INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help you understand markings or notations which may appear on this reproduction.

1. The sign or “target” for pages apparently lacking from the document photographed is “Missing Page(s)”. If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure you of complete continuity.

2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed the photographer has followed a definite method in “sectioning” the material. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark √.

1. Glossy photographs or pages ____
2. Colored illustrations, paper or print ____
3. Photographs with dark background ____
4. Illustrations are poor copy ____
5. Pages with black marks, not original copy ____
6. Print shows through as there is text on both sides of page ____
7. Indistinct, broken or small print on several pages √
8. Print exceeds margin requirements ____
9. Tightly bound copy with print lost in spine ____
10. Computer printout pages with indistinct print ____
11. Page(s) _________ lacking when material received, and not available from school or author.
12. Page(s) _________ seem to be missing in numbering only as text follows.
13. Two pages numbered _________ Text follows.
14. Curling and wrinkled pages ____
15. Other _________________________________________________________________

University Microfilms international
THE VICTIOUS CIRCLE HYPOTHESIS:
FACT OR FANTASY?

by
Vimal W. Atukorala

submitted to the
Faculty of the College of Arts and Sciences
of The American University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
in
Economics

1981
The American University
Washington, D.C. 20016
THE VICIOUS CIRCLE HYPOTHESIS:
FACT OR FANTASY?

BY
Vimal W. Atukorala

ABSTRACT

After generalized floating was introduced in 1973, some countries underwent rapid exchange rate depreciations which were often translated into higher growth rates of prices and wages. The latter often led to further depreciations in the exchange rate and that would set off another round of price and wage hikes. It was said that this was a self-perpetuating cycle. The problem was particularly acute for countries which had some degree of formal indexation of wages to prices. Countries experiencing this cycle were dubbed "vicious circle countries."

Many economists have argued that such a self-perpetuating cycle cannot exist without monetary accommodation. We agree with this reasoning. This dissertation investigates the hypothesis that an economy adjusting from one steady-state to another in response to some exogenous shock may have the ability to display vicious cycle symptoms as a segment of the adjustment process.
The symptoms, in the context of the present model, are a rising rate of unemployment, rising growth rate of prices and a depreciating exchange rate. The possibility of cyclical behavior is ruled out by assumption, consistent with the neoclassical, flexible price model that is used. Also, the money supply is exogenously determined so that monetary accommodation will have to be a result of discretionary policies.

A well known closed economy model is extended to the open economy in order to test this hypothesis. It has the ability to display vicious circle symptoms in the short-run but is assumed to be stable in the long-run. The reduced form macrodynamic system consists of the unemployment rate, growth rate of prices and expected prices as the state variables and the growth rate of the money supply, changes in real government expenditure and the ratio of private financial wealth to the stock of money as control variables.

The model is estimated (using quarterly data) for the U.S. for the 1970's, after being converted into a set of empirically testable hypotheses. It is shown that the reduced form system is quite successful in tracking the actual data and that the model is indeed stable. The system is then brought to a steady-state and the exogenous shock is introduced via an increase in the growth rate of the money supply. It is shown that vicious circle symptoms
are displayed by the model during a particular segment of the adjustment process just prior to reaching the new steady-state.

Noteworthy features of this exercise are the long-lags involved in the adjustment cycle (about 9 years from the time of the shock to the steady-state) and also the prolonged period of time through which the vicious circle phase lasts (about 14 quarters). Also, recent developments in the adjustment theory literature such as exchange rate overshooting and asset markets adjusting faster than goods markets are evident from these exercises. Furthermore, they indicate that the model is very sensitive to changes in the growth rate of the money supply and that the exchange rate and unemployment rate are (in that order) the quickest to respond to the shock.
ACKNOWLEDGMENTS

The author wishes to thank the members of his dissertation committee, Professors Lloyd Atkinson, Thomas Dernburg and Robert Auerbach for their assistance and encouragement throughout all phases of this dissertation.

Special thanks are due to Professor Atkinson who, as chairman of the committee, spent many hours going through the finer points in this dissertation with the author and reading what must have seemed like endless drafts of each chapter. He has greatly influenced the final outcome of this dissertation and his contributions are too numerous to acknowledge individually.

Thanks are also due to Professor John F.O. Bilson of the Graduate School of Business, University of Chicago for inspiring the author's interest on vicious circles.
# TABLE OF CONTENTS

**ACKNOWLEDGEMENTS**

<table>
<thead>
<tr>
<th>Chapter</th>
<th>INTRODUCTION, SCOPE AND METHODOLOGY</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Criticism of the Problem</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>An Alternate Definition of the Vicious Circle</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>The Theoretical Model</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>The Portfolio Balance Approach</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Determination of Vicious Circle</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>22</td>
</tr>
</tbody>
</table>

**II. THE LITERATURE**

<table>
<thead>
<tr>
<th>Purpose.</th>
<th>Other Models of the Vicious Circle</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vicious Circles as a Peripheral Issue</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>The Key Differences</td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>

**III. THE MACRO-ECONOMIC MODEL**

<table>
<thead>
<tr>
<th>Purpose.</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumptions.</td>
<td>41</td>
</tr>
<tr>
<td>The Dynamic Equations</td>
<td>42</td>
</tr>
<tr>
<td>The Structural Equations</td>
<td>44</td>
</tr>
<tr>
<td>The Structural Model</td>
<td>45</td>
</tr>
<tr>
<td>The Relationships and the Steady-State</td>
<td>50</td>
</tr>
<tr>
<td>The Dynamic Properties</td>
<td>54</td>
</tr>
</tbody>
</table>

**IV. THE STATISTICAL HYPOTHESIS**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Exchange Rate Equation</td>
<td>61</td>
</tr>
<tr>
<td>The Unemployment Rate Equation</td>
<td>65</td>
</tr>
<tr>
<td>The Price Equation</td>
<td>65</td>
</tr>
<tr>
<td>Model Estimation and Results</td>
<td>65</td>
</tr>
<tr>
<td>The h-Test</td>
<td>69</td>
</tr>
<tr>
<td>Further Experiments With Functional Form</td>
<td>71</td>
</tr>
<tr>
<td>Interpreting the Results</td>
<td>78</td>
</tr>
<tr>
<td>Stability Analysis</td>
<td>84</td>
</tr>
<tr>
<td>The Steady-State Solution</td>
<td>85</td>
</tr>
</tbody>
</table>
## Chapter V. SIMULATION EXPERIMENTS

### Methodology of Simulation

Methodology of Simulation

### The Monetary Shock

The Monetary Shock

### A Monetary Shock to the Steady-State

A Monetary Shock to the Steady-State

### Formal and Informal Indexation

Formal and Informal Indexation

### Summary

Summary

## Chapter VI. SUMMARY AND CONCLUSION

### Vicious Circles and Economic Policy

Vicious Circles and Economic Policy

### Vicious Circles--A Final Evaluation

Vicious Circles--A Final Evaluation

### Concluding Summary

Concluding Summary

## APPENDICES

### A Formal Derivation of the Model

A Formal Derivation of the Model

### Statistical Abstract

Statistical Abstract

### A Note on Deriving U.S. Claims on Foreigners and Foreign Claims on the U.S.

A Note on Deriving U.S. Claims on Foreigners and Foreign Claims on the U.S.

## GLOSSARY OF SYMBOLS

Glossary of Symbols

## BIBLIOGRAPHY

Bibliography
LIST OF ILLUSTRATIONS

1. Money and Asset Market Equilibrium. ........ 19
2. Schematic of Macro-economic Model ........ 51
3. Steady-state Relationships Between Adjusted Real Wages, Unemployment and Real Output Per Unit of Capital ........ 52
4. Dynamic Adjustment Path of the Economy ........ 58
5. Actual and Simulated Values of the Unemployment Rate ...................... 96
6. Actual and Simulated Values of Prices .......... 97
7. Actual and Simulated Values of the Exchange Rate ..................... 98
8. Simulated Values of the Unemployment Rate, Prices and the Exchange Rate ................... 102
9. Simulated Values of Unemployment, Prices and the Exchange Rate With a 0.12% Increase in the Growth Rate of M1 Introduced in 1975:1 .................. 105
10. Pattern of Dynamic Adjustment of U in Response to a 0.12% Increase in the Growth Rate of M1 Starting 1975:1 .......... 106
11. Pattern of Dynamic Adjustment of P in Response to a 0.12% Increase in the Growth Rate of M1 Starting 1975:1 .......... 107
12. Pattern of Dynamic Adjustment of E in Response to a 0.12% Increase in the Growth Rate of M1 Starting 1975:1 .......... 108
13. Pattern of Dynamic Adjustment of the Unemployment Rate In Response to a Shock to the Steady-State .......... 115
14. Pattern of Dynamic Adjustment of Prices in Response to a Shock to the Steady-State .......... 116
15. Pattern of Dynamic Adjustment of the Exchange Rate in Response to a Shock to the Steady-State .................. 117

16. Adjustment Paths of Unemployment, Prices and the Exchange Rate in Response to a 0.12% Monetary Shock to the Steady-State. ........ 119

17. Adjustment Paths of Unemployment, Prices and the Exchange Rate in Response to a 6% Monetary Shock to the Steady-State. .... 122

18. Relationships Between Adjusted Real Wages, Unemployment and Real Output Per Unit of Capital . ............. 152

19. Macro-economic Model. .................. 160

20. Exchange Rate Overshooting. ............. 169

LIST OF TABLES

1. Simplified Macro-dynamic Model .................. 43
2. Key Structural Equations.......................... 44
3. Regression Results................................ 67
4. Select Regressions on the Exchange Rate
   Equation With One Period Lags ................... 73
5. Select Regressions on the Exchange Rate
   Equation With Two Period Lags ................... 74
6. Country/Currency Weights Used to Construct
   Effective Exchange Rate Index ................... 76
7. The Exchange Rate Equation With the Growth
   Rate of Relative Prices as an Explanatory
   Variable...................................... 77
8. The Exchange Rate With the Growth Rate of
   Relative Prices Lagged One Period............... 77
9. Probable Intermediate and Short Term Impacts
   of an Increase in Individual Components of
   Financial Wealth on the Exchange Rate .......... 90
10. Steady-State Values of Unemployment, Prices
    and the Exchange Rate With and Without the
    Monetary Shock.................................. 113
11. Untransformed Data Used in Regressions......... 180
12. Transformed Data for Regressions............... 183
13. Composite Foreign Producer Price Index and
    Domestic Producer Price Index .................. 186
14. Actual and Simulated Values of the State
    Variables..................................... 187
15. Total U.S. Assets Abroad and U.S. Liabilities
    to Foreigners at Year's End ................. 191
CHAPTER I

INTRODUCTION, SCOPE AND METHODOLOGY

Introduction

The world moved to a system of generalized floating in the wake of the Jamaica Conference of 1973. Thereafter, the experience of the advanced industrialized economies has led many to argue that generalized floating may not be a panacea for international monetary problems. While all industrial economies have displayed unusually high exchange rate fluctuations in the short-run, some have experienced appreciating trends externally, along with low rates of inflation and unemployment, and sustained growth in real output. Notable amongst these countries are Germany and Switzerland. However, countries such as Italy and the United Kingdom have undergone continual exchange rate depreciation, high rates of inflation and unemployment, and low rates of growth in real output. These two groups have been dubbed the virtuous and vicious circle countries, respectively.

The problems of the vicious circle countries received widespread attention during the period 1975-77: it was discussed at the annual meetings of The World Bank/IMF in 1976 when the delegates of France, Italy and the United Kingdom
decided to air their grievances in public. Their basic complaint centered on the impact of the diverging rates of inflation amongst major trading partners and the potential for the vicious circle problem to arise. The French delegate described the problem as follows:

A fall in the exchange rate on the market is reflected, even before the slightest impact is felt on the export volume, in an immediate rise in the cost of imports. Thus, in the first phase, the external depreciation of the currency aggravates the internal inflation rate. These two phenomena follow and re-inforce each other, setting in motion a cumulative process at the end of which the currency's exchange value continues to fall.2

The subject gained further publicity in the latter part of 1976 when the United States took exception to this view and argued instead that domestic monetary policy and heavy management of the exchange rate were responsible.

From the U.S. perspective, the vicious circle thesis, ... fails to look behind the rate change to its basic cause -- usually differentials in domestic inflationary pressures. Other things being equal, widening inflation differentials will depreciate the "equilibrium" rate of the country with higher inflation just as certainly under fixed parities as under floating rates. The actual exchange rate may be held through intervention for a time, but with finite reserves and borrowing power, the exchange rate adjustment required by differential inflation rates must ultimately come. When it does, import

---


2Ibid., p. 74.
and domestic price increases will follow and must properly be attributed to the devaluing country's higher inflation—not to the devaluation.³

That was what a Treasury Department document to the OECD had to say about the problem. This line of reasoning has been supported by Thomas Willett, who has emerged as a leading U.S. advocate of floating exchange rates and critic of vicious circles. In his view, to be discussed at length later, the inflation differentials are caused by differences in domestic economic policies and excessive management of the exchange rate.⁴ This idea has also won the support of The Bank for International Settlements, which claims the following:

One need not be an orthodox monetarist to see that a 30% rise in the money supply in 1973 caused a sharp decline in the value of sterling that same year. In Italy, the money supply was already expanding at an excessive rate in 1973.⁵

The BIS report goes on to argue that the contractual indexation schemes which prevailed in the U.K. and Italy


throughout the period were responsible for exacerbating the inflationary impact.

The vicious circle, in the minds of many government officials, may be summed up as follows: a depreciation of the exchange rate (e.g., due to a monetary expansion) will lead to a rise in the growth rate of prices of imported goods. Due to indexation, this increase will be rapidly passed-through to general prices (e.g., the GNP deflator). As the inflation rate diverges from its steady-state and moves ahead of the corresponding rate of its major trading partners, the exchange rate depreciates beyond what was warranted by the monetary expansion, partly due to the anticipated trade deficit and also due to the reduction in the expected net yields of the assets denominated in the currency of that country. (The latter idea is in accordance with the portfolio balance approach to exchange rates, which will be discussed later.)

Criticism of the Problem

This statement, however, reflects a simple minded approach to the problem. In particular, a vicious circle in its pure form of a self perpetuating cycle cannot exist without adequate monetary validation. As the internal price level of a country begins to rise, it will be accentuated temporarily by the formal (or informal) indexation schemes and expectations of a higher rate of inflation.
It will also set in motion several offsetting forces such as higher nominal interest rates, lower real output and a higher rate of unemployment. As the impact of higher unemployment and interest rates are felt on the market, the rate of price increase will also decline. Such an environment should theoretically abort the vicious circle. But if the Central Bank expands the money supply in response to the higher rate of unemployment and interest rates, the country can easily slide back into another round of exchange rate depreciation, higher growth rates of wages and prices and subsequent unemployment. It is to this that the Treasury Department paper, representing the official U.S. view, and the BIS report refer in particular. Other leading International Economists disagree. Rudiger Dornbusch had this to say about the preceding version of the vicious circle theory:

Unless monetary policy validates the depreciation it will ultimately undo itself. There can be little disagreement with this conclusion, except that it is fundamentally irrelevant as an observation about policy. The relevant policy setting is one where widespread indexation, for example, will immediately translate depreciation into wage and price inflation with the consequence of growing unemployment if the Central Bank fails to accommodate through further monetary expansion. The Central Bank may in practice have very little power to stop this inflationary process ... .

---

Willett's criticism of vicious circles bears a striking resemblance to the "inappropriate domestic policy" thesis found in the Treasury Departments paper to OECD. His criticism of the vicious circle is made in the context of explaining the differing rates of inflation between major trading partners. The higher domestic rate of inflation is attributed to expanding domestic aggregate demand designed to meet purely domestic objectives. This, in his view, is responsible for an induced increase in imports despite the fact that the country's currency may be depreciating simultaneously. Hence, a depreciating exchange rate does not automatically lead to a reduction in imports, as dictated by conventional wisdom. The higher monetary growth rate fuels the growth rate of prices directly and indirectly, via higher import prices in a period of depreciating exchange rates. Therefore, Willett's views are closely linked to the now familiar "domestic policy" arguments made by others.

We have now presented two sets of criticism of the vicious circle thesis in its present form. Willett represents the view which has most often been aired in public and has frequently been the subject of journalistic discussions. Dornbusch's criticism represents a more perceptive view, questioning the policy relevance of criticism already made by Willett, et al. We will now attempt to define our own version of the vicious circle
and then attempt to answer some of the points raised by Willett. In doing so, we implicitly accept the criticism made by Dornbusch and give the present definition a radically different interpretation.

An Alternate Definition of the Vicious Circle

Our version of the vicious circle problem attempts to examine the impact of an exogenous shock to a system, presently in the steady-state, and its impact on certain key macro variable as they adjust from the initial steady-state to another steady-state in response to the exogenous shock: in our case, this is introduced via an increase in the growth rate of the money supply. As the variables respond to the shock, we pose the problem of the model displaying the classic vicious circle symptoms in a purely transitory fashion during a particular segment of the adjustment process. Our problem is to determine if such symptoms could indeed be displayed by an indexed economy and, if so, define the conditions under which they could exist. This is quite a departure from the monetary validation issue discussed so far. Our definition of the problem focuses on a short-run adjustment problem which may be experienced by indexed economies. (By indexed, we refer to formal contractual indexation as in Britain and Italy in the mid 1970's, as well as very informal indexation based on price expectations, as is often the case in the
U.S.). It raises the possibility of vicious circle symptoms appearing in the short-run and not the full scale vicious circle envisaged by its critics and proponents. Therefore, the issue, using our definition, boils down to one of examining empirically the short-run adjustment path where there is no monetary validation. In many ways, this does not constitute a 'vicious circle' problem but it is more of an 'adjustment problem' of an indexed economy.

We now attempt to give our interpretation a more cogent explanation. For example, consider the phase of an adjustment cycle (e.g., in response to an exogenous shock) when expectations are being re-adjusted to a higher rate of domestic inflation. Theory dictates that this phase of the cycle can be overcome if the monetary authorities maintain a neutral stance, i.e., the steady-state growth rate of the money supply in the face of rising inflation, interest rates and unemployment and a depreciating exchange rate. These are the classic vicious circle symptoms to which we have alluded earlier, in the context of defining our "adjustment problem." It is the phase of the adjustment cycle when expectations are being re-adjusted for a permanently higher rate of inflation which is said to display the symptoms and is of particular importance to us. In order to test the validity of this proposition, we will use a simple neoclassical macro-model, which is discussed later in this chapter and explained in detail in Chapter III and Appendix A.
Having defined our interpretation of vicious circles, we will now attempt to handle Willett's criticism. It hinges on the induced effects on imports via income due to domestic monetary/fiscal policies. They must therefore rest on a long-run time frame and not the short-run, within which our vicious circle is defined. Since our definition encompasses a short-run adjustment problem, Willett's argument cannot be treated as one which dismisses this particular version of the vicious circle. In fact, the way we envisage our dynamics, the induced effect on imports via income coupled with a depreciating exchange rate will appear before the problem phase of the adjustment path manifests itself; we will have more to say on this in the section dealing with dynamics in Chapter III.

We now examine the possibility of other types of vicious circles. Namely, the probability of vicious circle symptoms being displayed during the adjustment process simply because the rate of inflation is higher under flexible exchange rates than under fixed exchange rates. We also examine the probability of long-run vicious circles appearing due to perfect capital mobility. The fixed versus flexible exchange rate argument with regard to inflation runs as follows: a small open economy can export its inflation under fixed rates while it cannot do so under flexible rates. In the short-run, a fixed rate will permit a country to over value its exports (due to the short-run inelasticity of the
partner country's imports) and also have its partner absorb
some of its inflation by having it expand its reserve base
due to the excess volume of domestic reserves generated
as a result of defending the (domestic) exchange rate.
In order to prevent the partner's rate from appreciating,
they will have to absorb the excess (domestic) reserves,
thereby expanding their money supply. Hence, the higher
import prices and expanded monetary base in the foreign
country are the doings of the domestic country, which
exported the inflation. Under flexible rates, a deprecia-
tion of the exchange rate will translate immediately into
prices via the J-curve (which assumes that prices will
adjust faster than quantity, in response to a devaluation)
and in an indexed economy this may, after a short lag,
lead to the "troubled" phase of the adjustment path, which
can be misconstrued as a vicious circle since it displays
the same symptoms. Transmission of inflation via exchange
rates has become more of a problem for inflation prone
countries in recent times: for example, Britian in the
late 1970's adopted a policy of maintaining a high exchange
rate with the idea of controlling inflation, despite the
adverse impact on the trade balance.  

7Organization for Economic Cooperation and Develop-
ment, Monetary Targets and Inflation Control (Paris:
Organization for Economic Cooperation and Development, 1979),
pp. 48-52.
The possibility of long run vicious circles due to a perfect capital mobility assumption arises due to the following reason: the period when expectations are being re-adjusted for a higher rate of inflation is characterized by rising nominal rates of interest and unemployment, amongst other things. But perfect capital mobility also implies that the domestic (nominal) interest rate cannot diverge from the "world" rate of interest, since capital inflows will wipe out any differential. This also implies that, in the absence of sterilization policies, the capital inflow will enlarge the base money supply. In the context of our theory, this is equivalent to monetary accommodation when expectations are being re-adjusted for a higher rate of inflation. The result will be a true vicious circle envisaged by its proponents and discussed earlier by us.

We have now shown how the perfect capital mobility assumption could lead to this result. A capital inflow will exacerbate the rate of inflation which will create upward pressure on interest rates. This will cause more capital inflows under the present assumption. The result will be a continuous vicious circle.

This particular assumption was widely used by the flow equilibrium models of Mundell and Fleming. But

---

recent experience has shown that capital mobility is far from perfect. Our brief expose of the asset market (portfolio balance) approach to exchange rates later in this chapter will help clarify this issue. Our model assumes imperfect capital mobility and asset substitution, since it is most unlikely that the perfect capital mobility assumption can be satisfied in reality. Secondly, like most long run models, we have a stock/flow interaction which prevents the exchange rate from being determined purely by a single approach. The long run exchange rate will be determined by a variety of forces from the trade and capital flow sides of the balance-of-payments, as implied by equation 9 of chapter III, depicting the exchange rate. Once this criticism of the long-run problem is accepted, we return to the short-run (adjustment problem) variety of vicious circles. The reader is given a brief exposure to some of the fundamental assumptions and propositions of the model in the next section, while the formal model itself will be presented in chapter III. After the section on the model, we will present the asset market approach to exchange rates, followed by a brief outline of what is to be expected in the following chapters of the dissertation and a summary of the present chapter.

The Theoretical Model

This is a straightforward extension of Stein's 1974 model to an open economy.\(^9\) The approach is strictly neoclassical in that we assume prices are fully flexible and that the labor market is equilibrated by the 'natural' rate of unemployment in the long run. In addition, we have incorporated indexation parameters to the equation describing the growth of nominal wages and a pass-through coefficient designed to measure the independent influence exerted by the exchange rate and the growth rate of foreign prices on domestic prices. However, the steady-state properties of this model require that the independent influence be zero and that real wages grow at the same rate as the trend rate of growth in productivity.

The steady-state system consists of three state variables, i.e., growth rate in prices and expected prices and the rate of unemployment, and three control variables which are the growth rate of the money supply, change in government expenditure and the change in the ratio of private financial wealth to the stock of money. The system is too complex to perform a meaningful stability analysis and so we assume the Routh-Hurwitz conditions are satisfied and the system is dynamically stable. By imposing steady-state

conditions on the model, we are able to derive the long-run solution. The model itself will be capable of generating short-run vicious circle results. Our earlier discussion touched on the possibility of long-run vicious circle results but dismissed it on the grounds that the perfect capital mobility assumption cannot be satisfied. Therefore, our initial hypothesis dictates that the possibility of instability must exist in these short-run equations. However, this is an empirical question which can be resolved at a later stage. But since this section is devoted to a discussion of the theoretical properties, we will now move on to a discussion of the wealth constraint.

Little is known about the behavior of financial wealth outside the steady-state. Nevertheless, we proceed by drawing the Gurley & Shaw distinction between 'outside' and 'inside' money, where outside money represents wealth to which there corresponds no debt and inside money which, as Harry Johnson emphasizes, is money created against private debt.¹⁰ The assets and liabilities of our domestic private sector are assumed to cancel each other out, leaving wealth to consist of outside money, foreign securities and

domestic government securities. In order to simplify our problem further, we assume that only one type of foreign security and one type of domestic government security are available, along with domestic outside money for the wealth constraint. The model in chapter III will include a discussion of the specific formulation of the wealth constraint. Another unique characteristic of this model is the absence of an explicit tax function. Here, we follow Stein in satisfying the government budget constraint by assuming that all real net government expenditure can be satisfied by net real taxes and changes in the government debt. Furthermore, we assume that real consumption per unit of capital depends on real income per unit of capital and real private financial wealth per unit of capital, instead of real disposable income as is the case in most models.

The next question is obviously why we have chosen to define our variables relative to the stock of physical capital, e.g., real consumption per unit of capital. The answer is that this model does not require the accumulation of capital to cease in the steady-state. Within a Keynesian framework, this requirement implies decreasing aggregate income to reach a zero savings rate in long run equilibrium. Therefore, the analysis is not long-run, in the sense that it does not permit complete capital deepening effects which could lead to a golden age. To obtain constant savings and technological growth in the steady-state, we work with
appropriate quantities relative to the stock of physical
capital so that in equilibrium, all real quantities grow
at the same rate as capital stock. 11

The extension of this model to an open economy also
calls for certain additional assumptions regarding expecta-
tions formations mechanisms: we have followed Dornbusch
in assuming that goods market prices adjust slowly compared
to asset market prices, thus opening up the possibility
of exchange rates overshooting/undershooting in response
to policy changes. 12 Such an assumption is justified based
on recent developments in capital markets, where information
flows have disseminated rapidly in these small, well
organized markets, while the more cumbersome and relatively
large, unorganized goods markets have responded to informa-
tion flows with considerable time lags. We formalize these
observations by assuming that price expectations in goods
markets are formed adaptively. More will be said about
the exchange rate and expectations at a later stage, when
it will be discussed in detail. We will also distinguish
between traded and non-traded goods and assume that
domestically produced traded goods respond to demand signals
with a lag compared to prices of imported goods. This leads

11Stephen J. Turnovsky, Macroeconomic Analysis and
Stabilization Policy (London: Cambridge University Press,
1977), chap. 7.

12Rudiger Dornbusch, "Expectations and Exchange Rate
1161-76.
to the familiar J-curve effect in devaluation theory and will be useful to us in our dynamic analysis. Since a high degree of exchange rate volatility in industrial countries has gained notoriety in the past few years, the asset market or portfolio balance approach has been developed to explain this phenomenon. The wealth constraint of our model attempts to incorporate this new development and the next section attempts a succinct description of the theory.

The Portfolio Balance Approach

This approach was developed primarily in the mid 1970's by Frenkel, Kouri, Dornbusch, et al.\(^\text{13}\) Recent attempts to test the theory on the U.S. $/Deutschemark rate have led to positive results and support for the asset market model.\(^\text{14}\) The crux of this approach is to view the exchange rate as the relative price of two assets, i.e., the demand/supply for a particular currency is determined by the demand for assets denominated in that (national) currency relative to assets denominated in another currency. Although the approach itself is becoming a "textbook example" only now, the journal literature indicates that it rests

---


on some very restrictive assumptions. Perhaps, the most crucial assumption is that asset stock equilibrium prevails in the short-run while the existing stock of securities can be changed (net) only by flows of investments and savings in the long-run. In addition, it also assumes that assets denominated in different currencies are highly substitutable and that asset markets adjust rapidly in response to information flows, e.g., interest rate differentials.

We now follow Dornbusch and trace the dynamics implied by this model. Figure 1 shows the domestic money and asset market equilibrium conditions, given a fixed stock of each. Along MM the domestic money market is in equilibrium. Higher domestic interest rates create a stock excess supply of money (since interest bearing assets will be substituted for real balances) so that equilibrium requires a depreciation and therefore a rise in the value of foreign assets in terms of domestic currency. This will increase the valuation of domestic portfolios,

---


NOTE: This diagram is adapted from R. Dornbusch, "Monetary Policy Under Exchange Rate Flexibility," (Cambridge: Massachusetts Institute of Technology, 1978), p. 16.

