1} + b \theta (1 - \theta) \Delta s_{t-1} \\
 & + \frac{b \theta^2 \rho_m}{1 + b \theta - b \theta \rho_m} \Delta m_t - \frac{b \theta^2 \rho_{m^*}}{1 + b \theta - b \theta \rho_{m^*}} \Delta m_t^* \\
 & + u_t
 \end{aligned} \tag{41'}$$

As we see in eq. (41'), the price levels and interest rates are now non-observable. The appropriate way of estimating this "monetarist-GAS" model is to estimate the four equations of (39)²² and (41') as a system. An unconstrained version of eq. (41') can be written as:

$$\begin{aligned}
 s_t = & \text{const.} + \theta m_t - \theta m_t^* \\
 & - \alpha_1 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-1} + \alpha_1 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-1}^* \\
 & - \alpha_2 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-2} + \alpha_2 \theta \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-2}^* \\
 & - b \theta (1 - \alpha_1 - \alpha_2) (b_0 - b_0^*) \left[\frac{1}{c_1} (\alpha_1 + \alpha_2) + \frac{\alpha}{b} \right] t \\
 & + (1 - \theta) s_{t-1} + \xi_1 \Delta s_{t-1} + \xi_2 \Delta m_t + \xi_3 \Delta m_t^* + u_t
 \end{aligned} \tag{42'}$$

This equation (42') incorporates the assumptions:

- (1) Exchange rate adjust gradually,
- (2) Equal elasticities, and
- (3) Equal coefficients for the two countries.

²² We don't take into account the price equations because due to price flexibility changes in money supply have one-to-one effect on prices (neutrality assumption).

The restrictions which are attributed to the rational expectations hypothesis are now as follows:

$$\xi_1 = b\theta\lambda(1-\theta)$$

$$\xi_2(\theta\xi_3 - \theta\rho_m^*\xi_3 + \theta^2\rho_m^{**}) = \xi_3(\theta\xi_2 - \theta\rho_m\xi_2 - \theta^2\rho_m^*) \quad (43')$$

I can conduct a specification test of the joint assumptions of rationality, equal elasticities and coefficients, and the GAS hypothesis. The spot exchange rate equations without these assumptions is:

$$\begin{aligned} s_t = & \text{const.} + \xi_4 m_t + \xi_5 m_t^* + \xi_6 y_{t-1} + \xi_7 y_{t-1}^* + \xi_8 y_{t-2} + \xi_9 y_{t-2}^* \\ & + \xi_{10} s_t + \xi_{11} s_{t-1} + \xi_{12} \Delta s_{t-1} + \xi_{13} \Delta m_t + \xi_{14} \Delta m_t^* + u_t \end{aligned} \quad (44')$$

With a likelihood ratio test by estimating both the constrained and the unconstrained systems, I test the above hypotheses. For testing the rationality hypothesis, the constrained likelihood is obtained from (41') and (39), while the unconstrained is obtained from (42') and (39). The joint test of rationality, GAS hypothesis, and the elasticity restrictions may be accomplished in comparison of likelihoods from (41') and (39); and (44') and (39).²³

23 Only the first four equations from (39).

I continue the same procedure for case 2 of Table I.1 which I call the "Monetary-GAP" model because prices adjust gradually ($\lambda < 1$) while the spot exchange rate adjusts instantaneously ($\theta = 1$) and PPP holds.

Equation (41) looks now, with $\theta = 1$, as follows:

$$\begin{aligned}
 s_t = & \text{const} + \lambda \left[1 + \frac{(b(2-\alpha_1-\alpha_1) - ac_1)(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} \right] m_t \\
 & - \lambda \left[1 + \frac{(b(2-\alpha_1-\alpha_2) - ac_1)(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} \right] m_t^* \\
 & - \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} \left[a - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1} \\
 & + \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} \left[a - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1}^* \\
 & - \frac{\alpha_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} \left[a - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2} \\
 & + \frac{\alpha_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} \left[a - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2}^* \\
 & + \frac{1-\lambda}{ac_1 - ac_1\lambda + b\lambda} [ac_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1} \\
 & - \frac{1-\lambda}{ac_1 - ac_1\lambda + b\lambda} [ac_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1}^* \\
 & + \frac{b\lambda(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} [b(2-\alpha_1-\alpha_2) - ac_1] i_t \\
 & - \frac{b\lambda(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} [b(2-\alpha_1-\alpha_2) - ac_1] i_t^*
 \end{aligned}$$

$$\begin{aligned}
& -b\lambda(1-\alpha_1-\alpha_2)(h_0-h_0^*) \left[\frac{\lambda[\alpha c_1 - b(1-\alpha_1-\alpha_2)]}{c_1(\alpha c_1 - \alpha c_1\lambda + b\lambda)} + \frac{\alpha(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} + \frac{1}{c_1} \right] m_t \\
& + \frac{b\lambda^2 \rho_m}{1+b\lambda-b\lambda\rho_m} \Delta m_t \\
& - \frac{b\lambda^2 \rho_{m^*}}{1+b\lambda-b\lambda\rho_{m^*}} \Delta m_t^* \\
& + u_t
\end{aligned} \tag{41''}$$

To estimate this "Monetary 'GAP'" model we must estimate the six equations of (39) and (41'') as a system. An unconstrained version of eq. (41'') is the following:

$$\begin{aligned}
s_t = & \text{const.} + \lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2)-\alpha c_1](1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \right] m_t \\
& - \lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2)-\alpha c_1](1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \right] m_t^* \\
& - \frac{\alpha_1 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1} \\
& + \frac{\alpha_1}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-1}^* \\
& - \frac{\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2} \\
& + \frac{\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \left[\alpha - \frac{b\lambda}{c_1} (1-\alpha_1-\alpha_2) \right] y_{t-2}^* \\
& + \frac{\alpha_2(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} [\alpha c_1 - b\lambda(1-\alpha_1-\alpha_2)] p_{t-1}
\end{aligned}$$

$$\begin{aligned}
& - \frac{(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} [ac_1 - b\lambda(1-\alpha_1 - \alpha_2)] p_{t-1}^* \\
& + \frac{b\lambda(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} [b(2-\alpha_1 - \alpha_2) - ac_1] i_t \\
& - \frac{b\lambda(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} [b(2-\alpha_1 - \alpha_2) - ac_1] i_t^* \\
& - b\lambda(1-\alpha_1 - \alpha_2)(b_0 - b_0^*) \left[\frac{\lambda[ac_1 - b(1-\alpha_1 - \alpha_2)]}{c_1(ac_1 - ac_1\lambda + b\lambda)} + \frac{\alpha(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} + \frac{1}{c_1} \right] i_t \\
& + \mu_1 \Delta m_t \\
& + \mu_2 \Delta m_t^* \\
& + u_t
\end{aligned} \tag{42''}$$

Equation (42'') incorporates the assumptions:

- (1) Prices adjust gradually with a speed λ to nominal demand changes,
- (2) Equal elasticities, and
- (3) Equal coefficients for the domestic and foreign country.

The rational expectations restriction is now:

$$\mu_1(\lambda\mu_2 - \lambda\rho_{m^*}\mu_2 + \lambda^2\rho_{m^*}) = \mu_2(\lambda\mu_1 - \lambda\rho_m\mu_1 - \lambda^2\rho_m) \tag{43''}$$

Now, I conduct a specification test of the joint assumptions of

rationality, the GAP hypothesis, equal elasticities, and equal coefficients. A spot exchange rate equation free of these assumptions may be written as

$$s_t = \text{const.} + \mu_3 m_t + \mu_4 m_t^* + \mu_5 y_{t-1} + \mu_6 y_{t-1}^* + \mu_7 y_{t-2} + \mu_8 y_{t-2}^* \\ + \mu_9 p_{t-1} + \mu_{10} p_{t-1}^* + \mu_{11} i_t + \mu_{12} i_t^* + \mu_{13} t + \mu_1 \Delta m_t + \mu_2 \Delta m_t^* + u_t \quad (44'')$$

For testing the rational expectations hypothesis, the constrained likelihood is obtained from (41'') and (39) as a system, while the unconstrained from (42'') and (39). The joint test of rationality restrictions, GAP hypothesis, and the elasticity restrictions embedded in the "monetary-GAP" model may be accomplished in a similar comparison of likelihoods from (41'') and (39); and (44'') and (39).

The last case is the most restricted of Table I-1 (case 1) where prices and spot exchange rate adjust instantaneously ($\lambda=0=1$). This is the "monetarist" model.

Going now to eq. (41) and putting the above constraints I have:

$$s_t = \text{const.} + m_t - m_t^* \\ - \alpha_1 \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-1} + \alpha_1 \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-1}^* \\ - \alpha_2 \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-2} + \alpha_2 \left[\alpha - \frac{b}{c_1} (1 - \alpha_1 - \alpha_2) \right] y_{t-2}^*$$

$$\begin{aligned}
& - b(1-\alpha_1-\alpha_2)(b_0-b_0^*)\left[\frac{1}{c_1}(\alpha_1+\alpha_2) + \frac{\alpha}{b}\right]t \\
& + \frac{b\rho_m}{1+b-b\rho_m} \Delta m_t - \frac{b\rho_{m^*}}{1+b-b\rho_{m^*}} \Delta m_t^* + u_t
\end{aligned} \tag{41'''}$$

The appropriate way of estimating this "monetarist" model is to estimate the four equations of (39) and equation (41''') as a system.²⁴ An unconstrained version of eq. (41''') can be written as:

$$\begin{aligned}
s_t &= \text{const} + m_t - m_t^* \\
& - \alpha_1 \left[\alpha - \frac{b}{c_1}(1-\alpha_1-\alpha_2) \right] y_{t-1} + \alpha_1 \left[\alpha - \frac{b}{c_1}(1-\alpha_1-\alpha_2) \right] y_{t-1}^* \\
& - \alpha_2 \left[\alpha - \frac{b}{c_1}(1-\alpha_1-\alpha_2) \right] y_{t-2} + \alpha_2 \left[\alpha - \frac{b}{c_1}(1-\alpha_1-\alpha_2) \right] y_{t-2}^* \\
& - b(1-\alpha_1-\alpha_2)(b_0-b_0^*)\left[\frac{1}{c_1}(\alpha_1+\alpha_2) + \frac{\alpha}{b}\right]t \\
& + \pi_1 \Delta m_t + \pi_2 \Delta m_t^* + u_t
\end{aligned} \tag{42'''}$$

Equation (42''') incorporates the assumptions:

- (1) Unitary elasticity of money,
- (2) Equal income elasticities, and
- (3) Equal coefficients for the domestic and foreign country.

²⁴ See footnote 22 above.

The rational expectations hypothesis restrictions which may be represented in terms of unconstrained parameters are:

$$\pi_1(\pi_2^{-\rho} \pi_m^* \pi_2^{+\rho} \pi_m^*) = \pi_2(\pi_1^{-\rho} \pi_m \pi_1^{+\rho} \pi_m) \quad (43''')$$

I can conduct a specification test of the joint assumptions of rationality, the unitary elasticity of money, the equal income elasticities, and the equal coefficients. A spot exchange rate equation free of these assumptions may be written as:

$$s_t = \text{const} + \pi_3 m_t + \pi_4 m_t^* + \pi_5 y_{t-1} + \pi_6 y_{t-1}^* + \pi_7 y_{t-2} + \pi_8 y_{t-2}^* \\ + \pi_9 t + \pi_{10} \Delta m_t + \pi_{11} \Delta m_t^* + u_t \quad (44''')$$

In conducting the rational expectations specification tests, the constrained likelihood is obtained by estimating (41''') and (39) as a system, while the unrestricted likelihood may be similarly obtained from (42''') and (39). A joint test of rationality restrictions, and the elasticities restrictions embedded in the "monetarist" model may be accomplished in a similar comparison of likelihoods from (41''') and (39)' and (44''') and (39).

The resulting likelihood ratio statistic $-2 \log \left[\frac{L^c(\hat{\Sigma}^c)}{L^u(\hat{\Sigma}^u)} \right]$ is distributed asymptotically as $\chi^2(q)$,

where, q = the number of constraints,

L^c = maximized likelihood of the constrained system,

L^u = maximized likelihood of the unconstrained system,

$\hat{\Sigma}^c$ = the resulting estimated $\hat{\Sigma}$ for the constrained system,

$\hat{\Sigma}^u$ = the resulting estimated $\hat{\Sigma}$ for the unconstrained system.

Comparison of this statistic with the critical $\chi^2_{(q)}$, then tests the null hypothesis.

III.3 Autoregressive-Moving Average [ARMA(p,q)] Process

By introducing rational expectations, the model focuses on "news" as the determinant of unanticipated changes in the exchange rate. The relevant news in this model is changes in the monetary conditions domestic and foreign. These forecasts yield time series data for the news shown in the explanatory variables.

If exchange rate is proportional to those seven independent variables in each period - equation (38) - and the variables in turn, represent the best estimate, given currently available information, the exchange rate should diverge from exchange rate in the previous period by the amount of the contemporaneous revision in those seven variables ("news").

I use here an autoregressive-moving average - ARMA (p,q) - representation for the two independent exogenous variables time series. The forecast error, or innovation, in the two variables (money supplies) time-series process represents the new information contained in the

current in the current observation on each variable. Based on the realization of the current innovations in the money supply, individuals revise their expectations about the future value of these seven variables because they all are functions of the money supply.

If the expectations of future exchange rates are rational, the expectation of next period's revision in expectation, $(E_{t+1} - E_t)m_{t+j+1}$ is zero. Thus,

$$E_t s_{t+1} = s_t,$$

or

$$m_{t+1} = m_t + \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)m_{t+j+1}.$$

The same holds for the other exogenous variable m_{t+j}^* .

Equation (38) one period ahead becomes:

$$\begin{aligned} s_{t+1} = & s_t + \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)m_{t+j+1} \\ & - \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)m_{t+j+1}^* \\ & - \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)y_{t+j+1} \\ & + \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)y_{t+j+1}^* \\ & - \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)y_{t+1} \\ & + \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_{t+1} - E_t)y_{t+1}^* \end{aligned}$$

$$\begin{aligned}
& - \frac{\alpha_2 b \theta \lambda / c_1}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j (E_{t+1} - E_t) y_{t-1+j} \\
& + \frac{\alpha_2 b \theta \lambda / c_1}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j (E_{t+1} - E_t) y_{t-1+j}^* \\
& + \frac{\theta(1-\lambda)}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j (E_{t+1} - E_t) p_{t+j} \\
& - \frac{\theta(1-\lambda)}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j (E_{t+1} - E_t) p_{t+j}^* \\
& - \frac{b \theta \lambda (1 - \alpha_1 - \alpha_2)(b_0 - b_0^*)}{c_1} \epsilon_t \\
& + \frac{1 - \theta}{1 + b \theta \lambda} \sum_{j=0}^{\infty} \left(\frac{b \theta \lambda}{1 + b \theta \lambda} \right)^j (E_{t+1} - E_t) s_{t+j} + u_{t+1} \quad (45)
\end{aligned}$$

The model in this section is based on the notion that, in forming their expectations of future money, rational economic agents will exploit the fact that money supply functions (m and m^*) are stochastic processes which exhibit a high degree of serial correlation. Based on the observation that the current realization of m is greater than anticipated, agents will revise their expectations of future money supply, and therefore the exchange rate, upward. Further, the magnitude of the revision of the future independent variables associated with the realization of a disturbance in current money supply will depend on the parameters of the time-series representation of these variables. In the next section, the quantitative relationship between an innovation in money supply and the revision in exchange rate is derived from a general ARMA representation. The same procedure can be followed for the other exogenous variable (m_t^*), too.

III.3.1 The Money Supply Process

More formally, the time series behavior of money supply²⁵ is modeled as an ARMA process which is driven by a series of independent shocks or "innovations" in the process. Thus,

$$m_t = \rho_1 m_{t-1} + \rho_2 m_{t-2} + \dots + \rho_p m_{t-p} + \varepsilon_t + \mu_1 \varepsilon_{t-1} + \mu_2 \varepsilon_{t-2} + \dots + \mu_q \varepsilon_{t-q} \quad (46)$$

An ARMA model of order (p,q) can be equivalently characterized as a pure moving average (MA) model of infinite order. That is, the time series representation

$$m_t = \varepsilon_t + \psi_1 \varepsilon_{t-1} + \psi_2 \varepsilon_{t-2} + \psi_3 \varepsilon_{t-3} + \dots \quad (47)$$

is numerically equivalent to the model

$$m_t = \rho_1 m_{t-1} + \rho_2 m_{t-2} + \dots + \rho_p m_{t-p} + \varepsilon_t + \mu_1 \varepsilon_{t-1} + \dots + \mu_q \varepsilon_{t-q} \quad (48)$$

$$\text{for } \psi_s = \mu_s + \sum_{j=1}^s \rho_j \psi_{s-j}$$

Expressed in the pure moving average (MA) form, the time series model summarizes the relationship between the forecasted value of the variable and the realization of the disturbance term:

²⁵ Using the same procedure we can also find the time series process for the other exogenous variable of eq.(38).

$$\frac{dm_{t+s}}{d\varepsilon_t} = \frac{dm_t}{d\varepsilon_{t-s}} = \psi_s \quad (49)$$

Since the disturbance terms are white noise by construction, the expectation of all future values of ε is zero. When the current forecast error ε_t is realized, the predicted value of money supply at each date in the future is revised proportionally to ε_t :

$$E_t m_{t+s} - E_{t-1} m_{t+s} = \psi_s \varepsilon_t \quad (50)$$

The present value of the revision, at time t , in the anticipated path of future money supply is

$$\sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s E_t m_{t+s} - E_{t-1} m_{t+s} = \left[\sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s \psi_s \right] \varepsilon_t. \quad (51)$$

In the infinite horizon case, the value of $\sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s \psi_s$ can be calculated directly from the parameters μ_s and ρ_j of the ARMA (p,q) representation of the process. It is shown in Appendix 3 that

$$\sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s \psi_s = \frac{1 + \sum_{s=1}^q \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s \mu_s}{1 - \sum_{j=1}^p \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^j \rho_j} \quad (52)$$

III.3.2. The Model

Substituting into eq. (38) the time series characterization of the revision in the predicted path of future money supply for the two countries yields:

$$\begin{aligned}
 s_t = & \text{const.} + \frac{\theta\lambda}{1+b\theta\lambda} \left[\sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s \Psi_s \right] \varepsilon_{1t} \\
 & - \frac{\theta\lambda}{1+b\theta\lambda} \left[\sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^s \Psi_s \right] \varepsilon_{2t} \\
 & - \frac{(\alpha c_1 - b)\theta\lambda}{c_1} y_t + \frac{(\alpha c_1 - b)\theta\lambda}{c_1} y_t^* \\
 & - \frac{\alpha_1 b\theta\lambda}{c_1} y_t + \frac{\alpha_1 b\theta\lambda}{c_1} y_t^* \\
 & - \frac{\alpha_2 b\theta\lambda}{c_1} y_t + \frac{\alpha_2 b\theta\lambda}{c_1} y_t^* \\
 & + \theta(1-\lambda)p_t - \theta(1-\lambda)p_t^* \\
 & - \frac{b\theta\lambda(1-\alpha_1-\alpha_2)(b_0-b_0^*)}{c_1} t \\
 & + (1-\theta)s_{t-1} + b\theta\lambda(1-\theta)\Delta s_{t-1} + u_t
 \end{aligned} \tag{53}$$

where, Ψ_s = the parameters of the moving average representation,

ε_{1t} = the innovations of m series, and

ε_{2t} = the innovations of m^* series.

