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The Implications of Fiscal Conditions and Growing Internationalization for Monetary Policies and Financial Market Conditions 1/

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Abstract

The paper argues that the endogenous behavior of monetary authorities provides an important channel through which fiscal policy influences financial variables, and that growing internationalization has increased the sensitivity of financial conditions to fiscal policy. The core of the argument is that fiscal policy influences exchange rates, particularly to the extent that it affects the expected after-tax returns on capital located in different countries, and that the sensitivity of exchange rates to fiscal policy increases with growing internationalization. In addition, financial conditions reflect the actual and expected responses of the monetary authorities to exchange rates.

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1/ An earlier version of this paper was presented at a conference sponsored by the Board of Governors of the Federal Reserve System on "Monetary Aggregates and Financial Sector Behavior in Interdependent Economies," held May 26-27, 1988. The views expressed are my own and should not be regarded as the views of the International Monetary Fund. Much of the analysis reflects my collaboration with Michael Dooley. I am grateful for comments from Michael Dooley and Donald Mathieson.

Contents

Summary

The paper argues that the endogenous behavior of monetary authorities provides an important channel through which fiscal policy influences financial variables, and that growing internationalization has increased the sensitivity of financial conditions to fiscal policy. The core of the argument is that changes in fiscal policy instruments influence exchange rates, particularly to the extent that the policy changes affect the expected after-tax returns on capital located in different countries, and that the sensitivity of exchange rates to fiscal policy increases with growing internationalization. In turn, exchange rate developments affect the expected and actual behavior of the monetary authorities, which causes financial market conditions to change.

The arguments suggest that the increasing integration and globalization of financial markets is not the only "cause"--and may not even be the primary cause--of the increasing volatility of financial market conditions. The growing internationalization of decisions about real economic variables may imply an increasing need to harmonize or coordinate policies if financial stability is to be maintained and a deterioration in macroeconomic performance is to be avoided. Moreover, any form of harmonization or coordination of monetary policies among the major industrial countries may lack credibility and viability unless fiscal conditions are also harmonized or disciplined.

The endogenous nature of monetary policy and the role of fiscal policy in conditioning the environment in which monetary policy must operate raise issues for the design and application of macroeconometric models. Just as the credibility and viability of any particular strategy for monetary policy in reality may depend on fiscal conditions, the performance of a given rule for monetary policy in a macroeconometric model cannot generally be evaluated without specifying which tax or spending parameters the fiscal authorities adjust, and how quickly, in response to the emergence of budget imbalances that threaten to persist.

I. Introduction

This paper has been prepared in response to a request to analyze the implications of growing internationalization for monetary aggregates and financial sector behavior. The paper does not address the implications of internationalization for the demand for liquid assets, 1/ but instead concentrates essentially on the implications for the supply of liquid assets--in particular, for the behavior of the monetary authorities.

It is customary to conduct policy analysis, and to make forecasts, under the assumption that monetary policy can be taken as exogenous. While it seems clear that monetary authorities can control their policy instruments with a high degree of precision, and could hit targets for money growth rates or other intermediate variables with reasonable accuracy if they wanted to, it is also true that the authorities have rarely, if ever, been prepared to adhere rigidly to predetermined paths for their policy instruments or intermediate target variables no matter what. Central banks have exercised considerable discretion to deviate from, redefine, or abandon the money growth targets they have announced over the past dozen years, 2/ and private market participants have consequently devoted considerable attention to analyzing, predicting, and adjusting to the behavior of central banks. The behavior of the monetary authorities has not been exogenous, and macroeconomic analysis based on the assumption of exogenous monetary policy may be misleading.

In focusing on the implications of growing internationalization for monetary aggregates and financial sector behavior, this paper links together four main points. The first point is that the behavior of monetary aggregates and financial conditions depends to a large extent on the actual and expected behavior of the monetary authorities. A second point, which reflects one dimension of growing internationalization, is that the behavior of the monetary authorities in recent years has been guided to an important extent by exchange rate objectives. The third point is that the behavior of exchange rates depends considerably on the actual and expected behavior of the fiscal authorities, particularly to the extent that changes in fiscal policy instruments affect the expected after-tax returns on physical capital located in different countries. And the fourth point is that growing internationalization has made exchange rates more sensitive to the expected behavior of the fiscal authorities, which has also made the settings of

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1/ As Helliwell, Cockerline, and Lafrance (1988) emphasize, growing internationalization has made it more difficult to assume that demands for national moneys are insensitive to the expected returns on financial investments in foreign currencies.

2/ See Isard and Rojas-Suarez (1986) for a review of the experience with monetary targeting.

monetary policy instruments and the behavior of monetary aggregates and financial sector conditions more sensitive to the expected behavior of the fiscal authorities.