Figure 1. Money and Asset Market Equilibrium
since they contain foreign denominated assets. The exchange rate therefore plays a role in the valuation of portfolios. The domestic asset market will be in equilibrium along the XX curve. Higher domestic interest rates will raise the demand for domestic assets and require an exchange rate appreciation to reduce the valuation of wealth and asset demand, in order to restore equilibrium. (Note that in figure I, r is the domestic nominal interest rate and e is the exchange rate, defined as the number of units of foreign currency per unit of domestic currency.)

According to this, an increase in domestic money or foreign interest rates will lead to a depreciation. A net increase in external assets or the domestic interest rate will lead to an appreciation. The exchange rate is linked to the current account through net external assets. A current account surplus will lead to an accumulation of these assets and, over time, to an appreciation of the exchange rate. The impact of a current account surplus is to shift the MM function to M'M' since the excess demand for money due to greater wealth requires a higher rate of interest. The opposite argument applies to the XX schedule, shifting it to X'X', thereby appreciating the exchange rate to e'. We will see later that our empirical results for the United States for the 1970's is consistent with this theory.

Note that in contrast to the Mundell-Fleming model, this theory makes no explicit assumptions about capital
mobility. Portfolio re-adjustment calls for a once-and-for-all recomposition of assets in response to the signal (e.g., interest rate differential widening) and the exchange rate will continue to change until stock equilibrium is restored. Once this happens, only further policy changes will induce investors to change their asset composition. Hence, this theory implies that ever widening interest rate differentials will be required to maintain ceaseless capital flows. There could be no 'world' rate of interest: capital is relatively immobile.

Determination of Vicious Circle Behavior

We define our version of the vicious circle earlier as a short-run adjustment problem leading to vicious circle symptoms. It has also been emphasized that this could be the adjustment path taken by an indexed economy. Therefore, the simulation exercise in this dissertation sets out to investigate the conditions under which the short-run equations could lead to vicious circle behavior. This will of course depend on the signs and magnitudes of the estimated coefficients, as well as the control inputs, e.g., the growth rate of the money supply. It should be noted that both Italy and the U.K., the countries which displayed vicious circle behavior most prominently in the mid 1970's, were highly (contractually) indexed economies and also fitted into the classic 'small open economy' mold. It is in these countries that exchange rate fluctuations have the greatest
potential of being passed-through to prices.

Since the model is being constructed as a theoretical contribution, we may be compelled to make major simplifications in order to simulate and estimate this model. But it will display the same dynamic properties. This, and other methodological problems associated with the estimation and simulation work will be discussed at length in chapters IV and V.

Summary

This section attempts to summarize the discussion which has taken place so far. We have defined a 'validation' and 'adjustment problem' view of the vicious circle. The 'validation' view has been criticized as a problem in monetary accommodation (the Dornbusch view) and as a consequence of improper domestic policies (the Willett view). We agree with Dornbusch's criticism and dismiss Willett's view as being applicable in the long-run not in the short-run. We then define our vicious circle as a short-run adjustment problem and show how long-run vicious circles might exist under the assumption of perfect capital mobility with no sterilization. But since this assumption itself is unrealistic, and given the implications of the portfolio balance approach for perfect capital mobility, we dismiss this possibility. By this process of elimination, we clarify our own definition of the short-run adjustment problem.
This is the central focus of the dissertation. It is designed to determine if a segment of the adjustment path of an indexed economy can display such symptoms. If so, we attempt to define the policies under which they could exist and suggest policies which could avoid such symptoms.

Given the nature of the problem, we have decided to use a general equilibrium approach and extend a well known model to include a foreign sector. The model will be capable of generating vicious circle symptoms in the short-run, and by imposing steady-state conditions on it, we can derive the long-run solution. Given the third order system of differential equations which constitute the dynamic part of the long run solution, it is not possible to give the stability analysis a meaningful economic interpretation. We therefore initially assume that the system is stable but in explaining the dynamics, we make further assumptions in order to reduce it to a second order system. This enables us to draw phase diagrams and explain the workings of the model more systematically. A formal derivation is done in Appendix A.

A recent development in the exchange rate literature has been the asset market approach; it has been used to explain the high degree of exchange rate volatility in developed market economies. Preceding sections have outlined this approach, its emphasis on asset stocks (as opposed to flows) and its relevance to vicious circles via exchange
rate fluctuations. It also highlights the added importance attached to the wealth constraint and some of the difficulties encountered in formulating such a constraint for an open economy. We have attempted to follow Stein as closely as possible in order to maintain the simple but elegant structure of his original model. However, we have had to make some restrictive assumptions in the process.

The second chapter will be devoted to a discussion of the literature on vicious circles. The third chapter will be a formal presentation of the model and its dynamics. Chapter IV will be a discussion of the model in a form amenable to empirical work. This chapter will also contain the empirical results and an interpretation of both the short-run results and the long-run (steady-state) results. Chapter V will contain the results of the simulation experiments and their interpretation. Chapter VI will contain the summary and conclusions.
CHAPTER II

THE LITERATURE

Other Models of the Vicious Circle

This chapter is devoted to a survey of the literature on vicious circles. To the best of this author's knowledge, specific vicious circle models have been constructed by Bilson, Basevi and DeGrauwe and Frankel and Giavazzi. In addition, papers by Dornbush, Sachs and Willett have touched on the subject. A useful survey of this literature has been done already by Goldstein. Other writing on the subject include several newspaper articles which appeared in the late 1970's as well as numerous reports.


2 Dornbusch, "Exchange Rate Flexibility,"; Jeffrey Sachs, "Wage Indexation, Flexible Exchange Rates and Macro-Economic Policy," (Cambridge: Harvard University, 1978); Willett, "International Monetary Reform."

and proceedings of international organizations. Since we have already touched on most of the journalistic endeavours, our concentration will be on the theoretical models and how they differ from the present model.

It must be stressed at the outset that most of the other models use the 'traditional' vicious circle view (i.e., causation from exchange rates into wages and prices and back into the exchange rate) while we have given it the 'adjustment problem' interpretation (i.e., vicious circle symptoms being displayed at a particular segment of the adjustment cycle). Indeed, our interpretation hardly warrants the vicious circle title tagged to it, since it is not a vicious circle in the classic sense of the word.

We proceed by examining Bilson's work and then move on to the work of Frankel and Giavazzi and then to Basevi and DeGrauwe. Lastly, we examine Goldstein's views and then compare and contrast our model to the other models.

The point of departure for Bilson's first (1977) paper is his justification for using the monetary approach to the exchange rate. This theory assumes that the exchange

---


5Bilson, "Vicious Circles," (1977).
rate is determined by the stock equilibrium of relative currency prices, i.e., the exchange rate is based on the relative supplies and demands for two currencies. Accordingly, the exchange rate is viewed as a function of money supply, and the traditional determinants of money demand, namely, the real income and the interest rate, all viewed relative to the corresponding variable in the foreign country. The theory also assumes flexible prices and purchasing power parity. Other structural equations include an aggregate demand expression and equations describing the growth rates of wages and prices. No provisions have been made for aggregate supply or the labor market. Instead, it is assumed that all demand is satisfied out of existing stocks and that unemployment is proxied by a deviation of output from trend. However, explicit recognition is made of the influence that relative prices may have on aggregate demand; this is done by introducing a term representing the 'real' exchange rate, \( \frac{P_d}{eP_f} \) where \( P_d \) and \( P_f \) are the levels of domestic and foreign prices, respectively, (while \( e \) is the exchange rate defined as domestic currency units per unit of foreign currency), as a determinant of aggregate demand, and has become common in recent open economy macro models.\(^6\) This

\(^6\)Such formulations have been widely used in Dornbusch, *Open Economy Macroeconomics*. 
theory implies that an increase in the growth rate of
domestic prices will cause a switch into imported goods,
assuming that some degree of substitution exists. Through
this technique, the influence of relative prices, as
opposed to net exports in the traditional Keynesian aggregate
demand identity, enters domestic aggregate demand. The
price equation encompasses the traditional cost push/
demand pull elements while the growth rate of wages is
determined by the deviation of the level of wages from
prices. No explicit recognition is given to the rate of
unemployment or growth in productivity. The dynamics of
this model are described by two reduced form differential
equations in wages and prices. Bilson is quick to emphasize
that the model's ability to generate vicious circles
depends crucially on the values of the parameters; he
incorporates special pass-through parameters to make this
point.

Surprisingly, the dynamics envisaged by Bilson for
this model are similar to our model, in that vicious
circles are assumed to be a segment of an adjustment process.
The shock to his system, however, comes from a real increase
in foreign prices which appreciates the domestic exchange
rate and exerts demand pressures on domestic output.
These factors exacerbate the rate of growth of prices and
reduce real wages. Nominal wage pressures will now begin
to build up and substitution back into foreign goods will
begin to take place. This will cause the exchange rate to depreciate. It is then that vicious circle symptoms are said to appear.

Since Bilson also seems to view the vicious circle as a short-run adjustment problem in this paper, he implicitly assumes that short-run substitution between domestic and foreign traded goods can take place, i.e., no J-curve effect, in response to changes in foreign prices and/or the exchange rate. Also, the monetary approach to the exchange rate has been criticized by others since the purchasing power parity assumption does not usually hold in the short-run and the empirical evidence has been unsatisfactory. A useful segment of this exercise is a set of "do's" and "don'ts" to combat vicious circles. Expanding aggregate demand and/or the money supply are the policies which should not be implemented, while contracting the money supply and/or a fiscal policy induced reduction in aggregate demand are suggested as the correct policy prescriptions. One will see later that these remedies are also consistent with the outcome of our model.

In his more recent (1979) paper, Bilson reports to the traditional definition of the vicious circle.\(^8\) The unique feature here is an endogenous money supply function, which can virtually guarantee vicious circle results if the parameters are of the right sign and magnitude. His rationale is that "since monetary accommodation is at the heart of the vicious circle debate, it is necessary to consider specifically the endogenous determination of the money supply. ... it is assumed that the monetary authorities adjust the money supply around a target level...in response to the deviation of both exchange rates and real output from their equilibrium levels."\(^9\) It is also assumed that interest rate differentials are determined purely by the deviation of the actual exchange rate from its steady-state level, i.e., through the interest rate parity condition. No provisions are made for the domestic influences on each interest rate, (e.g., the demand for real balances or the expected rate of inflation). The other crucial difference compared to his 1977 paper lies in the specification of the equation depicting the rate of inflation. Here, it is assumed that the growth rate of prices will be a function of the excess demand for goods; the supply side is determined by Cobb-Douglas type

\(^8\)Bilson, "Vicious Circles," (1979).

\(^9\)Ibid., p. 10.
production functions with a fixed stock of capital, with labor and imported goods as the variable inputs. Therefore, the relative price term plays a crucial role in determining the rate of inflation, since it enters price determination through both the demand and supply sides. The growth rate of nominal wages is related to the level of real wages; if the latter increases it will have a damped impact on the growth of nominal wages and vice-versa. This completes the structural specification of the model. Once again, Bilson is quick to emphasize the importance of the pass-through coefficients. Since the price deflator he has used for real wages is based on a weighted average of the prices of domestic and foreign goods, the influence of foreign prices (in domestic currency terms) is introduced explicitly into the growth rate of nominal wages. By contrast, our model assumes an indirect form of indexation since the exchange rate and foreign price influence feed the growth rate of prices and this, in turn, influences price expectations (assumed to be formed adaptively). It is through this expectations term that the foreign influence feeds the growth rate of nominal wages (see figure 2 of chapter III).

Bilson's steady-state also differs from ours since no provisions have been made for the growth of wages and prices; but the model can be modified to handle this. An useful part of his dynamic analysis is to use the model to simulate the outcome of certain endogenous variables in
response to an increase in the money supply. However, unlike our model, the values of the parameters were stipulated by him and not estimated. Since openness of the economy is an issue in the vicious circle debate, two hypothetical economies, one 'open' and the other 'less-open' were defined, based on the magnitude of the parameter values for the simulations. The results of these exercises were as follows: (i) the money market parameters both supply and demand elasticities have a negligible impact on the effectiveness of monetary policy: this is attributed to a trade-off between the initial response and the speed of adjustment. (ii) the response of aggregate demand to the monetary expansion is negatively related to the openness of the economy, i.e., the effectiveness declines as the share of imported goods in final demand increases and the cost of imported inputs increase. (iii) an increase in the speed of wage and price adjustment reduces the effectiveness of monetary policy. The second and third conclusions are intuitively plausible given the structure of the model. The first is a little dubious but Bilson's reasoning follows a somewhat circuitous route: "... if the demand for money becomes more sensitive to the interest rate, the size of the initial depreciation will increase and so, consequently, will the initial stimulus to aggregate demand. However, this change will also increase the speed of adjustment, so that the expansion in aggregate demand
will be eroded more rapidly. If these two factors offset each other, the elasticities will be zero.\textsuperscript{10}

Another paper dealing specifically with the vicious circle problem was written by Frankel and Giavazzi.\textsuperscript{11} Like Bilson's 1979 paper, they endogenized the money supply by assuming "... that the monetary authorities accommodate any price change so as to keep real income constant...," thereby making any comparison with our model rather difficult.\textsuperscript{12} The coefficients for their wage equation included distributed lags of past inflation rates which sum to unity. A foreign price term was included in the price equation, along with the growth of nominal wages but a distributed lag scheme with coefficients summing to unity was used here as well. All this implies that, depending on the specific lag structure used, the results could guarantee a vicious circle. Even if the distributed lag scheme was not used, the theoretical use of monetary accommodation can lead to vicious circle results, as discussed earlier. This reasoning led them to conclude that "... rather than the existence of vicious/virtuous circles depending on the values of the parameters and thus being an empirical question, it is guaranteed if 100 percent long-run pass-through is assumed in the institutional

\footnotesize{
\textsuperscript{10}Ibid., p. 25.
\textsuperscript{11}Frankel and Giavazzi, "A New View," pp. 3-4.
\textsuperscript{12}Ibid., p. 2.
}
arrangements, and is ruled out if less than 100 percent pass-through is assumed.  

A paper which treats the vicious circle in a comparative static framework was written by Basevi & DeGrauwe. At the outset, the authors state that "while we recognize that this does not do justice to the essentially dynamic nature of the vicious circle hypothesis, we consider that if we can prove that a 'vicious' ('virtuous') situation may be reached under comparative statics, this might happen even in a truly dynamic framework." Once again, the model is not similar to ours in that it concentrates on two sub-sectors, financial and prices (as opposed to the Bilson and Frankel-Giavazzi models which concentrated on open economy wage-price sector dynamics). The paper follows Dornbusch's 1976 paper in spirit, assuming that asset market prices adjust faster than goods market prices, thus opening up the possibility of exchange rate overshooting. In addition, it assumes price rigidity and interest rate targeting with the monetary authorities unable to control the money supply in the short-run. Then, several scenarios are sketched out to illustrate the consequences of different stimuli. One such scenario portrays

---

13 Ibid., p. 5.
14 Basevi and DeGrauwe, "Vicious Circles."
15 Ibid., p. 280.
16 Dornbusch, "Expectations and Exchange Rate."
the validation version of the vicious circle as follows: the initial perturbation is triggered by the inability of authorities to control the money supply in the short-run. This causes the asset markets to re-adjust, thereby leading to an exchange rate depreciation which overshoots its steady-state level. This exacerbates the price level, which is already being fueled by the money supply which is out of control in the short-run. A higher price level will cause the level of real output to decline and unemployment to edge upwards, creating the usual stagflation symptoms. At this point, the usual economic reasons as well as a 'crisis of confidence' will set in, causing asset markets to re-adjust (depreciate) the exchange rate, and the process will repeat itself. This, of course, assumes no countervailing policies will be implemented (e.g., incomes policies) and also on the definition of short-run used by the authors, since it should be possible to control the money supply in the long-run. The distinction between short-run inability and long-run ability to control the money supply is a worthwhile point to make since, all too often, we forget that in some advanced market economies, interest rate policy does not have an immediate impact on the demand for money (e.g., Spring of 1980 in the U.S.). But the way we have defined the vicious circle problem enables us to get by without making this distinction, i.e., the problem we pose is what symptoms can the adjustment
path display when an economy is adjusting from one steady-state to another in response to an exogenous shock. The other crucial differences lie in their assumptions of price rigidity and interest rate targeting while we assume flexible prices and endogenous interest rates, consistent with neoclassical modelling.

**Vicious Circles as a Peripheral Issue**

The paper by Sachs concerns itself with the implications of wage indexation and macro-economic policy in an open economy. He arrives at the conclusion that real money balances will remain unchanged in equilibrium if the economy is fully indexed. A fiscal expansion will lower import prices (via an appreciating exchange rate) and lower the rate of growth of wages and prices; the real money supply will expand to the point where the demand for money rises to equilibrate the money market at the world rate of interest, since the paper assumes perfect capital mobility. In his view, therefore, "the most important lessons of the models of real wage resistance are that domestic aggregate demand shocks will affect output, fluctuations in aggregate demand abroad will be transmitted to the domestic economy, and domestic monetary policy will be largely ineffective in raising domestic output. In the

\[17\] Sachs, "Wage Indexation."
absence of countercyclical fiscal policy, a decline in aggregate demand may both lower output and raise prices via a currency depreciation." These conclusions generally support the dynamics envisaged by our model since real wage resistance is crucial to vicious circles. The role of fiscal policy will be discussed later by us.

Finally, we report on a survey article written by Goldstein in which he reported on the current state-of-the-art on the vicious circle debate in the broader context of macro-policy formulation under flexible exchange rates. He has identified a few areas which he regards as correct issues pertaining to vicious circles and a few he does not agree with: we have touched on most of these issues in the past and will re-capitulate them here. The correct issues, in his view, are (i) a depreciating exchange rate can indeed have a significant impact on a country's domestic prices, wages and export prices. Various studies are cited to back-up this claim. (ii) Flexible exchange rates shorten the time lag between money supply changes and domestic price changes. In addition to the traditional demand pull factors, it is assumed here that price changes will be exacerbated by an exchange rate depreciation. (iii) Exchange rate movements could be influenced by expectational

\[18\text{Ibid., p. 32.}\]
\[19\text{Goldstein, "Flexible Exchange Rates."}\]
\[20\text{Ibid., pp. 23-27.}\]
factors well beyond the control of the domestic government. The areas which Goldstein feels are misrepresented include (i) that the exchange rate depreciation and domestic inflation are both endogenous, reacting often to monetary growth. (ii) A vicious circle cannot exist in the long-run (i.e., is purely a short-run problem) unless its macro policies are faulty. (iii) The vicious circle scenario is too partial equilibrium in nature, e.g., it neglects the expenditure reducing role of exchange rate depreciation. (iv) The forces which could stabilize the exchange rate are not mentioned in the argument, e.g., the market's view of the long-term prospects for monetary and fiscal policies in a weak exchange rate country.\(^{21}\)

With the exception of factors outside the purely economic realm, e.g., expectational factors beyond the scope of the domestic government, we have already touched on the other issues raised by him. The factors which we have not discussed are, nevertheless, very important but cannot be presented in the context of our model. But we will follow Goldstein and discuss some of these issues in the final chapter.

The Key Differences

This concludes our survey of the literature. Perhaps the most important distinction to be drawn between many of the vicious circle models presented here (a la Bilson, \(^{21}\)Ibid., pp. 22-35.)
Frankel-Giavazzi) is that ours is a general equilibrium
model for a single country, while the other models view
it in a partial equilibrium, wage-price-exchange rate
dynamics framework. We attempt to capture the feedback
effects through the reduced form equations in our model;
the results of this venture are presented in chapter IV.
However, a truly general equilibrium model would also
have to incorporate the behavior of other countries. While
we have made some attempt to capture some of these influ­
ences by using trade-weighted (multilateral) exchange
rates and a financial wealth variable which includes claims
on foreigners and liabilities to foreigners in our empirical
work, it is a poor substitute for a complete structural
model. Of course, such an exercise is left for others!

We now move on to presenting the building blocks of
our theoretical model.
CHAPTER III

MACRO-ECONOMIC MODEL

Purpose

This chapter attempts to explain the formal model we have used to test our hypothesis. While a more complete (and rigorous) derivation is found in appendix A, the purpose of this chapter is to explain in non-technical terms the fundamental characteristics of the model so that the reader will be able to understand its dynamic properties and how it relates to our hypothesis. As stated earlier, the model is based on a 1974 paper by Stein.\(^1\) In subsequent work he converted this model to a system of empirically testable propositions.\(^2\) In the latter papers, he summarized the model without a formal derivation and this chapter is designed to follow those summaries in spirit. Of course, the crucial differences between his work and ours lie in the open economy extensions which are consistent with our hypothesis set forth in chapter I. Therefore, we will pay particular attention to these extensions.

\(^1\)Stein, "Inflation and Monetarism."

Assumptions

Only the most crucial assumptions are stated here. But it may be necessary to augment these assumptions as the different sectors of the model are constructed. Therefore, we leave the peripheral assumptions to the appendix. We assume that prices are completely flexible in the long-run and that price expectations are formed adaptively. The labor market is equilibrated by the natural rate of unemployment and the supply side of the model is characterized by an aggregate neoclassical production function. We also assume a two country world where the Marshall-Lerner conditions are said to hold. Each country has one interest bearing asset (consol) which is imperfectly substitutable for the corresponding foreign asset. This also implies imperfect capital mobility between the two countries. The growth rate of the current spot exchange rate and expected spot rate are equal and the exchange rate floats freely. Asset market prices are assumed to adjust faster than goods market prices in response to a shock. Each country is assumed to have a traded and non-traded good. With these simple assumptions in mind, we now move on to a presentation and discussion of the building blocks of the model.

The format followed hereafter will include a presentation of the key dynamic equations of the model, with a brief discussion of the system. These reduced form equations
were derived from a set of structural equations which constitute the general equilibrium system. With the latter equations, we discuss the structural relationships of the model. Then, the dynamics and steady-state properties are discussed verbally. All this is presented formally and in much greater detail in appendix A. A complete glossary of symbols used here is found at the end of appendices. Also, in order to facilitate cross-referencing with appendix A, the corresponding equation number in the appendix will be provided in the text.

The Dynamic Equations

The macro-dynamic system is summarized in table 1. It uses the unemployment rate, \( U \), growth rate of prices, \( \dot{p} \), and expected prices, \( \dot{p}^{\ast} \), as the state variables and changes in real government expenditure, \( DG \), the growth rate in the money stock, \( \dot{M}^S \) and the change in the ratio of private financial wealth to the stock of money, \( D\delta \), as the control variables. The variable "D" defines a differential operator, i.e., \( D\equiv\text{d}(\cdot)/\text{d}t \) while a "\( \cdot \)" above a variable defines its growth rate, e.g., \( \dot{p}=\text{Dp}/p \). The "\( \ast \)" refers to the expected value of a variable.

Units of physical capital is signified by \( K \) so that \( \dot{M}^S-K \) defines the growth rate of the money supply less the growth rate of the capital stock. The \( DU, \text{Dp} \) and \( \text{Dp}^{\ast} \) refer to the change in the rate of unemployment, change in the growth rate of prices and expected prices, respectively.
### TABLE 1

**SIMPLIFIED MACRO-DYNAMIC MODEL**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Equation Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>$DU = \Pi_{11}g_1(U) - \Pi_{12}p + \Pi_{13}p^* - \Pi_{14}DG$</td>
<td>1-55</td>
</tr>
<tr>
<td>$Dp = -\Pi_{21}g_1(U) + \Pi_{22}p + \Pi_{23}p^* + \Pi_{24}DG + \Pi_{25}(M^s - K)$</td>
<td>2-66</td>
</tr>
<tr>
<td>$Dp^* = \Pi_{31}p - \Pi_{31}p^*$</td>
<td>3-56</td>
</tr>
</tbody>
</table>

In the steady state, $DU = 0$ and $Dp = Dp^* = 0$. The coefficient $\Pi_{31}$ represents the speed of adjustment of $p^*$ to $p$ and is signified by $\rho$ in the structural model. Since the $\Pi$'s are a simplified presentation of the actual coefficients, it is difficult to give a meaningful interpretation to the stability analysis. Therefore, we assume for the moment that the Routh-Hurwitz conditions hold and that the system is stable. When the model is estimated in a subsequent chapter, we will show that it is actually stable.

It is also difficult to discuss the dynamics implied by the model in table 1 without examining the underlying structural model. But when steady-state properties are imposed on the dynamic equations, they yield the long-run solution to the model. We now present the structural equations, followed by a short discussion of various
relationships implied by these equations. Then, the
steady-state properties and dynamics will be presented.

The Structural Equations

Since we have briefly outlined the fundamental charac-
teristics of the model in the first chapter, presented below
are the key short-run structural equations.

**TABLE 2**

**KEY STRUCTURAL EQUATIONS**

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-27</td>
<td>[ \frac{B_d}{r_d} + \frac{eB_f}{r_f} + \frac{B_d^f}{r_d} + M ] [ \frac{\delta}{M} ]</td>
<td>Ratio of private financial wealth to the stock of money.</td>
</tr>
<tr>
<td>5-32</td>
<td>[ y = g(U) ]</td>
<td>Real output per unit of capital.</td>
</tr>
<tr>
<td>6-46</td>
<td>[ y^d = y^d(m, \delta, p^*, p, x, G, r_d) ]</td>
<td>Real aggregate demand per unit of capital.</td>
</tr>
<tr>
<td>7-47</td>
<td>[ E = E(x, G, p^*, p, m, \delta) ]</td>
<td>Real excess demand per unit of capital.</td>
</tr>
<tr>
<td>8-39</td>
<td>[ r_d = r_d(U, p^*, m, \delta, r_f) ]</td>
<td>Nominal (domestic) interest rate</td>
</tr>
<tr>
<td>9-44</td>
<td>[ \dot{e} = e(y, y_f, p, p_f, r_d, r_f, e^*) ]</td>
<td>Growth rate of the exchange rate.</td>
</tr>
<tr>
<td>10-53</td>
<td>[ \dot{W} = \phi_1 p^* - \phi_2 U + \lambda ]</td>
<td>Growth rate of nominal wages.</td>
</tr>
<tr>
<td>11-51</td>
<td>[ U = f(v/A(t), G) ]</td>
<td>Unemployment Rate</td>
</tr>
<tr>
<td>Equation Number</td>
<td>Text/Appendix</td>
<td>Equation</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------</td>
<td>----------</td>
</tr>
<tr>
<td>12-64</td>
<td></td>
<td>$D_m/m = m^s - K$</td>
</tr>
<tr>
<td>13-56</td>
<td></td>
<td>$D_p^* = \rho (p-p^*)$</td>
</tr>
<tr>
<td>14-60</td>
<td></td>
<td>$p = p(U_{LC}, E, e+p_f^e-p_d)$</td>
</tr>
</tbody>
</table>

**NOTE:** Readers are urged to consult appendix A for formal derivations and the theory behind each of these equations. The expected signs of the coefficients are also indicated (wherever possible) in the appendix.

**The Structural Model**

Perhaps, our single most important contribution to the adjustment theory literature is the extension of the financial wealth variable to the open economy. This is crucial to any model using the portfolio balance approach to short-run exchange rate determination. Equation 4 defines the relationship we have chosen to use. The subscripts "d" and "f" signify domestic and foreign respectively, while $B$ refers to Bonds and $B_f^d$ refers to domestic bonds held by foreigners (recall that we limit each country to one interest bearing asset). The $r$ refers to the corresponding nominal interest rate in each country while the $e$ refers to the exchange rate defined as the number of
units of domestic currency per unit of foreign currency. M defines the stock of (outside) money. Private financial wealth is assumed to consist of only outside assets. This is consistent with the Gurley and Shaw distinction between 'outside' and 'inside' assets, where outside assets were defined as assets to which no debt corresponded, i.e., created by fiat. It is assumed that all inside (private) assets and liabilities cancel each other out. Therefore, domestic private assets are assumed to consist of a single outside domestic interest bearing asset (i.e., government interest bearing debt held by the private sector) and domestic (outside) money and the foreign interest bearing asset. But since domestic interest bearing assets held by foreigners constitutes outside assets for them, we deduct this from foreign bonds held by the domestic country.