To simplify the notation, let $\phi = \sum_{s=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^s \psi_s$. Using this notation, the current value of the revision, at time t , in the anticipated path of the future exogenous variables is denoted $\phi\epsilon_t$. Equation (53) can be written as:

$$\begin{aligned}
 s_t = & \text{const.} + \frac{\theta\lambda}{1+b\theta\lambda} \phi\epsilon_{1t} - \frac{\theta\lambda}{1+b\theta\lambda} \phi\epsilon_{2t} \\
 & - \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] y_t + \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] y_t^* \\
 & + \theta(1-\lambda)p_t - \theta(1-\lambda)p_t^* \\
 & - \frac{b\theta\lambda(1-\alpha_1-\alpha_2)(b_0-b_0^*)}{c_1} t \\
 & + (1-\theta)s_{t-1} + b\theta\lambda(1-\theta)\Delta s_{t-1} + u_t
 \end{aligned} \tag{54}$$

Expressing the forecast errors of the two independent exogenous variables in terms of current and lagged values and the independent endogenous variables in terms of some instrumental variables²⁶ yields the following system of equations:

$$m_t = \mu_m + \rho_{m1}m_{t-1} + \rho_{m2}m_{t-2} + \dots + \rho_{mp}m_{t-p} + \epsilon_{1t}$$

$$m_t^* = \mu_{m^*} + \rho_{m^*1}m_{t-1}^* + \rho_{m^*2}m_{t-2}^* + \dots + \rho_{m^*p}m_{t-p}^* + \epsilon_{2t}$$

²⁶ See equations (39).

$$\begin{aligned}
y_t &= \text{const.} + \frac{c_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} m_t + \frac{a_1 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-1} + \frac{a_2 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-2} \\
&\quad - \frac{c_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} p_{t-1} + \frac{bc_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} i_t + \frac{b_0 b\lambda(1-\alpha_1-\alpha_2)}{ac_1-ac_1\lambda+b\lambda} t + \varepsilon_{3t} \\
y_t^* &= \text{const.}^* + \frac{c_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} m_t^* + \frac{a_1 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-1}^* + \frac{a_2 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-2}^* \\
&\quad - \frac{c_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} p_{t-1}^* + \frac{bc_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} i_t^* + \frac{b_0^* b\lambda(1-\alpha_1-\alpha_2)}{ac_1-ac_1\lambda+b\lambda} t + \varepsilon_{4t} \\
p_t &= \text{const.}' + \frac{b\lambda}{ac_1-ac_1\lambda+b\lambda} m_t - \frac{a\alpha_1 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-1} - \frac{a\alpha_2 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-2} \\
&\quad + \frac{ac_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} p_{t-1} + \frac{b^2\lambda}{ac_1-ac_1\lambda+b\lambda} i_t - \frac{ab_0 b\lambda(1-\alpha_1-\alpha_2)}{ac_1-ac_1\lambda+b\lambda} t + \varepsilon_{5t} \\
p_t^* &= \text{const.}^* + \frac{b\lambda}{ac_1-ac_1\lambda+b\lambda} m_t^* - \frac{a\alpha_1 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-1}^* - \frac{a\alpha_2 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-2}^* \\
&\quad + \frac{ac_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} p_{t-1}^* + \frac{b^2\lambda}{ac_1-ac_1\lambda+b\lambda} i_t^* - \frac{ab_0^* b\lambda(1-\alpha_1-\alpha_2)}{ac_1-ac_1\lambda+b\lambda} t + \varepsilon_{6t}
\end{aligned} \tag{55}$$

and

$$\begin{aligned}
\Delta s_t &= \text{const.} + \frac{\theta\lambda}{1+b\theta\lambda} \phi(m_t - \mu m - \rho m_1 m_{t-1} - \dots - \rho_{mp} m_{t-p}) + \alpha_0 \Delta m_t + \alpha_1 \Delta m_{t-1} + \dots + \alpha_{p-1} \Delta m_{t-(p-1)} \\
&\quad - \frac{\theta\lambda}{1+b\theta\lambda} \phi(m_t^* - \mu m^* - \rho m_1^* m_{t-1}^* - \dots - \rho_{mp} m_{t-p}^*) + \beta_0 \Delta m_t^* + \beta_1 \Delta m_{t-1}^* + \dots + \beta_{p-1} \Delta m_{t-(p-1)}^* \\
&\quad - \frac{\theta\lambda}{c_1} [ac_1 - b(1-\alpha_1-\alpha_2)] [y_t - \text{const.} - \frac{c_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} m_t - \frac{a_1 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-1} \\
&\quad - \frac{a_2 b\lambda}{ac_1-ac_1\lambda+b\lambda} y_{t-2} + \frac{c_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} p_{t-1} - \frac{bc_1(1-\lambda)}{ac_1-ac_1\lambda+b\lambda} i_t - \frac{b_0 b\lambda(1-\alpha_1-\alpha_2)}{ac_1-ac_1\lambda+b\lambda} t]
\end{aligned}$$

$$\begin{aligned}
& + \frac{\theta\lambda}{c_1} [ac_1 - b(1-\alpha_1-\alpha_2)] [y_t^* - \text{const.}^* - \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} m_t^* - \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1}^* \\
& - \frac{\alpha_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-2}^* + \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1}^* - \frac{bc_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} i_t^* - \frac{b^* b\lambda(1-\alpha_1-\alpha_2)}{ac_1 - ac_1\lambda + b\lambda} t] \\
& + \theta(1-\lambda) [p_t - \text{const.}' - \frac{b\lambda}{ac_1 - ac_1\lambda + b\lambda} m_t + \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1} + \frac{\alpha_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-2} \\
& - \frac{ac_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1} - \frac{b^2\lambda}{ac_1 - ac_1\lambda + b\lambda} i_t + \frac{ab_0 b\lambda(1-\alpha_1-\alpha_2)}{ac_1 - ac_1\lambda + b\lambda} t] \\
& - \theta(1-\lambda) [p_t^* - \text{const.}'^* - \frac{b\lambda}{ac_1 - ac_1\lambda + b\lambda} m_t^* + \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1}^* + \frac{\alpha_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-2}^* \\
& - \frac{ac_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1}^* - \frac{b^2\lambda}{ac_1 - ac_1\lambda + b\lambda} i_t^* + \frac{ab_0^* b\lambda(1-\alpha_1-\alpha_2)}{ac_1 - ac_1\lambda + b\lambda} t] \\
& + (1-\theta)\Delta s_{t-1} + \varepsilon_t
\end{aligned} \tag{56}^{27}$$

$$\text{where, } \phi = \left[\frac{1}{1 - \frac{b\theta\lambda\rho_1}{1+b\theta\lambda} - \frac{b\theta\lambda\rho_2}{(1+b\theta\lambda)^2} - \dots - \frac{b\theta\lambda\rho_p}{(1+b\theta\lambda)^p}} \right].$$

In the unrestricted version of the model, the first difference of the spot exchange rate responds to current and lagged changes in money supply, real income, price level and interest rate as well as the innovations in the process of these variables. In equation (56)

²⁷ See Appendix 4 for the intermediate steps of eq. (56).

the α_i and β_i coefficients are measures of the "excess sensitivity"²⁸ of the exchange rate to m_t and m_t^* , that is, sensitivity in excess of the response attributable to the new information contained in the current values of the above variables. The empirical work discussed in this section could provide estimates of the α_i and β_i parameters and tests the implication of the exchange rate determination that it exhibits no excess sensitivity to current $m(\alpha_i = 0)$ and $m^*(\beta_i = 0)$. The exchange rate determination under rational expectations could be tested by estimating the system in its structural representation, eqs. (55) and (56), by Full-Information-Maximum-Likelihood (FIML) both with and without the restrictions of $\alpha_i = 0$ and $\beta_i = 0$, and then forming a likelihood ratio statistic.

I can test the GAP hypothesis by putting $\lambda = 1$. Equation (56) becomes now:

$$\begin{aligned} \Delta s_t = & \text{const} + \frac{\theta}{1+b\theta} \phi(m_t - \mu_m - \rho_{m1} m_{t-1} - \dots - \rho_{mp} m_{t-p}) + \alpha_0 \Delta m_t + \alpha_1 \Delta m_{t-1} + \dots + \alpha_{p-1} \Delta m_{t-(p-1)} \\ & - \frac{\theta}{1+b\theta} \phi(m_t^* - \mu_{m^*} - \rho_{m^*1} m_{t-1}^* - \dots - \rho_{m^*p} m_{t-p}^*) + \beta_0 \Delta m_t^* + \beta_1 \Delta m_{t-1}^* + \dots + \beta_{p-1} \Delta m_{t-(p-1)}^* \\ & - \frac{\theta}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] [y_t - \text{const} - \alpha_1 y_{t-1} - \alpha_2 y_{t-2} - b_0(1-\alpha_1-\alpha_2)t] \end{aligned}$$

²⁸ See Flavia (1981) using this model for estimating the consumption function.

$$\begin{aligned}
& + \frac{\theta}{c_1} [ac_1 - b(1-\alpha_1-\alpha_2)] y_t^* - \text{const}^* - \alpha_1 y_{t-1}^* - \alpha_2 y_{t-2}^* - b_0^*(1-\alpha_1-\alpha_2)t] \\
& + (1-\theta)\Delta s_{t-1} + \varepsilon_t.
\end{aligned} \tag{57}$$

The constrained likelihood is obtained from (55) and (57) as a system, while the unconstrained from (55) and (56).

The GAS hypothesis can be tested by putting $\theta=1$. The (56) becomes as follows:

$$\begin{aligned}
\Delta s_t = & \text{const} + \frac{\lambda}{1+b\lambda} \phi(m_t - \mu_m - \rho_{m1} m_{t-1} - \dots - \rho_{mp} m_{t-p}) + \alpha_0 \Delta m_t + \alpha_1 \Delta m_{t-1} + \dots + \alpha_{p-1} \Delta m_{t-(p-1)} \\
& - \frac{\lambda}{1+b\lambda} \phi(m_t^* - \mu_{m^*} - \rho_{m^*1} m_{t-1}^* - \dots - \rho_{m^*p} m_{t-p}^*) + \beta_0 \Delta m_t^* + \beta_1 \Delta m_{t-1}^* + \dots + \beta_{p-1} \Delta m_{t-(p-1)}^* \\
& - \frac{\lambda}{c_1} [ac_1 - b(1-\alpha_1-\alpha_2)] [y_t - \text{const} - \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} m_t - \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1} \\
& - \frac{\alpha_2 b\lambda}{b\lambda \frac{1}{1} \frac{1}{1}} y_{t-2} + \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1} - \frac{bc_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} i_t - \frac{b_0 b\lambda(1-\alpha_1-\alpha_2)}{ac_1 - ac_1\lambda + b\lambda} t] \\
& + \frac{\lambda}{c_1} [ac_1 - b(1-\alpha_1-\alpha_2)] [y_t^* - \text{const}^* - \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} m_t^* - \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1}^* \\
& - \frac{\alpha_2 b\lambda}{b\lambda \frac{1}{1} \frac{1}{1}} y_{t-2}^* + \frac{c_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1}^* - \frac{bc_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} i_t^* - \frac{b_0^* b\lambda(1-\alpha_1-\alpha_2)}{ac_1 - ac_1\lambda + b\lambda} t] \\
& + (1-\lambda) [p_t - \text{const} - \frac{b\lambda}{ac_1 - ac_1\lambda + b\lambda} m_t + \frac{\alpha_1 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-1} + \frac{\alpha_2 b\lambda}{ac_1 - ac_1\lambda + b\lambda} y_{t-2} \\
& - \frac{ac_1(1-\lambda)}{ac_1 - ac_1\lambda + b\lambda} p_{t-1} - \frac{b^2\lambda}{ac_1 - ac_1\lambda + b\lambda} i_t + \frac{ab_0 b\lambda(1-\alpha_1-\alpha_2)}{ac_1 - ac_1\lambda + b\lambda} t]
\end{aligned}$$

$$\begin{aligned}
& -(1-\lambda)[p_t^* - \text{const}'^* - \frac{b\lambda}{\alpha c_1 - \alpha c_1 \lambda - b\lambda} m_t^* + \frac{\alpha \alpha_1 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1}^* + \frac{\alpha \alpha_2 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2}^* \\
& - \frac{\alpha c_1 (1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1}^* - \frac{b^2 \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t^* + \frac{\alpha b_0^* b\lambda (1-\alpha_1 - \alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} \varepsilon_t] \\
& + \varepsilon_t.
\end{aligned} \tag{58}$$

For testing, then the GAS hypothesis, the constrained likelihood is obtained from (55) and (58) as a system, while the unconstrained from (55) and (56).

Now, I test the "monetarist" hypothesis where $\lambda = \theta = 1$. Equation (56) becomes:

$$\begin{aligned}
\Delta s_t &= \text{const} + \frac{1}{1+b} \phi(m_t - \mu_m - \rho_{m1} m_{t-1} - \dots - \rho_{mp} m_{t-p}) + \alpha_0 \Delta m_t + \alpha_1 \Delta m_{t-1} + \dots + \alpha_{p-1} \Delta m_{t-(p-1)} \\
& - \frac{1}{1+b} \phi(m_t^* - \mu_{m^*} - \rho_{m^*1} m_{t-1}^* - \dots - \rho_{m^*p} m_{t-p}^*) + \beta_0 \Delta m_t^* + \beta_1 \Delta m_{t-1}^* + \dots + \beta_{p-1} \Delta m_{t-(p-1)}^* \\
& - \frac{1}{c_1} [\alpha c_1 - b(1-\alpha_1 - \alpha_2)] [y_t - \text{const} - \alpha_1 y_{t-1} - \alpha_2 y_{t-2} - b_0 (1-\alpha_1 - \alpha_2) \varepsilon_t] \\
& + \frac{1}{c_1} [\alpha c_1 - b(1-\alpha_1 - \alpha_2)] [y_t^* - \text{const}^* - \alpha_1 y_{t-1}^* - \alpha_2 y_{t-2}^* - b_0 (1-\alpha_1 - \alpha_2) \varepsilon_t] \\
& + \varepsilon_t.
\end{aligned}$$

This joint hypothesis of $\lambda = \theta = 1$ is conducted by using the constrained likelihood estimating (55) and (59) as a system, while the unrestricted likelihood may be similarly obtained from (55) and (56).

IV. EMPIRICAL EVIDENCE

In this chapter I present the results of the model which is represented in the previous chapter and I also show the formal tests of the different hypotheses. I use eight different exchange rates (nine countries)¹ which are the followings:

$$s_1 = \frac{\$}{DM}, s_2 = \frac{\$}{C\$}, s_3 = \frac{\$}{\pounds}, s_4 = \frac{\$}{Y}, s_5 = \frac{\$}{FF}, s_6 = \frac{\$}{Lr}, s_7 = \frac{\$}{SF}, \text{ and } s_8 = \frac{\$}{Dr}.$$

The empirical results presented below are based on monthly data for the period March 1973 through August 1984.² All data came from various issues of the O.E.C.D.'s Main Economic Indicators, and the variables are in natural logarithms.

The variable spot exchange rate (s_t) is measured in cents per unit of foreign currency at the end of the period. The domestic money supply (m_t)³ is the adjusted M1 plus quasi-money (M2) measured in dollars at the end of the period. The foreign money supply (m_t^*) is the adjusted M2 measured in units of foreign currency, end of period. An index of the adjusted total industrial production is used as proxy for the domestic (y_t) and foreign (y_t^*) real income. At the end, the consumer price index is used for measuring the price level of each country and the discount rates for measuring the short-term interest rates.

¹United States, Germany, Canada, United Kingdom, Japan, France, Italy, Switzerland, and Greece.

²Switzerland's data starts September 1975 until August 1984.

³Domestic country is the United States (U.S.A.).

IV.1. Ordinary Least Squares Estimates (OLS)

I started estimating the "monetary-unrestricted" equation (41) with an OLS method ignoring at the moment the coefficients of the independent variables which the rational expectations procedure gave to me.⁴ With this estimation I would like to see if the signs of the variables are correct according to my theory and also the level of significance of the parameters. The results are given in Table IV.1 below.

As Table IV-1 shows the signs are correct except very few variables which have wrong signs are significant. Evidence of serial correlation does not appear in the errors (DW $\approx$ 2.00). The coefficients with asterisks have a t-statistic which indicates that they are significantly different from zero at the levels referred in notes below the Tables. From the t-statistic we see that the constant terms are not significantly different from zero.

In constructing my model, I had assumed that the elasticities, and the speed of price adjustment are equal in both countries. Equation (41) is estimated by relaxing these assumptions. Equation (1) below includes those constraints which are the following:

$$\beta_1 = -\beta_2,$$

$$-\beta_3 = \beta_4.$$

⁴ I estimate eq.(41) as a reduced form.

$$-\beta_5 = \beta_6,$$

$$\beta_7 = -\beta_8, \text{ and}$$

$$\beta_9 = -\beta_{10}.$$

The reduced form of the constrained equation is now as follows:

$$\begin{aligned} s_t = & \beta_0' + \beta_{12}(m_t - m_t^*) - \beta_{34}(y_{t-1} - y_{t-1}^*) - \beta_{56}(y_{t-2} - y_{t-2}^*) + \beta_{78}(p_{t-1} - p_{t-1}^*) \\ & + \beta_{910}(i_t - i_t^*) - \beta_{11}t + \beta_{12}s_{t-1} + \beta_{13}\Delta s_{t-1} + \beta_{14}\Delta m_t - \beta_{15}\Delta m_t^* + u_t' \quad (1) \end{aligned}$$

The estimates of eq.(1) are in Table IV-2. For testing these hypotheses, I do a likelihood ratio test between eq.(41) and (1). The results of this test are in Table IV-6. From the likelihood ratio statistic we reject the null hypothesis in Germany, Canada, France, Italy and Switzerland. We cannot reject it at the 10 percent level of significance in United Kingdom and Japan.

Table IV-3 show the estimates of eq. (41') where $\lambda = 1$. This is the "Monetarist-CAS" model where prices are fully flexible. By making a comparison between eqs. (41) and (41'), I test the null hypothesis ($H_0: \lambda = 1$) of price flexibility. Table IV-6 shows the results of this test and the null hypothesis is rejected in four countries. We cannot reject the null hypothesis in England, France and Switzerland.

If now I would estimate eq. (41') as relative money and relative

income, the results are a little different and are presented in Table IV.3a. Testing the null hypothesis of price flexibility between eq.(1) (Table IV-2) and (41'a) (Table IV-3a) I find results which reject the null hypothesis in Japan and Italy but no rejections occur in the other countries (Table IV.7).

Equation (41'') is shown in Table IV.4. Prices are adjusted gradually there ($\lambda < 1$) but PPP holds ($\theta = 1$). We can test this hypothesis by comparing eqs. (41) and (41''). Table IV-6 indicates the likelihood ratio test of the null hypothesis where $\theta = 1$. The hypothesis is rejected in all countries. I estimate the same eq. (41'') as relative variables (Table IV-4a) and I do the same test for the null hypothesis between eqs. (41''a) and (1) and the results appear in Table IV-7 where the null hypothesis is rejected everywhere.

The last case is where prices adjust instantaneously and PPP holds, too ($\lambda = \theta = 1$). This is eq. (41''') and is exhibited in Table IV-5. I also estimate the same equation as relative variables in Table IV-5a. The joint tests for the null hypotheses are pointed out in Tables IV-6 and IV-7, between eqs. (41) and (41'''); and (1) and (41'''a) respectively. This joint hypothesis is rejected everywhere. From these tests we see that PPP does not hold in any country.

At the end I estimate eq. (41''') by taking into consideration the monetarist hypothesis that the money coefficients are unity; the results are in Table 5-1. The null hypothesis ($H_0: \beta_1 = -\beta_2 = 1$) is shown in Table IV.6. Likelihood ratio test between (41''') and (41'''b) rejects the null hypothesis for all countries. Table IV-5.1a displays the

monetarist hypothesis of the relative monies ($\beta_{12} = 1$) and the test of this null hypothesis between eqs. (41'''a) and (41'''c) is shown in Table IV-7. The monetarist hypothesis ($H_0: \beta_{12} = 1$) is rejected everywhere.

TABLE IV-1

OLS Estimates of eq.(41): $s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_{t-1} + \beta_4 y_{t-1}^* - \beta_5 y_{t-2} + \beta_6 y_{t-2}^* + \beta_7 p_{t-1} - \beta_8 p_{t-1}^* + \beta_9 i_t - \beta_{10} i_t^* - \beta_{11} t + \beta_{12} s_{t-1} + \beta_{13} \Delta s_{t-1} + \beta_{14} \Delta m_t - \beta_{15} \Delta m_t^* + u_t$
the "monetary-unrestricted" model

VAR	COEFFICIENTS							
s_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0	4.7796 (6.6250)	-1.8598 (1.3080)	-.4275 (2.6163)	-3.3468 (3.6733)	-3.0908 (4.2595)	-6.0071*** (2.3027)	-10.5278 (5.7961)	---
m_t	-.0583 (.8791)	.0603 (.1595)	.1071 (.3377)	.1392 (.3381)	.2528 (.3505)	.2697 (.2147)	1.3042 (.4827)	---
m_t^*	-.1567 (.4748)	-.0377* (.0214)	-.2292 (.1399)	-.0895 (.2559)	.0376 (.1211)	.3078**** (.0826)	-.2093 (.2280)	---
y_{t-1}	-1.3553*** (.5493)	.0163 (.1239)	-.2185 (.2664)	-.2787 (.2779)	-.7502**** (.2834)	-.7302**** (.2299)	-.6835 (.4831)	---
y_{t-1}^*	.5745** (.2782)	.1888* (.0957)	.1756 (.1519)	.3126 (.2614)	.1385 (.1528)	-.0475 (.0736)	-.4084 (.2503)	---
y_{t-2}	1.0360** (.5087)	.0229 (.1183)	.2189 (.2691)	.2967 (.2872)	.8757**** (.2929)	.6595**** (.2297)	.9682 (.4266)	---
y_{t-2}^*	.2865 (.2888)	-.0613 (.0931)	.0481 (.1508)	-.0625 (.2359)	-.0899 (.1588)	.1209 (.0746)	.5825 (.2497)	---
p_{t-1}	.9669* (.5540)	.3749**** (.1422)	.5032* (.3045)	.3827 (.2843)	.2622 (.3192)	-.0709 (.2395)	.4725 (.3987)	---
p_{t-1}^*	-2.0251*** (.8516)	.1138 (.1872)	-.1105 (.0997)	.2103 (.1640)	-.1407 (.6000)	.2468 (.1847)	-.1512 (.7261)	---

TABLE IV-1

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
i_t	.0053 (.0099)	-.0056*** (.0023)	-.0007 (.0046)	-.0092* (.0047)	-.0067 (.0046)	.0026 (.0037)	-.0045 (.0075)	---
i_t^*	-.0259**** (.0083)	-.0002 (.0012)	.00005 (.0016)	-.0020 (.0038)	-.0016 (.0035)	-.0065**** (.0025)	-.0031 (.0098)	---
ϵ	.0021 (.0077)	-.0039** (.0017)	-.0010 (.0033)	-.0045 (.0039)	-.0033 (.0065)	-.0100*** (.0035)	-.0134 (.0058)	---
s_{t-1}	.7099**** (.0681)	.7862**** (.0586)	.8967**** (.0553)	.9783**** (.0460)	.9953**** (.0615)	.8229**** (.0567)	.9226 (.0842)	---
Δs_{t-1}	-.2352**** (.0822)	.0026 (.0904)	-.0094 (.0993)	-.0064 (.0936)	-.1642* (.0972)	-.0439 (.0925)	-.1158 (.1176)	---
Δm_t	1.1249 (1.2674)	.3728 (.2922)	-.2543 (.6424)	-1.4357* (.7318)	-.7649 (.7096)	-.3673 (.5485)	-1.3885 (.8618)	---
Δm_t^*	1.1874 (.7230)	-.0063 (.1510)	.1539 (.2556)	.6690 (.9310)	-.4598 (.3596)	-.3564 (.2926)	.0670 (.3175)	---
R^2	.8618	.9842	.9764	.9503	.9829	.9947	.9583	---
DW	1.8682	1.9027	1.9962	2.0741	2.0981	2.0570	2.1284	---
N	138	138	138	138	138	138	108	---
S.E.	.0548	.0125	.0280	.0315	.0311	.0246	.0350	---
log L(.)	213.336	417.786	306.058	289.776	291.556	323.927	217.362	---