The paper is divided into several sections. Section II briefly reviews some important perspectives on how monetary policy strategies can influence both the relative stability of different financial variables and the general degree of financial market instability, and on the role that exchange rate developments have played in influencing the evolution of monetary policy strategies. Section III, which draws extensively on Dooley and Isard (1988), discusses how exogenous changes in different types of fiscal variables--tax parameters, expenditures on tradable and nontradable goods, and stocks of debt--can influence the stability of relative prices and exchange rates in a nonmonetary model. Section IV then links the credibility and viability of monetary policy strategies--and hence, the nature and degree of financial market instability--to pressures emanating from fiscal conditions. A final section provides some conclusions.

II. Monetary Policy Strategies and Financial Market Conditions

1. Monetary policy strategies and the relative stability of different financial variables

Although central bankers have no formal motto, the universally accepted goal of monetary policy is the achievement of "sustainable non-inflationary growth." Central bankers have several types of "instruments" that they can manipulate in their pursuit of price level stability and real economic growth. These instruments include the interest rates (or prices) at which they transact, the quantities of assets (international reserves and domestic central bank credit) and liabilities (high-powered money) on their balance sheets, and various regulatory settings (e.g., required reserve ratios).

While monetary authorities generally tend to monitor and analyze a large amount of information in pursuing their ultimate targets of price-level stability and real economic growth, and to exercise considerable discretion in linking their actions to available information, they have also tended to adopt strategies that involve targets or objectives for "intermediate" variables, such as the growth rates of monetary aggregates. A discussion of the rationale for adopting intermediate targets is beyond the scope of this paper, and reviews of the debate over rules versus discretion for monetary policy can be found elsewhere. 1/ Central bankers seem to believe implicitly that the

1/ For example, see Isard and Rojas-Suarez (1986) and Flood, Isard, and Rogoff (1988).

debate should be resolved on the middle ground. Intermediate targets that are taken seriously as guidelines can be beneficial by making the monetary authorities more accountable and predictable, but rigid rules for central bank behavior are undesirable and lack credibility. This paper emphasizes that one of the reasons that rigid monetary rules lack credibility is that fiscal conditions change over time.

It is clear that the type of intermediate targets or guidelines the central bankers adopt--or more generally, the "monetary policy reaction function"--is a major determinant of the relative stability of different financial variables. An exchange rate pegging strategy, for example, may require the monetary authorities to accept a relatively high degree of interest rate variation and relatively wide month-to-month fluctuations in the growth rates of bank reserves and other monetary aggregates. Similarly, the pursuit of targets for monetary aggregates may require the monetary authorities to tolerate relatively wide swings in exchange rates.

2. Monetary policy strategies and the general degree of financial market instability

It is sometimes alleged that monetary authorities have at times adopted strategies that have increased the instability of financial variables in general. For example, it can be argued that the Federal Reserve's day-to-day operating procedure designed to control the quantity of nonborrowed reserves during the period from October 1979 through the summer of 1982 contributed to greater day-to-day variability of interest rates and exchange rates than the subsequent approach based on the quantity of borrowed reserves. And it is not clear that any financial variables were more stable under the former approach.

Other examples of how monetary authorities can generate financial market instability have focused on the ability of central banks to generate uncertainty, or to operate in a manner that fails to provide an anchor for market expectations. In the current context, the desirability of providing an anchor for market expectations should be taken into account when central banks consider whether to allow long-term interest rates to influence the degree of restraint that they exercise in providing reserves to the banking system. 1/ Although

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1/ For the United States, published reports of the meetings of the Federal Open Market Committee (FOMC) and the February 1988 report to Congress on monetary policy objectives suggest that increases in long-term interest rates during the spring of 1987, and again in late summer, may have led the FOMC to seek somewhat greater restraint than they would have if their decisions had been based on all available information other than long-term interest rates. See Federal Reserve Board (1988), pp. 11-13.

long-term interest rates may often provide a gauge of the direction in which inflation expectations are moving, in general the level of long-term interest rates reflects expectations about the path of short-term interest rates. Accordingly, despite the importance of central bank actions to resist a rise in inflation expectations, a policy in which either bank reserves or short-term interest rates are adjusted partly in reaction to changes in long-term interest rates would appear to be a policy that allows the general level of interest rates to drift without a firm anchor. This suggests that the appropriate strategy would be for the monetary authorities to react to changes in a "model-based" forecast of inflation that provided an objective assessment of the inflationary implications of changes in exchange rates, economic activity, and other underlying conditions, but that was not judgmentally adjusted in light of changes in long-term interest rates.