It becomes apparent that the endogenous variables of the model are the unemployment rate, the growth rate of prices and expected prices, real wages, real balances per unit of capital, the nominal interest rate and the exchange rate (to the extent that the latter's growth rate can be influenced by domestic variables). The exogenously determined variables include all the foreign variables, the growth rate of productivity, \( \dot{\lambda} \), which is also equal to the growth rate of technology (by assumption) and the growth rate of effective labor, \( n \), and the (relatively
constant) ratio of effective labor supplied per unit of capital, which is discussed only in appendix A.

The output side of this model is characterized by an aggregate neoclassical production function exhibiting Harrod Neutral technical change. From this, we are able to derive equation 5, which shows that real output per unit of capital, $y$, is some function $g$ of the unemployment rate. The aggregate demand side is derived from the Keynesian aggregate demand identity. Equation 6 describes real aggregate demand per unit of capital, $y^d$, as some function $y^d$ of real balances per unit of capital, $m$, the ratio of private financial wealth to the stock of money, the growth rates of prices and expected prices, effective labor per unit of capital, $x$, (where effective labor is the natural labor force adjusted for technology), real government expenditure, $G$, (which is a policy variable) and the domestic nominal interest rate. The exogenous variables have been dropped from this equation and it is presented in 'reduced form,' with $\delta$ and $G$ retained as policy variables. Note that, as stated in the first chapter, an explicit tax function is not used in the model. The government budget constraint is assumed to be entirely satisfied by net real taxes and changes in the government debt. This also complicates the formulation of a real disposable income definition which should be a determinant of real consumption per unit of capital. However, consumption in this model is
assumed to be determined by the ratio of private financial wealth to the stock of money instead of disposable income (see equation 34 of appendix A). This obviates the need for an explicit treatment of disposable income. Real excess demand per unit of capital, \( E \), (equation 7) is derived from equations 5 and 6. It is also presented in reduced form. Equation 8 presents the nominal interest rate, \( r_d \). The foreign interest rate, \( r_f \) is introduced as a determinant since it may induce an exogenous change in the domestic interest rate. The other variables in this equation are self-explanatory. Equation 9 describes the growth path of the exchange rate. It is based on the balance-of-payments (BOP) equilibrium condition that net real exports per unit of capital will exactly offset net real capital exports per unit of capital (see equations 71-73 in appendix A). It is also designed to incorporate the stock/flow interaction of our model in the exchange rate determination process. In particular, the short-term stock adjustment aspects are covered by the interest rate differentials between the two countries while the long term trade flows will be determined by the real incomes per unit of capital and the expected rates of inflation. Since the expected and actual spot exchange rates grow at the same rate (by assumption), \( \delta e / \delta e^* = 1 \). Equation 10 determines the growth rate of nominal wages. It is assumed to be dependent on the growth rates of expected prices.
productivity and the rate of unemployment. The magnitude of the $\phi_1$ coefficient is important to the vicious circle argument since it provides the mechanism through which increases in price expectations are translated into wage increases. It is an informal link and should not be confused with contractual indexation which vicious circle countries are purported to have had in the mid 1970's.

The unemployment rate (equation 11) is determined by the level of real wages adjusted for technology and the level of real government expenditure. Equation 12 shows that real balances per unit of capital, $D_m/m$, will grow at the same rate as the real money supply, $\dot{m}^S$, minus the growth rate of the capital stock, $K$. This is a steady-state relationship. The level of real balances outside the steady-state will be determined by real output per unit of capital and the domestic interest rate (see equation 28 of appendix A). Equation 13 shows that the change in the growth rate of expected prices will be determined adaptively, with the $\rho$ coefficient measuring the speed of adjustment. This is also consistent with our assumption of asset market prices adjusting faster than goods market prices. Finally, equation 14 determines the growth rate of general prices. It is functionally dependent on the growth rate of unit-labor-costs, $ULC$, real excess demand per unit of capital, $E$, and the independent influence exerted by the growth rates of the exchange rate and foreign
(general) prices. The term \( p_d \) refers to the growth rate of domestic production prices. No foreign inputs enter into the production of these goods. Therefore, it is assumed to reflect purely domestic costs, so that subtracting it from the growth rates of the exchange rate and foreign prices will yield a true picture of the degree of pressure exerted by exchange rate and foreign price changes. All unfinished and finished imports are assumed to influence domestic prices through the general price term. This completes our overview of the structural model. A schematic of the model is presented in figure 2. The next section discusses the various relationships implied by these structural equations and their steady-state properties.

**The Relationships and the Steady-State**

We now discuss the interaction of the goods and labor markets. Equilibrium in the labor market is defined relative to the natural rate of unemployment, \( \bar{u} \), while equilibrium in the goods market will prevail when real excess demand per unit of capital is zero. Both these conditions will be true in the steady-state, thereby implying that when levels of positive excess demand exist, the actual rate of unemployment will be below the natural rate and vice-versa. \( \bar{y} \) defines the equilibrium level of real output per unit of capital. These relationships are shown in figure 3.
Figure 2. Schematic of the Macro-economic Model
Figure 3. Steady-state relationships between adjusted real wages, unemployment and real output per unit of capital.
The growth rate of prices and expected prices will be equal and constant in the steady-state so that \( D\hat{p} = D\hat{p}^* = 0 \). The domestic production price and the general price are assumed to grow at the same rate. By assuming that relative prices, i.e., \( p_d/ep_f \), are constant in the steady-state, we are able to show that \( \hat{p}_d = \hat{e} + \hat{p}_f \). This implies that the last term of the general price equation (equation 14) will be zero. Since real excess demand per unit of capital will also be zero, it implies that the growth rate of general prices will be determined solely by the growth rate of unit-labor-costs. The coefficient on this term is assumed to equal one in the steady-state so that \( \hat{p} = \hat{w} = \lambda \). By rearranging terms, we see that \( \hat{w} - \hat{p} = \hat{v} = \lambda \). This is the relationship depicted in figure 3, showing real wages to be growing at the same rate as productivity. (Also, remember that productivity and technology are assumed to grow at the same rate.)

The growth rate of prices, \( \hat{p} \), will be \( \hat{p} = \hat{M}_s - \hat{k} \). The growth rate of the exchange rate will be equal to the growth rate of the relative money stocks per unit of capital, i.e.,

\[
\hat{e} = (\hat{M}_s - \hat{k}_s) - (\hat{M}_f - \hat{k}_f)
\]

Capital stock, in turn, is assumed to grow at the same rate as the (exogenously determined) effective labor force, \( n \), i.e., \( \hat{k} = n \).

We now move on to a discussion of the foreign sector. It was stated earlier that net real capital exports per unit of capital will exactly offset net real exports per unit of capital. We now qualify this by adding that, in the
steady-state, the BOP will be in equilibrium so that no country will be able to accumulate claims against the other. If, for example, the domestic country did accumulate claims, the monetary base will be expanding and the steady-state conditions we enunciated earlier will become invalid. $M^S$ will no longer be strictly a control variable. We also assume that real government expenditure will be constant so that $DG=0$. These conditions help us explain why the ratio of private financial wealth to the stock of money must also be constant. It was stated earlier that the BOP is in equilibrium and $DG=0$ in the steady-state. This implies that the composition of foreign and domestic assets must not be changing and also that the stock of government interest bearing assets must be constant since government expenditure is constant. Therefore, $D_6=0$. The most important steady-state relationship have now been presented. Our next task is to explain how the endogenous variables will behave outside the steady-state. In order to do this, we shock the system by increasing the growth rate of the money supply and trace the dynamics (verbally) to the new steady-state.

The Dynamic Properties

The fundamental hypothesis of this dissertation is that in the process of adjusting from one steady-state to
another, an economy may be able to display vicious circle symptoms during a segment of the adjustment cycle. Assume that the economy is at some initial steady-state. Our experiment will be to shock this state by increasing the growth rate of the money supply permanently and observing the adjustment process to determine if the vicious circle phase could appear. The said increase will cause interest rates to decline instantly and, given our assumption of asset market prices adjusting faster than goods market prices, a portfolio re-composition in favor of the foreign asset will occur, thereby exacerbating the rate of depreciation of the exchange rate. It is possible that the new rate of depreciation will overshoot its new steady-state growth path, but this is a peripheral issue which is dealt with at length in the appendix. Other forces will also be at work in the domestic sector. The lower rate of interest will spur capital spending and increase real balances so that aggregate demand will rise, lower unemployment below the natural rate and increase real income. Rising aggregate demand also means increased imports, which will exacerbate the rate of depreciation of the exchange rate even further. Several forces will now be working on the growth rate of prices. The classic excess demand conditions and the influence of a rapidly depreciating exchange rate will be the most prominent (see equation 14) amongst these forces. Rising prices will cause expectations to be re-adjusted
for a permanently higher growth rate of prices. It is during this phase that nominal interest rates will edge upwards and the exchange rate will continue to depreciate despite higher interest rates since, in a longer time frame, the stock/flow interaction will cause trade flows to dominate exchange rate movements. Re-adjusting expectations to a higher growth rate of prices also means higher excess demand (e.g., higher imports) since people may refuse to postpone their purchase decisions. Of course, we assume throughout that no retaliatory action will be taken by the partner country and that no exchange rate intervention is forthcoming from the authorities. The higher growth rate of prices will also cause real output/income to decline and the rate of unemployment to edge back up above the natural rate. Also, remember that higher expected prices will exacerbate wage demands which, in turn, will raise real wages and the rate of unemployment (see equation 11). In summary, the period of low unemployment, rising real output and low interest rates and real wages will give away to declining real output, rising interest rates, prices and price expectations, a rapidly depreciating exchange rate, rising real wages and higher unemployment. These symptoms are characteristic of a recession and will soon lead to unemployment rates above the natural rate. It is due in part to rising prices, which can be attributed to rapid transmission of price expectations into wage demands and to
exchange rate depreciation. It is this which we characterize as the 'vicious circle phase' of adjustment. If no discretionary policy measures are taken, the growth rate of prices will gradually diminish (we assume flexible prices) and real output and unemployment will edge back to their steady-state levels. Of course, it is entirely possible that the natural rate of unemployment may shift (e.g., drift upwards) over time, but we assume that this does not happen in the adjustment period under consideration. The new steady-state growth rates of prices and the exchange rate, which we assume implicitly is depreciating, will be higher in comparison to the initial steady-state. The dynamic behavior of these variables along with several other endogenous (non-state) variables is discussed in detail in appendix A. Since they are not crucial to our argument, we have not included them in this chapter. The dynamic adjustment process is spelt out in figure 4, in the \( (p, U) \) plane for the interested reader.

Our next chapter prepares the simplified macrodynamic model (table 1) for estimation, stability analysis and a derivation of the steady-state properties. Due to the large number of variables involved in this chapter and the corresponding appendix, we are compelled to use some of the variable notation in the theoretical part to signify different variables in the empirical part. This is done partly to maintain some consistency with the symbols
NOTE: For simplicity, assume that the natural rate of unemployment is equal to the steady-state growth rate of prices, so that \((\bar{\rho} , \bar{U}) = ((\bar{M}^s - \bar{K})_a, \bar{U}) = A\). The rate of monetary growth per unit of capital is now raised by AZ to \((\bar{M}^s - \bar{K})_b\). The economy follows trajectory ABCYZ to the new steady-state \((\bar{\rho} , \bar{U}) = ((\bar{M}^s - \bar{K})_b, \bar{U}) = Z\). The EE curve shifts along \(P_1P_1\) to \(E_1E_1\) (from \(E_0E_0\)). EE and PP define the locus of points along with \(DU=0\) and \(D\bar{\rho}=0\), respectively. The 'vicious circle' phase of adjustment is displayed during the CY segment of the trajectory.

Figure 4. Dynamic Adjustment Path of the Economy
commonly used in the literature in this field. Although it has been kept at a minimum, readers should be on their guard for changes in variable names when they reach the next chapter. Of course, all name changes will be explicitly acknowledged.
CHAPTER IV

THE STATISTICAL HYPOTHESIS

Objectives

The objective of this section is to discuss the estimation of the model presented in chapter III. In order to do so, we recapitulate the original definition of the vicious circle and then describe the preparation of our long-run dynamic system (table 1) for statistical estimation. When the estimation process is completed, we discuss the stability properties of the model and derive its steady-state properties. This will also be discussed in detail. Before proceeding, it should be noted that many simplifications have to be made to the original dynamic system in order to make it amenable to OLS estimation. With this caveat in mind, we move on to a discussion of the model.

Recall that our hypothesis of the vicious circle refers only to its symptoms phase and not the 'classic' vicious circle envisaged by its proponents. We dismissed that version as a problem in monetary accommodation. The phase which we hypothesize may exist is a segment of an adjustment cycle resulting from an exogenous shock. Therefore, we discuss it purely in a short run context and
our long-run dynamic system must be converted into a short-run system before estimation can take place. Once again, we follow Stein in expanding his model to accommodate the open economy extensions that we have done. Since our short-run hypothesis depends so much on the behavior of the exchange rate, we have estimated a short-run exchange rate equation which, as we mentioned earlier, is based on the asset market theory of exchange rate determination.

The Exchange Rate Equation

The theoretical model constructed earlier led to a macro-dynamic system summarized in table 1 of the previous chapter. Here, we have three state variables in the rate of unemployment, prices and expected prices. The three control variables are changes in real government expenditure per unit of capital, the growth rate of the money stock and the change in the ratio of private financial wealth to the stock of money. Noting that price expectations are formed adaptively, we will have to abandon this equation since serious econometric problems, i.e., multicollinearity, can be encountered by estimating an equation of this form. Instead, we substitute the exchange rate as an endogenous variable and hypothesize that the exchange rate in the short run is determined by the lagged values of the state

1Stein, "Inflation and Monetarism," and "Black Box."
variables and the three control variables. We have experimented with many lag structures and chosen the form presented below since it yielded the best "fit." Also, note that the original system in table 1 is in differential equation form while the present system is in the form of difference equations. The model was estimated for the U.S., for 1970:4 to 1979:4. But the transformations on the data and the autoregressive lags reduced the actual number of observations to 33. Although quarterly data was used for the estimation, all growth rates were between corresponding quarters, e.g., 1970:1 to 1971:1, as opposed to consecutive quarters. It was found that this method yields a better "fit" (i.e., predicted values of the state variables) as opposed to using consecutive quarters with seasonally adjusted data. Furthermore, the standard deviations are smaller.

Before presenting the equations, we will also say a few words about the data and transformations performed on it before running the regressions. The variables are defined as follows:

\[ E(T) = \text{The corresponding quarter (annualized) growth rate of the effective exchange rate, and } T \text{ indicates the time period. This (multilateral) exchange rate index is defined as the number of units of foreign currency per unit of domestic currency.} \]

\[ P(T) = \text{The annualized growth rate of the GNP deflator.} \]

\[ DG(T-\delta) = \text{The change in an index of federal, state and local government purchases per unit of capital (where capital is a translog index} \]
of capital stock) between corresponding quarters,
e.g., \( DG(T) = \frac{G(T)}{K(T)} - \frac{G(T-4)}{K(T-4)} \).

the \( K \) refers to the capital stock index and the \( (T-6) \) refers to a 3 quarter moving average of the 3 preceding quarters and hence, \( DG(T-6) = \frac{1}{3}(DG(T-1) + DG(T-2) + DG(T-3)). \)

\( M(T-6) \)=A 3 preceding quarter moving average of the annualized growth rate of M1, i.e., if the (annualized) growth rate between quarter \( T-4 \) and \( T \) is \( M(T) \), then \( M(T-6) = \frac{1}{3}(M(T-1) + M(T-2) + M(T-3)) \).

\( \gamma(T-6) \)=A 3 preceding quarter moving average of the annualized growth rate of the stock of outside assets. Outside assets are defined as government interest bearing debt held by the private sector plus total U.S. claims on foreigners minus total foreign claims on the U.S. (The specific derivation of the variable is the subject of an appendix C. As in \( M(T-6) \), the (annualized) corresponding quarter growth rate of total financial wealth will be \( \gamma(T) \) and \( \gamma(T-6) = \frac{1}{3}(\gamma(T-1) + \gamma(T-2) + \gamma(T-3)). \)

\( U(T) \)=Percent of civilian labor force unemployed.

This defines all the variables used in our statistical hypothesis. The data used in the estimation (both transformed and untransformed) along with the exact sources that were used and a better description of the transformations will be presented in the statistical appendix. In the definition of these variables, we adhered to Stein's procedure, both in terms of formulating the statistical hypothesis and in selecting the variables.\(^2\) Perhaps, the major differences lie in the definition of financial wealth and the introduction of an exchange rate equation. However,

\(^2\)Stein, "Black Box."
we defined wealth to consist of private (as opposed to total financial wealth) in the model, and our sudden switch to total financial wealth deserves an explanation. The model was constructed under the assumption of freely floating exchange rates, consistent with the other literature in this area. But constant exchange rate management is a fact of life and is captured in the effective exchange rate series which we use. Therefore, any definition of financial wealth must include the government's reserves used for intervention purposes. For convenience, we assume that the majority of official reserves are held for this purpose and re-define claims on foreigners and foreign claims on the U.S. to include official assets.

Another area in our statistical hypothesis which deserves some explanation is the use of 3 quarter moving averages in the control variables. Intuitively, it tells us that the state variables will respond slowly to changes in the control inputs and is theoretically equivalent to using a lag structure.\(^3\) The results obtained by using this scheme were quite good, and will become evident later on. It is also an approximation to the solution of the differential equation system (table 1 of our model) worked out by Stein.\(^4\) The 3 period lags for the

\(^3\)Ibid., p. 208.

\(^4\)Ibid.
state variables and 3 quarters for the moving averages of the control variables have been chosen as a result of empirical investigation and is also heuristically appealing in terms of the response lags due to policy changes. With that brief exposé on the data, we now present the exchange rate equation:

$$E(T) = \beta_{10} + \beta_{11} U(T-3) + \beta_{12} P(T-3) + \beta_{13} E(T-3) + \beta_{14} DG(T-\delta) + \beta_{15} M(T-\delta) + \beta_{16} \gamma(T-\delta) \quad (15)$$

The Unemployment Rate Equation

The same predetermined variables are used to determine the rate of unemployment in this model:

$$U(T) = \beta_{20} + \beta_{21} U(T-3) + \beta_{22} P(T-3) + \beta_{23} E(T-3) + \beta_{24} DG(T-\delta) + \beta_{25} M(T-\delta) + \beta_{26} \gamma(T-\delta) \quad (16)$$

The Price Equation

$$P(T) = \beta_{30} + \beta_{31} U(T-3) + \beta_{32} P(T-3) + \beta_{33} E(T-3) + \beta_{34} DG(T-\delta) + \beta_{35} M(T-\delta) + \beta_{36} \gamma(T-\delta) \quad (17)$$

Again, all variables have been defined previously. Therefore, the estimated equations consist of equations 15, 16 and 17.

Model Estimation and Results

As stated earlier, the model was estimated for the United States for the period 1970:4 to 1979:4. The data
was obtained from four sources: the (multilateral) effective exchange rate series from The Federal Reserve Board, the (Implicit) GNP deflator and M1 (unadjusted) series from the IMF (IFS Databank), the Unemployment Rate, Government Purchases, Government Debt, Stock of U.S. Claims on Foreigners and Foreign Claims on the U.S. were from the Survey of Current Business (various issues). The last two variables had to be converted into quarterly series by us, since only annual data is available; our derivation is described in an appendix. Lastly, the Translog Capital Stock Index had also to be converted into a quarterly series here but the annual index was obtained from the Bureau of Labor Statistics. All the data used with detailed descriptions of sources and the derivations are contained in the statistical abstract. But note that the series we use for empirical work defines the exchange rate as units of foreign currency per unit of domestic currency.

Estimation of any time series data is subject to the problem of autocorrelation. This is particularly true with quarterly data and therefore, we present here only the OLS estimates with a fourth order autoregressive lag using a Cochrane-Orcutt correction. The uncorrected estimates as well as the lower order autoregressive structures had significant autocorrelation problems as evidenced by the D-W statistics and we do not bother to present them, other than to discuss them briefly.
<table>
<thead>
<tr>
<th>Independent Variables and Supplementary Statistics</th>
<th>Dependent Variables</th>
<th>U(T)</th>
<th>P(T)</th>
<th>E(T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td></td>
<td>1.58**</td>
<td>1.34</td>
<td>17.16**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.96)</td>
<td>(0.93)</td>
<td>(3.75)</td>
</tr>
<tr>
<td>U(T−3)</td>
<td></td>
<td>0.65**</td>
<td>-0.21</td>
<td>-0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.27)</td>
<td>(-1.34)</td>
<td>(-0.26)</td>
</tr>
<tr>
<td>P(T−3)</td>
<td></td>
<td>0.35**</td>
<td>0.86**</td>
<td>-0.36</td>
</tr>
<tr>
<td>(t)</td>
<td></td>
<td>(18.38)</td>
<td>(9.52)</td>
<td>(-1.25)</td>
</tr>
<tr>
<td>E(T−3)</td>
<td></td>
<td>0.07**</td>
<td>-0.04</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.86)</td>
<td>(-1.57)</td>
<td>(1.28)</td>
</tr>
<tr>
<td>DG(T−δ)</td>
<td></td>
<td>0.05**</td>
<td>0.34**</td>
<td>-0.22*</td>
</tr>
<tr>
<td>(t)</td>
<td></td>
<td>(3.95)</td>
<td>(9.27)</td>
<td>(-2.15)</td>
</tr>
<tr>
<td>M(T−δ)</td>
<td></td>
<td>-0.18**</td>
<td>0.21</td>
<td>-3.34**</td>
</tr>
<tr>
<td>(t)</td>
<td></td>
<td>(-4.81)</td>
<td>(1.61)</td>
<td>(-7.13)</td>
</tr>
<tr>
<td>γ(T−δ)</td>
<td></td>
<td>-0.04**</td>
<td>0.04</td>
<td>0.31**</td>
</tr>
<tr>
<td>(t)</td>
<td></td>
<td>(-4.24)</td>
<td>(1.65)</td>
<td>(3.39)</td>
</tr>
<tr>
<td>SEE</td>
<td></td>
<td>0.31</td>
<td>0.53</td>
<td>2.86</td>
</tr>
<tr>
<td>$R^2 \frac{1}{\bar{R}}$</td>
<td></td>
<td>0.95</td>
<td>0.94</td>
<td>0.84</td>
</tr>
<tr>
<td>D-W (1st order serial correlation only)</td>
<td></td>
<td>1.51</td>
<td>1.94</td>
<td>2.01</td>
</tr>
<tr>
<td>h</td>
<td></td>
<td>1.26</td>
<td>0.20</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**Significant at the 99 percent level.

*Significant at the 95 percent level.

$\frac{1}{\bar{R}}$ before the $p$ transformation for the Cochrane-Orcutt correction.
Several caveats must be acknowledged about the results presented in table 3. The D-W statistic is designed for use in the special case of 1st order serial correlation, where lagged dependent variables are not used as independent variables. But as a general comment, serial correlation was reduced significantly (using the h-statistic criterion, described below) by using a 4th order autoregressive lag structure in all the equations. In the unemployment rate equation, a 5th order lag structure (not reported here) reduced 1st order serial correlation even further.

It is interesting to note the differences between the corrected and uncorrected estimates. In each case, the uncorrected estimates displayed serious autocorrelation according to the D-W and h-statistics. Some of the coefficients also changed significantly when the correction was introduced: for instance, in the unemployment rate equation the constant term, lagged unemployment, government purchases, money supply and financial wealth coefficients changed. In the price equation, the constant term and unemployment rate coefficients changed significantly while in the exchange rate equation all the coefficients except government purchases changed significantly. Also, in each equation, the standard error of estimate (SEE) of the

---

corrected equation was lower and the $R^2$ higher than the uncorrected equation. We have reported at length on both the corrected and uncorrected estimates only for the model presented in table 1, these results will be used later as a point of departure into our simulation work. Meanwhile, the other experiments on various functional forms etc., are reported here without reference to their uncorrected estimates. Of course, the reader's attention will be called to other econometric problems which may arise in these equations. Most of the latter experiments were carried out on the exchange rate equation since it had the highest SEE. Since the determinants of the exchange rate play a vital role in our theory, we will emphasize the economic aspects involved with various functional forms during the discussion.

The h-Test

As we said earlier, the D-W statistic is invalid in the presence of lagged dependent variables used as independent variables. But Durbin has developed an alternative test (called the h-test) to be used in such a situation.\(^6\) The procedure involves calculating the "h-statistic" and using this as a standard normal deviate to

---

test the hypothesis that $\rho=0$ (where $\rho$ is the 1st order serial correlation coefficient). A detailed presentation of this statistic is beyond the scope of this chapter, but a good discussion of its uses and limitations are found in Maddala.\footnote{Maddala, \textit{Econometrics}, p. 372.}

To simplify our task, we have used the convention that if the computed value of $h$ lies between $\pm 1.96$, i.e., $-1.96 < h < 1.96$, we are able to accept the null hypothesis that $\rho$ is not significantly different from zero at the 95 percent level of confidence. Establishing such a criterion is common in the hypothesis testing literature.\footnote{J. Kmenta, \textit{Elements of Econometrics} (New York: Macmillan Publishing Co., 1971): chap. 5.}

The $h$-statistic is presented in our results (where applicable) along with the D-W statistic. It is interesting to note that if the D-W statistic is close to two where lagged dependent variables are used as regressors, the computed value of $h$ is close to zero, indicating the low probability of 1st order serial correlation. Using the $h$-statistic, we accept the null hypothesis that $\rho$ is not significantly different from zero in the results presented in table 3. This statistic was also computed for regressions which are not reported in tabular form. We will report on the results wherever possible so that readers will be aware of serial correlation problems.
Further Experiments With Functional Form

We have attempted running the regressions with several different lag structures on the lagged state variables and with several different transformations on the control variables. Experiments with the autoregressive lag structure led us to conclude that in general, a 4th order lag structure minimized 1st order serial correlation. Therefore, we use this lag structure with the Cochrane-Orcutt correction throughout our regression work.

The present form (table 3) yielded satisfactory results for the price and unemployment equations while better results were obtained for the exchange rate equation using shorter lags for the state variables and shorter lag structures for the control variables. A noteworthy feature of the exchange rate equation is the magnitude of the coefficient on the $M$ (which is $M_1$) term, which is unusually large. Changes in the lags on the state variables did not change the magnitude of this coefficient much (always greater than 2.9) but when the lag structures of the state variables were reduced, for example, to the annualized growth rate of the preceding quarter, the magnitude of the $M$ coefficient decreased to about 1.3. When the lag was increased to two quarters on the control variables, the coefficient of $M$ began to increase again, and fell in the vicinity of 2.5. Throughout all this, the coefficient on the financial wealth variable remained small (less than 1)
but highly significant. Also, the $R^2$ coefficient remained in the 80 percent range. The coefficient of the government purchases variable, although small, was also important and became significant at the 95 percent level in some of the regressions.