TABLE IV-2

OLS Estimates of Eq. (1): $s_t = \beta_0' + \beta_{12}(m_t - m_t^*) - \beta_{34}(y_{t-1} - y_{t-1}^*) - \beta_{56}(y_{t-1} - y_{t-2}^*) + \beta_{78}(p_{t-1} - p_{t-1}^*)$
 $+ \beta_{910}(i_t - i_t^*) - \beta_{11}t + \beta_{12}s_{t-1} + \beta_{13}\Delta s_{t-1} + \beta_{14}\Delta m_t - \beta_{15}\Delta m_t^* + u_t'$

VAR	COEFFICIENTS							
	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0'	.3891 (.3075)	.4652** (.2164)	.7865**** (.2659)	.1867 (.6126)	.0216 (.1530)	-1.1046**** (.3631)	-.1486 (.4348)	---
$(m_t - m_t^*)$	.0490* (.2574)	.0178 (.0161)	.1993**** (.0704)	.0490 (.1345)	-.0341 (.0871)	-.2214**** (.0628)	.2164 (.2003)	---
$(y_{t-1} - y_{t-1}^*)$	-.4673 (.2457)	-.0998 (.0862)	-.2103 (.1316)	-.3324 (.2089)	-.1929 (.1361)	-.0149 (.0695)	.3008 (.2241)	---
$(y_{t-2} - y_{t-2}^*)$	.2898 (.2432)	.0819 (.0830)	.1632 (.1297)	.1714 (.2004)	.2866** (.1349)	-.1177 (.0724)	-.1496 (.2237)	---
$(p_{t-1} - p_{t-1}^*)$	-.0938 (.4059)	.0569 (.0746)	.0524 (.0572)	-.1955 (.1203)	.1748 (.2622)	-.2997** (.1457)	.3008 (.2991)	---
$(i_t - i_t^*)$	.0109 (.0066)	-.0006 (.0009)	-.0010 (.0014)	.0002 (.0029)	-.0036 (.0027)	.0069**** (.0020)	-.0026 (.0063)	---
t	-.0002 (.0018)	-.0002 (.0001)	.0007* (.0004)	.0002 (.0001)	.0002 (.0006)	-.0040**** (.0010)	-.0021 (.0014)	---
s_{t-1}	.8654**** (.0525)	.8883**** (.0463)	.9732**** (.0209)	.9677**** (.0411)	.9930**** (.0347)	.8068**** (.0566)	.9799**** (.0478)	----

TABLE IV-2

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
Δs_{t-1}	-.2397**** (.0837)	-.0076 (.0908)	-.0142 (.0904)	.0546 (.0881)	-.0896 (.0882)	.0728 (.0911)	-.0456 (.1114)	---
Δm_t	.5002 (1.2116)	.5745** (.2744)	-.3249 (.6041)	-1.1848* (.7006)	-.4859 (.6741)	-.0724 (.5508)	-.9338 (.8916)	---
Δm_t^*	1.5650** (.6849)	-.0745 (.1479)	.2270 (.2468)	.6633 (.8793)	-.5481 (.3560)	-.0781 (.2776)	-.0225 (.3172)	---
R^2	.8445	.9827	.9748	.9475	.9817	.9940	.9497	---
DW	1.9003	1.9653	2.0206	2.0889	2.0989	2.0262	1.9794	---
N	138	138	138	138	138	138	108	---
S.E.	.0570	.0128	.0284	.0317	.0316	.0257	.0375	---
log L(.)	205.224	411.593	301.612	286.017	286.719	314.965	207.224	---

Note: Standard errors in parentheses.

* Significant at the 10 percent level.

** Significant at the 5 percent level.

*** Significant at the 2 percent level.

**** Significant at the 1 percent level.

TABLE IV-3

OLS Estimates of eq. (41'): $s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_{t-1} + \beta_4 y_{t-1}^* - \beta_5 y_{t-2} + \beta_6 y_{t-2}^* - \beta_7 t + \beta_8 s_{t-1} + \beta_9 \Delta s_{t-1}$
 The "Monetarist-Gas" model $+ \beta_{10} \Delta m_t - \beta_{11} \Delta m_t^* + u_t$

VAR	COEFFICIENTS							
s_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0	-1.4177 (2.8767)	.4114 (1.0691)	.3006 (1.2693)	-4.7641* (2.8138)	-2.2848 (1.9874)	-5.4153**** (1.6961)	-8.9070**** (3.1005)	-2.8334** (1.3784)
m_t	.2322 (.4627)	.0248 (.1353)	-.0237 (.2708)	.3039 (.2727)	.1906 (.2744)	.4429** (.2010)	1.2377**** (.3993)	.3858* (.2059)
m_t^*	-.2497 (.1681)	-.0031 (.0182)	-.0726 (.0820)	.2322* (.1341)	.1406 (.1000)	.2362**** (.0654)	-.2120 (.2134)	-.1040*** (.0416)
y_{t-1}	-.9534* (.4993)	-.0435 (.1131)	-.3575 (.2508)	-.2166 (.2658)	-.5567** (.2467)	-.7947**** (.2133)	-.7469* (.3959)	-.3537* (.2029)
y_{t-1}^*	.4904* (.2769)	.1391 (.0910)	.1757 (.1483)	.1463 (.2301)	.1314 (.1523)	-.1217* (.0678)	-.3951* (.2327)	.1787** (.0902)
y_{t-2}	.8697* (.5065)	-.0029 (.1162)	.3463 (.2531)	.2436 (.2794)	.6219*** (.2626)	.8163**** (.2172)	.9103** (.4055)	.3455* (.2030)
y_{t-2}^*	-.0379 (.2811)	-.0992 (.0904)	.0060 (.1462)	-.1664 (.2303)	-.1316 (.1482)	.0369 (.0675)	.6695**** (.2319)	.0371 (.0932)
t	-.0007 (.0035)	-.0004 (.0012)	.0008 (.0018)	-.0044 (.0030)	-.0035 (.0027)	-.0075**** (.0023)	-.0103**** (.0037)	-.0026 (.0018)

TABLE IV-3

Continued

VAR	\$/DM		\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF\$/Dr
s_{t-1}	.8785**** (.0499)	.8842**** (.0459)	.9648**** (.0212)	.9160**** (.0372)	.9661**** (.0295)	.9189**** (.0283)	.9430**** (.0345)	.9368**** (.0268)
Δs_{t-1}	-.2645**** (.0839)	.0082 (.0911)	-.0488 (.0906)	.1060 (.0858)	-.0990 (.0853)	-.0925 (.0859)	-.1170 (.1021)	-.1888** (.0879)
Δm_t	.3049 (1.2229)	.5579* (.2867)	-.1582 (.6116)	-1.1016 (.7147)	-.6359 (.6890)	-.6137 (.5437)	-1.2858 (.8293)	-.1936 (.5509)
Δm_t^*	1.4724** (.6879)	-.0708 (.1533)	.1087 (.2427)	.1746 (.8722)	-.6197* (.3552)	-.2957 (.2932)	-.0030 (.3034)	-.0121 (.0489)
R^2	.8469	.9827	.9757	.9467	.9821	.9944	.9576	.9962
D.W.	1.9068	1.9599	2.0144	2.0486	2.0969	2.0507	2.1551	2.0207
N	138	138	138	138	138	138	108	138
S.E.	.0568	.0128	.0279	.0321	.0313	.0250	.0346	.0255
log L(.)	206.309	411.641	304.044	284.921	288.423	319.614	216.407	316.898

TABLE IV-3a

OLS Estimates of eq. (41'a) as difference: $s_t = \beta_0' + \beta_{12}(m_t - m_t^*) - \beta_{34}(y_{t-1} - y_{t-1}^*) - \beta_{56}(y_{t-2} - y_{t-2}^*) - \beta_7 t$
 $+ \beta_8 s_{t-1} + \beta_9 \Delta s_{t-1} + \beta_{10} \Delta m_t - \beta_{11} \Delta m_t^* + u_t$

		COEFFICIENTS						
VAR								
s_t	\$/DM		\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF\$/Dr
β_0'	.2459 (.2728)	.5027*** (.1932)	.6624**** (.2183)	-.4424 (.4179)	.1384 (.1277)	-.5421** (.2467)	-.2099 (.3978)	-.1437** (.7222)
$(m_t - m_t^*)$	.0377 (.1356)	.0089 (.0127)	.1587**** (.0543)	-.0823 (.0900)	-.0668 (.0841)	-.0997** (.0482)	.1372 (.1598)	.0980** (.0429)
$(y_{t-1} - y_{t-1}^*)$	-.3728 (.2362)	-.1102 (.0822)	-.2058 (.1302)	-.1764 (.1936)	-.2035 (.1326)	.0551 (.0682)	.2254 (.2110)	-.1074 (.0827)
$(y_{t-2} - y_{t-2}^*)$	.3826 (.2332)	.0697 (.0805)	.1543 (.1289)	.1927 (.2012)	.2451* (.1317)	-.0192 (.0689)	-.1899 (.2161)	.1009 (.0835)
t	-.0002 (.0003)	-.0002** (.0001)	.0004* (.0002)	.0001 (.0001)	-.0004 (.0003)	-.0010*** (.0004)	-.0007 (.0006)	.0069 (.0004)
s_{t-1}	.9215**** (.0393)	.8859**** (.0423)	.9758**** (.0202)	.9393**** (.0281)	.9762**** (.0266)	.9369**** (.0299)	.9957**** (.0337)	.9923**** (.0176)

TABLE IV-3a

(Continued)

VAR	\$ / DM		\$ / C\$	\$ / £	\$ / Y	\$ / FF	\$ / Lr	\$ / SF\$ / Dr
Δs_{t-1}	-.2618**** (.0824)	-.0044 (.0875)	-.0127 (.0899)	.0953 (.0837)	-.0734 (.0849)	.0223 (.0874)	-.0497 (.1079)	-.1518* (.0887)
Δm_t	.3943 (1.2129)	.5768** (.2722)	-.4476 (.5911)	-.8845 (.6827)	-.5469 (.6725)	-.3664 (.5628)	-.8026 (.8756)	-.0635 (.5578)
Δm_t^*	1.5173** (.6832)	-.0637 (.1466)	.1846 (.2427)	.1545 (.8545)	-.6111* (.3531)	-.0286 (.2874)	-.1104 (.3063)	-.0126 (.0500)
R^2	.8412	.9826	.9746	.9456	.9814	.9934	.9490	.9958
D.W.	1.9218	1.9531	2.0177	2.0371	2.0839	1.9882	1.9966	2.0095
N	138	138	138	138	138	138	108	138
S.E.	.0572	.0127	.0283	.0321	.0316	.0267	.0373	.0263
log L(.)	203.760	411.157	300.991	283.588	285.598	308.865	206.497	310.662

TABLE IV-4

OLS Estimates of Eq. (41''): $s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_{t-1}^* + \beta_4 y_{t-1} - \beta_5 y_{t-2} + \beta_6 y_{t-2}^* + \beta_7 p_{t-1} - \beta_8 p_{t-1}^* + \beta_9 i_t - \beta_{10} i_t^* - \beta_{11} \epsilon + \beta_{12} \Delta m_t - \beta_{13} \Delta m_t^* + u_t$

The "Monetary-GAP" model:

VAR	COEFFICIENTS							
	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
s_t								
β_0	29.6656**** (8.4225)	-3.4162* (2.0653)	14.7592**** (4.5191)	-7.4878 (8.4996)	48.6720**** (5.1295)	-13.9799**** (3.8421)	20.4234**** (7.7699)	---
m_t	-1.9524* (1.1731)	.0802 (.2540)	.3773 (.6311)	.3329 (.7794)	-3.5297**** (.4781)	-.1942 (.3560)	2.4660**** (.7595)	---
m_t^*	-.1876 (.6472)	-.1267**** (.0325)	-1.7342**** (.2009)	.5841 (.5872)	1.1171**** (.1852)	1.2328**** (.0967)	-.4597 (.3638)	---
y_{t-1}	-2.3361**** (.7356)	-.1562 (.1962)	-.2672 (.4949)	.1619 (.6419)	-1.3850**** (.5118)	-.8833** (.3759)	-3.4386**** (.6876)	---
y_{t-1}^*	1.0861**** (.3735)	.3441** (.1485)	.1919 (.2793)	-.0221 (.6047)	.0439 (.2834)	.1090 (.1248)	-.8475** (.3985)	---
y_{t-2}	1.10906* (.6906)	.1621 (.1880)	-.5661 (.4850)	-.2982 (.6618)	.0619 (.5133)	.2564 (.3669)	2.3671**** (.6562)	---
y_{t-2}^*	1.4442**** (.3629)	.1850 (.1447)	.4564 (.2779)	.4284 (.5431)	.3484 (.2908)	.2854** (.1255)	.3885 (.3988)	---

TABLE IV-4

Continued

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
P_{t-1}	2.2202**** (.7351)	1.2034**** (.2059)	2.4918**** (.5291)	-1.1886* (.6146)	.9909* (.5864)	-.0563 (.4087)	.0770 (.6318)	---
p_{t-1}^*	-6.2887**** (1.0170)	.2923 (.2977)	-.9940**** (.1582)	.2762 (.3798)	-7.7109**** (.6947)	.3981 (.3154)	-5.6731**** (.8330)	---
i_t	.0283** (.0132)	-.0244**** (.0030)	.0411**** (.0069)	.0339**** (.0091)	.0296**** (.0073)	.0258**** (.0058)	.0399**** (.0099)	---
i_t^*	-.0747**** (.0092)	.0019 (.0019)	-.0059** (.0029)	-.0310**** (.0082)	-.0023 (.0064)	-.0286**** (.0033)	-.0348** (.0151)	---
ϵ	.0254*** (.0101)	-.0115**** (.0026)	.0061 (.0062)	-.0019 (.0091)	.0760**** (.0078)	-.0252**** (.0058)	.00003 (.0088)	---
Δm_ϵ	3.4700** (1.7012)	-.5406 (.4505)	-.2570 (1.1978)	-.7315 (1.6940)	.7536 (1.2824)	-.5105 (.9393)	-1.9768 (1.3783)	---
Δm_ϵ^*	.9020 (.9855)	.1169 (.2402)	1.0469** (.4638)	-.4023 (2.1544)	-.1365 (.6656)	-1.1753*** (.4926)	.3694 (.5051)	---
R^2	.7386	.9591	.9159	.7287	.9401	.9843	.8898	---
DW	.7657	.6121	.5028	.3020	.6028	.6660	.8269	---
N	138	138	138	138	138	138	108	---
S.E.	.0748	.0199	.0524	.0730	.0578	.0421	.0564	---
log L(.)	169.375	352.263	218.431	172.697	205.039	248.507	164.845	---

TABLE IV-4a

OLS Estimates of eq. (41'a) as difference: $s_t = \beta'_0 + \beta_{12}(m_t - m^*_t) - \beta_{34}(y_{t-1} - y^*_{t-1}) - \beta_{56}(y_{t-2} - y^*_{t-2}) + \beta_{78}(p_{t-1} - p^*_{t-1})$
 $+ \beta_{910}(i_t - i^*_t) - \beta_{11}t + \beta_{12}\Delta m_t - \beta_{13}\Delta m^*_t + u_t$

VAR s_t	COEFFICIENTS							
	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β'_0	3.6549**** (.4159)	4.5118**** (.0979)	8.3388**** (.8876)	1.6728 (1.4923)	3.8842**** (.2081)	-5.6875**** (.2862)	2.3859*** (.9883)	---
$(m_t - m^*_t)$	.0271 (.4551)	.0547* (.0325)	.9134**** (.2839)	.5887* (.3248)	-1.6305**** (.1887)	-.9859**** (.0594)	.6281 (.4792)	---
$(y_{t-1} - y^*_{t-1})$	-.8645** (.4325)	-.3336** (.1690)	-.4963 (.5461)	-.1771 (.5110)	.4520 (.3767)	-.2279* (.1158)	.0957 (.5437)	---
$(y_{t-2} - y^*_{t-2})$	.1478 (.4277)	-.1186 (.1661)	.5987 (.5449)	-.1451 (.4894)	.2958 (.3798)	-.3710**** (.1181)	-.0763 (.5430)	---
$(p_{t-1} - p^*_{t-1})$	.1825 (.7161)	-.2699* (.1455)	.6516**** (.2369)	-.7860**** (.2889)	2.5657**** (.6959)	-.4178* (.2437)	.1153 (.7239)	---
$(i_t - i^*_t)$	.0802**** (.0091)	-.0049**** (.0019)	.0056 (.0061)	.0434**** (.0053)	.0032 (.0076)	.0288**** (.0024)	.0606**** (.0132)	---
t	-.0024 (.0032)	-.0021**** (.0002)	.0016 (.0016)	.0004 (.0003)	-.0026 (.0017)	-.0133**** (.0015)	-.0023 (.0033)	---

TABLE IV-4a

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
Δm_t	1.2986 (2.1412)	-.1977 (.5469)	-.4654 (2.5642)	-1.5529 (1.7133)	-1.6089 (1.8839)	.1684 (.9366)	-1.5250 (2.1559)	---
Δm^*_t	2.8296*** (1.2038)	-.2989 (.2988)	3.0255**** (1.0174)	-.4780 (2.1484)	-1.2269 (.9994)	-.5482 (.4694)	.3358 (.7617)	---
R^2	.5059	.9277	.5376	.6804	.8522	.9823	.6971	---
DW	.4235	.3578	.1587	.2861	.2418	.6481	.2910	---
N	138	138	138	138	138	138	108	---
S.E.	.1008	.0259	.1206	.0777	.0889	.0438	.0910	---
log L(.)	125.438	313.008	100.778	161.403	142.682	240.563	110.249	---

TABLE IV-5

OLS Estimates of eq.(41'''): $s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_{t-1} + \beta_4 y_{t-1}^* - \beta_5 y_{t-2} + \beta_6 y_{t-2}^* - \beta_7 t + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* + u_t$
 The "Monetarist" model

VAR s_t	\$/DM	\$/C\$	\$/£	COEFFICIENTS \$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0	14.2729**** (5.0117)	10.4845**** (1.8561)	14.6290**** (5.1233)	-31.5297**** (6.5059)	11.7405* (5.9886)	-18.5382**** (4.9125)	-38.7067**** (8.7282)	-.2928 (4.3910)
m_t	-2.9642**** (.7776)	-.7208**** (.2595)	-1.7366 (1.1177)	1.5564** (.6695)	-3.6710**** (.7620)	.3157 (.5997)	3.4378**** (1.1606)	-.7130 (.6465)
m_t^*	-.1037 (.3084)	-.0970**** (.0352)	-.0625 (.3407)	1.4263**** (.3135)	1.6739**** (.2745)	1.3575**** (.1664)	2.3501**** (.5625)	-.3254*** (.1301)
y_{t-1}	-.6756 (.9174)	-.1095 (.2289)	-2.3486** (1.0206)	.7138 (.6569)	-.4371 (.7570)	-1.7759**** (.6169)	-2.3108** (1.1591)	1.7851**** (.6406)
y_{t-1}^*	1.2049*** (.5073)	.0893 (.1812)	-.3639 (.6079)	-.3751 (.5720)	.2609 (.4724)	.0310 (.2056)	.0792 (.6945)	1.0775**** (.2806)
y_{t-2}	.4824 (.9321)	-.1244 (.2347)	2.6801*** (1.0275)	.0846 (.6970)	.8958 (.8077)	1.6460*** (.6305)	3.0017*** (1.1768)	1.4942** (.6461)
y_{t-2}^*	1.1642** (.5048)	.0006 (.1806)	.7119 (.6058)	.4749 (.5714)	.5788 (.4548)	.0644 (.2041)	1.1448 (.6933)	1.1455**** (.2828)
t	.0246**** (.0059)	.0053** (.0024)	.0120 (.0074)	-.0249**** (.0071)	.0088 (.0084)	-.0286**** (.0065)	-.0440**** (.0105)	-.0019 (.0057)
Δm_t	1.3202 (2.2613)	.1884 (.5706)	.5335 (2.5440)	-.6470 (1.7826)	-.0245 (2.1189)	-2.3972 (1.6442)	-.4809 (2.4730)	-.6150 (1.7862)
Δm_t^*	1.4725 (1.2731)	-.0927 (.3104)	2.3934*** (.9885)	1.4704 (2.1708)	.0728 (1.0996)	-1.7721** (.8777)	-.5242 (.9059)	.1598 (.1579)

TABLE IV-5

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
R ²	.4667	.9279	.5700	.6625	.8252	.9472	.6089	.9591
DW	.2878	.3058	.2127	.2333	.1898	.2034	.3017	.3242
N	138	138	138	138	138	138	108	138
S.E.	.1052	.0259	.1167	.0802	.0972	.0760	.1040	.0828
log L(.)	120.171	313.198	105.791	157.634	131.101	165.001	96.445	153.151

TABLE IV-5.1

LSQ Estimates of eq.(41''b): $s_t = \beta_0 + m_t - m_t^* - \beta_3 y_{t-1} + \beta_4 y_{t-1}^* - \beta_5 y_{t-2} + \beta_6 y_{t-2}^* - \beta_7 t + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* + u_t$

VAR	COEFFICIENTS							
s_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0	-9.9129**** (1.2924)	-1.0729 (.6902)	9.8755**** (1.1528)	-1.3923* (.7169)	-5.6882**** (1.8672)	-4.4356**** (1.0497)	-14.2135**** (1.8415)	-8.0581**** (.6691)
m_t	1	1	1	1	1	1	1	1
m_t^*	-1	-1	-1	-1	-1	-1	-1	-1
y_{t-1}	2.3422**** (.8933)	1.9796**** (.6979)	3.7227**** (.9191)	-.2419 (.7828)	1.8992 (1.3567)	.1748 (1.0799)	1.6643 (1.3611)	1.8309**** (.6944)
y_{t-1}^*	1.7206**** (.5339)	.6847 (.5563)	-.6883 (.6078)	-.6481 (.6977)	.8499 (.8441)	.5842 (.3663)	.5725 (.7983)	1.1498**** (.3048)
y_{t-2}	-1.6905* (.9619)	-.2928 (.7235)	-3.8926**** (.9492)	-1.6201** (.7968)	-1.7413 (1.4397)	-.5912 (1.1283)	-3.1737** (1.3837)	-1.2876* (.7068)
y_{t-2}^*	1.6700**** (.5210)	1.6187**** (.5414)	.3038 (.6023)	-.1262 (.6895)	1.1745 (.8185)	.6438 (.3634)	1.5342* (.7992)	1.2698**** (.3059)
t	.0035**** (.0004)	-.0011**** (.0003)	.0004 (.0004)	-.0012*** (.0005)	.0036**** (.0006)	.0049**** (.0005)	.0060**** (.0005)	.0042**** (.0004)

TABLE IV-5.1

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
Δm_t	-.6211 (2.4278)	1.6518 (1.7278)	-1.3407 (2.5071)	2.3579 (2.0964)	.2369 (3.7399)	-1.3998 (2.8942)	-1.0772 (2.7694)	-1.3658 (1.9204)
Δm_t^*	-2.2364 (1.3741)	-1.6736* (.9612)	-2.7881**** (.9948)	-.3701 (2.6422)	-4.1361** (1.9237)	-2.2817 (1.4708)	-1.2988 (1.0145)	-.4949**** (.1585)
DW	.2870	.1824	.2361	.1819	.1206	.1113	.2043	.4380
N	138	138	138	138	138	138	108	138
S.E.	.1145	.0817	.1194	.0980	.1765	.1372	.1227	.0911
log L (.)	107.327	154.016	101.553	128.813	47.686	82.416	77.498	138.880

Note: LSQ = Nonlinear Least Squares

TABLE IV-5a

OLS Estimates of eq. (41''a) as difference:

$$s_t = \beta_0' + \beta_{12}(m_t - m_t^*) - \beta_{34}(y_{t-1} - y_{t-1}^*) - \beta_{56}(y_{t-2} - y_{t-2}^*) - \beta_7 t + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* + u_t$$

VAR s_t	COEFFICIENTS							
	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0'	5.1850**** (.3939)	4.4821**** (.0800)	6.9767**** (.7629)	-4.0397**** (1.2735)	4.6508**** (.1202)	-6.5557**** (.4632)	9.1989**** (.7111)	.7453** (.3423)
$(m_t - m_t^*)$	-1.0764**** (.2895)	.0643*** (.0263)	.4314* (.2285)	-.6257** (.2791)	-2.3019**** (.1968)	-1.1322**** (.1049)	-2.8564**** (.3768)	.6264**** (.2060)
$(y_{t-1} - y_{t-1}^*)$	-.1176 (.5393)	-.2198 (.1720)	-.3297 (.5592)	.2802 (.6081)	.2645 (.4502)	-.1515 (.2002)	-.1760 (.6857)	-1.0351*** (.4084)
$(y_{t-2} - y_{t-2}^*)$	.5157 (.5328)	-.2285 (.1679)	.5325 (.5601)	.1127 (.6333)	.5487 (.4490)	.0349 (.2020)	.5988 (.6986)	-.5073 (.4175)
t	.0024**** (.0007)	-.0018**** (.0001)	-.0020** (.0008)	.0025**** (.0004)	-.0085**** (.0005)	-.0132**** (.0006)	.0099**** (.0013)	-.0041** (.0020)
Δm_t	.7313 (2.7722)	-.0629 (.5691)	-1.3643 (2.5906)	-.1970 (2.1481)	-1.6844 (2.2796)	-1.8771 (1.6548)	2.8229 (2.8026)	-2.8758 (2.7891)
Δm_t^*	3.0331* (1.5542)	-.2761 (.3104)	3.0403**** (1.0335)	.7498 (2.6904)	-.7426 (1.2055)	-1.3571 (.8392)	-.5540 (.9874)	.3562 (.2502)

TABLE IV-5a

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
R ²	.1575	.9202	.5025	.4519	.7792	.9420	.4489	.8922
DW	.2146	.2700	.1575	.1134	.1668	.1685	.1835	.1229
N	138	138	138	138	138	138	108	138
S.E.	.1307	.0270	.1241	.1009	.1080	.0788	.1216	.1329
log L(.)	88.6108	306.1420	95.7205	124.1740	114.9750	158.4670	77.9243	86.3080

TABLE IV-5.1a

LSQ Estimates of eq (41'''c) as difference:

$$s_t = \beta_0' + (m_t - m_t^*) - \beta_{34}(y_{t-1} - y_{t-1}^*) - \beta_{56}(y_{t-2} - y_{t-2}^*) - \beta_7 \varepsilon + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* + u_t$$

VAR	COEFFICIENTS							
s_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
β_0'	2.3748**** (.0479)	1.6555**** (.0333)	8.8706**** (.0531)	3.3739**** (.0510)	2.7252**** (.0636)	2.8486**** (.0538)	1.9369**** (.0683)	.1302**** (.0467)
$(m_t - m_t^*)$	1	1	1	1	1	1	1	1
$(y_{t-1} - y_{t-1}^*)$	.8696 (.6219)	1.0218* (.5551)	.5449 (.5632)	-.1113 (.6789)	.3497 (.7932)	.4624 (.4055)	1.2549 (.9623)	1.0303*** (.4119)
$(y_{t-2} - y_{t-2}^*)$	-.6686 (.6259)	.7423 (.5448)	-.5889 (.5705)	-1.1732* (.6780)	-.5121 (.7939)	.0370 (.4102)	-2.1096** (.9699)	.5598 (.4201)
ε	.0017**** (.0005)	-.0019**** (.0003)	.0004 (.0004)	-.0034**** (.0004)	.0024**** (.0006)	.0024**** (.0004)	.0025**** (.0006)	.0005 (.0003)
Δm_t	-.7800 (3.2495)	.9359 (1.8510)	-1.6154 (2.6390)	.9374 (2.3912)	-.7103 (4.0289)	-2.9564 (3.3592)	-3.5684 (3.8806)	-2.8875 (2.8132)
Δm_t^*	-.5.3092**** (1.7886)	-2.8552**** (.9695)	-3.4347**** (1.0411)	1.2041 (2.9839)	-3.7566* (2.0779)	-.6272 (1.6929)	-.1018 (1.3994)	-.5394** (.2308)

TABLE IV-5.1a

(Continued)

VAR	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
DW	.1979	.1599	.1636	.1223	.0764	.0528	.1215	.1663
N	138	138	138	138	138	138	108	138
S.E.	.1536	.0880	.1265	.1129	.1909	.1599	.1727	.1340
log L(.)	65.7604	142.6980	92.5350	108.2790	35.8131	60.1632	39.4971	84.5965

TABLE IV-6

Likelihood Ratio Tests for the Models of Tables IV.1 to IV.5 ($H_0: \beta_1 = -\beta_j$, $H_0: \lambda=1$, $H_0: \theta=1$, $H_0: \lambda = \theta=1$)

		\$/DM	\$/C\$	\$/f	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
$H_0: \beta_1 = -\beta_j$									
LRS	$\chi^2_{(5)}$	16.224****	12.386**	8.892	7.518	9.674*	17.924****	20.276****	---
$H_0: \lambda=1$									
LRS	$\chi^2_{(4)}$	14.054****	12.290**	4.028	9.710**	6.266	8.626*	1.910	---
$H_0: \theta=1$									
LRS	$\chi^2_{(2)}$	87.922****	131.046***	175.254****	234.158****	173.034****	150.840****	105.034***	---
$H_0: \lambda=\theta=1$									
LRS	$\chi^2_{(6)}$	186.330****	209.176****	400.534****	264.284****	320.910****	317.852****	241.834****	---
$H_0: \beta_1 = \beta_2=1$									
LRS	$\chi^2_{(2)}$	25.68****	318.364****	8.476**	57.642****	166.830****	165.170****	37.894****	28.542****

Note: LRS = Likelihood ratio statistic

**** = significant at the 1 percent level

** = significant at the 5 percent level

* = significant at the 10 percent level

TABLE IV-7

Likelihood Ratio Tests for the Models of Tables IV-2, IV-3a, IV-4a, IV-5a. ($H_0: \lambda=1$, $H_0: \theta=1$, $H_0: \lambda=\theta=1$)

		\$/DM	\$/C\$	\$/x	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
$H_0: \lambda=1$									
LRS	$\chi^2_{(2)}$	2.928	.872	1.242	4.858*	2.242	12.200***	1.454	---
$H_0: \theta=1$									
LRS	$\chi^2_{(2)}$	159.572****	197.170****	401.668****	249.228****	288.074****	148.804****	193.950****	---
$H_0: \lambda=\theta=1$									
LRS	$\chi^2_{(4)}$	233.226****	210.902****	411.783****	323.686****	343.488****	312.996****	258.599****	---
$H_0: \beta_{12}=1$									
LRS	$\chi^2_{(1)}$	45.701****	326.888****	6.371**	31.790****	158.324****	196.608****	76.854***	3.423*

Note: See Table IV-6

IV.2. Full Information Maximum Likelihood Estimates (FIML)

In this section, I use the Full Information Maximum Likelihood (FIML) method to estimate the "monetarist" model ($\lambda=0=1$). I estimate first the four equations of (39) and eq. (41''') as a system and the results are presented in Tables IV.2-1 and IV.2-2. This system is the constrained one where rational expectations, unitary elasticity of money, equal income elasticities and equal coefficients for the domestic and foreign country are taken into consideration.

Second, the system of equations (39) and (42''') is estimated by relaxing the rational expectations restrictions. A Likelihood ratio test between the system (39) and (41'''); and (39) and (42''') allows us to conduct a rational expectations specification test. Table IV.2-3 contains likelihood ratio statistics for the REH restrictions - equation (43'''). Clearly the restrictions implied by the REH are rejected for these exchange rates and for the "monetarist" model.

At the end, equations (39) and (44''') are estimated as a system. This is the unconstrained system and by making a likelihood ratio test between this system and the restricted one - equations (39) and (41''') we can test the joint hypotheses of rationality, unitary money elasticities, equal income elasticities and equal coefficients. The results of this joint test are in Table IV.2-3. The values of the likelihood ratio statistics suggest that acceptance of the null hypothesis is in order.

Now, let us consider the structural estimates obtained in this

analysis. These results, presented in Table IV.2-1 and IV.2-2, are very supportive of the model of foreign exchange. Equation (41''') proves to be the best point of reference for determining the hypothesized sign and magnitude of the structural parameters. Further all coefficients of equation (41''') are statistically significant at the 1 percent level. Finally, the magnitudes of my estimated coefficients are almost plausible.

TABLE IV.2-1

FIML Estimates of the "Monetarist" Model, Eqs. (41''') - (42''') - (44''')

Coefficient	USA ≠ W. GERMANY		
	Eq.(41''')	Eq.(42''')	Eq.(44''')
π_1	---	-3.9069 (4.3103)	-164.989**** (3.5460)
π_2	---	16.6999**** (1.8996)	-492.430**** (1.0282)
π_3	---	1	-2.8498**** (.8637)
π_4	---	-1	-.1006 (.3534)
π_5	---	---	-1.3511 (1.2245)
π_6	---	---	1.9194**** (.5604)
π_7	---	---	1.0206 (1.2796)
π_8	---	---	.6444 (.4997)
π_9	---	---	.0237**** (.0065)

TABLE IV.2-1

(Continued)

USA ≠ W. GERMANY			
Coefficient	Eq(41''')	Eq(42''')	Eq(44''')
α	1.3374**** (.2615)	.5483 (.3290)	---
α_1	1.3905**** (.0289)	1.3839 (.0297)	---
α_2	-.4274**** (.0290)	-.4154 (.0298)	---
b	-1.6699**** (.1655)	-9.3020 (4.2283)	---
c_1	---	---	---
ρ_m	.7984**** (.0220)	.7956 (.0219)	---
ρ_{m*}	.4261**** (.0633)	.3954 (.0644)	---
DW	.9246	.9039	.8166
log L(.)	1829.95	1834.01	1817.76

TABLE IV.2-2

FIML Estimates of the "Monetarist" model, eqs.(41''') - (42''') - (44''')

USA ≠ FRANCE				USA ≠ ITALY			
Coefficient	Eq.(41''')	Eq.(42''')	Eq.(44''')	Coefficient	Eq.(41''')	Eq.(42''')	Eq.(44''')
π_1	---	-3.8906 (4.7431)	-166.0060**** (3.4731)	π_1	---	-7.6391** (3.8333)	253.610**** (1.8192)
π_2	---	9.8272**** (2.4769)	-283.559**** (1.2447)	π_2	---	1.4796 (1.5887)	365.937**** (1.0907)
π_3	---	1	-3.3536**** (1.1456)	π_3	---	1	.6286 (.8892)
π_4	---	-1	1.8203**** (.44906)	π_4	---	-1	1.4518**** (.2718)
π_5	---	---	-.8267 (.8692)	π_5	---	---	-1.7890*** (.6923)
π_6	---	---	-.1270 (.4289)	π_6	---	---	.1140 (.2016)
π_7	---	---	1.3689 (.8961)	π_7	---	---	1.5791** (.7371)
π_8	---	---	.7799* (.4036)	π_8	---	---	-.0248 (.1945)
π_9	---	---	.0046 (.0134)	π_9	---	---	-.0324**** (.0103)

TABLE IV.2.2

(Continued)

Coefficient	USA # FRANCE			Coefficient	USA # ITALY		
	Eq. (41''')	Eq.(42''')	Eq.(44''')		Eq(41''')	Eq. (42''')	Eq.(44''')
α	1.1014**** (.3108)	.0378 (.4181)	---	α	1.2436**** (.1934)	.7329**** (.1965)	---
α_1	1.4023**** (.0388)	1.4017**** (.0392)	---	α_1	1.3816**** (.0357)	1.4060**** (.0364)	---
α_2	-.4459**** (.0396)	-.4384**** (.0398)	---	α_2	-.4434**** (.0364)	-.4525**** (.0370)	---
b	-2.1737**** (.1893)	-39.9096 (223.802)	---	b	-4.2139**** (.4427)	-14.9242**** (3.1144)	---
c_1	---	---	---	c_1	---	---	---
ρ_m	.7794**** (.0218)	.7757****	---	ρ_m	.8425**** (.0211)	.8377**** (.0218)	---
ρ_{m*}	.5846**** (.0409)	.5577****	---	ρ_{m*}	.8631**** (.0303)	.7668**** (.0516)	---
DW	.5367	.3282	.5189	DW	.5908	.1915	.2736
log L(.)	1783.80	1788.66	1819.67	log L(.)	1717.88	1732.99	1752.46

TABLE IV.2-3.

Likelihood Ratio Test for restriction implied by the rational expectations hypothesis and the joint hypotheses

	<u>REH[Eq.(43''')]</u>	<u>Joint Hypotheses[Eq.(43'''), $\pi_3 = -\pi_4 = 1$, $\pi_6 = -\pi_5$, $\pi_8 = -\pi_7$]</u>
<u>Exchange Rate</u>		
\$/DM	$\chi^2_{(1)} = 8.12^{**}$	$\chi^2_{(5)} = 24.38^{**}$
\$/FF	$\chi^2_{(1)} = 9.72^{**}$	$\chi^2_{(5)} = 71.74^{**}$
\$/Lr	$\chi^2_{(1)} = 30.22^{**}$	$\chi^2_{(5)} = 69.16^{**}$

Note: * significant at the 5 percent level
 ** significant at the 1 percent level

V. ALTERNATIVE FORMULATIONS OF THE MODEL

In Chapter III, I layed out a short-run "monetary-unrestricted" model and through this framework I tested hypotheses of Rational Expectations, Gradually Adjustment of Prices, and Gradually Adjustment of the Spot Exchange Rate. This chapter takes as its frame of reference the experience with floating exchange rates and seeks to explain, in the light of today's theories, the pattern of exchange rate movements by using many different variables which may affect the spot exchange rate.

The first equation can be the following:

$$\begin{aligned}
 s = & \beta_0 + \beta_1(m - m^*) + \beta_2(y - y^*) + \beta_3(i_s - i_s^*) + \beta_4(i_L - i_L^*) + \\
 & + \beta_5(\pi^e - \pi^{*e}) + \beta_6(TB - TB^*) + \beta_7(BD - BD^*) + \beta_8(g - g^*) + \\
 & + \beta_9(R - R^*) + \beta_{10}(W - W^*) + \beta_{11}f + \beta_{12}s_{-1} + u.
 \end{aligned}$$

where, m = money supply,

y = real income,

i_L = nominal long-term interest rate,

i_s = nominal short-term interest rate,

π^e = expected inflation,

TB = trade balance,

BD = budget deficit,

g = real income growth ($GNP_t - GNP_{t-1}/GNP_{t-1}$),

R = level of foreign reserves,

W = real wealth,

f = the forward exchange rate, and

s_{-1} = lagged spot exchange rate.

The variables in lower case letters are in natural logarithms and the asterisk denotes the foreign country. The above equation is a restricted one because we have assumed that the coefficients of the independent variables are equal for both countries. We can estimate the same equation as unrestricted, where its country has different coefficients, and with an F test we test the null hypotheses ($\beta_{1i} = \beta_{1j}$).

The unrestricted equation (1) looks as follows:

$$\begin{aligned}
 s = & \beta_0 + \beta_{1i}m + \beta_{1j}m^* + \beta_{2i}y + \beta_{2j}y^* + \beta_{3i}s + \beta_{3j}s^* + \\
 & + \beta_{4i}i_L + \beta_{4j}i_L^* + \beta_{5i}\pi^e + \beta_{5j}\pi^{*e} + \beta_{6i}TB + \beta_{6j}TB^* + \beta_{7i}BD + \\
 & + \beta_{7j}BD^* + \beta_{8i}g + \beta_{8j}g^* + \beta_{9i}R + \beta_{9j}R^* + \beta_{10i}W + \beta_{10j}W^* + \\
 & + \beta_{11}f + \beta_{12}s_{-1} + u
 \end{aligned} \tag{2}$$

The above equations are estimated by using OLS and then a Cochran - Orcutt procedure to correct for serial correlation. From the existing theory we know the signs of β 's which are expected to be as follows. The β_1 coefficient is positive because an increase in relative money supply causes the spot rate to increase and the currency depreciates. The β_2 must be negative because an increase in productivity gets reflected in a decrease in the exchange rate, (the domestic currency appreciates). The β_3 and β_4 coefficients are positive because an increase in interest rate means that the money supply has fallen and consequently the spot exchange rate rises (currency depreciates).¹ A decrease in the expected inflation rate, raises the demand for domestic money and thus causes a currency appreciation, β_5 positive. Coefficients β_6 and β_7 must be positive and negative respectively. Theory suggests that in an open economy, an increased budget deficit inevitably means higher interest rates for the country which allow an inflow of foreign savings to supplement net domestic savings in financing the budget deficit. The rise in interest rates will cause the currency to appreciate (spot rate to fall). The capital inflow (borrowing from abroad to finance the budget deficit) increases the current account deficit. The trade balance is deteriorated. An appreciation of the currency also causes the trade balance to deteriorate due to reductions of exports (loss of competitiveness).

¹ Relatively higher domestic interest rates reduce the demand for real balances, raise prices, and therefore bring about a currency depreciation.

The coefficient of the relative growth (β_8) is negative for the same reason as coefficient β_2 above. The coefficient β_9 must be negative. An increase in foreign reserves means that the country is a net exporter (balance of payments in surplus). If the country sterilizes, its money supply will stay constant and the increased demand for its currency by the foreigners will cause an appreciation of the exchange rate.²

The coefficient of real wealth must have a negative sign, too. An increase in wealth for a country means an increase in its assets which also include foreign assets. This means that the country sells reserves in order to buy interest bearing foreign assets. This appreciates its currency for the same reason as the previous paragraph (spot rate falls).

The coefficients of the last two terms β_{11} and β_{12} must be positive. If the forward rate and the lagged spot rate increase, the current rate will increase, too.

I estimate equations (1) and (2) using data from March 1973 until August 1984. The money supply data is nominal M_2 , seasonally adjusted (M_1 plus quasi-money). Real income is measured by industrial production.

² If there is no sterilization the money supply will increase and there will be an indirect effect on its currency value. This effect will depreciate a little its currency but the direct effect which will dominate is the currency appreciation due to the increased demand for its currency by foreign countries.

For the long-term interest rate I use the yield of long-term Government bonds. The short-term interest rate is representing by the official discount rate. Proxies for the unobservable expected inflation are typically constructed from variables such as long-term interest rate, the preceding twelve-month period CPI or WPI inflation rates, or with an inflation rate autoregression³. Here I don't use any forecasting equation but just the long-term interest rate as a proxy. The trade balance are exports minus imports. The budget deficit represent the cumulated U.S. or foreign deficit. The real income growth is the percentage change of the proxy industrial production. The level of foreign reserves are the official reserves excluding gold. For the real wealth variable a good proxy is the cumulated trade balance. The forward exchange rate is the U.S. dollar per unit of foreign currency exchange rate 90 days forward. The variable s_{-1} is the lagged spot exchange rate, and u is a disturbance term. The disturbance term may be a serially correlated; I shall also consider allowing for lagged adjustment in eq.(1).