These results tell us that the growth rate of the money supply and financial wealth were the most significant of our explanatory variables in the determination of the exchange rate. It adds credence to the theory that asset stocks are a major determinant of the exchange rate. The magnitude of the coefficient of $M$ brings forth the idea of exchange rates overshooting in the short run due to changes in monetary policy. Since $\partial E/\partial M > 3$, it suggests that, ceteris paribus, a 1 percent increase in the growth rate of $M_1$ will cause the rate of depreciation of $E$ in the succeeding period to increase by 3 percent. The results of some of the supplementary regressions run on the exchange rate equation are shown in tables 4 and 5. The h-test, using our earlier criterion, confirms the presence of 1st order serial correlation in the first equation of each table; therefore, they must be accepted with caution. The D-W statistic confirms the presence of serial correlation in the second equation of table 5. Note that instead of 3 quarter moving averages, specific period lags have been used with the control variables. We also attempt to show here that the exchange rate responds rapidly to policy changes.
### TABLE 4
SELECT REGRESSIONS ON THE EXCHANGE RATE EQUATION WITH ONE PERIOD LAGS

<table>
<thead>
<tr>
<th>Constant</th>
<th>U(T-1)</th>
<th>P(T-1)</th>
<th>E(T-1)</th>
<th>DG(T-1)</th>
<th>M(T-1)</th>
<th>(T-1)</th>
<th>$R^2$</th>
<th>SEE</th>
<th>DW</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.47*</td>
<td>-0.54</td>
<td>-0.03</td>
<td>0.56**</td>
<td>-0.11</td>
<td>-1.29**</td>
<td>0.16*</td>
<td>0.16*</td>
<td>3.1</td>
<td>2.41</td>
<td>-3.06</td>
</tr>
<tr>
<td>(2.21)</td>
<td>(-0.82)</td>
<td>(-0.13)</td>
<td>(3.52)</td>
<td>(-1.21)</td>
<td>(-2.83)</td>
<td>(2.39)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.78**</td>
<td>-0.58*</td>
<td>-0.01</td>
<td>-2.47**</td>
<td>0.35**</td>
<td>0.72</td>
<td>3.6</td>
<td>2.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4.16)</td>
<td>(-2.57)</td>
<td>(-0.16)</td>
<td>(-7.46)</td>
<td>(6.31)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.28</td>
<td>-0.09</td>
<td>0.49**</td>
<td>-0.06</td>
<td>-1.41**</td>
<td>0.14*</td>
<td>0.80</td>
<td>3.1</td>
<td>2.33</td>
<td>-1.47</td>
<td></td>
</tr>
<tr>
<td>(1.97)</td>
<td>(-0.42)</td>
<td>(3.64)</td>
<td>(-0.82)</td>
<td>(-3.36)</td>
<td>(2.14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** All regressions use OLS with a 4th order autoregressive lag on the Cochrane-Orcutt correction.

*Significant at the 95 percent level.

**Significant at the 99 percent level.
TABLE 5
SELECT REGRESSIONS ON THE EXCHANGE RATE EQUATION WITH TWO PERIOD LAGS

<table>
<thead>
<tr>
<th>Constant</th>
<th>U(T-2)</th>
<th>P(T-2)</th>
<th>E(T-2)</th>
<th>DG(T-2)</th>
<th>M(T-2)</th>
<th>T-2</th>
<th>R^2</th>
<th>SEE</th>
<th>DW</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.22*</td>
<td>-0.51</td>
<td>0.12</td>
<td>0.15</td>
<td>-0.17</td>
<td>-2.25**</td>
<td>0.22*</td>
<td>0.81</td>
<td>3.1</td>
<td>1.62</td>
<td>2.03</td>
</tr>
<tr>
<td>(2.48)</td>
<td>(-0.80)</td>
<td>(0.46)</td>
<td>(1.0)</td>
<td>(-1.84)</td>
<td>(-4.8)</td>
<td>(2.59)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.92**</td>
<td>-0.03</td>
<td>-0.14</td>
<td>-2.63**</td>
<td>0.22**</td>
<td>0.80</td>
<td>3.0</td>
<td>1.57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3.96)</td>
<td>(-0.17)</td>
<td>(1.73)</td>
<td>(-8.95)</td>
<td>(4.97)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.06*</td>
<td>0.14</td>
<td>0.15</td>
<td>-0.13</td>
<td>-2.19**</td>
<td>0.17*</td>
<td>0.80</td>
<td>3.07</td>
<td>1.61</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>(2.23)</td>
<td>(0.52)</td>
<td>(1.05)</td>
<td>(-1.47)</td>
<td>(-4.83)</td>
<td>(2.32)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: All regressions use OLS with a 4th order autoregressive lag on the Cochrane-Orcutt correction.

*Significant at the 95 percent level.

**Significant at the 99 percent level.
In our present formulation, all changes in foreign economic policy affect the exchange rate through the financial wealth variable via a recomposition of asset stocks, according to the portfolio balance theory. Since our theory is based on the assumption that a close relationship exists between the exchange rate and prices, we decided to re-run the exchange rate equation with the original transformations, i.e., \( (T-\delta) \) on the control variables but to substitute relative prices for domestic prices (in this case, the GNP deflator) and observe if the results would change significantly. We used the same set of weights as the effective exchange rate series (reproduced here in table 6) to weight the producer price index of each country and derive a composite foreign price index. The annualized growth rate of this index minus the annualized growth rate of the U.S. producer price index is used as the growth rate in relative prices. (The producer price indices were obtained from IFS). Our hypothesis is that, using these definitions, as relative prices grow at a positive rate, the growth rate of the exchange rate should increase, i.e., recall that the exchange rate is defined as the number of foreign currency units per unit of domestic currency.

With the original transformations performed on all variables (i.e., the same as table 3) we obtain the results in table 7. This table shows us that the price variable
TABLE 6
COUNTRY/CURRENCY WEIGHTS USED TO CONSTRUCT EFFECTIVE EXCHANGE RATE INDEX (BASE PERIOD MARCH, 1973)

<table>
<thead>
<tr>
<th>Country/Currency</th>
<th>Weight in Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany/deutsche mark</td>
<td>.208</td>
</tr>
<tr>
<td>Japan/yen</td>
<td>.136</td>
</tr>
<tr>
<td>France/franc</td>
<td>.131</td>
</tr>
<tr>
<td>U.K./pound</td>
<td>.119</td>
</tr>
<tr>
<td>Canada/dollar</td>
<td>.091</td>
</tr>
<tr>
<td>Italy/lira</td>
<td>.090</td>
</tr>
<tr>
<td>Netherlands/guilder</td>
<td>.083</td>
</tr>
<tr>
<td>Belgium/franc</td>
<td>.064</td>
</tr>
<tr>
<td>Sweden/krona</td>
<td>.042</td>
</tr>
<tr>
<td>Switzerland/franc</td>
<td>.036</td>
</tr>
<tr>
<td>Sum</td>
<td>1.000</td>
</tr>
</tbody>
</table>


which had not been significant before has now become highly significant. The "fit" of the equation has also improved. The negative coefficient of the relative price term may be due to a J-curve effect since the sign of this coefficient changes with the lag structure. Also, note that the financial wealth variable which had remained significant throughout all our previous experiments with the exchange rate equation has now become less-significant. One possible explanation of this is that a portfolio recomposition occurs in response to expected inflation rate differentials since the expected relative yields on assets will shift in favor of the country with the lower inflation rate. Once relative prices are entered as an
### Table 8

**Relative Prices Lagged One Period**

The Exchange Rate with the Growth Rate of

<table>
<thead>
<tr>
<th></th>
<th>1.89 n.a.</th>
<th>0.85 2.7</th>
<th>(1.87)</th>
<th>12.88**</th>
<th>(4.86)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.92) (-2.26)</td>
<td><strong>0.4</strong></td>
<td><strong>0.24</strong></td>
<td><strong>0.39</strong></td>
<td>-0.37</td>
<td></td>
</tr>
<tr>
<td>(3.73)</td>
<td><strong>0.13</strong></td>
<td><strong>0.2</strong></td>
<td><strong>0.3</strong></td>
<td><strong>0.2</strong></td>
<td><strong>0.2</strong></td>
</tr>
</tbody>
</table>

**Note:** n.a. = not applicable

### Table 7

**Rate of Relative Prices as an Explanatory Variable**

The Exchange Rate Equation with the Growth

<table>
<thead>
<tr>
<th></th>
<th>1.92 n.a.</th>
<th>0.85 2.7</th>
<th>(1.74)</th>
<th>0.39**</th>
<th>(3.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.88) (-2.36)</td>
<td><strong>0.27</strong></td>
<td><strong>0.2</strong></td>
<td><strong>0.37</strong></td>
<td><strong>0.3</strong></td>
<td><strong>0.3</strong></td>
</tr>
<tr>
<td>(3.29)</td>
<td><strong>0.22</strong></td>
<td><strong>0.2</strong></td>
<td><strong>0.2</strong></td>
<td><strong>0.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** p refers to the composite index of foreign prices.
TABLE 7
THE EXCHANGE RATE EQUATION WITH THE GROWTH RATE OF RELATIVE PRICES AS AN EXPLANATORY VARIABLE

<table>
<thead>
<tr>
<th>Constant</th>
<th>U(T-3)</th>
<th>P_f-P_d(T-3)</th>
<th>E(T-3)</th>
<th>DG(T-δ)</th>
<th>M(T-δ)</th>
<th>δ(T-δ)</th>
<th>R²</th>
<th>SEE</th>
<th>DW</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.4**</td>
<td>-0.44</td>
<td>-0.93**</td>
<td>0.54**</td>
<td>0.06</td>
<td>-2.39**</td>
<td>-2.39**</td>
<td>0.87</td>
<td>2.52</td>
<td>1.99</td>
<td>0.004</td>
</tr>
<tr>
<td>(3.89)</td>
<td>(-0.56)</td>
<td>(-3.68)</td>
<td>(3.99)</td>
<td>(0.44)</td>
<td>(-7.28)</td>
<td>(-7.28)</td>
<td>(1.67)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: P_f refers to the composite index of foreign prices.

TABLE 8
THE EXCHANGE RATE WITH THE GROWTH RATE OF RELATIVE PRICES LAGGED ONE PERIOD

<table>
<thead>
<tr>
<th>Constant</th>
<th>U(T-1)</th>
<th>P_f-P_d(T-1)</th>
<th>E(T-1)</th>
<th>DG(T-1)</th>
<th>M(T-1)</th>
<th>γ(T-1)</th>
<th>R²</th>
<th>SEE</th>
<th>DW</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.22**</td>
<td>-0.33</td>
<td>0.37</td>
<td>-0.20</td>
<td>-0.27*</td>
<td>-3.21**</td>
<td>0.27**</td>
<td>0.85</td>
<td>2.7</td>
<td>1.92</td>
<td>n.a.</td>
</tr>
<tr>
<td>(3.2)</td>
<td>(-0.59)</td>
<td>(1.74)</td>
<td>(-0.88)</td>
<td>(-2.36)</td>
<td>(-5.41)</td>
<td>(3.29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.88**</td>
<td>0.39</td>
<td>-0.21</td>
<td>-0.25*</td>
<td>-3.13**</td>
<td>0.24**</td>
<td>0.85</td>
<td>2.7</td>
<td>1.89</td>
<td>n.a.</td>
<td></td>
</tr>
<tr>
<td>(4.86)</td>
<td>(1.87)</td>
<td>(-0.93)</td>
<td>(-2.26)</td>
<td>(-5.52)</td>
<td>(3.73)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: n.a.—not applicable
explanatory variable, the inflation effects are captured in the price differential term as opposed to the financial wealth term.

The results in table 8 indicate that the relative price term influences the exchange rate in a positive fashion in the very short-run, although it is not significant. Furthermore, the financial wealth term has once again become significant. This may indicate that the exchange rate is determined purely in the asset markets in this time frame, i.e., the forces which may influence the exchange rate through the current account cannot operate within one year.

Interpreting the Results

In this segment we attempt to provide an economic rationale for our econometric results. Some coefficients in the unemployment and exchange rate equations in table 3 were not what theory dictates they should be: in particular, the price and government purchases variable coefficients in the unemployment equation are positive and significant at the 99 percent level. But how can increases in government purchases over the last few years lead to higher unemployment in the current period? Or, how can an increase in the annualized growth rate in prices three quarters earlier lead to higher unemployment in the current quarter? Experimenting with lags and the functional form of the
unemployment rate equation led to some very interesting results. Readers must be cautioned that significant positive 1st order serial correlation was found in these results, using the h-test. Our conclusion is that, given the functional form specified in table 3, changes in government purchases influenced the unemployment rate through the growth rate in prices. When the lag on the growth rate of prices is decreased, the government purchases variable becomes insignificant but remains positive. When the lag on the growth rate of prices is eliminated, the government purchases term becomes negative, as theory dictates, but is not significant at the 95 percent level. Through all experiments with the lag on the growth rate of $P$, and even without the lag, the coefficient on $P$ remained positive and significant at the 99 percent level, thereby indicating that higher growth rates of the price level are associated with higher rates of unemployment. When $P$ is eliminated from the unemployment equation, the $R^2$ declines significantly (down from the 90 percent range to the 70 percent range) and the government purchases coefficient remains negative, although insignificant. Therefore, in our model, (table 3) an increase in government purchases first influences the growth rate in prices via aggregate demand, and through prices, affects the rate of unemployment. A word of caution is in order: it is obvious that multicollinearity is present here.
Since this may lead to biased t-statistics, the insignificance of the coefficient of the DG variable (in our experiments, not shown here in tabular form) should be treated with skepticism. It is only when the lag in P is reduced or eliminated that government purchases directly influences the rate of unemployment. When a lagged growth rate of prices is present, this direct influence is more than offset by the indirect influence through the growth rate of prices. Also, note that the government purchases variable is highly significant in the price equation. This type of reasoning will be useful once again, when the steady-state properties are discussed. In summary, a positive and highly significant relationship is found between the growth rate of prices and the rate of unemployment. But when this relationship is reversed, we find a negative relationship between the annualized growth rate of prices and the unemployment rate three quarters ago. The latter relationship, however, is not significant at the 95 percent level.

It is interesting to note that we hypothesized a similar relationship between the growth rate of prices and the rate of unemployment when we described what could be the 'symptoms' phase of the adjustment path. Recall that we said the exchange rate induced inflation will lead to higher rates of unemployment and lower real output when expectations are being re-adjusted for a higher rate of inflation.

---

The direct relationship between the exchange rate and the unemployment rate is an interesting one. Table 3 tells us that an increased growth rate of the exchange rate influences the unemployment rate positively while (lagged) higher rates of unemployment will lead to a depreciating exchange rate. Hence, an asymmetry between the influence of the exchange rate changes on the rate of unemployment (which is significant at the 99 percent level) and the unemployment rate's influence on the exchange rate (which is not significant). This finding also leads in the direction of vicious circle symptoms since we hypothesize that, in the short-run, as expectations are being re-adjusted higher unemployment rates, interest rates and lower real output can prevail domestically while the exchange rate will be depreciating. Other than this, the signs of the coefficients are as expected. We find that the rate of unemployment influences prices negatively (as stated earlier) thereby confirming that as the rate of unemployment increases the growth rate of prices decreases (e.g., Phillips Curve relationship). Curiously enough, the growth rate of the money stock and the growth rate of financial wealth are not significant in the price equation. The possibility of multicollinearity between these two variables does exist, since the growth rate of the money stock will, via the interest rate, influence the growth rate of financial wealth. In fact, when financial wealth is excluded from the price
equation, the coefficient on the money stock term turns negative! Although this coefficient is very small and insignificant it indicates that U.S. claims on foreigners may increase due to the monetary expansion and this might have a negative impact on the base money supply. By eliminating the money variable and rerunning this equation, we observe that financial wealth, with a negative coefficient, becomes significant at the 95 percent level, i.e., the growth in financial wealth has a damped effect on the growth rate of prices when M is excluded from the price equation.

The three control variables we have used DG, M and \( \gamma \) are all significant in the Unemployment and Exchange Rate equations while only the DG (government purchases) variable is significant in the Price equation. The influence of the less-significant control variables on the price equation has already been discussed. The particular lag structure used by Stein and us suits the purpose well: the results indicate that the state variables respond rather slowly to changes in policy.\(^1\) However, the purpose of the three quarter moving averages is to permit the state variables to respond completely to policy changes instead of shifting over entirely to the next observation (and perhaps a switch in policy). The lagged endogenous variables have

not fared so well. For example, in the exchange rate equation it seems pointless to include a three period lagged exchange rate as an explanatory variable under generalized floating, when exchange rates are so volatile. Also, it is difficult to see how unemployment three quarters ago could directly influence the growth rate of the exchange rate. Despite these pitfalls, the results are quite good. The three quarter lag and three quarter moving average model does have empirical merit, as demonstrated by these results.

After all this experimentation, we have to pick one model to work with hereafter. Since most of the experiments were conducted on the exchange rate equation, the choices in picking the "right" model boils down to one of choosing an exchange rate equation which has the same (referring to the U(T) and P(T) equations) set of transformations performed on the three control variables and differs only in the specific lags used on the state variables. However, the specification which is most theoretically consistent with the formal model is presented in table 3. Therefore, we use that model (and coefficients) as a point of departure for our stability analysis work and the derivation of steady-state properties included in this chapter and the simulation experiments of the next chapter.
Stability Analysis

Table 3 can be presented in matrix form as follows:

\[
\begin{bmatrix}
U(T) - 1.58 \\
P(T) - 1.34 \\
E(T) - 17.16
\end{bmatrix} =
\begin{bmatrix}
0.65 & 0.35 & 0.07 \\
-0.21 & 0.86 & -0.04 \\
-0.18 & -0.36 & -0.16
\end{bmatrix}
\begin{bmatrix}
U(T-3) \\
P(T-3) \\
E(T-3)
\end{bmatrix} +
\begin{bmatrix}
0.05 & -0.18 & -0.04 \\
0.34 & 0.21 & 0.04 \\
-0.22 & -3.34 & 0.31
\end{bmatrix}
\begin{bmatrix}
\gamma(T-\delta) \\
\gamma(T-\delta) \\
\gamma(T-\delta)
\end{bmatrix}
\]

What is of importance to us in equation 18 is the coefficient matrix of the lagged state variables: we will call this matrix \( A \).

By inspecting matrix \( A \), we can immediately write down its characteristic determinant as the following:

\[
|A| =
\begin{bmatrix}
(0.65 - \lambda) & 0.35 & 0.07 \\
-0.21 & (0.86 - \lambda) & -0.04 \\
-0.18 & -0.36 & (-0.16 - \lambda)
\end{bmatrix}
\]

After some tedious manipulation, we are able to determine the characteristic equation for \( |A| \), which is as follows:

\[-\lambda^3 + 1.35\lambda^2 - 0.39\lambda - 0.093 = 0\]

From this equation, we are now able to determine the roots \( \lambda_1, \lambda_2, \lambda_3 \) with the help of a computer. They are,
The stability condition for the distinct real root is that $|\lambda_1| < 1$. $\lambda_1$ does satisfy this condition. For roots $\lambda_2, \lambda_3$ which are complex, we have,

$$M = \sqrt{(0.75)^2 + (0.23)^2} = 0.78$$

Stability (damped oscillations) requires that $|M| < 1$, and in the present case this requirement is satisfied. We therefore conclude that the estimated coefficients presented in table 3 will lead to stable results.

The Steady-State Solution

Based on some of the behavioral characteristics we attribute to the model in a previous chapter, we can derive a set of steady-state solutions for our estimated model (equation 18), restated here for convenience as equations 19, 20 and 21.

$$U(T) = 1.58 + 0.65U(T-3) + 0.35P(T-3) + 0.07E(T-3) + 0.05DG(T-6) - 0.18M(T-\delta) - 0.4\gamma(T-\delta)$$  (19)

$$P(T) = 1.34 - 0.21U(T-3) + 0.86P(T-3) - 0.04E(T-3) + 0.34DG(T-6) + 0.21M(T-\delta) + 0.04\gamma(T-\delta)$$  (20)

$$E(T) = 17.16 - 0.18U(T-3) - 0.36P(T-3) - 0.16E(T-3) - 0.22DG(T-6) - 3.34M(T-\delta) + 0.31\gamma(T-\delta)$$  (21)

Before we begin, the reader should remember that the state we call "steady-state" is a device which has been concocted for analytical convenience and that some of the assumptions on which it is based are rather unrealistic.

Furthermore, some of the results we obtain may be different from the outcome of the short-run estimated equations (e.g., signs of the coefficients may change) and we may be hard pressed for a sound economic rationale for such behavior. Even Stein raised serious doubts about his own work on the steady-state and was forced to curtail some of his comments.\textsuperscript{12}

With this caveat in mind, we now present the steady-state assumptions on which these results are based. They are as follows:

\begin{align*}
U(T) &= U(T-3) = \overline{U} = U_e \quad (i) \\
DG(T) &= DG(T-3) = DG(T-\delta) = 0 \quad (ii) \\
P(T) &= P(T-3) = P_e \quad (iii) \\
E(T) &= E(T-3) = E_e \quad (iv) \\
M(T) &= M(T-3) = M(T-\delta) = M_e \quad (v) \\
\gamma(T) &= \gamma(T-3) = \gamma(T-\delta) = \gamma_e \quad (vi) \\
\end{align*}

The subscript "e" must not be confused with the exchange rate: it implies 'equilibrium' or steady-state value of the variable in question. Condition (i) tells us that the long run rate of unemployment will be equal to the natural rate of unemployment, denoted here by $U_e$. We assume it is constant over the 1970s, the period for which the model was estimated. Condition (ii) claims that real government purchases per unit of capital will be constant so that the change in this variable will be zero, i.e., $DG=0$. (This implies that changes in the real government debt held by

\textsuperscript{12}Stein, "Black Box," p. 218.
the private sector must also be zero.) The steady-state growth rate of prices will be determined independently by the long-run equilibrium growth rates of the control inputs $M_e$ and $\gamma_e$. However, through the financial wealth variable, monetary policies followed by foreign nations will influence the steady-state growth rate of domestic prices. A similar argument applies to the steady-state growth rate of the effective exchange rate variable. It will be influenced by the growth rates of relative money stocks, which influence the composition of financial wealth. The equilibrium growth rate of the money stock is a control input and is determined exogenously. So is financial wealth. In a closed economy, it is possible to assume that these two variables grow at the same rate, but it is impossible to do so in an open economy.

Also, note that many of the properties identified in conditions (i)-(vi) are inconsistent with the steady-state properties set forth when the theoretical model was presented. Notable amongst these are the steady-state properties of the growth rate of prices and financial wealth. These are some of the compromises we had to make in order to create a model amenable to empirical work. The reasons will become clear when we discuss the steady-state properties later on. Given the conditions (i)-(vi) and equations 19, 20 and 21, after much tedious manipulation, we arrive at the steady-state solutions for $U$, $P$ and $E$, with $M_e$ and $\gamma_e$ as control inputs.
In equations 22-24, the constant terms can be easily explained by setting $M_g = Y_g = 0$. The constant term in equation 22 is our model's estimate of the natural rate of unemployment for the U.S. in the 1970s. A rate of 5.2 percent sounds reasonable and is consistent with other estimates for this rate. The constant term of equation 24 is the average annualized rate of appreciation of the U.S. dollar in the steady state. The explanation is fairly simple. Our empirical work (as well as the steady-state solution) suggests that the exchange rate is highly sensitive to growth in the money stock, $M$. When the latter is constrained to zero, the exchange rate will be influenced by the money supply growth rates of the partner countries which form the basis for an exchange rate index (see table 6). Specifically, their currencies will depreciate vis-a-vis the U.S. dollar and hence, our results suggest that the effective exchange rate will appreciate at an annual rate of 14.6 percent. This explanation leads to a declining growth rate of prices in the absence of monetary growth. The appreciating exchange rate and zero monetary growth rate indicate that imported goods will be cheaper and that excess demand for goods and services will be zero. All this will have a dampening impact on prices. These

---

results also challenge the widely held belief that the U.S. is a relatively closed economy. The transmission mechanism from the exchange rate into prices (proxied here by the GNP deflator) in the long-run seems to behave here as it would in any relatively open economy. It remains to be seen what would happen if the reverse sequence occurred (i.e., if the constant term in the steady-state exchange rate equation were negative, what would be the growth rate of prices? What would be the import substitution effect, if any?) Of course, one should note by the magnitude of the M coefficients of both the $P_e$ and $E_e$ equations (23, 24) that if $M_e$ began to grow at a positive rate, the impact of the constant terms would disappear and $P_e$ will begin to rise and $E_e$ will start to depreciate. It also means that, holding financial wealth constant, the domestic money stock should be growing at an average annual rate of 4.2 percent in order to keep the exchange rate constant: this will lead to an equilibrium growth rate of prices of about 5 percent per annum, while the natural rate of unemployment will hover around 7.2 percent. These estimates seem quite realistic for the U.S.

During a discussion of the steady-state properties of the financial wealth variable in the theoretical model, we mentioned that it was one of the more troublesome aspects of our model. The time has come to take a closer look at this variable and describe its behavior in the context of
our model. Table 9 helps us identify its components and make some projections about the impact of a change in one (or more) of these components on the growth rate of the exchange rate. Once again, we assume that official reserves are maintained for the sole purpose of exchange rate intervention. Table 9 has been constructed by running regressions on each of the components of financial wealth against the exchange rate. (With a 4th order autoregressive lag, 1st order serial correlation was not a problem here; the D-W ranged from 1.8 to 2.0.)

TABLE 9

PROBABLE INTERMEDIATE AND SHORT TERM IMPACTS OF AN INCREASE IN INDIVIDUAL COMPONENTS OF FINANCIAL WEALTH ON THE EXCHANGE RATE

<table>
<thead>
<tr>
<th>Components of Total Financial Wealth</th>
<th>Exchange Rate</th>
<th>Short Term</th>
<th>Intermediate Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Debt</td>
<td>+</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>Total Claims on Foreigners</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Total Liabilities to Foreigners</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

NOTE:  + appreciation  
       - depreciation  
       ? indeterminate

The table can be interpreted as follows: increased government debt will, in the short run, lead to higher
interest rates and via the asset market theory, lead to an appreciating exchange rate. In the intermediate to long-run, it will increase government purchases and dampen the appreciation. Hence, it is not possible to determine a priori which forces will predominate. The results from this regression indicate that the coefficient is small and insignificant. An increase in the claims on foreigners will appreciate the exchange rate via the current account. This is also consistent with the theoretical literature which has the current account playing an increasingly larger role in models of exchange rate determination.\textsuperscript{14} As claims on foreigners increase, remittances back to the U.S. in terms of repatriated profits and interest earnings also increase. This affects the 'factor services income' account of the current account and thereby leads to an appreciation of the exchange rate. The regression coefficient was large (greater than 1) and highly significant, lending further support to the theoretical literature. The coefficient on the liabilities to foreigners was also large and significant: it had a negative sign, indicating that this was an outpayment in the current account balance and would depreciate the exchange rate. To re-capitulate, our definition of the total financial wealth variable used the following identity:

\[ \text{Total Financial Wealth} = \text{Government Debt} + \text{Total Claims on Foreigners} - \text{Total Liabilities to Foreigners} \]  

\textsuperscript{14}Dornbusch, \textit{Open Economy Macroeconomics}, chap. 13.
Since the forces which tended to appreciate the exchange rate in this definition predominated, it becomes clear why we always obtained a positive coefficient for financial wealth in the exchange rate equation.

It is interesting to note that the coefficient of the $M_e$ variable in the steady-state exchange rate equation (equation 24) is slightly larger than the estimated coefficient for this variable in the short-run exchange rate equation. Thus, we can conclude that the growth rate of the exchange rate is very sensitive to the growth rate of $M_1$ in the long run and short run. This bit of empiricism stands up as evidence for the body of literature which advocates assigning monetary policy for external balance and is quite important from the standpoint of policy formulation.  

Our final task is to explain why a high rate of monetary growth and/or financial wealth can raise the natural rate of unemployment in the long-run (see equation 22). Conventional wisdom dictates that an increase in either of these variables should decrease the rate of unemployment in the short run. This is confirmed by the results presented in table 3. What is also revealed in

---

the unemployment rate equation of table 3 is a positive relationship between the lagged growth rate in prices and the rate of unemployment. We explained earlier how this occurred and why it was consistent with our original hypothesis. Since we are now dealing with the steady-state relationships, it is easily seen that an increase in the growth rate of the money stock will increase the growth rate of prices. This, in turn, will tend to increase the natural rate of unemployment. Similar reasoning applies to financial wealth: we hypothesize that its positive relationship to the equilibrium growth rate of prices also affects the natural rate of unemployment. The former relationship was explained at length in an earlier paragraph. The empirical evidence on the relationship between unemployment and prices was also discussed earlier. Therefore, all the long-run relationships have now been explained.