From equation (1) we can test the PPP hypothesis. When PPP holds, $\beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = 0$. This null hypothesis can be tested with an F test. Also the monetarist model can be tested comparing the null hypothesis $\beta_1 = 1$ with the alternative eq.(1). The GAP hypothesis is tested by putting

³ See Frankel (1981)

$\beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = 0$. And last the GAS hypothesis may be tested when $\beta_{12} = 0$. An F test between the restricted and the unrestricted equation allows me to test the above null hypotheses.

The estimates of eqs. (1) and the restricted ones are showing in Tables V.1. to V.6. Table V-7 shows the F statistics for testing the null hypotheses. The equal elasticities hypothesis between the two countries is rejected for U.S.A. and Canada. We cannot reject this hypothesis for the other countries. The PPP hypothesis is rejected for every country. The monetarist hypothesis is rejected everywhere, too. Finally, the GAP and GAS hypotheses cannot be accepted anywhere.

Table V-8. presents the likelihood ratio tests for the above hypotheses. Again, the equal elasticities hypothesis cannot be rejected between U.S.A. and Canada. The PPP and the monetarist hypothesis are rejected everywhere. The GAP hypothesis cannot be accepted anywhere and the GAS hypothesis is accepted only for U.S.A. and West Germany.

TABLE V-1

$$\text{ARI Estimates of eq. (1): } S = \beta_0 + \beta_1(m - m^*) + \beta_2(y - y^*) + \beta_3(i_s - i_s^*) + \beta_4(i_L - i_L^*) + \\ + \beta_6(TB - TB^*) + \beta_8(g - g^*) + \\ \beta_9(R - R^*) + \beta_{11}f + \beta_{12}s_{-1} + u.$$

VAR	COEFFICIENTS				
S	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
C	2.0102**** (.4606)	-.1726**** (.0637)	-.0200 (.0693)	.0484**** (.0147)	-.0292 (.0387)
(m - m*)	-.3879* (.2069)	-.0098* (.0059)	-.0055 (.0153)	-.0121 (.0086)	.0132 (.0184)
(y - y*)	-.290 (.2181)	.0136 (.0188)	-.0056 (.0173)	-.0463*** (.0180)	-.0239 (.0155)
(i _s - i _s *)	-.0047 (.0066)	-.0015**** (.0004)	-.0029**** (.0004)	-.0013 (.0003)	-.0006 (.0007)
(i _L - i _L *)	.0114 (.0072)	.0004 (.0007)	-.0014**** (.0005)	-.0010* (.0006)	-.0024**** (.0009)
(TB - TB*)	-.0000003 (.000002)	-.00000009 (.0000002)	-.0000004 (.0000005)	-.00000007 (.0000003)	-.0000005 (.0000003)
(g - g*)	.1031 (.6262)	-.0047 (.0762)	-.0488 (.1119)	.0110 (.0719)	-.1096 (.1027)
(R - R*)	-.000004* (.000002)	.0000002 (.0000002)	-.0000001 (.0000002)	-.0000001 (.0000002)	.0000003 (.0000003)
f	.9572**** (.0765)	1.0191**** (.0186)	.9779**** (.0169)	1.0006**** (.0095)	1.0084**** (.0107)
s ₋₁	-.3553**** (.0450)	.0246 (.0180)	.0206 (.0166)	-.0163 (.0099)	-.0089 (.0111)
$\bar{R}^2$	.9462	.9997	.9991	.9995	.9991
DW	1.860	2.060	1.882	1.989	2.019

TABLE V-2

ARI Estimates of eq. (2): $s = \beta_0 + \beta_{1i}m + \beta_{ij}m^* + \beta_{2i}y + \beta_{2j}y^* + \beta_{3i}i_s + \beta_{3j}i_s^* + \beta_{4i}i_L + \beta_{4j}i_L^* + \beta_{6i}TB + \beta_{6j}TB^* + \beta_{8i}g + \beta_{8j}g^* + \beta_{9i}R + \beta_{9j}R^* + \beta_{11}f + \beta_{12}s_{-1} + u.$

VAR	COEFFICIENTS				
	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
C	4.8081**** (1.6345)	.1089 (.1776)	.2693	.1683* (.0953)	-.3338** (.1570)
m	-.3408 (.2867)	-.0256 (.0199)	-.0306	-.0484** (.0212)	.0163 (.0208)
m*	.0851 (.3623)	.0191** (.0092)	.0233	.0386*** (.0148)	-.0113 (.0315)
y	-.0182 (.2956)	.0071 (.0169)	-.0081	-.0423** (.0183)	.0277 (.0236)
y*	-.1985 (.2538)	-.0124 (.0214)	-.0366	.0503** (.0236)	.0348 (.0315)
i _s	.0051 (.0091)	-.0018**** (.0005)	-.0013	-.0008 (.0006)	-.0014* (.0008)
i _s *	.0009 (.0095)	.0018**** (.0004)	.0031****	.0005 (.0005)	.0040** (.0018)
i _L	.0070 (.0086)	-.0017* (.0009)	-.0037****	-.0015* (.0008)	-.0039**** (.0012)
i _L *	-.0374**** (.0122)	.00003 (.0007)	.0002	.0009 (.0007)	.0024 (.0018)

TABLE V-2

(Continued)

TB	.0000002 (.000002)	.00000002 (.00000002)	-.00000006	-.00000002 (.00000003)	-.00000002 (.00000004)
TB*	-.0031 (.0029)	.0000001 (.0000001)	-.00000004	-.000007 (.0002)	-.0031 (.0023)
g	-.0999 (1.6403)	-.1607 (.1445)	-.3446	-.2105 (.1881)	-.4265 (.2640)
g*	.5674 (.6825)	-.0269 (.0804)	.1146	-.0618 (.0835)	.0605 (.1272)
R	.0000005 (.000006)	.0000005 (.0000003)	-.0000002	-.0000007 (.0000005)	-.0000003 (.0000006)
R*	.000003 (.000002)	.000001 (.000001)	.0000003	.0000003 (.0000002)	-.0000004 (.0000004)
f	.9350**** (.0818)	.9814**** (.0253)	.9692****	.9902**** (.0109)	1.0066**** (.0114)
s ₋₁	-.3819**** (.0447)	.0225 (.0197)	.0149	-.0267** (.0121)	-.0063 (.0121)
$\bar{R}^2$	.9224	.9997	.9991	.9996	.9991
DW	1.737	2.052	1.897	1.942	1.929

TABLE V-3

AR1⁴ Estimates of eq. (1) when $\beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = 0$ (PPP)

VAR	COEFFICIENTS				
S	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
C	4.3868**** (.5838)	4.3772**** (.3066)	5.7344**** (.7714)	2.6841**** (.2943)	4.0414**** (.5876)
(m-m*)	-.3824 (.3803)	.0409 (.1053)	.1315 (.2131)	.2674 (.3126)	-.0938 (.2537)
(y-y*)	-.0113 (.1969)	.1018 (.0750)	-.2677** (.1277)	-.0670 (.1305)	.0233 (.2077)
(i _s - i _s *)	-.0107 (.0101)	.0076**** (.0019)	.0048* (.0029)	-.0045 (.0056)	-.0102 (.0087)
$\bar{R}^2$	.7783	.9294	.8750	.4079	.7207
DW	2.109	2.071	1.832	2.034	1.905

Note: I have corrected for first-order serial correlation of the error term by using the Cochrane-Orcutt procedure.

⁴ First order autoregressive (serial correlation)

TABLE V-4

LSQ⁵ Estimates of eq. (1) when $\beta_1 = 1$ (Monetarist Hypothesis)

VAR S	COEFFICIENTS				
	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
C	-1.4653**** (.2537)	6.6353**** (.7415)	3.8471**** (.2239)	-.9512**** (.1516)	-1.1520**** (.1643)
(m-m*)	1	1	1	1	1
(y-y*)	-.0982 (.1909)	-.7981**** (.2827)	.2634**** (.0997)	.5244**** (.1984)	-.1642* (.0869)
(i _s - i _s *)	-.0069 (.0060)	-.0239**** (.0059)	-.0035 (.0025)	.0181**** (.0026)	.0185**** (.0031)
(i _L - i _L *)	-.0256**** (.0045)	-.0465**** (.0151)	.0148**** (.0025)	-.0346**** (.0064)	-.0219**** (.0048)
(TB-TB*)	.00001**** (.000004)	.000007 (.000004)	-.0000001 (.000004)	-.00001**** (.000004)	.000004* (.000002)
(g-g*)	-.9902 (1.0870)	.1220 (2.0860)	-1.8744** (.9368)	-.2481 (1.0981)	.1705 (.8553)
(R-R*)	-.000006** (.000003)	-.000008**** (.000002)	.000009**** (.000001)	.000005**** (.000002)	-.00001**** (.000002)
f	.9519**** (.0995)	-.4110 (.5042)	.9693**** (.1506)	.9229**** (.1480)	.8930**** (.0874)
s ₋₁	.0152 (.1016)	-.6680 (.4876)	-.0065 (.1482)	.2232 (.1578)	-.1574* (.0952)
log L(.)	215.074	171.577	224.438	210.767	224.200
DW	.717	.267	.188	.274	.396

⁵ Nonlinear least squares

TABLE V-5

ARI Estimates of eq. (1) when $\beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = 0$ (GAP Hypothesis)

VAR S	COEFFICIENTS				
	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
C	4.4968**** (.5975)	4.4422**** (.3096)	5.7130**** (.7760)	2.6791**** (.2852)	3.9559**** (.5928)
(m-m*)	-.4570 (.3907)	.0192 (.1062)	.1244 (.2147)	.2750 (.3138)	-.0373 (.2576)
(y-y*)	-.0079 (.1979)	.0973 (.0749)	-.2661** (.1282)	-.0616 (.1317)	.0347 (.2072)
(i _s - i _s *)	-.0117 (.0104)	.0072**** (.0019)	.0043 (.0031)	-.0038 (.0058)	-.0068 (.0091)
(i _L - i _L *)	.0079 (.0120)	.0041 (.0030)	.0018 (.0045)	-.0024 (.0058)	-.0131 (.0103)
$\bar{R}^2$	.7885	.9292	.8755	.4224	.7079
DW	2.123	2.029	1.828	2.032	1.937

TABLE V-6
ARI Estimates of eq. (1) when $\beta_{12} = 0$ (GAS hypothesis)

VAR s	COEFFICIENTS				
	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
C	.4529**** (.1652)	-.1352** (.0595)	-.0113 (.0701)	.0407**** (.0137)	-.0369 (.0380)
(m-m*)	-.0770 (.0651)	-.0073 (.0057)	-.0051 (.0156)	-.0108 (.0083)	.0115 (.0183)
(y-y*)	-.0533 (.0970)	.0072 (.0186)	-.0038 (.0175)	-.0406** (.0175)	-.0214 (.0153)
(i _s - i _s *)	-.0040 (.0030)	-.0015**** (.0004)	-.0028**** (.0004)	-.0013**** (.0003)	-.0008 (.0006)
(i _L - i _L *)	.0040 (.0028)	.0002 (.0007)	-.0015**** (.0005)	-.0012** (.0006)	-.0024**** (.0009)
(TB-TB*)	.0000005 (.000002)	-.00000007 (.0000002)	-.0000003 (.0000005)	-.00000009 (.0000003)	-.0000005 (.0000003)
(g-g*)	-.2437 (.7211)	-.0114 (.0762)	-.0293 (.1110)	-.0009 (.0724)	-.1126 (.1022)
(R-R*)	-.000003** (.000001)	.0000001 (.0000002)	-.0000001 (.0000002)	-.00000008 (.0000002)	.0000003 (.0000003)
f	.8952**** (.0377)	1.0338**** (.0149)	.9972**** (.0068)	.9865**** (.0040)	1.0028**** (.0081)
R ²	.9756	.9997	.9992	.9995	.9992
DW	.654	2.080	1.878	1.982	2.014

TABLE V - 7

F Statistics tests for the null hypotheses of the spot exchange rates between countries:

	\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
$H_0: \beta_{1i} = \beta_{1j}$	1.75	1.37	1.29	1.51	1.42
H_0 : PPP hypothesis	38.44**	437.06**	591.16**	1,723.92**	1,549.56**
H_0 : Monetarist Hypothesis	268.23*	88,096.97**	8,491.67**	27,555.43**	6,289.28*
H_0 : GAP Hypothesis	.30	1.84	.150	.57	1.71
H_0 : GAS Hypothesis	38.21	1.83	1.51	2.61	.54

Note: The F statistic is calculated as $F(q, df) = \left[\left(\frac{SSR^c - SSR^u}{SSR^u} \right) \frac{df}{q} \right]$

where df = the degrees of freedom of the unconstrained equation,

q = the number of constraints,

SSR^c = the sum of squared residuals from the constrained regression, and

SSR^u = the sum of squared residuals from the unconstrained regression.

* significant at the 5 percent level

** significant at the 1 percent level

[If $F > F_c$ we reject the H_0 (null hypothesis)]

TABLE V - 8

Likelihood Ratio Tests for the null hypotheses of the spot exchange rates between countries:

		\$/DM	\$/C\$	\$/£	\$/FF	\$/SF
$H_0: \beta_{1i} = \beta_{1j}$	$\chi^2_{(7)}$	12.608	24.684**	10.258	11.638	11.29
$H_0: \text{PPP Hypothesis}$	$\chi^2_{(6)}$	142.888**	427.186**	447.968**	612.006**	495.834**
$H_0: \text{Monetarist Hypothesis}$	$\chi^2_{(1)}$	154.036**	901.578**	555.414**	741.838**	450.908**
$H_0: \text{GAP Hypothesis}$	$\chi^2_{(1)}$	.394	1/884	.170	.184	1.696
$H_0: \text{GAS Hypothesis}$	$\chi^2_{(1)}$	34.63**	1.978	1.636	2.796	.694

Note: The Likelihood ratio statistic $-2 \log \left[\frac{L^c(\hat{\Sigma}^c)}{L^u(\hat{\Sigma}^u)} \right]$ is distributed asymptotically as $\chi^2_{(g)}$, where $g =$ the number of constraints, $L^c(\hat{\Sigma}^c) =$ the Likelihood function of the constrained equation, and $L^u(\hat{\Sigma}^u) =$ the Likelihood function of the unconstrained equation.

* significant at the 5 percent level

** significant at the 1 percent level

Another alternative formulation of the model can be by estimating this reduced form of the following "monetary overshooting" equation.

$$s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_5 p_{t-1}^* + \beta_6 p_{t-1}^* + \beta_7 s_{t-1} + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \epsilon_t. \quad (3)$$

If the prices are perfectly flexible the coefficients β_5 and β_6 will be zero ($\beta_5 = \beta_6 = 0$). Under perfect flexible prices eq.(3) becomes:

$$s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_7 s_{t-1} + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \epsilon_t \quad (4)$$

Equation (4) shows that prices adjust instantaneously ($\lambda=1$) but there is deviation from PPP which is represented by the term s_{t-1} . If now we assume that PPP holds ($\theta=1$), the coefficient

β_7 becomes zero ($\beta_7=0$). Equation (3) becomes:

$$s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_5 p_{t-1}^* - \beta_6 p_{t-1}^* + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \epsilon_t \quad (5)$$

Finally, I can put both restrictions ($\lambda=\theta=1$) to eq.(3) and I get

eq.(6) which shows price flexibility and PPP.

$$s_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \varepsilon_t \quad (6)$$

With these estimations, I would like to see if the signs of the variables are correct according to my theory and also the level of significance of the parameters and the other statistics. The results are given in Table V-9 to Table V-12.

TABLE V - 9

OLS Estimates of eq. (3):

$$S_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_5 p_{t-1} - \beta_6 p_{t-1}^* + \beta_7 S_{t-1} + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \epsilon_t$$

VARIABLES	COEFFICIENTS							
S_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
C	.4837 (1.6693)	.6439* (.3354)	.2912 (.5325)	-.7923 (1.0390)	-.3006 (.5318)	-.6026 (.7111)	4.6822 (2.1448)	-1.2599**** (.4415)
M_t	.3211 (.2631)	-.0354 (.0788)	.0582 (.1457)	.0023 (.1290)	.1209 (.1878)	.0639 (.1227)	.4909 (.1991)	.2668**** (.1172)
m_t^*	-.4301 (.2622)	-.0237 (.0184)	-.2604** (.1175)	.0921 (.2220)	.1175 (.1022)	.1308** (.0598)	-.2594 (.2097)	-.0884**** (.0389)
y_t	-.1557 (.1836)	-.0273 (.0574)	-.0584 (.0613)	-.1008 (.1173)	-.0178 (.0903)	-.0461 (.0649)	-.0568 (.1213)	-.0412 (.0543)
y_t^*	.5645* (.2997)	.0349 (.0660)	.2787**** (.964)	.1322 (.1395)	.0334 (.1390)	-.0411 (.0596)	-.2110 (.2072)	.1436* (.0751)
p_{t-1}	.3348 (.3431)	.0082 (.0788)	.5179** (.2381)	-.1924* (.1150)	-.0333 (.1858)	-.1470 (.1316)	.2078 (.1971)	.0303 (.1046)
p_{t-1}^*	-.6781 (.6567)	.0351 (.1362)	-.1423* (.0787)	.0755 (.1476)	-.2706 (.3155)	-.1213 (.1408)	-1.3335 (.5778)	-.1515** (.0699)
S_{t-1}	.8389**** (.0451)	.8874**** (.0439)	.8916**** (.0399)	.9415**** (.0378)	.9522*** (.0388)	.9531**** (.0363)	.8591 (.0617)	.9090**** (.0303)
Δm_t	.1368 (.6067)	.7446**** (.1089)	.3018 (.3509)	-1.0748 (.6993)	1.1191*** (.3609)	.2140 (.3555)	-.9977 (.8398)	.4796 (.1470)
Δm_t^*	1.2116* (.6634)	-.0072 (.1428)	.3502* (.2042)	.5926 (.4265)	-.3745 (.3438)	.0043 (.2072)	.1714 (.3072)	.0107 (.0479)
Δy_t	-.6105 (.5163)	-.0843 (.1129)	-.1470 (.2492)	.1225 (.2947)	-.4897* (.2828)	-.7524*** (.2154)	-1.1159 (.4134)	-.3498* (.2044)
Δy_t^*	-.4336 (.2814)	-.1255 (.0859)	-.0183 (.1441)	-.2265 (.2307)	-.0617 (.1525)	.0413 (.0687)	-.0730 (.2557)	-.1566* (.0882)
$\bar{R}^2$	.835	.982	.975	.938	.978	.994	.950	.996
DW	2.506	1.913	1.946	1.854	2.197	2.183	2.050	2.414

TABLE V.10

OLS Estimates of equation (4):

$$S_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t - \beta_4 y_t^* + \beta_7 S_{t-1} + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \epsilon_t$$

VARIABLES	COEFFICIENTS							
S_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
C	-1.1191 (.7346)	.6480** (.3104)	-.2651 (.4608)	-.7543 (.4979)	.1554 (.3982)	.2790 (.1936)	.3002 (.6048)	-.6131 (.3798)
m_t	.1331 (.1230)	-.0071 (.0199)	.1123 (.1043)	-.0985 (.0959)	-.1307 (.1081)	-.1686** (.0839)	.1131 (.1175)	.0655 (.0900)
m_t^*	-.2215 (.1645)	-.0160 (.0131)	-.0955 (.0754)	.1118 (.0883)	.0701 (.0790)	.0787* (.0450)	-.2365 (.2044)	-.0971*** (.0401)
y_t	-.1667 (.1713)	-.0295 (.0493)	-.0509 (.0614)	.0179 (.0871)	.0070 (.0834)	.0586 (.0485)	.1142 (.0869)	-.0043 (.0494)
y_t^*	.6094** (.3073)	.0245 (.0580)	.1889** (.0850)	.0010 (.0821)	.0908 (.1268)	-.0844 (.0542)	-.0742 (.1605)	.1856*** (.0726)
S_{t-1}	.8440**** (.0448)	.8882**** (.0423)	.9706**** (.0201)	.9364**** (.0350)	.9596**** (.0284)	.9505**** (.0281)	.9813 (.0327)	.9303**** (.0264)
Δm_t	.4263 (1.2426)	.5474** (.2743)	-.2395 (.5830)	-.9172 (.7009)	-.2937 (.6719)	-.0808 (.5541)	-.8273 (.8495)	-.1076 (.5477)
Δm_t^*	1.3301* (.7111)	-.0486 (.1486)	.1132 (.2356)	.4143 (.8519)	-.6107* (.3564)	.0808 (.2861)	.1156 (.3069)	.0027 (.0491)
Δy_t	-.5335 (.5151)	-.915 (.1117)	-.4499* (.2306)	.1258 (.2827)	-.4437* (.2593)	-.6791* (.2171)	-1.0327 (.4181)	-.2941 (.2035)
Δy_t^*	-.4528 (.2865)	-.1402 (.0859)	.0613 (.1415)	-.1958 (.2254)	-.1426 (.1483)	.0814 (.0694)	-.2116 (.2458)	-.1691* (.0917)
$\bar{R}^2$	.823	.982	.975	.941	.980	.993	.947	.996
DW	2.253	1.900	2.080	1.844	2.234	2.052	2.169	2.294

TABLE V - 11

OLS Estimates of eq. (5): $S_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_5 p_{t-1} - \beta_6 p_{t-1}^* + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \varepsilon_t$