Our next chapter will be dedicated to the simulation experiments using the model presented in table 3.
CHAPTER V

SIMULATION EXPERIMENTS

Methodology of Simulation

This chapter lays out the results of our simulation experiments. Using the model presented in table 3 (chapter IV), the format used will be to first simulate the model with actual data over the estimation period in order to determine how well it 'tracks' the actual observations. Then, the growth rate of the money supply will be raised by a small margin in order to determine how the three state variables will respond to this exogenous shock. Also, note that the model was not constructed for forecasting purposes and therefore no attempt will be made to do so.

Recall that our initial hypothesis was to determine if an economy adjusting from one steady state to another in response to an exogenous shock could display vicious circle symptoms during a particular phase of the adjustment path. We use the steady state conditions discussed earlier in this dissertation to define an initial steady state situation. After ensuring that a steady-state growth path is simulated by the model, we will increase the growth rate of the money supply in order to determine the dynamic
path of adjustment of the model. Our hypothesis is that this path should display a vicious circle phase. In the process, we will also pay some attention to the stability properties of the model (since it was shown to be stable in the previous chapter), although this is only a peripheral issue right now.

Remember once again that $U(T)$ is the unemployment rate in quarter $T$; $P(T)$ and $E(T)$ represent the average annualized growth rates of the GNP deflator and the (multilateral) effective exchange rate, respectively. The simulations were performed for the period 1971:4 through 1979:4.

The program which performed the simulations was assigned the values of the control variables for the entire time span as control inputs, along with the actual values of $U$, $P$ and $E$ for the period 1971:1 to 1971:3 (in order to accommodate the T-3 lag in the right hand side of the equations). In the succeeding iterations the simulated values of $U$, $P$ and $E$ are substituted in to obtain the current values. The simulated values, plotted against the actual values are presented in figure 5, 6 and 7.

Like most other simulation models, the present model has difficulty tracking the turning points, particularly where the actual series was subject to sudden, sharp erratic fluctuations, e.g., the effective exchange rate series. However, the unemployment and price series (in that order) diagrams indicate that the simulation tracks the original
Figure 5. Actual and Simulated Values of the Unemployment Rate.

Unemployment Rate (Percent of the Civilian Labor Force)

actual
simulated

RMS Error = 0.60
Figure 6: Actual and Simulated Values of Prices.

RMS Error = 0.64

Annualized Growth Rate of the GNP Deflator

Actual values
Simulated values

3.89
5.58
7.26
8.94
10.62
12.30
12.38
Figure 7: Actual and Simulated Values of the Exchange Rate.

RMS Error = 4.21

Annualized Growth Rate of the Effective Exchange Rate
data quite well. Also, remember that the actual P and U series are not seasonally adjusted.

Our poorest simulation results were obtained (as expected) with the effective exchange rate series (figure 7). The 1970s was a decade of turmoil in the foreign exchange markets. Among the significant developments here were the de facto float introduced by President Nixon in the Summer of 1972, the resulting Smithsonian Conference which re-affirmed fixed rates and the chaos that followed, which ultimately led to the Jamaica Conference which legitimized floating exchange rates. The oil price shocks followed in 1974 and further price hikes were announced in the late 1970s. While exacerbating the rate of inflation over the long-run, these price hikes should also have helped appreciate the dollar in the short-run since it is used as the numeraire in oil transactions. Of course, events overseas, expectational factors, exchange rate management and political developments also effect this rate. But it is not possible to model all of this. While economic events overseas and rate management have been captured in reduced form through our definition of financial wealth, a better specification which accounts for price and income differentials, etc., may have been able to perform more accurately in tracking the series. Since so many domestic and foreign factors influence the exchange rate, we will not even attempt to unravel the mysteries behind the sudden,
sharp fluctuations in the actual series, other than to say that they cannot be explained in terms of domestic events per se. However, it is easier to explain movements in the growth rate of prices and the rate of unemployment.

Looking at figure 6, (growth rate of P) we know that during the early part of the 1970s, wage-price controls were in force and that the growth rate of prices may have been curtailed by that. The model's prediction for this period accounts for the controls in a very indirect fashion, since it was estimated over this period; but a divergence between the simulated and actual rates should be expected. The impact of wage-price decontrols and the oil price hikes are captured well by the simulation runs, and so are their aftermaths. The unemployment rate equation also performs well by the same criteria; the short, sharp fluctuations observed in the actual series can be attributed to the fact that we are using seasonally unadjusted data. By contrast, the simulated series seems to be much smoother, with the trend captured through the entire time span. The RMS errors shown at the bottom of each diagram basically confirms what we can observe by inspecting figures 5 through 7.¹

Figure 8 shows the simulated values of all three variables (U, P and E) superimposed on one diagram. The interesting thing to note about this diagram is that the vicious circle symptoms phase, which we hypothesized is displayed in 1979 by our simulations of the actual adjustment path, i.e., not adjusting from one steady-state to another. Inspection of the diagram reveals the following: a rising rate of unemployment, from 4.9% in 1971:1 to 5.6 percent in 1971:4; a constant growth rate of prices of about 8 percent per annum during the first three quarters and increasing thereafter, and also a depreciating effective exchange rate, although the rate of depreciation is rapidly diminishing. The latter may be due to the dollar rescue plan initiated by the Administration, reductions in oil imports and an increased demand for U.S. dollars by other nations to pay for their oil imports in response to the 1979 round of price hikes. Although prices have remained relatively constant in the first three quarters of 1979 compared to the corresponding quarters a year ago, the results also show that they had been rising steadily from the 1976-77 period, with a particularly sharp increase from 1977:4 to 1978:4. Since expectations were assumed to be formed adaptively, it follows that the brief respite from higher growth rates means nothing in terms of expectations being re-adjusted for a higher growth rate of prices. This also implies that nominal interest rates will be rising
Figure 8: Simulated Values of the Unemployment Rate, Prices and the Exchange Rate.
and real output will be declining. This is exactly what happened: all through 1979 interest rates increased and peaked in the Summer of 1980 while real output (proxied by us with the IFS industrial production index) declined from an annualized growth rate of 8.1 percent in 1979:1 to 1.0 percent in 1979:4.\(^2\) As stated earlier, the rapid rate of depreciation of the exchange rate may have been halted by the dollar rescue plan and the oil price hikes, but on its own, it may have continued to depreciate at a rapid rate. Therefore, we conclude that an economy can actually display vicious circle symptoms. It is interesting to note the behavior of M1 at some time prior to this phase. The highest annualized growth rate of M1 during the decade was observed during the period 1977:3 to 1978:3, when the rate exceeded 8 percent. To be sure, this is a far cry from the double digit rates of Italy and the U.K. in the early 1970s; but it would have been a factor contributing to higher growth rates of prices and the exchange rate in 1979. This is consistent with our empirical results. What is also consistent with these results is that higher growth rates in prices are associated positively with unemployment rates, thereby leading to the

symptoms discussed by us. Therefore, it is a foregone conclusion that if monetary growth rates were raised still higher, the same symptoms must appear in the adjustment process. Nevertheless, we will perform such an experiment and report on the results.

The Monetary Shock

The average annual growth rate of M1 for 1969-79 was 6 percent. For the period 1975-79 this rate increased to 7.1 percent. If we assumed that 6 percent is the steady-state growth rate of M1, we can introduce an increase in the growth rate at some point in time and observe what happens to the time paths of the three variables. We chose (somewhat arbitrarily) to increase M by a small margin of 0.12 percent in 1975:1 and observe what happened to the system. The result, with the time paths of all three variables superimposed on one another is shown in figure 9. The individual time paths taken by U, P and E in response to the shock are shown in figure 10, 11 and 12, respectively.

The results are interesting: they show that the exchange rate is the quickest to respond to the shock, followed by employment and then prices. In fact, prices do not respond at all until 1975:3 (see figure 11) and even then, the difference is imperceptible until 1976:2. A gradually diverging time path is seen from then on, with the annualized growth rate of prices well above the simulated
Figure 9: Simulated Values of Unemployment, Prices and the Exchange Rate With a 0.12% Increase in the Growth Rate of M_1 Introduced in 1975:1.
Figure 10. Pattern of dynamic adjustment of U in response to a 0.12% increase in the growth rate of M1 starting 1975:1.
Figure 11. Pattern of dynamic adjustment of P in response to a 0.12% increase in the growth rate of M1 starting 1975:1.
Figure 12. Pattern of dynamic adjustment of E in response to a 0.12% increase in the growth rate of M1 starting 1975:1.
rate prevailing without the shock. The divergence seems particularly pronounced starting in 1979:1.

By contrast, the unemployment rate and the exchange rate respond almost immediately. Starting in 1975:2, the unemployment rate is lower (see figure 10) with marked divergences between the actual simulated rate and the response to the shock being displayed at the turning points. However, as opposed to both the exchange rate and price series (figures 12 and 11, respectively) the unemployment series seems to be converging back to its original simulated series by 1979:4.

The exchange rate (figure 12) responds immediately (1975:1) to the shock. Again, the biggest divergences between the original (simulated) series and the newly constructed (in response to the shock) series are at the turning points. Like the price series, figure 12 indicates that by 1979:4 the exchange rate may be diverging from its original (simulated) series. All this is consistent with the steady-state properties we laid out earlier, since we expect prices to grow at a higher steady-state rate and the exchange rate to be depreciating at a higher rate in response to this shock.

Furthermore, these results show that the earlier Dornbusch assumption of asset market prices adjusting faster than goods market prices is consistent, since we assume that the exchange rate is determined in the asset
markets in the short-run. What is surprising is the rapid rate at which the labor market (proxied by the unemployment rate) begins to adjust to this shock. Since a "significant" response is not elicited from prices until 1976:2, one can assume that two major forces are at work on prices. The first includes the classic excess demand conditions with the unemployment rate and interest rate heading down in response to the shock. The second stems from the additional pressure on prices due to a rapidly depreciating exchange rate.

The different speeds of response of each market, i.e., labor, goods and foreign exchange tell us something about monetary policy in general. Assuming that the growth rate of the money supply is under the control of the monetary authorities in the short-run, it can be used as a "quick-fix" for the unemployment woes of a nation, provided the lagged response of prices can be dealt with in the same way. It would also be interesting to determine how the three state variables respond to an exogenous increase in government expenditure.

The results of figure 10, 11 and 12 are superimposed on one diagram and reproduced as figure 9. In contrast, to figure 8, it shows higher growth rates of prices and the exchange rate and a lower rate of unemployment. The time paths followed by the variables are similar to the previous results (see figure 8) with the differences

---

3Dornbusch, "Expectations and Exchange Rate Dynamics," p. 1161.
stemming from the magnitude of the growth rates. Also, the vicious circle symptoms which appear in 1979 are much more pronounced than before, i.e., prices grow faster, the exchange rate depreciates more rapidly at a given point in time (although its trend is still depreciating at a slower rate) and the unemployment rate has begun to rise after hitting a low of 4.7 percent in 1979:1, while without the stimulus, the low was 4.9 percent. Similarly, the GNP deflator grew at a constant rate of about 9.5 percent in the second and third quarters of 1979 while the corresponding rate without the stimulus was about 8.0 percent. We could easily experiment with different growth rates of M, but in each case, the results will be quite predictable since the time path will be the same with different growth rates of prices and the exchange rate, and lower or higher unemployment, depending on whether M is raised or lowered.

Another issue pertaining to these results is why we chose 1979 as exhibiting vicious circle symptoms when some earlier periods have also displayed the same symptoms (e.g., 1973:3 to 1974:4). The answer is that the oil price shocks were in the process of having an impact on the economy, as witnessed by the meteoric rise in the growth rate of prices and is therefore not a proper time to check for these symptoms. Prior to that period, the transition from fixed to floating exchange rates and the
decontrol of wages and prices was taking place and that too was an inopportune moment to check for vicious circle symptoms. This leaves 1979 as the period when these shocks were displayed without a significant external shock.

A Monetary Shock to the Steady-State

Recall that our fundamental hypothesis centers on the ability of an economy adjusting from one steady-state to another displaying vicious circle symptoms in the short run. In the process, we defined the characteristics which we believe are symptomatic of vicious circles. In order to test for this possibility in our model, we must first bring the system to a steady-state. We have assumed in a previous section that M1 grew at a 6 percent annual rate. Similarly, total financial wealth in the 1970s grew at 2.04 percent. We assume that this is the steady-state growth rate for this variable. By an earlier assumption, DG=0. By substituting these values into the steady-state equations 22-24, we obtain estimates of 8.26 percent, 8.38 percent and -5.73 percent for $U_e$, $P_e$ and $E_e$, respectively. By specifying the lagged values of $U$, $P$ and $E$ to be the estimates made above, and also using the steady-state assumptions made in this paragraph about the control inputs, we can re-simulate our model in order to determine its estimates of the steady-state values for $U$, $P$ and $E$. The variables denoted "S.S." of table 10 summarize these
### Table 10

**STEADY-STATE VALUES OF UNEMPLOYMENT, PRICES AND THE EXCHANGE RATE WITH AND WITHOUT THE MONETARY SHOCK**

<table>
<thead>
<tr>
<th>Unemployment</th>
<th>S.S.</th>
<th>W.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>S.S.</td>
<td>W.S.</td>
</tr>
<tr>
<td>Exchange Rate</td>
<td>S.S.</td>
<td>W.S.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>S.S. Unemployment</th>
<th>W.S. Unemployment</th>
<th>S.S. Prices</th>
<th>W.S. Prices</th>
<th>S.S. Exchange Rate</th>
<th>W.S. Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>+8.32</td>
<td>+8.32</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.62</td>
<td>+5.62</td>
</tr>
<tr>
<td>1972</td>
<td>+8.34</td>
<td>+8.34</td>
<td>+8.35</td>
<td>+8.35</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1973</td>
<td>+8.37</td>
<td>+8.37</td>
<td>+8.37</td>
<td>+8.37</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1974</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1975</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1976</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1977</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1978</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1979</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1980</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1981</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1982</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1983</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1984</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1985</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
<tr>
<td>1986</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+8.38</td>
<td>+5.63</td>
<td>+5.63</td>
</tr>
</tbody>
</table>

a. S.S.: steady-state simulation
results. They indicate that the model's estimates are 8.3 percent for the (natural) rate of unemployment, 8.3 percent for the growth rate of prices and a 5.8 percent rate of depreciation for the exchange rate. The slight discrepancies between our estimates from equations 22-24 and the model's simulated estimates can be attributed to rounding errors.

We now increase the growth rate of M very slightly from 6 percent to 6.72 percent in 1975:1 and see what happens to the system. This constitutes a departure from the steady-state. Although both DG and \( \gamma \) are free to deviate from their steady-state values, we assume for simplicity that they do not vary. Looking at table 10, the columns denoted "W.S." compared to columns "S.S." show how the state variables respond to the shock opposite their respective steady-state growth paths. Our tests showed that the system did not converge by 1979:4 and therefore we extended the simulation runs through 1985:4. But one must remember that convergence is not an issue here since the stability analysis performed on this model led us to stable results. Thus, we assume that it will ultimately converge to a sustainable equilibrium. The dynamic adjustment paths of each variable \( U, P \) and \( E \) in response to the 1975:1 shock are traced out in figures 13, 14 and 15. The results seem to show that the exchange rate and unemployment rate seems to have reached their new steady-state
Figure 13. Pattern of dynamic adjustment of the unemployment rate in response to a shock to the steady-state.
Figure 14. Pattern of dynamic adjustment of prices in response to a shock to the steady-state.
Figure 15. Pattern of dynamic adjustment of exchange rate in response to a shock to the steady-state.
values by 1984:2 while the growth rate of prices reached
this stage by 1981:4. One last note on this: when a
monetary growth rate of 6.72 percent is substituted into
our steady-state equations (equations 22-24) with the
previously mentioned 2.04 percent growth rate of financial
wealth, we obtain estimates of 8.6 percent for the natural
rate of unemployment, 9.6 percent for the equilibrium
growth rate of prices and a -8.2 percent rate for the
exchange rate. These values are consistent with the
simulated values for U, P and E for the mid 1980s, which
were 8.7 percent, 9.6 percent and -8.3 percent, respectively.
This leads us to conclude that the new steady-state may
have been reached by this time. Also, note that our steady-
state properties imply that a permanent increase in the
growth rate of the money supply will cause the steady-state
growth rate of prices to exacerbate and the exchange rate
to depreciate at a faster rate. Our empirical and simula-
tion results indicate that we were wrong in assuming,
as we did in the theoretical model, that the natural rate
of unemployment would be constant over one steady-state
period. But figure 16 indicates that almost a decade goes
by before all three state variables converge (to their
steady-states), e.g., 1975:1 to 1984:2 and therefore it
is quite reasonable that the natural rate of unemployment
shifts over the period.
Figure 16. Adjustment paths of unemployment, prices and the exchange rate in response to a 0.12% monetary shock to the steady-state.
The adjustment paths of all three variables in response to the shock are superimposed on one diagram and reproduced as figure 16. The vicious circle 'symptoms phase' of adjustment, which we hypothesized would lead to a depreciating exchange rate, rising levels of unemployment and a rising growth rate of prices is clearly displayed during the period 1977:2 to 1981:1, after which the change in the rate of depreciation of the exchange rate and the change in the growth rate of prices clearly abate. Two other comments are in order: first, an eight quarter lag appears between the time the monetary shock is introduced and the start of the vicious circle phase, i.e., 1975:1 to 1977:2. Secondly, this phase occurs just before the time when the system seems to be heading back towards its steady-state growth path. These findings are consistent with the dynamics envisaged by our theoretical model (see figure 4, chapter III). What is surprising about our results is the length of time through which the vicious circle phase persists;

4It is interesting to note the implications of our results for the Global Monetarist Hypothesis. The latter implies that real variables are not affected and that money is neutral in the long-run. By contrast, our results indicate that since the unemployment rate has increased in the new steady-state, real output per unit of capital must also be lower; therefore, real variables are affected and money is not neutral in the long-run. Also, the adjustment process they envisage implicitly assumes rational expectations and is much shorter than the nine years required by our system to adjust to the new steady-state.
from 1977:2 to 1981:1. It is of course hoped that any government faced with such an adjustment path will use discretionary policies to change it! Another point worth noting is the precipitous decline (depreciation) of the exchange rate in response to the shock: after reaching a low (depreciation rate of about 8 percent), the rate of depreciation declines and reaches a peak in 1976:3) (depreciation rate of about 7.5%) before approaching its new steady-state growth path. The latter rate is about 8.4 percent. The sudden sharp response of the exchange rate (to the monetary shock) also adds credence to Dornbusch's hypothesis of exchange rates overshooting in the short run.5

Finally, we tackle the issue of increasing the growth rate of M well above the 0.72 percent which we used thus far. As stated during our simulation exercises with the actual data, the time paths traced will be similar to the smaller shock but the magnitudes of the growth rates and the unemployment rate will be higher. We experiment with this by increasing the growth rate of M by 6 percent above the steady-state growth and trace the adjustment paths of the three variables on figure 17. As expected, the adjustment paths differed only by the magnitudes of the values. Simulation through 1995:4 indicated that the new steady-state had indeed been reached by 1985:4. These values are 11.9 percent, 19.7 percent and -27.0 percent respectively,

Figure 17. Adjustment paths of unemployment, prices and the exchange rate in response to a 6% monetary shock to the steady-state.
for U, P and E. When this increase in M (annual growth rate of 12 percent) is substituted into our steady state equations 22-24, the results are a 11.2 percent natural rate of unemployment, 18.8 percent rate of price increase and a -26.5 percent rate of depreciation of the exchange rate. Therefore, it can be assumed that these are the actual steady-state values, with the differences attributed to rounding errors. These results also indicate that the model is very sensitive to changes in the growth rate of M.

Formal and Informal Indexation

Although the impact of exchange rate changes on the growth rate of prices is captured directly in our results (see table 3) the corresponding changes in the growth rate of prices on nominal wages is not measured so directly. The latter link is made informally through price expectations (see equation 10) in the model. But this link, which is so crucial to the vicious circle argument, may be in the form of wages being contractually indexed to the growth rate of prices (e.g., growth rate of wages linked 100 percent to the CPI, with provisions for a monthly review and adjustment) so that the "pass-through" from prices to wages is complete and rapid. Britain and Italy are the countries which are often cited as having widespread indexation of this sort.⁶

⁶For a useful survey of indexation in advanced marked economies see Anne R. Braun, "Indexation of Wages and
With the figures in the example above, it is obvious that the growth rate in wages will be exacerbated by the same percentage as the CPI with a monthly lag. Unit-labor-costs will now rise at a faster rate and through its impact on prices and real output, indexation will exacerbate the rate of exchange rate depreciation. The results also indicate that rising prices will cause the unemployment rate to increase. All this implies that if formal indexation of the type envisaged in the example did exist, the vicious circle phase we delineate in figures 16 and 17 may be prolonged, so that it will take much longer to reach the new steady-state. The new time lags for adjustment will depend on the degree of indexation and the lags encountered in adjusting wages to prices.

Summary

The objective of the chapter is to report on the simulation results. We first simulate the model using actual data and show the time paths of U, P and E as predicted by the model against the actual values for the 1970s. Since the simulations were performed for the estimation period, they yielded good results for the price and unemployment rate equations and poor results for the exchange rate. However, much went on in the international monetary policy

area in the 1970s and this may be a result of those occurrences. If this environment had been more tranquil, we should have been able to obtain better results. Interestingly enough, by superimposing the three variables on to one graph, we were able to show (according to a simulation of the actual time paths) that a vicious circle phase was actually encountered in the U.S. during 1979.

We then increase the growth rate of the money stock by 0.12 percent above the actual growth rate in order to determine the adjustment paths of the three variables. This shock was introduced in 1975:1. The results were a higher growth rate of prices and the exchange rate and a lower rate of unemployment.

Our initial hypothesis was the ability of an economy to display vicious circle symptoms in the process of adjusting from one steady-state to another. We then attempt to test this hypothesis by defining steady-state growth rates for M and γ (financial wealth) and, by using these values, make estimates of U, P and E in the steady-state via our derived steady-state equations, 22-24. These estimates were then substituted for the predetermined (lagged endogenous) variables, along with the steady-state growth estimates for M and γ. The simulated estimates for these values were approximately equal to the estimates which we derived via equations 22-24. By increasing the growth rate of M by 0.12 percent we were able to observe the time
paths of adjustment to the new steady-state. Two criteria were used to determine if this, in fact, was a steady-state. In addition to knowing the system was stable, we waited until the marginal values of the simulated variables returned to approximately zero and compared these values to the results of our calculated steady-state values. If they were equal, a new steady-state had been reached.

By graphing the three time paths of adjustment, on one diagram (figure 16) we saw that the vicious circle phase of adjustment is displayed eight quarters after the initial shock, just before the variables converge to their new steady-states. This behavior is consistent with our original hypothesis. However, the prolonged period over which this phase lasts (about 14 quarters) comes as a surprise. We have therefore established that a vicious circle phase can be displayed by an economy adjusting from one steady-state to another.

The next chapter will discuss some policy options available to a country actually experiencing a vicious circle phase (as the U.S. did in 1979, according to our simulations) rather than the theoretical adjustment between steady-states, and then summarize the highlights of the dissertation as a concluding comment.
CHAPTER VI

SUMMARY AND CONCLUSION

Vicious Circles and Economic Policy

This chapter is designed to summarize the work done so far and make some concluding comments about the appropriate policies to be used to get out of the 'vicious circle symptoms' phase of the adjustment path. At the outset, two comments are in order. Taking no discretionary policy measure is one way to handle it; in this case, the troubled phase of the adjustment path will pass-by (or so we hope!) as the induced recession slows the growth rates of prices and the exchange rate. But often, the cost of doing nothing will be too high (e.g., the political cost and the human suffering factor). Secondly, one may ask why policy measures cannot be implemented before the critical segment of the adjustment cycle is reached, so that it may be avoided altogether. The answer is that in an open economy, events often occur which cannot be predicted in advance. The result may be an adjustment path totally unlike the one envisaged by policymakers. Therefore, the emphasis will be on getting out of the 'vicious' phase (as opposed to avoiding) of the cycle assuming discretionary policy measures are taken, rather
than no policy at all. We will thereby begin by dis-
cussing the policy options available and the possible con-
sequences of such actions. The concluding section will
be a recapitulation of the key propositions in this
dissertation.

We mentioned earlier that Bilson's papers had argued
in favor of fiscal policy and Dornbusch in favor of demand
management.¹ We now discuss the impact of each set of
policies in view of the findings of the previous chapter.
Consider first a bond financed increase in government
expenditure. The immediate impact will be higher interest
rates (which will dampen the rate of depreciation) with
higher rates of employment and interest rates to follow.
This stimulus alone should be enough to arrest the vicious
circle phase of adjustment. Alternatively, a money financed
increase will be equivalent to monetary validation; the
consequences of this have already been discussed. A con-
tractionary fiscal or monetary policy could also be used
to change the time paths. The consequence of either policy
will be to lower aggregate demand and thereby reduce the
rate of inflation. But the unemployment rate will climb
even further. The impact of such policies will lead to
contradictory pressures being applied on the exchange rate:

¹John Bilson, "The 'Vicious Circle' Hypothesis,"
(1977, p. 21) and (1979, p. 34); Dornbusch, "Exchange
Rate Flexibility," p. 22.
a contractionary monetary policy will lead to higher interest rates and a lower rate of depreciation while lower levels of government spending will lead to lower interest rates and a rapidly depreciating exchange rate. However, in the long-run, the rate should appreciate since aggregate demand is being curtailed. But since the contractionary policies increase the rate of unemployment, the bond financed expansionary fiscal policy is recommended.

The other set of policies recommended by Dornbusch relate to demand management through wage-price controls.\(^2\) In our model (see equation 10) the nominal wage growth rate will be responding to two contradictory forces. If \(\phi_1 > \phi_2\) nominal wages will be growing at a faster rate and vice-versa. If wage price controls are imposed, the growth rate of prices should level-off and the exchange rate will depreciate at a less rapid rate. But this may not help the unemployment rate in the short-run since the inability to raise prices will deter employers from hiring workers. The symptoms phase will therefore be aborted only by moderation of the growth rates of the exchange rate and prices.

So far, we have discussed many different policies which will theoretically hasten the departure of these symptoms. But they all entail some form of adjustment

\(^2\)Ibid.
cost. In order to minimize these costs, an attractive alternative would be to use a combination of policies to stabilize the exchange rate and prices and bring down the rate of unemployment at the same time. For instance, consider wage-price controls in conjunction with a bond financed fiscal expansion. The controls will help stabilize prices and the exchange rate in the short-run while higher interest rates and government expenditure will lower the rate of depreciation and unemployment. Of course, the mere announcement of an effective stabilization package should help reduce the rate of depreciation of the exchange rate. Another alternative is monetary contraction coupled with a fiscal expansion; this may cause interest rates to rise to exorbitant levels and choke off any increases in aggregate demand, although the expansionary fiscal policy will compensate for this to some degree.

In any event, the short-term objective is to get out of the 'symptoms' phase of the adjustment cycle at the lowest possible adjustment cost. Other policy combinations are also available to accomplish this objective.

Vicious Circles--A Final Evaluation

Our final task is to re-evaluate the hypothesis in the light of the results obtained from the simulation experiments. Recall that the original hypothesis was that an open economy moving from one steady-state to another
may be able to display vicious circle symptoms as a particular phase of the adjustment cycle. If no discretionary policies were implemented to change the adjustment path of this phase, it would ultimately undo itself and reach the new steady-state. But as many critics charged, the problem may be one of monetary validation due to rising unemployment, due to the adverse consequences on prices and the exchange rate.

This possibility was discussed at length in the first chapter and we now attempt to speculate on the adjustment path if the monetary authorities raise the growth rate of the money supply (after the 1975:1 shock) further, in order to counter the rising rate of unemployment during the vicious circle phase of adjustment (see figure 16). Since the unemployment rate responds rather rapidly to monetary shocks (perhaps, due to the interest sensitive nature of labor intensive industries such as construction and automobiles) this course of action may be quite appealing to some. But if implemented, it may lead to the classic vicious circle symptoms envisaged by its proponents. To see this, let us assume that the growth rate of the money supply is raised in the middle of the vicious circle phase. In figure 16, this would be around 1979:1, when expectations are being re-adjusted for a higher rate of inflation. Following our earlier pattern, we expect the growth rate of the exchange rate to increase
(depreciate) quickly while the unemployment rate will edge downwards again. The rate of price increase will be exacerbated by the move. But the unemployment rate will start climbing again (about eight quarters later) and the vicious circle phase will reappear. If the money supply function is endogenized, the vicious circle phase can be built into the model. Therefore, those who argue that validation may be at the root of the problem are correct in doing so. But our results do not support the view that the vicious circle is a self-perpetuating cycle, as many of its proponents (particularly in the journalistic world) have argued.

Concluding Summary

This dissertation investigated the hypothesis that an economy adjusting from one steady-state to another could display vicious circle symptoms during a particular segment of the adjustment process. This phase is viewed purely as a short-run adjustment problem. If 'wrong' policies are implemented when these symptoms are displayed, what may result is a true vicious circle as envisaged by its proponents. If no policies are implemented, the symptoms phase will pass and the system will continue towards the new steady-state. If the 'right" policies are implemented, it could exacerbate the movement out of the symptoms phase of the adjustment process and could
very well lead to another set of problems, depending on the type of policies being implemented and a host of other exogenous factors.

The model we have constructed to test this hypothesis is an extension of a well known macro model by Stein which is stable in the long-run but has the ability to display short-run instability. By making some (drastic) modifications to the theoretical model, we have been able to convert it to a statistically testable model and estimated it for the U.S. for the 1970s. By imposing steady-state conditions, we have been able to derive empirically some of the long-run implications of the model and also show that it is indeed stable.

Finally, we have used these estimated coefficients to simulate the model. Since it was not designed for forecasting purposes, the simulations were performed over the estimation period. We were able to show that it tracked the data quite well for such a simple model. An interesting outcome of these simulations was that vicious circle symptoms existed in the U.S. in 1979 even without additional monetary stimulation. In the context of our model, this amounted to rising unemployment, a rising growth rate of prices and a depreciating exchange rate appearing simultaneously. Although these symptoms may have appeared before 1979, we rule them out as unfair test periods due to various external events which may have led to these results. Hence, Stein, "Unemployment, Inflation and Monetarism."
the appearance of vicious circle results with a 0.12 percent shock to the money supply should be a foregone conclusion. As expected, the growth rates of prices and the exchange rate accelerated while the rate of unemployment declined. All this leads to the conclusion that vicious circle symptoms could indeed appear during the adjustment process in an advanced market economy such as the U.S., and should not always be attributed to monetary validation.

But these results have no bearing on our original hypothesis, which claims that the adjustment path of an economy moving from one steady-state to another may display vicious circle symptoms in the short-run. In order to test it, we specified initial (steady-state) conditions and increased the growth rate of the money supply permanently to observe what would happen to the adjustment path. We saw that in the process of reaching the new steady-state, the system displays what we have described earlier as vicious circle symptoms. The entire process of adjustment from one steady-state to another took almost a decade while vicious circle symptoms (e.g., depreciating exchange rate, rising growth rate of prices and rising rates of unemployment) were displayed for almost 15 quarters, immediately preceding the new steady-state.

Since the model was estimated for the U.S., we conclude that the U.S. could indeed display vicious circle symptoms in adjusting from one steady-state to another,
in response to a monetary shock, provided government purchases remained constant and the financial wealth variable also grew at a constant rate. Of course, other types of shocks introduced through the control variables may very well lead to a 'vicious circle' phase of adjustment.
APPENDIX A

A FORMAL DERIVATION OF THE MODEL

The Model

The model presented here is a straightforward extension of Stein's model to an open economy with minor modifications to incorporate the characteristics of an indexed economy. A general equilibrium model of this nature requires several simplifying assumptions in order to keep it tractable. We discuss some of the most crucial assumptions below and then assemble the building blocks of the model, sector by sector. A glossary of symbols used here is provided at the end of the appendices. The three primary markets of this economy are the labor market, goods market and the money market.

The Assumptions

We assume a two country world under floating exchange rates. Ours is an 'open' economy, where no attempt is made to manage the exchange rate, i.e., no intervention. The Marshall-Lerner conditions hold for each country and there is asset substitutability between the financial assets of each country. Furthermore, we assume imperfect capital mobility between the two countries. Exchange

\footnote{Stein, "Unemployment, Inflation and Monetarism."}
rate determination in the short-run occurs primarily through the asset markets while in the long-run, the balance-of-payments (BOP) equilibrium condition will determine this rate. We will elaborate on these assumptions in greater detail when the foreign sector is discussed. Prices, although fully flexible, do not necessarily adjust instantaneously in this full employment model. Our assumption here is that goods market prices adjust slowly relative to asset market prices. This is consistent with real world phenomenon and has been formalized recently in the adjustment theory literature.2 We also assume that price expectations are formed adaptively while the growth rate of the current spot exchange rate is always equal to the growth rate of the expected spot rate.

The general format we will follow includes a detailed discussion of each sector of the model, and then the wage-price sector and the foreign sector. We will then present the steady-state properties and discuss the dynamic response of the model to an exogenous shock to the money supply. Given the third order system of differential equations describing the dynamic system, and given the complexity of the coefficients, it is

2See Dornbusch, "Expectations and Exchange Rate Dynamics."
impossible to work through the mathematics and give it a meaningful economic interpretation. We therefore assume that the Routh-Hurwitz conditions hold and the system is dynamically stable. We will elaborate on these assumptions and supplement them wherever necessary. We will now move through the building blocks of the model, starting with the financial sector.

Financial Wealth

Assume that domestic private financial wealth consists of (domestic) outside money balances, debt issued by the domestic public sector, and any debt issued by the foreign country and owned by domestic residents.³ Domestic private (inside) assets and liabilities are assumed to cancel each other out, thereby leaving wealth to consist entirely of outside assets.⁴ However, we note that the fraction of domestic assets held by the foreign country will constitute outside assets for them. Let us denote the assets as M (outside money), B_d (domestic government bonds), B_f (foreign bonds) and B^d (domestic assets held by foreigners). We also assume


that there are no distribution effects, i.e., aggregate demand depends on the total stock of assets and not on its distribution between households and business. The interest bearing assets are assumed to be homogeneous perpetuities paying $1 per annum so that their price is \( \frac{1}{r} \). The foreign securities are converted into domestic currency units and adjusted for expected changes in the exchange rate. Let us define \( e \) as the exchange rate in units of domestic currency per unit of foreign currency, and \( e^* \) as the expected exchange rate and \( r_d \) and \( r_f \) as the corresponding domestic and foreign interest rates, respectively. We also define \( \dot{v} \) above a variable as its growth rate, \( \frac{1}{(t)} \frac{d(v)}{dt} \), and treat \( \delta \) as the ratio of private financial wealth to the stock of money. Note that \( B^f_d \) is deducted from the domestic value of foreign bonds since, by our definition, domestic private financial wealth consists purely of outside assets to the domestic country.\(^5\)

\[
\delta = \frac{B_d}{r_d} + \frac{e B_r}{r_f + e^*} - \frac{B^f_d}{r_f} + M
\]

\( (26) \)


\(^6\) Thanks are due to Professor Robert Auerbach for this point.
We will see by equation 69 that the interest rate parity condition (given that $\hat{e}^*$ is proxied by the forward premium/discount) holds in the steady-state so that $r_d = r_f + \hat{e}^*$. By substituting this back into equation 26, we obtain the following:

\[
\delta = \frac{\frac{B_d + eB_f - B_f^d}{r_d} + M}{M}
\]

This is our definition of the ratio of private financial wealth to the stock of money in equilibrium. We will show later how real private financial wealth per unit of capital will remain constant in the steady state. Note that since domestic and foreign assets are substitutes, their composition in our portfolio depends on their risk adjusted expected relative yields.

The Money Market

The money market is described by the following relationship:

\[
m^S = \frac{M^S}{p} = \frac{M^d}{p} = \frac{M^d}{p}(y, r_d)
\]

Where $M^S$ is the (exogenously determined) money supply, $M^d/p$ is real balances and $y$ is real income per unit of capital. We let $m = MpK$, where $K$ denotes the units of physical capital; $m$ now defines real balances per unit of capital. We multiply equation 27 through by $m$ to obtain
\( \delta m \), real private financial wealth per unit of capital, which we defined earlier as remaining constant in the steady state. We will utilize this definition later on in our model. We will now move on to the goods and services market of the model, with the supply side considered first.

The Goods Market

Our economy is assumed to have an aggregate neoclassical production function exhibiting Harrod Neutral technical change. Real output is assumed to be homogeneous of degree one in its two arguments, \( L \) (labor) and \( K \) (capital). "A" represents a technical growth factor which is disembodied and grows at a constant rate. Hence, we have:

\[
Y = A(t) \cdot Y(K,L) \quad Y_1, Y_2 > 0 \quad (29)
\]

Since our production takes place at any given state of technology, we can drop the technical growth factor and write the output capital ratio for each level of technology as:

\[
\frac{Y}{K} = j(L/K) \quad j' > 0 \quad (30)
\]

Associated with each level of \( L/K \) is an unique rate of unemployment, \( U \), which is defined by the relationship \( h \), such that:
L/K = h(U) \quad h' < 0 \quad (31)

By substituting equation 31 into 30, we obtain a relationship defining real output per unit of capital in terms of the rate of unemployment, described as some function g:

\[ y = \frac{y}{K} = g(U) \quad g' < 0 \quad (32) \]

One should note that physical capital is assumed to be fully utilized at all times, as a result of a flexible rental price. This issue will become clear as the marginal product of capital is discussed along with the investment function later on.

We will now attempt to construct the demand side of our system. The following identity is used to describe the sector:

\[ y^d = \frac{y^d}{K} = \frac{C}{K} + \frac{I}{K} + \frac{\bar{G}}{K} - \frac{X}{K} \quad (33) \]

Where \( y^d \) is real aggregate demand per unit of capital, \( C/K \) is real consumption per unit of capital and \( I/K \) is real investment per unit of capital and \( X/K \) is real net exports per unit of capital. Real government expenditure, \( \bar{G} \) is determined exogenously. The endogenously determined components of equation 33 are characterized as follows:

\[ C/K = b(y, m\delta) \]
\[ = c(y, m, \delta) \quad 1 > c_1 > 0, \quad c_2 > 0, \quad c_3 > 0 \quad (34) \]
Equation 34 tells us that real consumption per unit of capital is some function $c$ of real income per unit of capital, real balances per unit of capital and the ratio of private financial wealth to the stock of money. One may note that this formulation does not depend on real disposable income. Instead, we have bypassed this argument by using $y$, $m$ and $\delta$. If we had used real disposable income, it would have required an explicit treatment of the tax function. We have ignored such a formulation by following Stein in assuming that net taxes affect consumption only through private wealth. Implicit here is the government budget constraint. Net taxes plus changes in the interest and non-interest bearing debt of the government are identically equal to the value of goods and services purchased by the government.\(^7\)

We now come to our investment function. Define effective labor as the product of the natural labor force, $L$ and an index of technology, $A$, so that effective labor, $N_2$, becomes $N_2 = AL$. We let $D$ be a differential operator, $D = d(\cdot)/dt$, and assume that effective labor grows at an exogenous rate $n$, such that $DN_2/N_2 = n$. Firms are assumed to desire a ratio of capital to effective labor such that the expected yield on capital is equal to its opportunity cost. The expected nominal yield on capital is the

\(^7\)Stein, "Inflation and Monetarism," p. 874.
sum of expected rent per unit of capital and the expected rate of inflation, $\hat{p}^*$. We assume that the expected rent is equal to the current marginal product of capital, $\Omega$. Then, firms will anticipate a yield of $\Omega + \hat{p}^*$, from new capital equipment that is purchased. The opportunity cost of acquiring this new capital is the nominal interest foregone, $r_d$. We now assume that the desired rate of growth of the $K/L$ ratio is positively related to $\Omega + \hat{p}^* - r_d$. We also assume that outside the steady-state, the marginal product of capital will not be equal to the real domestic interest rate. But when $\Omega = r_d - \hat{p}^*$, firms will wish to maintain $K/L$ constant. Desired capital will grow at the same rate as effective labor; we write the desired rate of investment per unit of capital as:

$$I/K = n + \Omega + \hat{p}^* - r_d$$  \hspace{1cm} (35)

We can also write equation 35 in general functional form as:

$$I/K = i(\Omega, \hat{p}^*, r_d, n)$$

Now, define $x$ as the ratio of effective labor per unit of capital, $x = N_2/K$. This leads to a redefinition of equation 32 in terms of effective labor per unit of capital instead of unemployment, and it takes the following form:

$$y = g(U) = y(x) \quad y' > 0$$  \hspace{1cm} (37)
The marginal product of capital also depends on effective labor per unit of capital:

\[ \Omega = \Omega(x) \quad \Omega'' < 0, \Omega' > 0 \]  

(38)

Equation 38 implies that an increase in effective labor per unit of capital will raise the marginal product of capital. The domestic nominal interest rate is determined as follows:

\[ r_d = r_d(U, \hat{p}^*, m, \delta, r_f) \]  

(39)

\[ r_{d1} < 0, r_{d2} > 0, r_{d3} < 0, r_{d4} > 0, r_{d5} = ? \]

\[ r_f \] is the corresponding foreign nominal interest rate which may induce an exogenous change in domestic interest rate policy; all other variables have been defined earlier.

We treat \( X/K \), real net exports per unit of capital to be functionally dependent on the following:

\[ X/K = X(\hat{p}, \hat{p}_f, y, y_f, \hat{e}*) \]  

\[ x_1 < 0, x_2 > 0, x_3 < 0, x_4 < 0, x_5 > 0 \]  

(40)

Once again, \( \hat{e}^* \) and \( y \) have been defined earlier while \( y_f, \hat{p}_f \) and \( \hat{p} \) represent foreign real output per unit of capital, and the foreign and domestic rates of inflation, respectively. \( \hat{p}_f \) and \( y_f \) are exogenous variables while \( \hat{p}, y \) and \( \hat{e}^* \) (which is equal to \( \hat{e} \) by assumption) are endogenously determined. We will also assume that net
real exports per unit of capital and net real capital exports per unit of capital are equal to zero in the steady state. This point is crucial to this model and the reasons will be discussed at length when the steady state properties are presented later on.

We will now move on to a discussion of the savings function in an open economy. By definition, real savings per unit of capital constitutes the following:

\[
S/K = y + X/K - C/K \tag{41}
\]

In functional form (by substituting equations 34 and 40), we obtain:

\[
S/K = y + X(p, y, e^*) - c(y, m, \delta) \tag{42}
\]

By dropping the (foreign) exogenous variables and expressing equation 42 in general functional form, we obtain the following:

\[
S/K = s(y, p, e^*, m, \delta)
\]

\[
0 > s_1 > 1, \quad s_2 < 0, \quad s_3 > 0, \quad s_4 < 0, \quad s_5 < 0 \tag{43}
\]

While most signs are self explanatory, the positive relationship between the expected growth rate of the exchange rate and real savings per unit of capital can be explained as follows: as the exchange rate depreciates, real exports per unit of capital will increase in volume. Thus, by equation 41 some proportion of the additional
revenue will enter into the savings stream while the rest will increase aggregate demand by equation 33.

An important endogenous variable we have not discussed so far is the exchange rate. Although the rate is technically determined by the BOP equilibrium condition in the long-run and the asset markets in the short-run, it does enter the excess demand function (which will be discussed shortly); we will handle this by expressing it in terms of its determinants. One should note, however, that the components of this equation are precisely the same as the determinants of net real exports per unit of capital and real net capital exports per unit of capital, as set forth in equations 70 and 71, which in turn determine the BOP equilibrium condition.

\[ \dot{e} = \dot{e}(y, y_f, \hat{P}, \hat{p}_f, r_d, r_f, \hat{e}^*) \]
\[ \dot{e}_1 > 0, \dot{e}_2 < 0, \dot{e}_3 > 0, \dot{e}_4 < 0, \dot{e}_5 < 0, \dot{e}_6 > 0, \dot{e}_7 = 1 \] (44)

The export and capital flow functions will be treated explicitly when the steady state properties are discussed later on. Meanwhile, note once again that \( y_f, p_f \) and \( r_f \) are exogenous variables while \( \dot{e} = \dot{e}^* \) by assumption and hence, \( \dot{e}_7 = 1 \).

We will now define a real excess demand identity for goods and services per unit of capital. Let this be the following:

\[ E = C/K + I/K + \bar{G}/K + X/K - Y/K \] (45)
In general functional form, equation 45 can be expressed as follows:

\[ E = c(y, m, \delta) + i(\omega, \dot{r}_d, n) + \frac{G}{K} + X(\dot{p}, \dot{p}_f, Y, Y_f, \dot{e}^*) - y(x) \] (46)

It is derived by substituting in equations 34, 36, 40 and 37, respectively. In addition to the foreign variables \( Y_f, p_f \) and \( r_f \), domestic variables such as the growth rate in effective labor, \( n \) are determined exogenously and drop out of the picture. The marginal product of capital, \( \Omega \), is determined by \( x \) as set forth in equation 38. Similarly, \( \dot{e}^* \) (which is equal to \( \dot{e} \) by assumption) and \( r_d \) are determined by the components of equations 44 and 39, respectively. We drop the exogenous variables from the latter equations, as we did previously, and obtain a reduced form excess demand function expressed in terms of the following:

\[ E = E(x, G, \dot{p}^*, \dot{p}, m, \delta) \] (47)

Although \( G \) and \( \delta \) are not endogenous, we use them as policy variables in our system and retain them for this purpose. The equilibrium condition in our goods market is established by the following identity:

\[ \frac{Y^d}{K} = \frac{Y}{K} = \bar{Y} \] (48)

Where \( \bar{Y} \) is the equilibrium level of real output per unit of capital.
The Labor Market

This section will handle the labor market and its relationship to the goods market. We define $x_f$ and $x_s$ as the units of effective labor per unit of capital demanded and supplied, respectively: the rate of unemployment, $U$, is some function $H$ of the excess demand for effective labor per unit of capital:

$$U = H(x_f - x_s/x_s) \quad h'<0, l \geq U \geq 0$$

(49)

We can now express equation 49 as the following:

$$H^{-1}(U) = x_f - x_s/x_s \quad (H^{-1})' < 0$$

(50)

Equation 50 expresses the excess demand for effective labor per unit of capital as some function $H^{-1}$ of the rate of unemployment. This, in turn, is related by some function $f$ to the real wage, $v$, adjusted for the level of technology at a given time, $A(t)$, and the level of real government expenditure, as shown in equation 51,

$$x_f - x_s/x_s = H^{-1}(U) = f(v/A(t), G) \quad f_1 < 0, f_2 > 0$$

(51)

We now differentiate equation 51 and treat it as time invariant to obtain the following:

$$DU = \beta_1(Dv/v - \dot{\lambda}) - \beta_2 DG$$

(52)

Where $\beta_1 = f_1/(H^{-1})', v/A > 0$

$\beta_2 = -f_2/(h^{-1})', G > 0$

$DA/A = \dot{\lambda}$
For simplicity, technological progress and productivity, \( \dot{\lambda} \), are assumed to grow at the same rate in the time period under consideration. Our labor market is equilibrated by the 'natural' rate of unemployment, \( \bar{U} \), so that equilibrium is said to prevail when \( U = \bar{U} \).\(^8\) Figure 18 depicts the relationship between the unemployment rate, adjusted real wages and the level of output.

We also note that a positive (negative) deviation from the natural rate of unemployment, \( U \), is an indicator of excess supply (demand) in the labor market. An excess supply (demand) in the labor market is also an indicator of excess supply (demand) in the goods market. We define the growth rate in nominal wages to be related to the following:

\[
\dot{W} = \phi_1 \dot{p}^* - \phi_2 U + \dot{\lambda}
\]

(53)

Where \( \dot{W} \) is the growth rate of nominal wages and all other variables are as defined earlier. In addition, we assume that coefficient \( \phi_2 \) represents a linearized version of the excess demand for effective labor per unit of capital, denoted by some function \( H \) of equation 49. Coefficient \( \phi_1 \) serves as a parameter of indexation linking growth in nominal wages to expected prices. This parameter represents an important

\(^8\)For the original treatment of this concept see Milton Friedman, "The Role of Monetary Policy," American Economic Review 58 (March 1968): 1-17.
Figure 18. Relationships between adjusted real wages, unemployment and real output per unit of capital.
characteristic of the vicious circle argument, as discussed earlier. It is the pass-through mechanism which facilitates the rapid transmission of 'imported inflation' throughout the economy. We assume that it is linear. We know a priori that \( \frac{Dv}{v} = \hat{\dot{\bar{w}}} - \dot{\bar{p}} \). By substituting equation 53 into 52 and solving for \( DU \), we obtain the following:

\[
DU = \beta_1 \left( \phi_1 \dot{p}^* - \phi_2 U + \lambda \right) - \gamma - \beta_2 DG
\]  

(54)

We earlier defined equilibrium to occur in the labor market at some 'natural' rate of unemployment, say \( \bar{U} \). Define \( x_1 = U - \bar{U} \), the deviation of the unemployment rate from the natural rate. Let us call this the effective rate of unemployment. Although \( \bar{U} \) could vary over long periods of time, we assume it to be constant over the time frame under discussion. Then, \( Dx_1 = DU \). By substituting this information back into equation 54, we obtain:

\[
Dx_1 = \beta_1 \phi_1 \dot{p}^* - \beta_1 \phi_2 x_1 - \beta_1 \dot{\bar{p}} - \beta_2 DG
\]  

(55)

This equation shows that the change in the deviation between actual unemployment and the natural rate is negatively related to the deviation \( x_1 \), negatively related to unanticipated inflation: \( \dot{p} - \dot{p}^* \), and negatively related to changes in government expenditure. Note that \( DG \) is a control variable while \( \dot{p} \) and \( \dot{p}^* \) are state variables.  

---

9Stein, "Inflation and Monetarism," pp. 876-80.
Expectations Formation:

It was stated earlier that price expectations will be formed adaptively; we now formalize this mechanism with an expression in terms of \( p \) and \( p^* \), current and expected prices, respectively:

\[
Dp^* = \rho (\dot{p} - \dot{p}^*)
\]  

(56)

Where \( \rho \) is a coefficient measuring the speed of adjustment of expected prices to current prices. Equation 56 will trace the path of expected prices in our dynamic system; the magnitude of \( \rho \) is crucial to the stability of our model.\(^{10}\)

The Price Equation

We now address the difficult problem of formulating a price equation in an open economy. We do so by first dichotomizing the domestic and foreign components and then attempting to derive some long-run properties of the general price level in terms of the domestic and foreign influences upon it. Our point of departure is a relationship expressing the general price level in terms of domestic and foreign prices (in terms of domestic currency), from which we attempt to derive some long-run relationships between domestic and foreign prices and the exchange rate.

Define the general price level as follows:

\[ p = \alpha p_d^+ (1-\alpha)ep_f \]  \( (57) \)

Where \( p \) represents general prices, e.g., GNP deflator, \( p_d \) is domestic production prices and \( ep_f \) is foreign prices expressed in terms of domestic currency. The coefficient \( \alpha \) is a weight measuring the influence of domestic production on the general price level. We assume this is constant. The distinction between domestically produced goods, i.e., non-traded goods, and general prices is made purely for analytical convenience. All foreign influences (e.g., primary, intermediate and finished goods) are assumed to feed the general price index, \( p \), through \( ep_f \).

If we now let \( \alpha \) be some function \( j_1 \) of relative prices, such that:

\[ \alpha = j_1 \left( \frac{p_d}{ep_f} \right) \quad j_1' < 0 \]  \( (58) \)

The constancy of \( \alpha \) implies that \( \dot{p}_d = \dot{e} + \dot{p}_d \). Since \( \dot{p} = \dot{p}_d \) in the steady state, it follows that the following will also be true in the steady state:

\[ \dot{p} = \dot{p}_d = \dot{e} + \dot{p}_f \]  \( (59) \)

With this steady state relationship in hand, we are now ready to define a simple short-run (disequilibrium) equation describing the growth rate of prices; let this be the following:
\[ \dot{p} = \epsilon_1 \dot{U}LC + \epsilon_2 (y^d - \bar{y}) + \epsilon_3 (\dot{e} + \dot{P}_f - \dot{P}_d) \] (60)

Equation 60 asserts that the growth rate in prices is influenced by the growth rate in unit-labor-cost \(U\check{LC}\), the excess demand for goods and services per unit of capital and the independent influence exerted on the growth rate of general prices by the growth rates of the exchange rate and foreign prices. \(\epsilon_3\) is a pass-through coefficient designed to capture these influences. We now replace the excess demand term in equation 60 by equation 47 and rewrite equation 60, utilizing the fact that \(U\check{LC} = \check{W} - \lambda\). We obtain the following expression:

\[ \dot{p} = \epsilon_1 (\check{W} - \lambda) + \epsilon_2 E(U, \check{P}, \check{P}^*, m, \delta, G) + \epsilon_3 (\dot{e} + \dot{P}_f - \dot{P}_d) \] (61)

We now replace \(\check{W}\) by equation 53 and begin to study the long run implications of the model. We note via equation 59 that the independent influence exerted by the exchange rate and foreign price growth rates will sum to zero in the steady state and the term represented by coefficient \(\epsilon_3\) will drop out. We also know that \(\dot{p} = \dot{p}^*\) in the steady state. By substituting these relationships, we can obtain the following:

\[ \dot{p} = \epsilon_1 (\check{P}^* - \phi U) + \epsilon_2 E(U, \check{P}^*, m, \delta, G) \] (62)

\[ = \epsilon_1 \phi_1 \check{P}^* - \epsilon_1 \phi_2 U^* \epsilon_2 E(U, \check{P}^*, m, \delta, G) \]

Where:
By differentiating equation 31 totally with respect to time, we derive the following:

\[ Dp = \gamma_1 DU + \gamma_2 Dp^* + \gamma_3 Dm/m + \gamma_4 D\delta + \gamma_5 dG \]  

(63)

We now substitute equations 54 and 56 for DU and Dp*, respectively, and note that growth in real balances per unit of capital will be equal to the growth in real money supply per unit of capital in the steady state. Hence, defining \( \dot{m}^S \) as the growth rate of real money,

\[ Dm/m = \dot{M}^S - \dot{p} - K = \dot{m}^S - K \]  

(64)

We also assume that the current rate of price change depends on previous monetary policies and not current policies. For this reason, a lag exists between \( \dot{p} \) and \( \dot{M}^S \). We substitute this information (equation 64) back into equation 63 and obtain the following:

\[
\begin{align*}
Dp &= \gamma_1 (\beta_1 \dot{p}^* - \beta_2 \dot{x}_1 - \beta_1 \dot{p} - \beta_2 DG) + \gamma_2 \rho (\dot{p} - \dot{p}^*) + \\
&\quad \gamma_3 (\dot{M}^S - \dot{p} - K) + \gamma_4 D\delta + \gamma_5 DG
\end{align*}
\]  

(65)

---

\(^{11}\) On this point, see Stein, "Inflation and Unemployment," p. 876.
By aggregating terms, we can now write the final form of the long-run price equation as follows:

\[
\dot{Dp} = -\gamma_1 \beta_1 \phi_2 x_1 + \left(\gamma_1 \beta_1 \phi_1 - \gamma_2 \rho\right) \dot{p}^* + \left(\gamma_2 \rho - \beta_1 - \gamma_3\right) \dot{p} + \gamma_3 \left(M^s - \dot{k}\right) + \left(\gamma_5 - \beta_2\right) \dot{DG} + \gamma_4 \dot{D\delta}
\]

(66)

We now have a long run dynamic system of third order differential equations with state variables \(x_1, \dot{p}, \dot{p}^*\) and control variables \(\dot{DG}, \dot{D\delta}\) and \(\dot{M}^s\). In matrix form, the system which consists of equations 55, 56 and 66 can be written as equation 67. This reduced form system of differential equations describes the time path of our economy and will be adapted for empirical and simulation work later on.

\[
\begin{pmatrix}
\dot{x}_1 \\
\dot{p} \\
\dot{p}^*
\end{pmatrix} =
\begin{bmatrix}
-\beta_1 \phi_2 & -\beta_1 & \beta_1 \phi_1 \\
-\gamma_1 \beta_1 \phi_2 & \left(\gamma_2 \rho - \beta_1 - \gamma_3\right) & \left(\gamma_1 \beta_1 \phi_1 - \gamma_2 \rho\right) \\
0 & \rho & -\rho
\end{bmatrix}
\begin{pmatrix}
x_1 \\
p \\
p^*
\end{pmatrix}
+ \begin{pmatrix}
-\beta_2 \\
(\gamma_5 - \beta_2) \\
0
\end{pmatrix} \dot{DG} + \begin{pmatrix}
\gamma_3 \\
\gamma_4 \\
0
\end{pmatrix} \dot{M}^s + \begin{pmatrix}
\gamma_4 \\
0 \\
0
\end{pmatrix} \dot{D\delta}
\]

(67)

The matrix representation of equation 67 is as follows:

\[
DX = AX + BC
\]

(68)
Where $X$ and $C$ are the vectors of state and control variables, respectively, and $A$ and $B$ are their coefficient matrices. The differential operator is represented as $D$, as stated earlier. A schematic of this model is presented in Figure 19.