VARIABLES	COEFFICIENTS							
S_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
C	9.2736**** (3.1946)	6.6891**** (.3143)	7.5937**** (.9386)	-14.5666**** (2.2069)	-1.2512 (1.2512)	-10.3478**** (1.5514)	27.6905 (2.3568)	-3.1578**** (1.2002)
m_t	1.3300*** (.5115)	-.4977**** (.1544)	-.1285 (.3259)	-1.2193**** (.2972)	-.0218 (.4444)	-.2653 (.3004)	1.8284 (.3011)	-.0045 (.3213)
m_t^*	-2.3157**** (.4796)	-.0813** (.0380)	-1.9552**** (.2142)	2.0814**** (.5284)	1.9600**** (.1743)	1.2416**** (.1180)	-.0227 (.3610)	-.2037* (.1068)
y_t	-.2374 (.3230)	-.3818**** (.1154)	-.0478 (.1336)	1.1537**** (.2643)	.3532* (.2107)	-.2113 (.16637)	-.5911 (.1987)	-.1098 (.1513)
y_t^*	2.2728**** (.5019)	.4092**** (.1355)	.7989**** (.2032)	-.6273* (.3535)	-.3210 (.3283)	-.1782 (.1462)	-1.0545 (.3423)	.9883**** (.1928)
p_{t-1}	3.5191**** (.6067)	-.4037*** (.1591)	5.2200**** (.2630)	.0558 (.2812)	2.9122**** (.3370)	1.8145**** (.2602)	1.7568 (.2808)	1.6236**** (.2534)
p_{t-1}^*	-5.8686**** (1.2900)	.7903**** (.2703)	-1.5141**** (.1213)	-1.1214**** (.3735)	-5.0289**** (.6068)	-2.6088**** (.2742)	-8.1983 (.5185)	-1.3274**** (.1714)
Δm_t	1.2745 2.1611	.2763 (.5649)	.0819 (1.2522)	.8190 (1.7592)	-2.5639 (1.6529)	-2.3375* (1.3288)	-1.3649 (1.4497)	-1.8098 (1.4714)
Δm_t^*	1.6669 (1.2338)	-.0767 (.3041)	1.4212**** (.5001)	-1.3491 (2.2940)	-1.1874 (.8770)	-1.4248** (.7087)	.5316 (.5286)	.2189* (.1297)
Δy_t	-.5717 (.9005)	.0826 (.2303)	1.3086*** (.5325)	-.0074 (.7184)	.1363 (.6648)	-.6618 (.5251)	-1.5204 (7121)	-.6686 (.5629)
Δy_t^*	-1.3468**** (.4870)	-.1970 (.1809)	-.6583** (.3077)	-.6184 (.5696)	-.3092 (.3625)	.0419 (.1688)	.7940 (.4283)	-.8007**** (.2388)
$\bar{R}^2$	.470	.924	.884	.635	.883	.962	.850	.970
DW	.329	.327	.410	.252	.350	.321	.555	.358

TABLE V -12

OLS Estimates of eq. (6): $S_t = \beta_0 + \beta_1 m_t - \beta_2 m_t^* - \beta_3 y_t + \beta_4 y_t^* + \beta_8 \Delta m_t - \beta_9 \Delta m_t^* - \beta_{10} \Delta y_t + \beta_{11} \Delta y_t^* + \varepsilon_t$

VARIABLES	COEFFICIENTS							
S_t	\$/DM	\$/C\$	\$/£	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
C	-5.7785****	6.4120****	7.9696****	-9.1470****	5.9598****	3.0809****	-3.2780	1.2610
m_t	(1.3381)	(.3050)	(1.8728)	(.9909)	(1.1258)	(.5505)	(1.9988)	(1.2251)
m_t^*	-.0161	-.1466****	.1205	-.6839****	-2.9520****	-2.2140****	-1.3331	-.8971****
	(.2376)	(.0395)	(.4564)	(.2391)	(.2151)	(.1833)	(.3401)	(.2794)
m_t^*	-.1686	-.0559**	-.3835	.6924****	1.9386****	.8131****	2.0305	-.3304***
	(.3182)	(.0273)	(.3286)	(.2191)	(.1766)	(.1239)	(.6031)	(.1288)
y_t	-.5000	-.3601****	.2649	.9155****	.5166**	.0524	.6629	-.3404**
	(.3297)	(.0982)	(.2669)	(.2059)	(.2571)	(.1524)	(.2699)	(.1580)
y_t^*	2.8409****	.2353*	-.1328	.1733	.6443	.1934	.7430	2.1995****
	(.5486)	(.1201)	(.3708)	(.2096)	(.3942)	(.1684)	(.5023)	(.1459)
Δm_t	.4660	.0316	-.0381	.1871	-.8964	-.8987	2.0155	-.3838
	(2.4040)	(.5738)	(2.5500)	(1.7914)	(2.1054)	(1.7409)	(2.6804)	(1.7841)
Δm_t^*	1.2741	-.0794	2.5324***	1.2448	-.1585	-.4522	-.2295	.2520
	(1.3757)	(.3122)	(1.0070)	(2.1797)	(1.1164)	(.8982)	(.9737)	(.1584)
Δy_t	-.1094	.1935	-2.9597****	.3455	-.5648	-.7622	-1.5528	-1.2130*
	(.9955)	(.2330)	(.9827)	(.7236)	(.8128)	(.6828)	(1.3262)	(.6575)
Δy_t^*	-1.5912****	-.1258	-.6341	-.5896	-.7398	.0063	-.1680	-1.2353****
	(.5418)	(.1805)	(.6156)	(.5758)	(.4616)	(.2180)	(.7806)	(.2821)
$\bar{R}^2$	.338	.920	.519	.615	.807	.934	.472	.955
DW	.263	.278	.203	.203	.190	.148	.196	.307

- * = Significant at the 10 percent level,
- ** = Significant at the 5 percent level,
- *** = Significant at the 2 percent level, and
- **** = Significant at the 1 percent level.

Note: For Switzerland the data start from September 1975 until

August 1984 because of lack of the M_2
data for the early 1970's.

Standard errors in parentheses.

As we see from Table V-9, the adjusted R^2 's, are high except in the regression of s_t between U.S.A. and West Germany. Evidence of serial correlation does not appear in the error terms except for a small negative serial correlation in West Germany and Greece. The coefficients do have the expected signs with few exceptions in those cases and only five are significant at a level higher than 10 percent. The five wrong-sign and significantly different from zero coefficients are Δm_t^* of West Germany, Δm_t^* of United Kingdom, p_{t-1} of U.S.A. at the regression with Japan, m_t^* of Italy, and Δy_t^* of Greece. The coefficients with asterisks have a t-statistic which indicates that they are significantly different from zero at the levels referred above.

From Table V-9 finally we can conclude crudely that the "monetary-overshooting" model of exchange rate behavior for those eight pairs of countries does have empirical content.

Table V-10 is the case of $\lambda = 1$, where prices are fully flexible but still the PPP does not hold ($\theta < 1$) because of high shipping and transaction costs in the short-run. This is the "Monetarist-GAS" case. The coefficients have the expected signs except Δm_t^* in Germany, m_t^* and m_t^* in Italy, and Δy_t^* in Greece which are significant and have wrong signs. Adjusted R^2 's are high and evidence of serial correlation does not appear in the errors (DW = 2.000). Then, the "Monetarist-GAS" hypothesis gives good results, too.

Now, Table V-11 shows the case where $\theta = 1$ (PPP holds) and prices are not flexible ($\lambda < 1$). The "Monetary-GAP" hypothesis. From the t-statistic, we see that most of the coefficients are significantly different from zero and a few are of wrong signs. The adjusted R^2 's and the DW statistics are low.

Finally, Table V-12 represents the most restricted case where PPP holds and prices are flexible ($\theta = \lambda = 1$). This is the "Monetarist" model. Here, we also see some evidence of serial correlation and $\bar{R}^2$'s are low, too. From the wrong-sign coefficients only a few are significant.

In Table V-13, I use a likelihood ratio test for testing the three null hypotheses $H_0(\lambda = 1, \theta = 1, \text{ and } \lambda = \theta = 1)$. As Table V-13 indicates, we reject the null hypotheses except $H_0: \lambda = 1$ which cannot be rejected between U.S.A. and France. Then using this model we can say that prices adjust gradually except between U.S. and France where price adjust relatively fast. But PPP does not hold anywhere. PPP is really a long-run phenomenon.

TABLE V - 13

Likelihood Ratio Test for the null hypotheses: ($\lambda = 1$, $\theta = 1$, and $\lambda = \theta = 1$).

		\$/DM	\$/C\$	\$/f	\$/Y	\$/FF	\$/Lr	\$/SF	\$/Dr
$H_0: \lambda=1$	$\chi^2_{(1)}$	11.238**	19.748**	16.692**	6.428*	3.726	21.372**	6.292*	23.080**
$H_0: \theta=1$	$\chi^2_{(1)}$	161.64**	216.286**	226.392**	257.438**	249.038**	260.128**	119.148**	292.592**
$H_0: \lambda=\theta=1$	$\chi^2_{(2)}$	194.444**	225.696**	425.054**	266.970**	320.134**	338.682**	256.931**	350.108**

Note: See Table V - 8

* significant at the 5 percent level

** significant at the 1 percent level

VI. POLICY IMPLICATIONS

In this Monetary and Real Model of Exchange Rate Determination, capital is fully mobile internationally and, with perfect substitutability between home and foreign securities, interest rates are equalized internationally. Output is demand determined.

Suppose, in this setting, that monetary expansion occurs at home. The resulting decline in interest rates leads to an international differential that brings about an incipient capital outflow. The currency depreciates (exchange rate increases) and, with elasticity conditions satisfied, demand shifts toward domestic goods. The induced increase in output leads to a rise in income and money demand until equality among international interest rates is restored at a higher level of output with a lower exchange rate.

An expansion in demand for home output arising from fiscal policy or an exogenous shift in demand leads to an increase in income and money demand, and hence a tendency for interest rates to increase. The induced capital inflows bring about currency appreciation, a loss in competitiveness, and hence a deterioration in the current balance that dampens or offsets the expansion.

The results of this thesis have implications for the international transmission of economic disturbances. The domestic monetary expansion results in inflation in the domestic economy after the price adjustment and this expansion is associated with an initial period of rising foreign prices, due to the increase in spot exchange rate, to be

followed by a later period, during which the foreign price level recedes to its original level.¹ Thus, the foreign country is seen to "import" inflation, but only over the period (t_1, t_2) ², the adjustment period. Real disturbances will also be transmitted internationally. However, detailed analysis of the dynamics resulting from a real disturbance originating in one country is considerably more difficult (since equilibrium prices in both countries are affected) but this subject is beyond the scope of the present research.

In the previous paragraph we saw that monetary policy pursued by one country will force the other into a long³ and possibly painful adjustment process if the latter remains completely inactive. Rather than passively accepting the consequences of domestic monetary policy, the foreign country may attempt to offset its effects. What is clear is that a one-shot adjustment in foreign money supply will not succeed in eliminating all the "imported" effects.

¹ Domestic prices adjust gradually and the spot exchange rate overshoots, $p_t = p_t^* + s_t \uparrow$, then foreign price in \$ goes up.

² See Figure III-1 above.

³ The time horizon depends on the speed of price adjustment.

Suppose that foreign policy-makers, unwilling to accept the externally imposed price increase, engage in monetary contraction. Such an action would superimpose a downward pressure on p_t^* . The problem here occurs because monetary adjustment alters the equilibrium price level in the country in which it occurs, but not in the other. Thus, the flexible exchange rates regime fails to insulate the economy from an external (nominal) disturbance and no simple policy (such a one-time discretionary monetary adjustment) exists, that will ensure insulation. A heavy burden of adjustment is placed upon the foreign country, the escape from which requires a costly policy of continual monetary adjustments.⁴

From the perspective of monetary policy my model shares a macroeconomic persuasion that monetary policy works, more or less, because the central bank can move the real money stock. On this view, exchange rates become a vehicle for monetary policy. One of the chief channels of monetary policy is the direct effect of money on interest rates and on the exchange rate and thereby on relative prices and aggregate demand. The empirical problem is of course whether this link makes price adjustment more rapid, or to put it differently, whether flexible rates make the Phillips curve steeper.

⁴ If the foreign policy were passive, the price of their exportables increase in the short-run and as a consequence their exports, income and employment will fall. With an active contractionary monetary policy, the aggregate demand, real income, and employment will fall, too.

Monetary policy under flexible rates and high capital mobility works not only by affecting the interest-sensitive components of aggregate demand but also by increasing net exports. Expansionary monetary policy will depreciate the currency (exchange rate will increase) and thereby, at least temporarily, improve our competitiveness.

The gain in competitiveness that is at least transitorily achieved by an expansionary monetary policy will no doubt by itself improve net exports and thus add to aggregate demand. There is, however, a potentially offsetting increase in imports arising from the domestic expansion in aggregate demand due to lower interest rates and thus higher investment and consumption spending. The net effect on the current account remains uncertain since it depends on the relative magnitudes of the decline in interest rates and the response to relative prices. It is certainly not a foregone conclusion (except when interest rates cannot at all decline from the world level) that monetary expansion and depreciation must improve the current account.

Monetary policy has an immediate effect on exchange rates. A change in the nominal quantity of money in the short run is a change in the real quantity of money which will bring about a change in interest rates. With changed interest rates and unchanged expectations, spot rates have to move to maintain yields in line internationally. If monetary policy affects exchange rate expectations, then the exchange rate adjustments have to be even more pronounced.

Movements in exchange rates affect the level of import prices

directly and spill over into consumer, wholesale and producer prices. The extent and speed of this spillover is an essential question from the perspective of monetary policy. While the increase in import prices is helpful in establishing a gain in competitiveness, it, of course, hurts from the point of view of inflation. The more rapid and the more substantial the spillover of import prices into domestic prices, the more inflationary is monetary policy and the less effective it is with respect to aggregate demand.

The factor which is usually held to be responsible for fluctuations in asset prices is changes in the expectations of asset holders concerning the returns (including capital gains) which are likely to accrue to particular assets. Expectations are also of critical importance in determining exchange rates. If everyone expects a particular currency to appreciate, the increase in the demand to hold that currency will force its appreciation, unless the monetary authorities permit its quantity to expand sufficiently to absorb the increase in demand. The problem is to identify the things which influence expectations concerning the returns to holding particular currencies and to explain why expectations have tended to fluctuate.

If the monetary approach is correct, then one of the critical determinants of the equilibrium value of any national money is the supply of that money available to be held. Hence, one of the critical variables influencing asset holders' expectations of future exchange rates is their prediction of the future supplies of various national monies. Expectations about money demand are also important. Further,

fiscal policy is likely to influence the exchange rate and, hence, expectations about the exchange rate, since budget deficits are frequently financed, at least in part, by the central bank.

Expectations of future exchange rates affect the willingness to hold domestic money. These expectations are assumed to be "rational" in the sense that they reflect asset holders' knowledge of the structure of the economy, in particular, the structure of the stochastic processes generating money demand and money supply.

From the perspective of policy makers, the most important real effects of exchange rate changes are their effects on employment, output and the price level. If prices of domestic output, and domestic wages tend to be fixed, in the short run, in terms of domestic money, then the expansion of the nominal demand for domestic goods which is induced by a decline in their relative price in world markets expands domestic output and employment. The price level is influenced directly by the impact of exchange rate changes on the prices of standardized internationally traded commodities. Beyond this direct influence, a depreciation contributes to inflation (and an appreciation contributes to deflation) through the gradual adjustment of the prices of non-traded goods and non-standardized traded goods the new prices of standardized traded goods and through the adjustments of wages to the unexpected changes in real incomes.

Policy conflict is likely to arise when two countries want to expand output and employment or reduce inflation simultaneously, and when each wants to use their mutual exchange rate in pursuing its

objective. Under flexible rates, this source of conflict can be eliminated by permitting the currency of the expansionary country to depreciate relative to the currency of the contractionary country.

The potential for policy conflict gives rise to the need for policy coordination. What the monetary approach contributes to the discussion of policy coordination is a clear understanding of the policies which must be coordinated. Specifically, to avoid the problem of competitive depreciation which plagued the thirties,⁵ it is usually suggested that governments agree not to intervene against their own currencies in the foreign exchange markets. The monetary approach suggests that this rule is fundamentally inadequate. What matters is the supply of money, not whether this money is created by buying domestic or foreign assets. A government can cause its currency to depreciate almost as well by having its central bank buy domestic bonds as by having it buy foreign currency. Thus, policy coordination requires essentially the coordination of monetary policies. Fiscal policies also matter to the extent that such policies are financed by money creation or have an impact on money demand.

It is worth discussing the insulation from foreign disturbances and independence of domestic monetary policy which a system of flexible rates is supposed to provide. The argument that flexible exchange rates insulate an economy from foreign disturbances is usually presented in a

5 See Mussa (1976).

long-run model in which national outputs are distinct and capital is immobile. In such a situation, the only link between the domestic economy and the rest of the world is through the relative price of domestic and foreign goods. Under flexible rates and fully flexible prices, the exchange rate adjusts this relative price so as to keep foreign demand for domestic goods constant, thereby, insulating the domestic economy.

Formally, this argument is correct. It may be essentially descriptive of the relationships between two countries which their economies are not integrated.⁶ But, the argument does not apply to relationships between highly integrated countries, like United States and Canada, let's say. If the United States experiences a deep recession, so will Canada, regardless of whether the Canadian dollar floats relative to the U.S.A. dollar. The reason is that goods markets and capital markets in the United States and Canada are all highly integrated. The automobile industry in the two countries is really a single industry. If the demand for autos falls in the U.S.A., the output of autos in both countries will fall. The same holds true for many other industries. Further, the integration of the capital markets provides an important channel for the transmission of disturbances. If aggregate demand in the U.S.A. falls, the U.S. demand for Canadian goods will fall, tending to produce a trade balance deficit for Canada. This

⁶ Like U.S.A. and China.

deficit, however, need not force a depreciation of the Canadian dollar and a corresponding cheapening of Canadian goods which restores U.S. demand for these goods. Rather, the trade imbalance can be financed by capital inflow into Canada, with the result that part of the reduction in U.S. aggregate demand is transmitted to Canada.

The failure of flexible exchange rates to insulate an economy from foreign disturbances implies that flexible exchange rates do not permit total independence of national stabilization policies. Flexible exchange rates do, however, permit different long-term rates of inflation. The explanation of why flexible rates permit different long-term rates of inflation returns us to the theme of perfect flexibility of prices in the long-run. It is now a well established principle of monetary analysis that fluctuations in the money supply have real effects on employment and output only if prices adjust gradually or if these fluctuations are not anticipated. The same is true for exchange rates. If one country's money depreciates continually relative to another country's money, these changes in the exchange rate will come to be anticipated. Once they are anticipated, they will cease to have any real effects.

VII. CONCLUSION

In developing this model I drew on the role of asset markets, goods markets, capital mobility, and expectations that have been emphasized in recent literature. I also drew on the fact of differential adjustment speeds in good and asset markets. In fact, the dynamic aspects of exchange rate determination in this model arise from the assumption that asset markets and exchange rates adjust fast relative to goods markets. Prices are adjusted gradually to a monetary expansion¹ and PPP does not hold during this adjustment process.

This model is a short-run one and a monetary expansion is inducing an immediate depreciation in the currency (exchange rate increases) and also the terms of trade (TOT) deteriorate.² During the adjustment process, gradually rising prices may be accompanied by an appreciating currency (exchange rate falls but will not reach its previous value).

In the short-run, however, the monetary expansion does exert real effects on interest rates, the TOT, and aggregate demand. This increase in aggregate demand causes output to rise above its equilibrium (natural) level during the adjustment period. To show this effect I

¹ Prices change due to aggregate demand shocks.

² The TOT are defined as: $TOT = p = \frac{eP^*}{P}$. An increase in e (currency devaluation) implies that domestic goods have become relatively cheaper and if the Marshall-Lerner condition holds, exports are increasing and imports falling. We refer to a rise in p as a terms of trade deterioration.

needed a Lucas (1973) supply function of the form

$y_t = y_{nt} + \beta(p_t - p_t^e) + \varepsilon_t$. Here, I have eliminated some of the complexity of the model by assuming that the equilibrium output is given by the equation $\tilde{y}_t = y_{nt} + \alpha_1(y_{t-1} - y_{n,t-1}) + \alpha_2(y_{t-2} - y_{n,t-2}) + \varepsilon_{st}$.

The monetary-approach models assumed instantaneous adjustment in all markets. An important modification was set forth here. I assumed that asset markets adjust instantaneously, whereas prices in goods markets adjust more slowly although the expectations are rational. The resulting exchange-rate-dynamics model retains all the long-run-equilibrium, or steady state, properties of the monetary approach. In the short-run, however, the exchange rate and the interest rate can diverge from their long-run levels³, so that monetary policy can have effects on real variables in the system.

Exchange rate dynamics, "overshooting", or "undershooting" occur in any model in which some markets do not adjust instantaneously.⁴ When they do not, exchange rate overshooting may accompany a perfectly foreseen adjustment process when goods prices adjust only slowly. That is, in response to a shock to the system (e.g. and increase in the money supply), the exchange rate will initially alter proportionately more than in the long-run, so that its adjustment path to the new long-run equilibrium is opposite in direction from the initial impulse. An increase in the

³ See Figure III-1 above (Chapter III).

⁴ The spot exchange rate "undershoots" in my model. See Appendix 6 for the mathematical proof.

money supply, for example , leads to a proportionately larger once-and-for-all depreciation of the currency (exchange rate "overshoots"), to be followed by currency appreciation throughout the rest of the adjustment process. Because, during the adjustment process, domestic prices are increasing while the exchange rate is falling, PPP does not hold except at long-run equilibrium.