The Routh-Hurwitz theorem tells us that the necessary and sufficient conditions for the roots of equation 67 to have negative real parts is that the leading principal minors of matrix $A$ must be positive.\textsuperscript{12} Since the coefficients of matrix $A$ are too complex to determine their signs relatively easily, we assume that the Routh-Hurwitz conditions are satisfied and stability prevails. But when the coefficients are actually estimated, we will demonstrate that the model does yield stable results. In order to give the theoretical results a meaningful interpretation, we will have to reduce it to a second order system; this will be done when we discuss the dynamics.

**Steady State Conditions**

The steady state properties of this system can be deduced from the foregoing analysis. In the open economy context, equation 59 defines the relationship between general prices, domestic prices, foreign prices and the

Figure 19. Macro-Economic Model (Adapted from figure 2).
exchange rate. Equilibrium will prevail in the goods market, money market and labor market. In the goods market, aggregate demand will exactly offset aggregate supply so that real excess demand per unit of capital will be zero. In the money market, the demand for real balances will grow at the same rate as the real money supply. The stock of physical capital will grow at the same rate as the effective labor force. The rate of unemployment will be at its natural rate. This is our deterministic equivalent of zero unemployment. It also implies that the effective rate of unemployment, $x_1$ will be zero.

The growth path of the exchange rate will be equal to the growth rates in the relative money supplies minus the growth rates in the relative capital stocks. For purely illustrative purposes, the growth rate assumed here is positive, and therefore, the exchange rate is assumed to be depreciating in the steady state. This implies that the growth rate of domestic money less the growth rate of capital stock is growing faster than the corresponding foreign rate in the steady state. The growth rates of prices and expected prices will be equal. By turning to equation 60, we see that the last two terms on the right hand side, represented by coefficients $\varepsilon_2', \varepsilon_3$ will drop out, thereby leaving prices to grow at the same rate as unit labor costs. Since the latter, by
definition, is equal to $\dot{w}-\dot{\lambda}$, by rearranging terms we see that real wages grow at the same rate as growth in productivity, as $\varepsilon_1$ is assumed to approach 1. Real savings per unit of capital will be constant. So will government purchases, implying that $DG=0$.

The behavior of the ratio of private financial wealth to the stock of money, $\delta$, poses some problems in the open economy context. In the steady state we assume that the private excess demand for interest bearing assets in the domestic country is exactly offset by the domestic public sector interest bearing debt plus the segment of the foreign interest bearing debt held in domestic portfolios. In order for this to be true, their risk adjusted expected rates of return in domestic currency must be equal. Hence, domestic and foreign nominal interest rates will be related by the following condition in the steady-state:

$$r_d = r_f + \dot{\varepsilon}*$$

(69)

Since $\dot{\varepsilon}=\dot{\varepsilon}*$ by assumption, we can show that real interest rates in the two countries must be equal. By substituting equation 59 for $\dot{\varepsilon}$ into equation 37, we obtain the following:

$$r_d = r_f + (\dot{p}-\dot{p_f})$$

(70)
In order to analyse changes in private financial wealth outside the steady state, we assume that the government budget is balanced. This will preclude changes in the government debt and hold constant one segment of financial wealth while the foreign component (net of domestic private debt) changes. Changes in private financial wealth can now be analysed in accordance with the changes in the foreign components. In the short-run, our capital mobility and asset substitution assumptions ensure that the magnitude and composition of the portfolio will change in response to expected relative yield differentials. In the steady state, since $DG=0$ and net real capital exports per unit of capital are equal to zero by assumption (the latter point is discussed at length in the next paragraph) it implies that $D\delta=0$. We also know that $m$ (real balance per unit of capital) will be constant, since $p=p^*=\hat{M}^{s-k}$. Hence, $m\delta$ must also be constant.

We mentioned earlier that net real capital exports per unit of capital must be zero; what follows is the rationale for this assumption. Our complete steady state condition with regard to the BOP is that net real exports per unit of capital must equal net real capital exports per unit of capital, which in turn must equal zero. Let us violate this assumption for a moment and examine what happens to our steady-state condition. Suppose net real
exports per unit of capital exceeds net real capital exports per unit of capital, i.e., \( X/K - N/K > 0 \) (where \( X/K \) was defined earlier and \( N/K \) is net real capital exports per unit of capital). This implies that the country will be accumulating foreign reserves in the steady state. This will expand the foreign reserve component of the high powered monetary base, which in turn will exacerbate the growth rate of the nominal money stock. This implies that the \( \delta \) variable will be affected, and in turn, the constancy of \( m\delta \) in the steady state will no longer be guaranteed. We also know that \( \dot{p} \) and \( \dot{p}^* \) will grow at faster rates due to a higher monetary growth rate if sterilization operations are not implemented. However, such policies cannot be conducted indefinitely. The growth path of the exchange rate will now become indeterminate since the accumulation of foreign reserves will slow its growth rate (depreciation) while a higher rate of monetary growth will hasten its rate of depreciation. It is difficult to determine the net result of these two conflicting forces \textit{a priori}. However, we recall that our present assumption about its growth rate calls for it to grow at the same rate as the relative money stocks adjusted for the growth rates of capital stocks.

These considerations imply that a non-zero BOP makes it difficult to define a steady state solution for the model. Therefore, we assume that \( X/K - N/K = 0 \), thereby
imposing BOP equilibrium in the steady state. These conditions stem directly from equation 59 and will be demonstrated more formally with the simple model used by Atkinson:¹³

\[ \frac{X}{K} = X(p - (\dot{e} + \dot{p}_f), y, y_f) \]  
\[ X_1 < 0, X_2 < 0, X_3 > 0 \]

\[ \frac{N}{K} = N(r_d - (r_f + \dot{e}^*)) \]  
\[ N' < 0 \]

\[ \frac{X(.)}{K} = \frac{N(.)}{K} \]  

Equation 71, which is a more formal statement of equation 40, claims that net real exports per unit of capital are a function of the difference between domestic and foreign inflation rate differentials less the growth rate of the exchange rate, and the domestic and foreign real incomes per unit of capital. Equation 72 asserts that net real capital exports per unit of capital is a function of the difference between domestic and foreign nominal interest rates plus the expected growth rate of the exchange rate. Equation 73 is the equilibrium condition for the BOP. We have already seen by equation 59 that

\[ \dot{p} = \dot{p}_f + \dot{\epsilon}, \]

but since \( y \) and \( y_f \) will be constant in the steady state, \( X/K \) has to be constant. Since real interest rates are constant and equal, \( N/K \) will be constant only if \( \dot{\epsilon}^* = \dot{p}^* - \dot{p}_f^* \). But since \( \dot{p}_f^* = \dot{p}_f \) and \( \dot{p}^* = \dot{p} \) in the steady state, by invoking equation 59 and the assumption that \( \dot{\epsilon} = \dot{\epsilon}^* \), we know that \( \dot{\epsilon}^* = \dot{p}^* = \dot{p}_f^* \). Hence, \( N/K \) must also be constant.

**Dynamics**

Given the initial assumption of dynamic stability, we now attempt to map the path traced by our economy in the \((\dot{p}, x_1)\) plane due to a permanent increase in the growth rate of the money supply. Referring to equation 67 and figure 19 is helpful at this point. It is also important to distinguish sharply between primary and secondary effects when discussing dynamics. We will attempt to explain the results heuristically and then work through them more formally with the help of a phase diagram. We begin from some initial steady state condition.

In the primary stage, an increase in the growth rate of the money supply will cause the domestic nominal (and real) interest rates to decline, creating a capital outflow and a portfolio readjustment in favor of foreign assets. Therefore, the exchange rate will begin to depreciate at a faster rate. Assuming the J-curve effect, the current account will move into deficit as import orders increase. Real balances per unit of capital will
also increase, since the opportunity cost of holding money has decreased. We will now begin to experience rising aggregate demand, along with a depreciating exchange rate. The effective rate of unemployment $x_1$ will become negative as the labor market heads towards a situation of excess demand and the goods market will do likewise. However, by the time these impacts are fully felt throughout the economy, we will be well into the next stage of adjustment.

Given our initial assumption of asset markets adjusting faster than goods markets, we can safely assume that both the composition and magnitude of the $m_\delta$ variable will change after the first impact. In particular, a decline in the domestic (nominal) interest rate leads to a larger holding of foreign denominated assets relative to domestic assets. As a result the exchange rate will depreciate (as discussed earlier) until the excess supply of domestic assets is willingly held or, alternatively, until expected relative yields have been equalized. We should note that had the stimulus come from a change in government spending, i.e., $DG>0$, which was financed via the bond market, the domestic interest rate would have risen and altered the composition of portfolios in favor of domestic assets. Such a situation would have slowed the growth rate of the exchange rate until expected relative yields have once again been equalized.
Exchange Rate Overshooting: A Digression

In this section, we investigate the possibility of the exchange rate overshooting its steady-state growth path in response to the monetary shock. It is predicated on the assumption that prices in asset markets will adjust faster than prices in goods markets. This possibility has been discussed previously by Dornbusch.

Figure 20, which follows Darby in spirit, traces the dynamic path of adjustment of prices and the exchange rate in response to an increase in the growth rate of the money supply.\textsuperscript{14} Recall that, in the steady-state, prices will grow at the same rate as the money supply less the growth rate of the capital stock. The exchange rate will grow at the same rate as relative money supplies, adjusted for the growth rates of capital stock. This is why the steady-state exchange rate is depicted at a lower point along the vertical axis of figure 20. Let us assume that the growth rate of the money supply is increased from $\tilde{M}^s$ to $\tilde{M}'^s$ at the time $t'$. The adjustment path of prices is shown by QRS. The shock will create an initial real increase in the money stock, increase real balances and depreciate the exchange rate. Since asset markets respond first, the exchange rate will depreciate beyond its new growth path initially but as the goods markets begin to adjust, the rate of depreciation will begin to diminish. Several factors will cause this: exports will

Figure 20. Exchange Rate Overshooting
be boosted by the depreciating exchange rate while, as goods markets adjust, rising prices will cause interest rates to increase and excess aggregate demand to decline. This implies that imports should decline, although they may have increased as excess demand conditions appeared even though the exchange rate was depreciating. Also, as excess demand conditions disappear, the unemployment rate will be edging upwards, i.e., $x_1$ will be approaching zero. The new steady state will be reached when prices are growing at the rate $(\dot{M}^S - \dot{k})'$ as shown in figure 20. The exchange rate will follow path ABC, with the overshooting occurring during segment AB of the adjustment path. Our empirical work indicates that the growth rate of the effective exchange rate series we use is highly sensitive to changes in M1, while the growth rate of prices is not as sensitive to these monetary changes in the same time frame, thereby adding some credence to the overshooting hypothesis.

One should also be aware of the differences between the overshooting envisaged by Dornbusch and the type discussed in the present model.\textsuperscript{15} Although they are both based on the differential speeds of adjustment of the goods and asset markets, the similarities seem to end

\textsuperscript{15}Specifically in Dornbusch, "Expectations and Exchange Rate Dynamics."
there. He assumes rational expectations and shows how the level of the exchange rate may overshoot. "Overshooting results from the requirement that the interest differential equal the anticipated rate of appreciation. Thus the spot rate has to go beyond the long run equilibrium rate to yield an expectation of appreciation." 16

By contrast, we assume nothing about the interest rate parity condition but do assume that flow equilibrium conditions will dominate the determination of the spot rate in the long run while asset markets will dominate its determination in the short run. In other words, the initial rate of depreciation which is determined in the asset markets gives away to the flow equilibrium factors (e.g., imports and exports) in the long run. Therefore, the stock equilibrium factors which caused the overshooting give away to flow equilibrium factors which bring the exchange rate back towards its steady state growth rate. Overshooting results from the initial stock equilibrium factors being damped by the long run flow equilibrium factors.

Dynamics, Once Again!

As prices grow at a faster rate, the expectations on the growth rate of prices will be gradually readjusted to reflect the higher growth rate of current prices. In the meantime, real income per unit of capital will be

16Dornbusch, Open Economy Macroeconomics, p. 209.
declining. This phase is characterized by a higher nominal interest rate, higher growth rate in nominal wages, a positive effective rate of unemployment (as real output declines), lower net real exports per unit of capital and, perhaps, a depreciating exchange rate. One may find it ironic that the exchange rate will continue to depreciate despite a higher nominal interest rate. However, the asset market approach tells us that ever widening interest rate differentials will be needed to create continuous portfolio adjustment. Moreover, despite declining imports, export prices will also be rising and expectations will be in the process of being readjusted for a higher rate of inflation. Therefore, the exchange rate will continue to depreciate but probably at a lower rate of depreciation. This is when the exchange rate, which has overshot its steady state growth path, begins to return to its normal growth path. It is at this stage of the adjustment process that we have the classic vicious circle symptoms. If the rate of monetary growth is increased once again to stem the rising unemployment and lower real output, the cycle will start all over again and we will have the classic vicious circle exactly as envisaged by its proponents. It can be aptly described as a problem in monetary accommodation and has its roots in political motives rather than purely economic motives. But if we were to incorporate a Central Bank
reaction function like some other models, the result will be a foregone conclusion: vicious circle behavior will be endogenized.\textsuperscript{17}

Bilson has argued that the appropriate policy to counter vicious circles is fiscal policy, while Dornbusch has argued in favor of incomes policies.\textsuperscript{18} These ideas will be examined in the final chapter, but for the sake of completing our argument, let us assume that no monetary or fiscal reaction is forthcoming and the economy is left to take its course. Therefore, in a full-employment, flexible price model such as this, one expects the growth rate in prices to slowly abate and excess supply conditions to disappear in both goods and labor markets. Similarly, all other variables will converge to their steady state growth paths asymptotically. However, in practical terms, it is inappropriate to think that a steady state will ever be reached, particularly in an open economy model such as this.

We will now attempt to present this analysis in more formal terms, with the help of equation 67 and a phase diagram. In order to reduce equation 60 to a second order system in the \((\dot{p}, x_1)\) plane so that a phase

\textsuperscript{17}For example, Bilson, "Vicious Circles" (1979).

\textsuperscript{18}Bilson, "Vicious Circles," (1979): 34; Dornbusch, "Exchange Rate Flexibility," p. 22.
diagram may be used, we follow Stein and define $Z$ as the difference between current and expected rates of price change, $Z = \dot{p} - \dot{p}^*$. Since $\dot{M}^S - \dot{k} = \dot{p} - \dot{p}^*$ in the steady state, $Z = 0$. Hence, we get:

$$\dot{p}^* = \dot{M}^S - \dot{k} - Z$$  \hspace{1cm} (74)

By substituting equation 74 into equation 55, we obtain the following:

$$Dx_1 = \beta_1 (\dot{M}^S - \dot{k} - Z) - \phi_2 x_1 \dot{p} - \beta_2 DG$$  \hspace{1cm} (75)

Defining the EE curve of figure 21 as the set of $(\dot{p}, x_1)$ along which $Dx_1 = 0$, we obtain equation 76 in $\dot{p}$:

$$\dot{p} = \phi_1 (\dot{M}^S - \dot{k} - Z) - \phi_2 x_1 \frac{\beta_2}{\beta_1} DG$$  \hspace{1cm} (76)

This curve describing $\dot{p}$ is negatively sloped since if $x_1$ rises, $\dot{W}$ declines by $\phi_2 \Delta x_1$ units. If $\dot{p}$ changed by the same amount $\dot{W} = 0$. Hence, $x_1$ will remain unaffected.

Similarly, we now substitute equation 74 into equation 66 and obtain the following expression:

$$D\hat{p} = -\gamma_1 \beta_1 \phi_2 x_1 + (\gamma_1 \beta_1 \phi_1 - \gamma_2 \beta_2) \dot{p}^* + (\gamma_2 - \beta_1 - \gamma_3) \dot{p} + \gamma_3 (\dot{M}^S - \dot{k}) + (\gamma_5 - \beta_2) DG + \gamma_4 D\delta$$  \hspace{1cm} (77)

Define the PP curve of figure 21 as the set of $(\dot{p}, x_1)$ along which $D\hat{p} = 0$ and obtain the following from equation 77:

$$\dot{p} = \frac{1}{\gamma_2 \beta_1 - \gamma_3} (\gamma_1 \beta_1 \phi_2 x_1 - (\gamma_1 \beta_1 \phi_1 - \gamma_2 \beta_2) \dot{p}^* + (\gamma_2 - \beta_1 - \gamma_3) \dot{p} + \gamma_3 (\dot{M}^S - \dot{k}) + (\gamma_5 - \beta_2) DG - \gamma_4 D\delta)$$  \hspace{1cm} (78)
Equations 76 and 78 are the general expressions for the EE and PP curves of figure 21. It is useful, once again, to recapitulate the stability properties of our model. Since the Routh-Hurwitz conditions are expected to hold, we also maintain that \((\gamma_2 \rho - \beta_1 - \gamma_3) > 0\), so that the stabilizing forces predominate. Furthermore, stability requires that the slope of the PP curve is algebraically greater than the slope of the EE curve. The slope of the PP curve depends on the sign of \(-\gamma_1\), which is equal to \(\epsilon_1 \phi_2 - \epsilon_2 E_1\) and has been presented earlier.

Figure 21 attempts to explain the dynamics of the models graphically, in two dimensions. For expository purposes, we assume the rate of monetary expansion per unit of capital moves from zero to \(\dot{M}^S = \dot{k} = OA > 0\). Since expectations are assumed to be formed adaptively, the ensuing inflation is not yet anticipated and \(\dot{p}^* = 0\). Hence, \(Z = \dot{M}^S - \dot{k} - \dot{p}^* = \dot{M}^S - \dot{k} - 0 = \dot{M}^S - \dot{k}\). However, the exchange rate must now move from \(\dot{\epsilon} = \dot{\epsilon}^* = 0\) to \(\dot{M}^S - \dot{k} < \dot{\epsilon} = \dot{\epsilon}^*\), since foreign exchange markets are expected to assimilate the news rapidly and the exchange rate will overshoot its growth path. If we further assume that the coefficient of \(Z\) is small enough to be ignored, the PP curve will rise by the full extent of the monetary expansion, from \(P_0 P_0\) to \(P_1 P_1\).

As real balances per unit of capital start to increase, the economy moves in the direction of OB where excess demand and negative effective rates of unemployment
Legend: The rate of monetary expansion per unit of capital is raised from zero to OA: the economy follows trajectory OBCDA to the new steady state $(\hat{p}, x_1) = (M^s - K, 0)$. The EE curve shifts along $P_1 P_1$ to $E_1 E_1$. The vicious circle phase is denoted by the segment CD.

Figure 21. Dynamic Adjustment in the $(\hat{p}, x_1)$ plane. (Adapted from figure 4.)
are said to prevail. As the inflationary phase quickens and spreads throughout the indexed economy, real output per unit of capital and real net exports per unit of capital will decline and nominal interest rates will increase while $E_0E_0$ moves along $P_1P_1$ towards $E_1E_1$, as wage negotiations are based upon higher rates of expected inflation. This will raise the growth rate of real wages and subsequently lead to higher rates of effective unemployment. The second phase of the adjustment process leads to the segment of the trajectory CD, where we have declining real output, steadily rising prices and positive effective rates of unemployment (we referred to the latter earlier, in the context of higher real wages: remember that it refers to positive deviations from the natural rate, $\bar{U}$). It is this phase which we characterize as the 'vicious circle' phase of adjustment. In a standard neo-classical model (such as Stein's) this phase of the adjustment path is lacking. However, these are closed economy models which make no provisions for pass-through or indexation impacts. Hence, less pressure is exerted on prices and expected prices. But when the additional pressure on the growth rate of prices via the exchange rate is transmitted from prices into expected prices and on into nominal wages (via indexation) and back into prices (via excess demand and unit labor cost) the rate of price increase is exacerbated and the period of expanding
real output per unit of capital declines. Hence, we have a short period of positive effective unemployment before the new steady state is reached. This is the novel feature of this model. It is due to the parameters $\phi_1, \epsilon_3$ which are the indexation and pass-through coefficients, respectively. We expect $0 < \phi_1, \epsilon_3 < 1$ since the stabilizing forces are presumed to prevail over the destabilizing forces.

If we pass the CD segment of the trajectory in figure 21 without any form of government intervention, i.e., counter-cyclical fiscal or monetary policy, the rising EE curve implies that the economy will eventually head for point A, where the $P_1P_1$ and $E_1E_1$ curves will intersect one another. OBCDA describes the motion of the economy to the new equilibrium point A, where $A=(\dot{p},x_1)=(M^s-K,0)$. This concludes the formal presentation of the model.
### TABLE 11

**UNTRANSFORMED DATA USED IN REGRESSIONS**

<table>
<thead>
<tr>
<th>SOURCES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>dSee appendix III for sources and derivation.</td>
</tr>
<tr>
<td>fSee Appendix C for sources and derivation.</td>
</tr>
<tr>
<td>Time</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1969 01</td>
</tr>
<tr>
<td>1969 02</td>
</tr>
<tr>
<td>1969 03</td>
</tr>
<tr>
<td>1969 04</td>
</tr>
<tr>
<td>1970 01</td>
</tr>
<tr>
<td>1970 02</td>
</tr>
<tr>
<td>1970 03</td>
</tr>
<tr>
<td>1970 04</td>
</tr>
<tr>
<td>1971 01</td>
</tr>
<tr>
<td>1971 02</td>
</tr>
<tr>
<td>1971 03</td>
</tr>
<tr>
<td>1971 04</td>
</tr>
<tr>
<td>1972 01</td>
</tr>
<tr>
<td>1972 02</td>
</tr>
<tr>
<td>1972 03</td>
</tr>
<tr>
<td>1972 04</td>
</tr>
<tr>
<td>1973 01</td>
</tr>
<tr>
<td>1973 02</td>
</tr>
<tr>
<td>1973 03</td>
</tr>
<tr>
<td>1973 04</td>
</tr>
<tr>
<td>1974 01</td>
</tr>
<tr>
<td>1974 02</td>
</tr>
<tr>
<td>1974 03</td>
</tr>
<tr>
<td>1974 04</td>
</tr>
<tr>
<td>1975 01</td>
</tr>
<tr>
<td>1975 02</td>
</tr>
<tr>
<td>1975 03</td>
</tr>
<tr>
<td>1975 04</td>
</tr>
<tr>
<td>1976 01</td>
</tr>
<tr>
<td>1976 02</td>
</tr>
<tr>
<td>1976 03</td>
</tr>
<tr>
<td>1976 04</td>
</tr>
<tr>
<td>1977 01</td>
</tr>
<tr>
<td>1977 02</td>
</tr>
<tr>
<td>1977 03</td>
</tr>
<tr>
<td>1977 04</td>
</tr>
<tr>
<td>1978 01</td>
</tr>
<tr>
<td>1978 02</td>
</tr>
<tr>
<td>1978 03</td>
</tr>
<tr>
<td>1978 04</td>
</tr>
<tr>
<td>1979 01</td>
</tr>
<tr>
<td>1979 02</td>
</tr>
<tr>
<td>1979 03</td>
</tr>
<tr>
<td>1979 04</td>
</tr>
</tbody>
</table>
### Table: Total U.S. Claims on Foreigners and Foreign Money Debt Held by the U.S. Private Sector (Values in Billions of U.S. $)

<table>
<thead>
<tr>
<th>Time</th>
<th>Total U.S. Claims on Foreigners ( ^b )</th>
<th>Total Foreign Money Debt on the U.S. ( ^c )</th>
<th>Government Debt Held by the Private Sector ( ^a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>150.60</td>
<td>83.50</td>
<td>228.60</td>
</tr>
<tr>
<td>1969</td>
<td>154.20</td>
<td>86.90</td>
<td>221.30</td>
</tr>
<tr>
<td>1969</td>
<td>156.60</td>
<td>90.00</td>
<td>218.70</td>
</tr>
<tr>
<td>1969</td>
<td>158.00</td>
<td>98.80</td>
<td>222.20</td>
</tr>
<tr>
<td>1970</td>
<td>161.50</td>
<td>92.60</td>
<td>224.30</td>
</tr>
<tr>
<td>1970</td>
<td>163.50</td>
<td>94.50</td>
<td>226.60</td>
</tr>
<tr>
<td>1970</td>
<td>164.20</td>
<td>96.00</td>
<td>223.60</td>
</tr>
<tr>
<td>1970</td>
<td>165.40</td>
<td>97.60</td>
<td>227.80</td>
</tr>
<tr>
<td>1971</td>
<td>169.30</td>
<td>100.40</td>
<td>229.60</td>
</tr>
<tr>
<td>1971</td>
<td>172.90</td>
<td>106.60</td>
<td>229.60</td>
</tr>
<tr>
<td>1971</td>
<td>175.70</td>
<td>117.10</td>
<td>237.70</td>
</tr>
<tr>
<td>1971</td>
<td>179.40</td>
<td>123.30</td>
<td>243.30</td>
</tr>
<tr>
<td>1972</td>
<td>186.60</td>
<td>139.60</td>
<td>250.30</td>
</tr>
<tr>
<td>1972</td>
<td>188.90</td>
<td>139.10</td>
<td>236.00</td>
</tr>
<tr>
<td>1972</td>
<td>193.00</td>
<td>151.40</td>
<td>247.60</td>
</tr>
<tr>
<td>1972</td>
<td>198.90</td>
<td>161.30</td>
<td>258.90</td>
</tr>
<tr>
<td>1973</td>
<td>208.50</td>
<td>169.20</td>
<td>264.40</td>
</tr>
<tr>
<td>1973</td>
<td>212.10</td>
<td>171.20</td>
<td>262.10</td>
</tr>
<tr>
<td>1973</td>
<td>214.30</td>
<td>173.20</td>
<td>257.50</td>
</tr>
<tr>
<td>1973</td>
<td>222.80</td>
<td>174.90</td>
<td>259.30</td>
</tr>
<tr>
<td>1974</td>
<td>230.70</td>
<td>178.90</td>
<td>262.00</td>
</tr>
<tr>
<td>1974</td>
<td>249.60</td>
<td>186.40</td>
<td>258.80</td>
</tr>
<tr>
<td>1974</td>
<td>245.50</td>
<td>191.50</td>
<td>259.60</td>
</tr>
<tr>
<td>1974</td>
<td>255.70</td>
<td>196.90</td>
<td>266.30</td>
</tr>
<tr>
<td>1975</td>
<td>265.90</td>
<td>201.40</td>
<td>288.60</td>
</tr>
<tr>
<td>1975</td>
<td>276.10</td>
<td>207.50</td>
<td>285.60</td>
</tr>
<tr>
<td>1975</td>
<td>281.20</td>
<td>211.50</td>
<td>310.00</td>
</tr>
<tr>
<td>1975</td>
<td>295.10</td>
<td>220.50</td>
<td>343.10</td>
</tr>
<tr>
<td>1976</td>
<td>308.10</td>
<td>229.30</td>
<td>346.00</td>
</tr>
<tr>
<td>1976</td>
<td>320.00</td>
<td>239.00</td>
<td>374.60</td>
</tr>
<tr>
<td>1976</td>
<td>331.00</td>
<td>249.60</td>
<td>389.90</td>
</tr>
<tr>
<td>1976</td>
<td>347.20</td>
<td>264.50</td>
<td>408.50</td>
</tr>
<tr>
<td>1977</td>
<td>349.30</td>
<td>266.80</td>
<td>422.30</td>
</tr>
<tr>
<td>1977</td>
<td>361.20</td>
<td>273.70</td>
<td>424.00</td>
</tr>
<tr>
<td>1977</td>
<td>368.20</td>
<td>292.60</td>
<td>433.30</td>
</tr>
<tr>
<td>1977</td>
<td>382.20</td>
<td>310.60</td>
<td>456.50</td>
</tr>
<tr>
<td>1978</td>
<td>399.70</td>
<td>328.60</td>
<td>477.90</td>
</tr>
<tr>
<td>1978</td>
<td>405.70</td>
<td>329.40</td>
<td>479.60</td>
</tr>
<tr>
<td>1978</td>
<td>417.10</td>
<td>344.40</td>
<td>486.50</td>
</tr>
<tr>
<td>1978</td>
<td>450.00</td>
<td>373.30</td>
<td>501.80</td>
</tr>
<tr>
<td>1979</td>
<td>458.40</td>
<td>374.60</td>
<td>519.80</td>
</tr>
<tr>
<td>1979</td>
<td>475.10</td>
<td>380.50</td>
<td>518.40</td>
</tr>
<tr>
<td>1979</td>
<td>500.20</td>
<td>404.00</td>
<td>521.50</td>
</tr>
<tr>
<td>1979</td>
<td>514.40</td>
<td>406.00</td>
<td>531.80</td>
</tr>
<tr>
<td>TABLE 12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSFORMED DATA FOR REGRESSIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES. ^Transformations were performed on the unemployment rate.

^Annualized growth rate of the GNP deflator (e.g., the 1970:1 observation is the growth rate from 1969:1 to 1970:1).

^Annualized growth rate of the effective exchange rate, i.e., same computation as note b.

^A moving average of the annualized change in federal, state and local government purchases per unit of capital over the three preceding quarters. (The series we use is a ratio of an index of federal, state and local government purchases to a translog index of capital stock. The annualized change in this ratio is found by determining the change in it between corresponding quarters; each observation in the table is a moving average of the latter variable over the three preceding quarters).

^A three preceding quarter moving average of the annualized growth rate of M1.

^A three preceding quarter moving average of the annualized growth rate of Total Financial Wealth (the latter is assumed to consist of Total Government Debt held by the private sector plus U.S. Claims on Foreigners minus Foreign Claims on the U.S.).

SOURCE: Table 11
<table>
<thead>
<tr>
<th>Time</th>
<th>Unemployment Rate</th>
<th>Growth Rate of GNP</th>
<th>Growth Rate of Effective Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969 01</td>
<td>+4.47</td>
<td>+5.73</td>
<td>-0.44</td>
</tr>
<tr>
<td>1969 02</td>
<td>+5.17</td>
<td>+4.85</td>
<td>-1.95</td>
</tr>
<tr>
<td>1969 03</td>
<td>+5.33</td>
<td>+5.10</td>
<td>-1.67</td>
</tr>
<tr>
<td>1969 04</td>
<td>+5.47</td>
<td>+3.90</td>
<td>-7.40</td>
</tr>
<tr>
<td>1970 01</td>
<td>+5.56</td>
<td>+4.73</td>
<td>-5.61</td>
</tr>
<tr>
<td>1970 02</td>
<td>+5.83</td>
<td>+5.30</td>
<td>-1.32</td>
</tr>
<tr>
<td>1970 03</td>
<td>+5.90</td>
<td>+5.22</td>
<td>-2.68</td>
</tr>
<tr>
<td>1970 04</td>
<td>+5.50</td>
<td>+4.71</td>
<td>-9.30</td>
</tr>
<tr>
<td>1971 01</td>
<td>+5.63</td>
<td>+4.34</td>
<td>-4.96</td>
</tr>
<tr>
<td>1971 02</td>
<td>+4.73</td>
<td>+6.26</td>
<td>-13.26</td>
</tr>
<tr>
<td>1971 03</td>
<td>+4.33</td>
<td>+5.64</td>
<td>-9.33</td>
</tr>
<tr>
<td>1971 04</td>
<td>+5.50</td>
<td>+8.00</td>
<td>-8.00</td>
</tr>
<tr>
<td>1972 01</td>
<td>+5.07</td>
<td>+9.87</td>
<td>+3.16</td>
</tr>
<tr>
<td>1972 02</td>
<td>+5.30</td>
<td>+7.58</td>
<td>-10.53</td>
</tr>
<tr>
<td>1972 03</td>
<td>+5.57</td>
<td>+10.27</td>
<td>+7.89</td>
</tr>
<tr>
<td>1972 04</td>
<td>+6.10</td>
<td>+11.61</td>
<td>+1.97</td>
</tr>
<tr>
<td>1973 01</td>
<td>+9.07</td>
<td>+11.57</td>
<td>-8.95</td>
</tr>
<tr>
<td>1973 02</td>
<td>+8.60</td>
<td>+10.15</td>
<td>-4.43</td>
</tr>
<tr>
<td>1973 03</td>
<td>+8.27</td>
<td>+9.89</td>
<td>-0.59</td>
</tr>
<tr>
<td>1973 04</td>
<td>+7.70</td>
<td>+7.58</td>
<td>+2.70</td>
</tr>
<tr>
<td>1974 01</td>
<td>+8.47</td>
<td>+5.75</td>
<td>+5.44</td>
</tr>
<tr>
<td>1974 02</td>
<td>+7.33</td>
<td>+5.44</td>
<td>+12.14</td>
</tr>
<tr>
<td>1974 03</td>
<td>+7.53</td>
<td>+4.80</td>
<td>+5.14</td>
</tr>
<tr>
<td>1974 04</td>
<td>+7.27</td>
<td>+4.76</td>
<td>+2.72</td>
</tr>
<tr>
<td>1975 01</td>
<td>+8.17</td>
<td>+5.36</td>
<td>+1.25</td>
</tr>
<tr>
<td>1975 02</td>
<td>+6.87</td>
<td>+6.12</td>
<td>-1.91</td>
</tr>
<tr>
<td>1975 03</td>
<td>+6.70</td>
<td>+6.13</td>
<td>-2.98</td>
</tr>
<tr>
<td>1975 04</td>
<td>+6.23</td>
<td>+6.22</td>
<td>-4.98</td>
</tr>
<tr>
<td>1976 01</td>
<td>+6.60</td>
<td>+6.20</td>
<td>-9.89</td>
</tr>
<tr>
<td>1976 02</td>
<td>+5.77</td>
<td>+7.06</td>
<td>-8.03</td>
</tr>
<tr>
<td>1976 03</td>
<td>+5.50</td>
<td>+7.28</td>
<td>-12.12</td>
</tr>
<tr>
<td>1976 04</td>
<td>+5.47</td>
<td>+8.29</td>
<td>-12.58</td>
</tr>
<tr>
<td>1977 01</td>
<td>+5.47</td>
<td>+8.29</td>
<td>-12.58</td>
</tr>
<tr>
<td>1977 02</td>
<td>+5.63</td>
<td>+8.65</td>
<td>-7.91</td>
</tr>
<tr>
<td>1977 03</td>
<td>+5.73</td>
<td>+8.96</td>
<td>-4.08</td>
</tr>
<tr>
<td>1977 04</td>
<td>+5.60</td>
<td>+8.87</td>
<td>-0.49</td>
</tr>
<tr>
<td>Time</td>
<td>Change in Government Purchases</td>
<td>Growth Rate of M1</td>
<td>Growth Rate of Total Financial Wealth</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------</td>
<td>--------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>1970 Q4</td>
<td>-7.79</td>
<td>+3.46</td>
<td>+8.82</td>
</tr>
<tr>
<td>1971 Q1</td>
<td>-7.13</td>
<td>+3.83</td>
<td>+9.74</td>
</tr>
<tr>
<td>1971 Q2</td>
<td>-5.82</td>
<td>+5.40</td>
<td>+1.91</td>
</tr>
<tr>
<td>1971 Q3</td>
<td>-4.96</td>
<td>+6.34</td>
<td>-4.83</td>
</tr>
<tr>
<td>1971 Q4</td>
<td>-3.94</td>
<td>+7.34</td>
<td>-4.87</td>
</tr>
<tr>
<td>1972 Q1</td>
<td>-3.88</td>
<td>+7.20</td>
<td>-5.84</td>
</tr>
<tr>
<td>1972 Q2</td>
<td>-2.22</td>
<td>+6.68</td>
<td>+1.91</td>
</tr>
<tr>
<td>1972 Q3</td>
<td>-1.93</td>
<td>+5.88</td>
<td>+1.42</td>
</tr>
<tr>
<td>1972 Q4</td>
<td>-1.63</td>
<td>+5.97</td>
<td>+0.42</td>
</tr>
<tr>
<td>1973 Q1</td>
<td>-2.16</td>
<td>+6.80</td>
<td>-0.93</td>
</tr>
<tr>
<td>1973 Q2</td>
<td>-1.70</td>
<td>+7.54</td>
<td>-1.34</td>
</tr>
<tr>
<td>1973 Q3</td>
<td>-0.57</td>
<td>+7.96</td>
<td>-0.87</td>
</tr>
<tr>
<td>1973 Q4</td>
<td>+1.11</td>
<td>+6.78</td>
<td>+1.24</td>
</tr>
<tr>
<td>1974 Q1</td>
<td>+2.46</td>
<td>+6.39</td>
<td>+2.89</td>
</tr>
<tr>
<td>1974 Q2</td>
<td>+3.52</td>
<td>+5.32</td>
<td>+3.38</td>
</tr>
<tr>
<td>1974 Q3</td>
<td>+5.49</td>
<td>+4.78</td>
<td>+3.38</td>
</tr>
<tr>
<td>1974 Q4</td>
<td>+7.44</td>
<td>+4.82</td>
<td>+3.31</td>
</tr>
<tr>
<td>1975 Q1</td>
<td>+9.94</td>
<td>+3.64</td>
<td>+4.74</td>
</tr>
<tr>
<td>1975 Q2</td>
<td>+2.85</td>
<td>+3.82</td>
<td>+6.39</td>
</tr>
<tr>
<td>1975 Q3</td>
<td>+5.83</td>
<td>+4.57</td>
<td>+11.06</td>
</tr>
<tr>
<td>1975 Q4</td>
<td>-15.41</td>
<td>+5.79</td>
<td>+17.15</td>
</tr>
<tr>
<td>1976 Q1</td>
<td>-17.59</td>
<td>+6.14</td>
<td>+23.20</td>
</tr>
<tr>
<td>1976 Q2</td>
<td>-12.09</td>
<td>+5.81</td>
<td>+26.94</td>
</tr>
<tr>
<td>1976 Q3</td>
<td>-6.49</td>
<td>+4.68</td>
<td>+26.93</td>
</tr>
<tr>
<td>1976 Q4</td>
<td>-9.63</td>
<td>+4.41</td>
<td>+24.47</td>
</tr>
<tr>
<td>1977 Q1</td>
<td>-2.00</td>
<td>+4.27</td>
<td>+20.69</td>
</tr>
<tr>
<td>1977 Q2</td>
<td>-2.45</td>
<td>+5.27</td>
<td>+17.33</td>
</tr>
<tr>
<td>1977 Q3</td>
<td>-1.96</td>
<td>+6.93</td>
<td>+14.68</td>
</tr>
<tr>
<td>1977 Q4</td>
<td>-8.82</td>
<td>+7.63</td>
<td>+11.62</td>
</tr>
<tr>
<td>1978 Q1</td>
<td>+0.12</td>
<td>+8.44</td>
<td>+9.12</td>
</tr>
<tr>
<td>1978 Q2</td>
<td>+0.18</td>
<td>+8.73</td>
<td>+8.33</td>
</tr>
<tr>
<td>1978 Q3</td>
<td>-3.38</td>
<td>+8.30</td>
<td>+8.91</td>
</tr>
<tr>
<td>1978 Q4</td>
<td>-9.99</td>
<td>+8.68</td>
<td>+9.44</td>
</tr>
<tr>
<td>1979 Q1</td>
<td>-1.23</td>
<td>+7.82</td>
<td>+9.67</td>
</tr>
<tr>
<td>1979 Q2</td>
<td>-1.28</td>
<td>+7.83</td>
<td>+9.76</td>
</tr>
<tr>
<td>1979 Q3</td>
<td>-1.64</td>
<td>+5.85</td>
<td>-9.92</td>
</tr>
<tr>
<td>1979 Q4</td>
<td>-2.27</td>
<td>+5.53</td>
<td>+10.23</td>
</tr>
<tr>
<td>Time</td>
<td>Composite Foreign Producer Price Index</td>
<td>U.S. Producer Price Index</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------</td>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>1969 01</td>
<td>61.24</td>
<td>59.90</td>
<td></td>
</tr>
<tr>
<td>1969 02</td>
<td>61.28</td>
<td>60.70</td>
<td></td>
</tr>
<tr>
<td>1969 03</td>
<td>62.66</td>
<td>61.20</td>
<td></td>
</tr>
<tr>
<td>1969 04</td>
<td>62.72</td>
<td>61.70</td>
<td></td>
</tr>
<tr>
<td>1969 01</td>
<td>65.13</td>
<td>62.70</td>
<td></td>
</tr>
<tr>
<td>1969 02</td>
<td>65.61</td>
<td>63.00</td>
<td></td>
</tr>
<tr>
<td>1969 03</td>
<td>65.82</td>
<td>63.40</td>
<td></td>
</tr>
<tr>
<td>1970 01</td>
<td>66.02</td>
<td>63.50</td>
<td></td>
</tr>
<tr>
<td>1970 02</td>
<td>66.16</td>
<td>64.30</td>
<td></td>
</tr>
<tr>
<td>1970 03</td>
<td>67.02</td>
<td>65.10</td>
<td></td>
</tr>
<tr>
<td>1971 01</td>
<td>67.95</td>
<td>65.60</td>
<td></td>
</tr>
<tr>
<td>1971 02</td>
<td>66.09</td>
<td>65.60</td>
<td></td>
</tr>
<tr>
<td>1972 01</td>
<td>69.00</td>
<td>66.90</td>
<td></td>
</tr>
<tr>
<td>1972 02</td>
<td>69.74</td>
<td>67.60</td>
<td></td>
</tr>
<tr>
<td>1972 03</td>
<td>70.79</td>
<td>68.60</td>
<td></td>
</tr>
<tr>
<td>1972 04</td>
<td>71.60</td>
<td>69.30</td>
<td></td>
</tr>
<tr>
<td>1973 01</td>
<td>72.20</td>
<td>72.70</td>
<td></td>
</tr>
<tr>
<td>1973 02</td>
<td>72.21</td>
<td>76.20</td>
<td></td>
</tr>
<tr>
<td>1973 03</td>
<td>78.60</td>
<td>79.30</td>
<td></td>
</tr>
<tr>
<td>1973 04</td>
<td>83.15</td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td>1974 01</td>
<td>89.99</td>
<td>85.30</td>
<td></td>
</tr>
<tr>
<td>1974 02</td>
<td>94.53</td>
<td>88.30</td>
<td></td>
</tr>
<tr>
<td>1974 03</td>
<td>97.46</td>
<td>94.60</td>
<td></td>
</tr>
<tr>
<td>1974 04</td>
<td>98.11</td>
<td>97.30</td>
<td></td>
</tr>
<tr>
<td>1975 01</td>
<td>98.68</td>
<td>97.90</td>
<td></td>
</tr>
<tr>
<td>1975 02</td>
<td>99.32</td>
<td>98.90</td>
<td></td>
</tr>
<tr>
<td>1975 03</td>
<td>100.18</td>
<td>101.00</td>
<td></td>
</tr>
<tr>
<td>1975 04</td>
<td>101.52</td>
<td>102.10</td>
<td></td>
</tr>
<tr>
<td>1976 01</td>
<td>104.21</td>
<td>102.60</td>
<td></td>
</tr>
<tr>
<td>1976 02</td>
<td>107.45</td>
<td>104.10</td>
<td></td>
</tr>
<tr>
<td>1976 03</td>
<td>119.61</td>
<td>105.40</td>
<td></td>
</tr>
<tr>
<td>1976 04</td>
<td>112.00</td>
<td>106.30</td>
<td></td>
</tr>
<tr>
<td>1977 01</td>
<td>114.89</td>
<td>108.60</td>
<td></td>
</tr>
<tr>
<td>1977 02</td>
<td>116.66</td>
<td>111.30</td>
<td></td>
</tr>
<tr>
<td>1977 03</td>
<td>117.69</td>
<td>111.40</td>
<td></td>
</tr>
<tr>
<td>1977 04</td>
<td>117.80</td>
<td>112.50</td>
<td></td>
</tr>
<tr>
<td>1978 01</td>
<td>119.66</td>
<td>115.40</td>
<td></td>
</tr>
<tr>
<td>1978 02</td>
<td>120.45</td>
<td>118.90</td>
<td></td>
</tr>
<tr>
<td>1978 03</td>
<td>121.49</td>
<td>120.00</td>
<td></td>
</tr>
<tr>
<td>1978 04</td>
<td>123.67</td>
<td>123.30</td>
<td></td>
</tr>
<tr>
<td>1979 01</td>
<td>126.69</td>
<td>125.00</td>
<td></td>
</tr>
<tr>
<td>1979 02</td>
<td>130.67</td>
<td>132.50</td>
<td></td>
</tr>
<tr>
<td>1979 03</td>
<td>134.88</td>
<td>136.70</td>
<td></td>
</tr>
<tr>
<td>1979 04</td>
<td>136.71</td>
<td>141.50</td>
<td></td>
</tr>
</tbody>
</table>


*a* See chapter IV (p. 75) for the methodology used to derive this index.
### TABLE 14

**ACTUAL AND SIMULATED VALUES OF THE STATE VARIABLES**

<table>
<thead>
<tr>
<th>Time</th>
<th>Unemployment Rate</th>
<th>Annualized Growth Rate of the GNP Deflator</th>
<th>Annualized Growth Rate of the Effective Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>actual(^a)</td>
<td>simulated</td>
<td>actual(^a)</td>
</tr>
<tr>
<td>1971 04</td>
<td>+5.50</td>
<td>+6.14</td>
<td>+4.73</td>
</tr>
<tr>
<td>1972 01</td>
<td>+6.27</td>
<td>+5.87</td>
<td>+4.61</td>
</tr>
<tr>
<td>1972 02</td>
<td>+5.93</td>
<td>+6.68</td>
<td>+3.88</td>
</tr>
<tr>
<td>1972 03</td>
<td>+5.47</td>
<td>+5.26</td>
<td>+3.96</td>
</tr>
<tr>
<td>1972 04</td>
<td>+4.90</td>
<td>+5.28</td>
<td>+4.15</td>
</tr>
<tr>
<td>1973 01</td>
<td>+5.33</td>
<td>+5.45</td>
<td>+4.34</td>
</tr>
<tr>
<td>1973 02</td>
<td>+4.89</td>
<td>+5.03</td>
<td>+5.49</td>
</tr>
<tr>
<td>1973 03</td>
<td>+4.73</td>
<td>+5.15</td>
<td>+6.56</td>
</tr>
<tr>
<td>1973 04</td>
<td>+4.30</td>
<td>+5.41</td>
<td>+7.22</td>
</tr>
<tr>
<td>1974 01</td>
<td>+5.56</td>
<td>+5.05</td>
<td>+8.00</td>
</tr>
<tr>
<td>1974 02</td>
<td>+5.67</td>
<td>+5.57</td>
<td>+9.07</td>
</tr>
<tr>
<td>1974 03</td>
<td>+5.57</td>
<td>+6.40</td>
<td>+10.27</td>
</tr>
<tr>
<td>1974 04</td>
<td>+6.10</td>
<td>+6.64</td>
<td>+11.51</td>
</tr>
<tr>
<td>1975 01</td>
<td>+9.07</td>
<td>+7.74</td>
<td>+11.57</td>
</tr>
<tr>
<td>1975 02</td>
<td>+8.69</td>
<td>+8.25</td>
<td>+10.15</td>
</tr>
<tr>
<td>1975 03</td>
<td>+8.27</td>
<td>+8.07</td>
<td>+9.69</td>
</tr>
<tr>
<td>1975 04</td>
<td>+7.70</td>
<td>+8.40</td>
<td>+7.59</td>
</tr>
<tr>
<td>1976 01</td>
<td>+8.47</td>
<td>+7.84</td>
<td>+5.75</td>
</tr>
<tr>
<td>1976 02</td>
<td>+7.33</td>
<td>+7.28</td>
<td>+5.44</td>
</tr>
<tr>
<td>1976 03</td>
<td>+7.53</td>
<td>+7.33</td>
<td>+4.50</td>
</tr>
<tr>
<td>1976 04</td>
<td>+7.27</td>
<td>+6.73</td>
<td>+4.76</td>
</tr>
<tr>
<td>1977 01</td>
<td>+8.17</td>
<td>+6.73</td>
<td>+5.36</td>
</tr>
<tr>
<td>1977 02</td>
<td>+6.87</td>
<td>+6.85</td>
<td>+6.12</td>
</tr>
<tr>
<td>1977 03</td>
<td>+6.70</td>
<td>+6.37</td>
<td>+6.13</td>
</tr>
<tr>
<td>1977 04</td>
<td>+6.23</td>
<td>+6.29</td>
<td>+6.22</td>
</tr>
<tr>
<td>1978 01</td>
<td>+6.88</td>
<td>+6.00</td>
<td>+6.29</td>
</tr>
<tr>
<td>1978 02</td>
<td>+5.57</td>
<td>+5.56</td>
<td>+7.02</td>
</tr>
<tr>
<td>1978 03</td>
<td>+5.93</td>
<td>+5.37</td>
<td>+7.82</td>
</tr>
<tr>
<td>1978 04</td>
<td>+5.47</td>
<td>+5.07</td>
<td>+8.29</td>
</tr>
<tr>
<td>1979 01</td>
<td>+6.23</td>
<td>+5.82</td>
<td>+8.36</td>
</tr>
<tr>
<td>1979 02</td>
<td>+5.47</td>
<td>+5.27</td>
<td>+8.62</td>
</tr>
<tr>
<td>1979 03</td>
<td>+5.73</td>
<td>+5.41</td>
<td>+8.96</td>
</tr>
<tr>
<td>1979 04</td>
<td>+5.60</td>
<td>+5.71</td>
<td>+8.37</td>
</tr>
</tbody>
</table>

\(^a\)Refer to table 12.
APPENDIX C
A NOTE ON DERIVING TOTAL U.S. CLAIMS ON FOREIGNERS AND CLAIMS ON THE U.S.

This note describes the method used to derive estimates of quarterly (end of quarter) stocks of U.S. claims on foreigners and liabilities to foreigners. They include both private and government assets and liabilities (both short and long term) so that assets used for exchange rate stabilization purposes can be counted in our definition of financial wealth. This becomes particularly relevant in explaining exchange rate behavior in the short-run.

We first select the end-of-year stocks of "U.S. Assets Abroad" and "U.S. Liabilities to Foreigners" as reported in Table 15. We then refer to the various June issues (1970-80) of the Survey of Current Business for table 1 of "U.S. International Transactions." This reports the quarterly flows of U.S. assets abroad and foreign assets in the U.S., on a net basis (i.e., a negative sign on U.S. assets abroad represents a capital outflow from the U.S., and hence, a net addition to U.S. claims on foreigners. Similarly, a positive sign on foreign assets in the U.S. indicates a net capital inflow and
therefore, a net addition to the stock of U.S. liabilities to foreigners).

From this, we are able to calculate the weights of quarterly capital inflows/outflows on a net basis. These weights can be used as a proxy for net additions to stocks on a quarterly basis. We therefore assign the end-of-year stock (as reported) to the 4th quarter and find the increment from year-to-year. This represents the flow. By weighting this flow by the quarterly weights (we calculated earlier), we obtain an estimate of the increment to the stocks on a quarterly basis. (Note that these weights are derived from unadjusted data and not from the adjusted data which is also reported.) By adding this quarterly increment to the stock of the preceding period, we obtain quarterly stock estimates of total U.S. international claims and liabilities.

The method is somewhat crude in that no adjustments are made for asset valuation changes on a quarterly basis. The end-of-year stocks are presented in table 15, and the derived quarterly estimates are reported in appendix B, table 11.
TABLE 15

TOTAL U.S. ASSETS ABROAD AND U.S. LIABILITIES TO FOREIGNERS AT YEAR'S END
(BILLIONS OF U.S. $)

<table>
<thead>
<tr>
<th>Year</th>
<th>U.S. Assets Abroad (U.S. Claims on Foreigners)</th>
<th>U.S. Liabilities to Foreigners (Foreign Claims on the U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>146.8</td>
<td>81.2</td>
</tr>
<tr>
<td>1969</td>
<td>158.0</td>
<td>90.8</td>
</tr>
<tr>
<td>1970</td>
<td>165.4</td>
<td>97.6</td>
</tr>
<tr>
<td>1971</td>
<td>179.4</td>
<td>123.3</td>
</tr>
<tr>
<td>1972</td>
<td>198.9</td>
<td>161.8</td>
</tr>
<tr>
<td>1973</td>
<td>222.8</td>
<td>174.9</td>
</tr>
<tr>
<td>1974</td>
<td>255.7</td>
<td>196.9</td>
</tr>
<tr>
<td>1975</td>
<td>295.1</td>
<td>220.5</td>
</tr>
<tr>
<td>1976</td>
<td>347.2</td>
<td>264.5</td>
</tr>
<tr>
<td>1977</td>
<td>382.9</td>
<td>310.6</td>
</tr>
<tr>
<td>1978</td>
<td>450.0</td>
<td>373.3</td>
</tr>
<tr>
<td>1979</td>
<td>514.4(^e)</td>
<td>406.0(^e)</td>
</tr>
</tbody>
</table>

\(^e\)estimate

GLOSSARY OF SYMBOLS

Greek Letters

\( \delta \), ratio of private financial wealth to the stock of money

\( \lambda \), growth rate of technology—also equal to the growth rate of productivity by assumption

\( \Omega \), marginal product of capital

Special Symbols

\( . \), growth rate of indicated variable, e.g., \( \frac{dp}{dt} \)

\( * \), expected value, e.g., \( \hat{p}^* \) is the expected growth rate of prices

Subscripts

d, domestic country

e, steady-state

f, foreign country

Note: The distinction between the foreign and domestic country is made (and hence, subscripts are used) only when the foreign sector enters into the discussion. Otherwise, subscripts are not used and it should be assumed that the domestic country is being discussed.

Other

\( B_f \), foreign bonds held by domestic residents

\( B_d \), domestic government bonds held by domestic residents

\( B_d^f \), domestic bonds held by foreigners

C, real consumption
D, differential operator, i.e., \( D = \frac{d(\cdot)}{dt} \)

E, real excess demand per unit of capital

e, exchange rate—defined as domestic currency units per unit of foreign currency

G, real government expenditure

I, real investment

K, units of physical capital

L, natural labor force

\( M^d \), demand for nominal balances

\( M^s \), nominal money supply/stock

m, real balances per unit of capital

\( m^s \), real money supply/stock

N, net real capital exports

\( N^2 \), effective labor force, i.e., natural labor force adjusted for technology

n, growth rate of the effective labor force

p, domestic general price level

\( p_d \), domestic production price index

r, nominal interest rate

S, real savings

t, time period

U, unemployment rate

\( \bar{U} \), natural rate of unemployment

v, real wages

W, nominal wages

X, net real exports

\( x_f \), demand for effective labor per unit of capital
$x$, effective labor employed per unit of capital

$x_s$, supply of effective labor per unit of capital

$x_1$, effective rate of unemployment, i.e., $x_1 = U - \bar{U}$

$y$, real income/output per unit of capital

$y^d$, real aggregate demand per unit of capital

$\bar{y}$, equilibrium level of real output/income per unit of capital
BIBLIOGRAPHY


International Monetary Fund. Summary Proceedings of the 31st Annual Meeting of the Board of Governors.