It should be emphasized that the monetary approach to the exchange rate does not claim that the exchange rate is determined only in the money (or the asset) market and that only stock considerations matter while flow relationships do not. Clearly, as we see from the general model and its alternative formulations, the exchange rate (like any other price) is determined in general equilibrium by the interaction of flow and stock conditions. In this respect the asset market equilibrium relationship that is used in this analysis may be viewed as a reduced form relationship that is chosen as a convenient framework creating suitable conditions for "economic laboratory".

The rational expectation framework is adopted to highlight the fact that overshooting is a problem concerning the appropriate choice of economic model. The rational expectations framework is appropriate to this end because it ensures that we do not confuse misspecification of models of exchange rate determination with errors in expectations (predictions) of exchange rates, which are caused by ad hoc expectations assumptions. In the rational expectations setting, any systematic errors in expectations are due to misspecifications of the underlying model.

This thesis has constructed and analyzed a simple open-economy

macroeconomic model of exchange rate determination between two interdependent economies. It is precisely within such a framework that fears about "imported inflation" are conventionally expressed. The analysis here has shown that if there is inflation in one country (resulting from monetary expansion), then the other country if it remains passive will experience periods of both rising and falling prices. Furthermore, the scope for retaliation in order to offset the effects of the external disturbance, may be quite limited in that a one-shot discretionary monetary adjustment cannot succeed. This underscores the need for coordinating certain economic policies even in a flexible exchange rate framework.

The theoretical framework and the empirical evidence allow me to form some tentative conclusions about the determination of exchange rates and the scope for monetary policy under flexible rates.

A first conclusion must concern the "right" model of exchange rate determination. I take the evidence, theoretical and empirical, to reject the "monetarist" approach in the narrow way in which it has been empirically implemented. My own preference remains with the "monetary-unrestricted" model that recognizes the determination of exchange rates in assets markets, the differential speeds of adjustment of assets and goods markets, and the central role of expectations of the future exchange rate in influencing the current rate. PPP in this model is only a long-run tendency.

Having reviewed in a broad manner the implications of theory and evidence for the role of monetary policy under flexible rates, I conclude with another aspect of the same question: to what extent do monetary factors account for the ongoing appreciation of the dollar? There is a worrying temptation and a

lot of controversy, in this connection, to look only to monetary factors as the dominant explanation. The other factors that I have mentioned in Chapter V above play their role, too. Of course, we should remember that real factors do have an impact on exchange rates. Also, political and psychological factors have their effect on the exchange rate.⁴

⁴ Among the longer-run factors, confidence in the American economic system is at a postwar high. Another major appeal of the dollar is the foreign perception of the U.S. as a highly profitable place in which to do business. In part, this view stems from the excellent profits of U.S. companies during the current recovery. But there are other factors. The Economic Recovery Tax Act of 1981 greatly reduced income taxes, particularly for high-income individuals, making the U.S. attractive to such people abroad. The dollar reflects the deterioration or improvement in the economic and political environment. Its recovery after 1980 is simply a corollary of the fundamental recovery in the economy. The U.S. budget deficit is also a reason for the high interest rates which have become a magnet for foreign capital. Also, less developed countries need to obtain dollars to repay loans and pay the imported oil from the OPEC countries. This not only adds to demand but also works to reduce the supply of dollars. This drives up its value. Exchange market intervention from some European Central Banks was pointless. If the Fed believes that it is not meeting the world demand for dollars, it can slow the dollar's rise by permitting faster money growth at home. But what will be the inflation after this expansionary monetary policy?

In summarizing this part we note that the ultimate effect of a monetary expansion is an equiproportionate increase in prices and the exchange rate. In the short-run, however, the monetary expansion does exert real effects on interest rates, the terms of trade⁵, and aggregate demand.

The null hypotheses that I have tested here are the following:

- (1) Equal elasticity and coefficients between countries ($H_0: \beta_i = -\beta_j$). This null hypothesis is rejected for Germany, Canada, France, Italy and Switzerland. The hypothesis cannot be rejected at a 10 percent level of significance in U.K. and Japan.
- (2) The price flexibility hypothesis ($H_0: \lambda=1$). This hypothesis is rejected for Germany, Canada, Japan, and Italy. We cannot reject it at a 10 percent level in U.K., France, and Switzerland.
- (3) The PPP hypothesis ($H_0: \theta = 1$). This null hypothesis is rejected everywhere.
- (4) The unitary money elasticities ($H_0: \beta_1 = -\beta_2 = 1$). Again, this hypothesis is rejected everywhere, and
- (5) The joint hypothesis ($H_0: \lambda = \theta = 1$). This joint hypothesis is rejected everywhere, too.

In the present framework (REH & GAPH) it continues to be true that in the short-run an increase in the nominal quantity of money is an increase in the real quantity of money. Accordingly, a monetary expansion has the conventional effect of increasing in the short-run the level of output⁶ and inducing inflation. Since the inflation that is induced by the expansion in real output serves to raise over time the price level, real balances will decline back to the initial level until in the long-run the expansion in money is fully matched by increased prices and output has returned to the full-employment level. By testing the different models (mostly their reduced forms) I could support my theory which emphasizes the "monetary-unrestricted" model. Prices adjust gradually towards their long-run equilibrium values and the speed of adjustment differs between countries. Not only is the speed of adjustment different between countries, but the elasticities and the coefficients of the variables differ, too. The hypothesis PPP is rejected everywhere and the monetarist hypothesis of the unitary money coefficient is also rejected. Thus, I conclude that my study can be considered part of the increasing amount of evidence which concludes that the "monetary-unrestricted" model of the exchange rate behavior does have empirical content.

5 $TOT = p = \frac{teP^*}{P} = \frac{P_m}{P_x}$

6 Inventories will fall because of the increased demand.

APPENDIX I

The four endogenous variables y_t , y_t^* , p_t , and p_t^* can be expressed as functions of the following instruments:

I take eq. (1) and I solve it for y_t ,

$$y_t = -\frac{K}{\alpha} + \frac{1}{\alpha} m_t - \frac{1}{\alpha} p_t + \frac{b}{\alpha} i_t - \frac{1}{\alpha} \varepsilon_t \quad (\text{A.1.1})$$

I substitute p_t with eq. (29) and I have:

$$\begin{aligned} y_t = & \text{const.} + \frac{1}{\alpha}(1-\lambda)m_t + \lambda y_t + \frac{\alpha_1 b \lambda}{\alpha c_1} y_{t-1} + \frac{\alpha_2 b \lambda}{\alpha c_1} y_{t-2} \\ & - \frac{1-\lambda}{\alpha} p_{t-1} - \frac{b \lambda}{\alpha} E_t(p_{t+1} - p_t) + \frac{b}{\alpha} i_t + \frac{b_0 b \lambda (1-\alpha_1-\alpha_2)}{\alpha c_1} t + \text{error}_t \end{aligned} \quad (\text{A.1.2})$$

Now, I substitute $E_t(p_{t+1} - p_t)$ with eq. (5) and the real income (y_t) becomes a function of the following variables:

$$\begin{aligned} y_t = & \text{const.} + \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} m_t + \frac{\alpha_1 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} y_{t-1} + \frac{\alpha_2 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} y_{t-2} \\ & - \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} p_{t-1} + \frac{b c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} i_t + \frac{b_0 b \lambda (1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} t + u_{t3} \end{aligned} \quad (\text{A.1.3})$$

Using the same procedure I make y_t^* a function of the following variables.

$$y_t^* = \text{const}^* + \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} m_t^* + \frac{\alpha_1 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} y_{t-1}^* + \frac{\alpha_2 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b \lambda} y_{t-2}^*$$

$$- \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1}^* + \frac{bc_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t^* + \frac{b_0^* b \lambda (1-\alpha_1 - \alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} t + u_{t4} \quad (A.1.4)$$

To make p_t and p_t^* functions of the exogenous and lagged endogenous I follow the steps:

I take eq.(29) and I substitute $E_t(p_{t+1} - p_t)$ with eq. (5) and y_t with eq. (1). I do the same for p_t^* . I substitute $E_t(p_{t+1}^* - p_t^*)$ in eq. (30) with eq. (6) and y_t^* with eq. (2). The final equations are:

$$p_t = \text{const} + \frac{b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} m_t - \frac{\alpha \alpha_1 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1} - \frac{\alpha \alpha_2 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2} \\ + \frac{\alpha c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1}^* + \frac{b^2 \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t^* - \frac{\alpha b_0^* b \lambda (1-\alpha_1 - \alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} t + u_{t5} \quad (A.1.5)$$

and

$$p_t^* = \text{const}^* + \frac{b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} m_t^* - \frac{\alpha \alpha_1 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1}^* - \frac{\alpha \alpha_2 b \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2}^* \\ + \frac{\alpha c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1}^* + \frac{b^2 \lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t^* - \frac{\alpha b_0^* b \lambda (1-\alpha_1 - \alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} t + u_{t6} \quad (A.1.6)$$

APPENDIX 2

The Money Supply Process

From eqs. (39): $m_t = m_{t-1} + \rho_m \Delta m_{t-1} + u_{t1}$, I go to eqs. (40):

$$E_t m_{t+j} = m_t + \sum_{i=1}^j \rho_m^i \Delta m_t \text{ following the steps:}$$

$$m_t = m_{t-1} + \rho_m \Delta m_{t-1} + u_{t1} \Rightarrow m_t - m_{t-1} = \rho_m \Delta m_{t-1} + u_{t1} \Rightarrow$$

$$\Rightarrow \Delta m_t = \rho_m \Delta m_{t-1} + u_{t1} \text{ and } \Delta m_{t+i} = \rho_m \Delta m_{t-1+i} + u_{t1} \quad (\text{A.2.1})$$

Taking expectations of eq. (A.2.1) I have,

$$E_t \Delta m_t = \rho_m E_t \Delta m_{t-1} \text{ and } E_t \Delta m_{t+i} = \rho_m E_t \Delta m_{t-1+i}$$

$$= \rho_m^2 E_t \Delta m_{t-2+i}$$

$$= \rho_m^3 E_t \Delta m_{t-3+i}$$

⋮

⋮

$$= \rho_m^i E_t \Delta m_t \Rightarrow$$

$$E_t \Delta m_{t+i} = \rho_m^i \Delta m_t \quad (\text{A.2.2})$$

and

$$E_t \Delta m_{t-1+i} = \rho_m^{i-1} \Delta m_t \quad (\text{A.2.3})$$

From eqs. (39) we have that

$$\begin{aligned}
 m_{t+j} &= m_{t-1+j} + \rho_m \Delta m_{t-1+j} + u_{t1+j} \\
 &= m_{t-2+j} + \rho_m \Delta m_{t-2+j} + \rho_m \Delta m_{t-1+j} + u_{t1+j} \\
 &= m_t + \rho_m \Delta m_t + \rho_m \Delta m_{t-1} + \dots + \rho_m \Delta m_{t-1+j} + u_{t1+j} \Rightarrow \\
 \Rightarrow m_{t+j} &= m_t + \sum_{i=1}^j \rho_m \Delta m_{t-1+i}
 \end{aligned} \tag{A.2.4}$$

The expected value of eq. (A.2.4) yields to eq. (A.2.5)

$$E_t m_{t+j} = m_t + \sum_{i=1}^j \rho_m E_t \Delta m_{t-1+i} \tag{A.2.5}$$

Substituting $E_t \Delta m_{t-1+i}$ of eq.(A.2.5) with eq.(A.2.3) I get,

$$\begin{aligned}
 E_t m_{t+j} &= m_t + \sum_{i=1}^j \rho_m \rho_m^{i-1} \Delta m_t \Rightarrow \\
 \Rightarrow E_t m_{t+j} &= m_t + \sum_{i=1}^j \rho_m^i \Delta m_t
 \end{aligned} \tag{A.2.6}$$

which is the first equation in (40).

Following the same procedure we find the second equation in eqs.(40).

Now, I substitute eq. (A.2.6) for the first term in eq. (38):

$$\frac{\partial \lambda}{1+b\partial \lambda} \sum_{j=0}^{\infty} \left(\frac{b\partial \lambda}{1+b\partial \lambda} \right)^j \left[m_t + \sum_{i=1}^j \rho_m^i \Delta m_t \right] =$$

$$\begin{aligned}
&= \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j \left[m_t + \frac{\rho_m}{1-\rho_m} (1-\rho_m^j) \Delta m_t\right] = \\
&= \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j \left[m_t + \frac{\rho_m}{1-\rho_m} \Delta m_t - \frac{\rho_m}{1-\rho_m} \Delta m_t \rho_m^j\right] = \\
&= \frac{\theta\lambda}{1+b\theta\lambda} \left[m_t + \frac{\rho_m}{1-\rho_m} \Delta m_t\right] \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j - \frac{\theta\lambda}{1+b\theta\lambda} \frac{\rho_m}{1-\rho_m} \Delta m_t \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda \rho_m}{1+b\theta\lambda}\right)^j = \\
&= \frac{\theta\lambda}{1+b\theta\lambda} \left(m_t + \frac{\rho_m}{1-\rho_m} \Delta m_t\right) \left(\frac{1}{1-\frac{b\theta\lambda}{1+b\theta\lambda}}\right) - \frac{\theta\lambda}{1+b\theta\lambda} \frac{\rho_m}{1-\rho_m} \Delta m_t \left(\frac{1}{1-\frac{b\theta\lambda \rho_m}{1+b\theta\lambda}}\right) = \\
&= \theta\lambda m_t + \frac{\theta\lambda \rho_m}{1-\rho_m} \Delta m_t - \frac{\theta\lambda \rho_m}{1-\rho_m} \frac{1}{1+b\theta\lambda-b\theta\lambda \rho_m} \Delta m_t = \\
&= \theta\lambda m_t + \frac{b\theta^2 \lambda^2 \rho_m^2}{1+b\theta\lambda-b\theta\lambda \rho_m} \Delta m_t \tag{A.2.7}
\end{aligned}$$

Following the same steps I find the other term m_t^* of eq. (38).

The term y_t and all others can be found as follows:

Assuming that

$$E_t y_{t+j} = y_t \tag{A.2.8}$$

Then

$$\sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t+j} = \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j y_t \tag{A.2.9}$$

The sum of this geometric series is:

$$\sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j y_t = \frac{1}{1-\frac{b\theta\lambda}{1+b\theta\lambda}} y_t = (1+b\theta\lambda) y_t \tag{A.2.10}$$

Substituting now (A.2.10) and the third equation of eqs. (39) in (38) I get

$$\begin{aligned}
& - \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{\tau} y_{\tau+j} = - \frac{(\alpha c_1 - b)\theta\lambda}{c_1} \text{const.} - \frac{(\alpha c_1 - b)\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} m_{\tau} - \\
& - \frac{(\alpha c_1 - b)\alpha_1 b\theta\lambda^2}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{\tau-1} - \frac{(\alpha c_1 - b)\alpha_2 b\theta\lambda^2}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{\tau-2} + \frac{(\alpha c_1 - b)\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} p_{\tau-1} - \\
& - \frac{(\alpha c_1 - b)b\theta\lambda(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} i_{\tau} - \frac{(\alpha c_1 - b)b_0 b\theta\lambda^2(1-\alpha_1 - \alpha_2)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \tau - \frac{(\alpha c_1 - b)\theta\lambda}{c_1} u_{\tau 3}
\end{aligned} \tag{A.2.11}$$

The other terms of eq.(38) can be found by using the same process, except the lagged spot rate which follows the following one:

$$s_{\tau} = s_{\tau-1} + \Delta s_{\tau} \tag{A.2.12}$$

and

$$E[s_{\tau-1+j} | I(\tau)] = s_{\tau} + j\Delta s_{\tau} \tag{A.2.13}$$

From eq(38) we have by substituting the $E_{\tau} s_{\tau-1+j}$ with eq. (A.2.13)

$$\begin{aligned}
& \frac{1-\theta}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{\tau} s_{\tau-1+j} = \frac{1-\theta}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j [s_{\tau} + j\Delta s_{\tau}] = \\
& = \frac{1-\theta}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j s_{\tau} + \frac{1-\theta}{1+b\theta\lambda} \sum_{j=0}^{\infty} j \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j \Delta s_{\tau} = \\
& = (1-\theta)s_{\tau} + b\theta\lambda(1-\theta)\Delta s_{\tau} = (1-\theta)(s_{\tau-1} + u_{\tau}) + b\theta\lambda(1-\theta)(\Delta s_{\tau-1} + u_{\tau}) = \\
& = (1-\theta)s_{\tau-1} + b\theta\lambda(1-\theta)\Delta s_{\tau-1} + (1-\theta)(1+b\theta\lambda)u_{\tau}
\end{aligned} \tag{A.2.14}^1$$

¹ $s_{\tau} = s_{\tau-1} + u_{\tau}$ and $\Delta s_{\tau} = \Delta s_{\tau-1} + u_{\tau}$ then $u_{\tau} = s_{\tau} - s_{\tau-1} = \Delta s_{\tau}$

$$\text{Note: } \frac{1-\theta}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^j s_t = \frac{1-\theta}{1+b\theta\lambda} s_t \frac{1}{1 - \frac{b\theta\lambda}{1+b\theta\lambda}} = \frac{1-\theta}{1+b\theta\lambda} s_t (1+b\theta\lambda) = (1-\theta)s_t \quad (\text{A.2.15})$$

$$\text{and } \frac{1-\theta}{1+b\theta\lambda} \sum_{j=0}^{\infty} j \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^j \Delta s_t = \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \sum_{j=0}^{\infty} j \gamma^j =$$

$$= \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \left\{ \frac{\partial}{\partial \gamma} \sum_{j=0}^{\infty} \gamma^{j+1} \right\} = \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \sum_{j=0}^{\infty} (j+1) \gamma^j =$$

$$= \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \sum_{j=0}^{\infty} j \gamma^j + \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \sum_{j=0}^{\infty} \gamma^j \Rightarrow$$

$$\Rightarrow \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \sum_{j=0}^{\infty} j \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^j = \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \frac{\partial}{\partial \gamma} \frac{1}{1-\gamma} - 1 =$$

$$= \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \frac{1}{(1-\gamma)^2} - 1 = \frac{1-\theta}{1+b\theta\lambda} \Delta s_t \frac{1}{\left(1 - \frac{b\theta\lambda}{1+b\theta\lambda}\right)^2} - 1 =$$

$$= \frac{1-\theta}{1+b\theta\lambda} \Delta s_t (1+b\theta\lambda)^2 - 1 = (1-\theta) b\theta\lambda \Delta s_t = b\theta\lambda (1-\theta) \Delta s_t \quad (\text{A.2.16})$$

APPENDIX 3

The general ARMA (p,q) model is

$$m_t = \rho_1 m_{t-1} + \rho_2 m_{t-2} + \dots + \rho_p m_{t-p} + \varepsilon_t + \mu_1 \varepsilon_{t-1} + \mu_2 \varepsilon_{t-2} + \dots + \mu_q \varepsilon_{t-q} \quad (\text{A.3.1})$$

and

$$\sum_{s=0}^{\infty} \frac{dm_{t+s}}{d\varepsilon_t} = \sum_{i=0}^{\infty} \psi_i \quad (\text{A.3.2})$$

where the ψ_i are the infinite series of moving average parameters in the pure moving average representation of the model:

$$m_t = \varepsilon_t + \psi_1 \varepsilon_{t-1} + \psi_2 \varepsilon_{t-2} + \dots \quad (\text{A.3.3})$$

Solving for ψ_i in terms of the estimated ρ_i and μ_i ,

$$\psi_0 = \mu_0 = 1 \quad (\text{A.3.4})$$

$$\frac{dm_t}{d\varepsilon_{t-i}} = \frac{\partial m_t}{\partial \varepsilon_{t-i}} + \sum_{j=1}^i \frac{\partial m_t}{\partial m_{t-j}} \frac{dm_{t-j}}{d\varepsilon_{t-i}} \quad \text{for } i=1, \infty \quad (\text{A.3.5})$$

$$\psi_i = \mu_i + \sum_{j=1}^i \rho_j \psi_{i-j} \quad (\text{A.3.6})$$

where $\rho_j = 0$, for $j > p$, $\mu_i = 0$, for $i > q$,

$$\sum_{i=1}^{\infty} \psi_i = \sum_{i=1}^{\infty} \mu_i + \sum_{i=1}^{\infty} \sum_{j=1}^i \rho_j \psi_{i-j} \quad (\text{A.3.7})$$

adding

$$\psi_0 = \mu_0, \quad (\text{A.3.8})$$

$$\sum_{i=0}^{\infty} \psi_i = \sum_{i=0}^{\infty} \mu_i + \sum_{i=1}^{\infty} \sum_{j=1}^i \rho_j \psi_{i-j} \quad (\text{A.3.9})$$

$$\sum_{i=0}^{\infty} \psi_i = \sum_{i=0}^{\infty} \mu_i + \sum_{j=1}^{\infty} \rho_j \sum_{i=j}^{\infty} \psi_{i-j} \quad (\text{A.3.10})$$

$$\sum_{i=0}^{\infty} \psi_i = \sum_{i=0}^{\infty} \mu_i + \sum_{j=1}^{\infty} \rho_j \sum_{i=0}^{\infty} \psi_i \quad (\text{A.3.11})$$

$$(1 - \sum_{j=1}^{\infty} \rho_j) \sum_{i=0}^{\infty} \psi_i = \sum_{i=0}^{\infty} \mu_i \quad (\text{A.3.12})$$

$$\sum_{i=0}^{\infty} \psi_i = \frac{\sum_{i=0}^{\infty} \mu_i}{1 - \sum_{j=1}^{\infty} \rho_j} = \frac{1 + \sum_{i=1}^q \mu_i}{1 - \sum_{j=1}^p \rho_j} \quad (\text{A.3.13})$$

APPENDIX 4

I rewrite eq. (38) for convenience,

$$\begin{aligned}
 s_t = & \text{const.} + \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t m_{t+j} - \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t m_{t+j}^* \\
 & - \frac{(ac_1-b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t+j} + \frac{(ac_1-b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t+j}^* \\
 & - \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t-1+j} + \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t-1+j}^* \\
 & - \frac{\alpha_2 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t-2+j} + \frac{\alpha_2 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t y_{t-2+j}^* \\
 & + \frac{\theta(1-\lambda)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t p_{t-1+j} - \frac{\theta(1-\lambda)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t p_{t-1+j}^* \\
 & - \frac{b\theta\lambda(1-\alpha_1-\alpha_2)(b_0-b_0^*)}{c_1} t + \frac{(1-\theta)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_t s_{t-1+j} + u_t \quad (A.4.1)
 \end{aligned}$$

At the period $(t-1)$ eq. (A.4.1) becomes:

$$\begin{aligned}
 s_{t-1} = & \text{const.} + \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} m_{t+j} - \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} m_{t+j}^* \\
 & - \frac{(ac_1-b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} y_{t+j} + \frac{(ac_1-b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} y_{t+j}^* \\
 & - \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} y_{t-1+j} + \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} y_{t-1+j}^*
 \end{aligned}$$

$$\begin{aligned}
& - \frac{\alpha_2 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} y_{t-2+j} + \frac{\alpha_2 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} y_{t-2+j}^* \\
& + \frac{\theta(1-\lambda)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} p_{t-1+j} - \frac{\theta(1-\lambda)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} p_{t-1+j}^* \\
& - \frac{b\theta\lambda(1-\alpha_1-\alpha_2)(b_0-b_0^*)}{c_1} t + \frac{(1-\theta)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j E_{t-1} s_{t-1+j} + u_{t-1} \quad (A.4.2)
\end{aligned}$$

The difference between eqs. (A.4.1) and (A.4.2) is:

$$\begin{aligned}
\Delta s_t = s_t - s_{t-1} &= \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) m_{t+j} - \frac{\theta\lambda}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) m_{t+j}^* \\
& - \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) y_{t+j} + \frac{(\alpha c_1 - b)\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) y_{t+j}^* \\
& - \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) y_{t-1+j} + \frac{\alpha_1 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) y_{t-1+j}^* \\
& - \frac{\alpha_2 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) y_{t-2+j} + \frac{\alpha_2 b\theta\lambda/c_1}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) y_{t-2+j}^* \\
& + \frac{\theta(1-\lambda)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) p_{t-1+j} - \frac{\theta(1-\lambda)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) p_{t-1+j}^* \\
& + \frac{(1-\theta)}{1+b\theta\lambda} \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j (E_t - E_{t-1}) s_{t-1+j} + u_t - u_{t-1} \quad (A.4.3)
\end{aligned}$$

Equation (A.4.3) through eq.(51) and (40) becomes:

$$\begin{aligned}
\Delta s_t &= \frac{\theta\lambda}{1+b\theta\lambda} \left[\sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j \psi_j \right] \varepsilon_{1t} - \frac{\theta\lambda}{1+b\theta\lambda} \left[\sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda}\right)^j \psi_j \right] \varepsilon_{2t} \\
& - \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] \varepsilon_{3t} + \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] \varepsilon_{4t}
\end{aligned}$$

$$+ \theta(1-\lambda)\varepsilon_{5t} - \theta(1-\lambda)\varepsilon_{6t}$$

$$+ (1-\theta) \varepsilon_{7t} + u_t - u_{t-1}$$

(A.4.4)

$$\text{I define } \Phi = \sum_{j=0}^{\infty} \left(\frac{b\theta\lambda}{1+b\theta\lambda} \right)^j \Psi_j$$

Now, the (A.4.4) becomes as follows:

$$\Delta s_t = \frac{\theta\lambda}{1+b\theta\lambda} \Phi \varepsilon_{1t} - \frac{\theta\lambda}{1+b\theta\lambda} \Phi \varepsilon_{2t} - \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] \varepsilon_{3t} + \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] \varepsilon_{4t}$$

$$+ \theta(1-\lambda)\varepsilon_{5t} - \theta(1-\lambda)\varepsilon_{6t} + (1-\theta)\varepsilon_{7t} + u_t - u_{t-1}$$

(A.4.5)

Equation (A.4.5) through eqs. (55) and (A.2.14) and adding some "excess sensitivity" terms we arrive at eq. (A.4.6).

$$\begin{aligned} \Delta s_t = & \text{const.} + \frac{\theta\lambda}{1+b\theta\lambda} \Phi (m_t - \mu_m - \rho_{m1} m_{t-1} - \dots - \rho_{mp} m_{t-p}) + \alpha_0 \Delta m_t + \alpha_1 \Delta m_{t-1} + \dots \\ & \dots + \alpha_{p-1} \Delta m_{t-(p-1)} \\ & - \frac{\theta\lambda}{1+b\theta\lambda} \Phi (m_t^* - \mu_{m^*} - \rho_{m^*1} m_{t-1}^* - \dots - \rho_{m^*p} m_{t-p}^*) + \beta_0 \Delta m_t^* + \beta_1 \Delta m_{t-1}^* + \dots + \beta_{p-1} \Delta m_{t-(p-1)}^* \\ & - \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] [y_t - \text{const.} - \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} m_t - \frac{\alpha_1 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-1} \\ & - \frac{\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} y_{t-2} + \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} p_{t-1} - \frac{b c_1(1-\lambda)}{\alpha c_1 - \alpha c_1 \lambda + b\lambda} i_t - \frac{b_0 b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1 \lambda + b} t] \end{aligned}$$

$$\begin{aligned}
& + \frac{\theta\lambda}{c_1} [\alpha c_1 - b(1-\alpha_1-\alpha_2)] [y_t^* - \text{const}^* - \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} m_t^* - \frac{\alpha_1 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{t-1}^* \\
& - \frac{\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{t-2}^* + \frac{c_1(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} p_{t-1}^* - \frac{bc_1(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} i_t^* - \frac{b^*b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \varepsilon_t] \\
& + \theta(1-\lambda) [p_t - \text{const}' - \frac{b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} m_t + \frac{\alpha\alpha_1 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{t-1} + \frac{\alpha\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{t-2} \\
& - \frac{\alpha c_1(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} p_{t-1} - \frac{b^2\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} i_t + \frac{\alpha b_0 b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \varepsilon_t] \\
& - \theta(1-\lambda) [p_t^* - \text{const}^{*'} - \frac{b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} m_t^* + \frac{\alpha\alpha_1 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{t-1}^* + \frac{\alpha\alpha_2 b\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} y_{t-2}^* \\
& - \frac{\alpha c_1(1-\lambda)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} p_{t-1}^* - \frac{b^2\lambda}{\alpha c_1 - \alpha c_1\lambda + b\lambda} i_t^* + \frac{\alpha b_0^* b\lambda(1-\alpha_1-\alpha_2)}{\alpha c_1 - \alpha c_1\lambda + b\lambda} \varepsilon_t] \\
& + (1-\theta) \Delta s_{t-1} + (1-\theta)\varepsilon_t
\end{aligned}$$

(A.4.6)¹

¹ $\varepsilon_{7t} = s_t - s_{t-1} = \Delta s_t = \Delta s_{t-1} + \varepsilon_t$

APPENDIX 5

FOREIGN EXCHANGE RATES

Annual averages - 1984

(CURRENCY UNITS PER DOLLAR)

COUNTRY	MONETARY UNIT	SPOT EXCHANGE RATE
*AUSTRALIA	DOLLAR	87.937
AUSTRIA	SCHILLING	20.005
BELGIUM	FRANC	57.749
BRAZIL	CRUZEIRO	1841.500
CANADA	DOLLAR	1.2953
CHINA, P.R.	YUAN	2.3308
DENMARK	KRONE	10.354
FINLAND	MARKKA	6.0007
FRANCE	FRANC	8.7355
GERMANY	D. MARK	2.8454
GREECE	DRACHMA	112.73
HONG KONG	DOLLAR	7.8188
INDIA	RUPEE	11.348
*IRELAND	POUND	108.64
ISRAEL	SHEKEL	165.02
ITALY	LIRA	1756.1
JAPAN	YEN	237.45
MALAYSIA	RINGGIT	2.3448
MEXICO	PESO	192.31
NETHERLANDS	GUILDER	3.2083
*NEW ZEALAND	DOLLAR	57.837
NORWAY	KRONE	8.1596
PHILIPPINES	PESO	14.169
PORTUGAL	ESCUDO	147.7
SINGAPORE	DOLLAR	2.1325
*SOUTH AFRICA	RAND	69.534
SOUTH KOREA	WON	807.91
SPAIN	PESETA	160.78
SRI LANKA	RUPEE	25.428
SWEDEN	KRONA	8.2706
SWITZERLAND	FRANC	2.35
TAIWAN	DOLLAR	39.633
THAILAND	BAHT	23.582
*UNITED KINGDOM	POUND	133.66
VENEZUELA	BOLIVAR	13.943
MEMO:		
#UNITED STATES	DOLLAR	138.19

* Value in U.S. cents.

Index of weighted average exchange value of U.S. dollar against currencies of other G-11 countries. March 1973=100. (see "Index of the Weighted Average exchange value of the U.S. dollar: revision" Federal Reserve bulletin, Aug.' 78, p.700.)

Source: Board of Governors of the Federal Reserve Bank, Federal Reserve Statistics release, January 7, 1985.

APPENDIX 6

Exchange Rate Undershooting

To see the effect of a change in money supply on the spot exchange rate, I take the derivatives of those two variables for the four different cases.

(1) The "monetary-unrestricted" model ($\theta < 1, \lambda < 1$):

$$\frac{\partial S_t}{\partial m_t} = \theta \lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2)]-(1-\lambda)}{\alpha C_1 - \alpha C_1 \lambda + b\lambda} \right]$$

The product of the right-hand side parameters is less than one, because $\theta \lambda < 1$. Then the exchange rate undershoots.

(2) The "monetary-GAS" model ($\lambda = 1, \theta < 1$):

$$\frac{\partial S_t}{\partial m_t} = \theta$$

Again, the exchange rate undershoots because $\theta < 1$.

(3) The "monetary-GAP" model ($\theta = 1, \lambda < 1$):

$$\frac{\partial S_t}{\partial m_t} = \lambda \left[1 + \frac{[b(2-\alpha_1-\alpha_2)-\alpha C_1](1-\lambda)}{\alpha C_1 - \alpha C_1 \lambda + b\lambda} \right]$$

This right-side product is less than one and exchange rate undershoots.

(4) The "monetarist" model ($\theta=1, \lambda=1$):

$$\frac{\partial S_t}{\partial m_t} = 1$$

The exchange rate change by the same proportion with the money supply.

In my model, we have an exchange rate undershooting, because the output is adjusted in response to changes in aggregate demand. The possibility that arises from the expansion in output in the short run is that the exchange rate depreciation will fall short of the monetary expansion rather than exceed it.

IX. BIBLIOGRAPHY

- Adler, Michael, and Bruce Lehmann, (1983) "Deviations from Purchasing Power Parity in the Long Run", The Journal of Finance, 38, December, pp. 1471-1487.
- Barro, Robert J. (1978) "A stochastic Equilibrium Model of an Open Economy under Flexible Exchange Rates", Q.J.E., 92, pp.149-64.
- Bergstrand, J.H. (1983) "Selected Views of Exchange Rate Determination After a Decade of 'Floating'", New England Economic Review, May/June 1983, pp. 14-29.
- Bhandari, Jagdeep, (1981) "A Simple Transnational Model of Large Open Economies", Southern Economic Journal, April.
- Bilson, J.F.O. (1976). "Rational Expectations and the Exchange Rate", in J.H. Frenkel & H.G. Johanson, eds. The Monetary Approach to the Balance of Payments, George Allen and Unwin, 1976.
- ____ (1978 a) "Rational Expectations and the Exchange Rate", in The Economics of Exchange Rates, edited by J. Frenkel and H.G. Johanson, Reading, MA: Addison-Wesley.
- ____ (1978 b) "The Monetary Approach to the Exchange Rate: Some Empirical Evidence", IMF Staff Papers, 25 , pp. 48-75.
- ____ (1979 a) "Recent Developments in Monetary Models of Exchange Rate Determination:", IMF Staff Papers, 26, pp. 201-223.
- ____ (1979 b) "The Deutsche-Mark/Dollar Rate: A Monetary Analysis", in Karl Brunne and Allan Meltzer, eds. Policies for Employment, Prices and Exchange Rates, Carnegie-Rochester Conference 11 (North-Holland).
- Bomhoff, E. and P. Korteweg. (1983) "Exchange Rate Variability and Monetary Policy under Rational Expectations", J.I.E 11, pp. 169-206.
- Dorabusch, R. (1976 a) "Expectations and Exchange Rate Dynamics", Journal of Political Economy, 84, no.6, December, pp. 1161-76.
- ____ (1976 b). "The theory of flexible Exchange Regimes and Macroeconomics Policy", Scandinavian Journal of Economics, 78 pp. 255-75, reprinted in J.A. Frenkel and H.G. Johanson (eds) (1978), op.cit.

- _____. (1978). "Monetary Policy under Exchange Rate Flexibility", in Managed Exchange Rate Flexibility: The Recent Experience, Federal Reserve Bank of Boston Conference Series, 20 pp.90-122.
- _____. (1983). "Exchange Rate Economics: Where Do we Stand?" in Bhandari and Putnam, eds. Economics Interdependence and Flexible Exchange Rates, The MIT Press: Cambridge, Mass.
- Driskill, Robert A. (1981). "Exchange Rate Dynamics: An Empirical Investigation", J. P. E., 89, no.2, April, pp. 357-71.
- Fama, E. F. (1970). "Efficient Capital Markets: A Review of Theory and Empirical Work", Journal of Finance, 25, pp. 383-417.
- _____. (1976). "Forward Rates and Predictors of Future Spot Rates", Journal of Financial Economics, 3, pp. 361-377.
- Fischer, Stanley (1977). "Stability and Exchange Rate Systems in a Monetarist Model of the Balance of Payments", In R.Z. Aliber (ed.), The Political Economy of Monetary Reform, pp. 59-73, New York: MacMillan.
- Flavin, M. A. (1981). "The Adjustment of Consumption to Changing Expectations about Future Income", J. P. E., vol. 89, no. 5, pp.974-1009.
- Flood, R. (1979). "An Example of Exchange Rate Overshooting" Southern Economic Journal, 46, pp. 168-78.
- Frankel, J. (1979). "On the Mark: The Theory of Floating Exchange Rates Based on Real Interest Differentials", A. E. R., 69, September, pp. 610-22.
- _____. (1984). "Monetary and Portfolio Balance Models of Exchange Rate Determination". Repr. in Bhandari and Putnam (eds.) 1984, op. cit.
- Frenkel, J. A. (1976). "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence", Scandinavian Journal of Economics, 78, pp. 255-76, reprinted in J.A. Frenkel and H.G. Johanson (eds.) (1978), op. cit.
- _____. (1977). "The Forward Exchange Rate, Expectations, and the Demand for Money: The German Hyperinflation", A. E. R., 67, pp.653-670.
- _____. (1980). "Exchange Rates, Prices and Money: Lessons from the 1920's", A. E. R., 70, no. 2, May, pp. 235-42.

- _____. (1981). "The Collapse of Purchasing Power Parity during the 1970's", European Economics Review, 16, pp. 145-65.
- _____. (1983). "Flexible Exchange Rates, Prices, and the Role of 'News': Lessons from the 1970's", pp. 3-41, in Bhandari and Putnam, op. cit.
- Frenkel, J. A. and H.G. Johnson (1976) The Monetary Approach to the Balance of Payments, George Allen and Unwin.
- _____. (ed.) (1978). The Economics of Exchange Rates: Selected Studies, Addison - Wesley.
- Frenkel, J.A., and R.M. Levich, (1975). "Covered Interest Arbitrage: Unexploited Profits?", J. P. E., 83, pp. 325-9.
- _____. (1977) "Transactions costs and interest arbitrage: tranquil versus turbulent periods", J. P. E., 85, pp. 1209-26.
- Friedman, Milton (1953) "The Case for flexible Exchange Rates", in Friedman, Essays in Positive Economics, University of Chicago Press.
- Genberg, H. (1978) "Purchasing Power Parity Under Fixed and Floating Exchange Rates", J.I.E., 8, pp. 247-76.
- Girton, L. and D. Roper. (1977) "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience", A.E.R. 67, no.4, September, pp. 537-48.
- Gordon, R. (1982) "Price Inertia and Policy Ineffectiveness in the United States, 1890-1980", J.P.E., vol.90, no.6, pp. 1087-1117.
- Gray, M. and S. Turnovsky (1979) "The Stability of Exchange Rates Dynamics under Perfect Myopic Foresight" I.E.R. 20, October, pp. 643-60.
- Hansen L. P. and R. Hodrick (1980). "Forward exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis", J. P. E. 88, pp. 829-53.
- Hartley, P. (1983). "Rational Expectations and the Foreign Exchange Market", In Exchange Rates and International Macroeconomics, edited by J. Frenkel, Chicago: University of Chicago Press for the N.B.E.R.
- Hodrick, R. J. (1978) "An Empirical Analysis of the Monetary Approach to the Determination of the Exchange Rate", in J. A. Frenkel and H. G. Johnson (eds) 1978, op. cit.

- Hoffman, D. L. and D.E. Schlagenhauf, (1983) "Rational Expectations and Monetary Models of Exchange Rate Determination", J. M. E., 11, March, pp. 247-260.
- Hoffman, D.L. and Schmidt (1981). "Testing the restrictions implied by the rational expectations hypothesis", Journal of Econometrics, 15, pp. 265-87.
- Isard, P. (1977). "How far can we push the Law of one Price?", A. E. R., 67, pp. 942 - 48.
- _____. (1980) "Factors Determining Exchange Rates: The Rate of Relative Price Levels, Balances of Payments, Interest Rates and Risk", International Finance Discussion Paper 171 (Federal Reserve System) December.
- Kimborough, Kent (1983). "Price, Output and Exchange Rate Movements in the Open Economy", J. P. E., January, 11,(1), pp. 25-44.
- Kohlagen, S. (1979). "On the Identification of Destabilizing Speculation", J.I.E., 9. pp. 321-40.
- Kravis, I.R. and R.E Lipsey (1978). "Price Behavior in the Light of Balance of Payment Theories", J. I. E. 8, May, pp.193-246,
- Krugman, P.R. (1978) "Purchasing Power Parity and Exchange Rates", J. I. E., 8, pp. 397-407.
- Levich R. (1978). "Tests of Forecasting Models and Market Efficiency in the International Money Market", in J. A. Frenkel and H. G. Johnson (eds.), op. cit.
- Leiderman, L. (1980). "Macroeconomics testing of the rational expectations and structural neutrality hypothesis for the United States", J. M. E. 6, pp. 69-82.
- Lucas R.E. Jr. (1973). "Some International Evidence on Output-Inflation Tradeoff", American Economic Review, 68, pp. 326-334.
- Magee S. (1978). "Contracting and Spurious Deviations from Purchasing Power Parity" in J.A. Frenkel and H.G. Johnson (eds.) op. cit.
- Mathieson, Donald (1977). "The Impact of Monetary and Fiscal Policy under Flexible Exchange Rates and Alternative Expectations Structures", I.M.F. Staff Papers, November, pp. 535-68.
- McCallum B.T. (1978). "Price level adjustments and the rational expectations approach to macroeconomic stabilization policy", Journal of Money Credit and Banking, 10, pp. 418-36.

- Miskin F.S. (1983). A Rational Expectations Approach to Macroeconometrics, The University of Chicago Press for the NBER.
- Mussa, Michael (1976). "The Exchange Rate, the Balance of Payments and Monetary and Fiscal Policy under a Regime of Controlled Floating" Scandinavian Journal of Economics, 2, pp. 229-48, reprinted in J. A. Frenkel and H.G. Johnson (eds.) (1978), op. cit.
- _____. (1978). "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market", in K. Brunner and A. Meltzer (eds.), op. cit.
- _____. (1979). "Macroeconomic Interdependence and Exchange Rate Regime", in Dorbusch R, and J. A. Frenkel, eds. International Economic Policy, Theory and Evidence, Baltimore: John Hopkins University Press.
- Muth, J. F. (1961). "Rational Expectations and the theory of price movements", Econometrica, 29, pp. 315-35.
- Officer, Lawrence (1976). "The Purchasing-Power Parity Theory of Exchange Rates: A Review Article", IMF Staff Papers, 23 (1), pp.1-60.
- Revankar, N.S. (1980). "Testing of the rational expectations hypothesis", Econometrica, 48, pp. 1347-65.
- Sargent, T. J. (1978) "Rational Expectations, Econometric Exogeneity, and Consumption", Journal of Political Economy, 86, pp. 673-700.
- Sargent, T. J. and N. Wallace (1973) "Rational expectations and the dynamics of hyperinflation", International Economic Review, 14, pp. 328-50.
- Shafer, J. R. and B. E. Loopesco (1983). "Floating Exchange Rates After 10 Years", Brookings Papers on Economic Activity, 1, pp. 1-86.
- Thurston, Thom. B. (1983). "Price Flexibility and Output 'persistence' in the Postwar U.S.", Universite Catholique de Louvain, Working Paper no. 8308.
- Wilson, C.A. (1979). "Anticipated Shocks and Exchange Rate Dynamics", J. M. E. 6, pp. 55-68.
- Wojia, G. (1980). "Unemployment and monetary policy under rational expectations: Some Canadian evidence", J. M. E. 6, pp. 59-68.