3. Exchange rates and the evolution of monetary policy strategies

Exchange rate pressures have played a major role in the evolution of monetary policy strategies for individual countries and, more broadly, in the evolution of the international monetary system. The Bretton Woods system of adjustable pegs broke down when a rise in inflation in the center country, the United States, put generalized pressures on all par values simultaneously. In recent years, policy authorities in the major industrial countries have reacted to sharp shifts in U.S. dollar exchange rates by taking coordinated actions designed, initially, to encourage exchange rate adjustment and, subsequently, to stabilize exchange rates around prevailing levels.

One of the major difficulties in designing policies to achieve macroeconomic stabilization objectives is that the behavior of exchange rates cannot be predicted with much confidence. There are some who remain optimistic about the prospect of explaining the behavior of exchange rates in terms of changes in economic "fundamentals," but there is also growing sentiment that exchange rate volatility has reflected speculative forces unrelated to fundamentals. 1/ The appropriate design of policies may depend importantly on which view is correct. The obvious difficulty with the former view is that econometric efforts to model exchange rates have achieved very little success. Proponents of this view must base their hopes on new approaches to modeling exchange rates.

The next section of the paper presents one such approach. This framework, which Michael Dooley and I have been struggling to make persuasive in a series of papers dating back to 1983, 2/ argues

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1/ See Dornbusch and Frankel (1987) for an expression of the latter point of view.

2/ These include Dooley and Isard (1983, 1986, 1987, 1988).

that changes in the relative attractiveness of making real investments in different countries can have a particularly powerful influence on exchange rates; thus, the (expected) tax rates on the returns to physical capital located in different countries may be particularly important variables for explaining the behavior of exchange rates. Given the impression that the 1980 presidential election changed the anticipated climate for investment in the United States, and the fact that the real user cost of capital in the United States was reduced considerably by the Economic Recovery and Tax Act of 1981, the framework may help explain the strong appreciation of the dollar in the early 1980s; similarly, given that the real user cost of capital in the United States was subsequently raised considerably by the Tax Reform Act of 1986 (which to some extent was anticipated), the framework may help explain the strong depreciation of the dollar after early 1985. 1/ The framework also provides an hypothesis for explaining the emergence of strong upward pressures on the pound sterling during the early months of 1988, as strengthening anticipations of tax reductions, which were subsequently verified by the March Budget, may have contributed under the prevailing strategy for monetary policy to upward pressures on domestic financial aggregates and growing doubts that the monetary authorities would continue to resist an appreciation of the pound. 2/

III. The Effects of Fiscal Conditions and Growing Internationalization in a Nonmonetary Model of Exchange Rate Determination

This section, which draws extensively on Dooley and Isard (1988), is divided into two subsections that spell out and interpret a formal model, a third subsection that considers the implications of changes in different types of fiscal parameters within the formal model, and two subsections that use the model results to draw inferences about sources of exchange rate volatility and the implications of growing internationalization.

1/ For estimates of the user cost of capital, see Evans and Kenward (1988) and Corker, Evans, and Kenward (1988).

2/ On the surface, the hypothesis does not appear to explain the 1988 U.K. experience as cleanly as it explains the U.S. experience insofar as the U.K. tax reductions did not apply as directly to income from physical capital residing in the United Kingdom. Issues of tax incidence and tax avoidance complicate the distinctions that are drawn between different types of tax changes in simple analytic models, as does the fact that tax rate changes are generally endogenous to other events, but the empirical observation that large exchange rate changes tend to accompany (or occur in anticipation of) major changes in tax rates suggests that this area of analysis is important.

1. A nonmonetary model with fiscal variables

Consider a two-country world in which the residents of each country consist of a representative risk-neutral private agent and the government. Each country produces a nontradable good and a tradable good that is homogeneous across countries. The asset menu consists of stocks of physical capital and government securities. Private agents may own physical capital in either country or claims on either government. Physical capital is formed entirely from nontradable goods 1/ and is required to produce both nontradables and tradables. There is a one-period lag between purchases of physical capital and the production of output. Government securities are promises to deliver nontradable goods (as interest and principal repayments) that mature one period after they are issued. 2/ There are no financial assets. 3/

Private agents are assumed to be optimizing units that make consumption and asset accumulation decisions to maximize the present discounted values of their utility streams, subject to initial endowments and budget constraints. Private income is earned entirely from the returns on assets; the model abstracts from labor. Governments are treated as units that set fiscal policy parameters exogenously, subject to budget identities. The analysis focuses on how exogenous and unanticipated changes in different types of fiscal parameters influence capital formation, economic activity, imbalances between domestic savings and investment (hence, external imbalances), relative prices, and exchange rates. Although the optimization problem is posed in the context of an infinite horizon (in order to avoid arbitrary conditions on terminal capital stocks), the analysis is essentially two-period comparative statics in which a change in fiscal conditions disrupts an initial stationary state equilibrium, leading to adjustments to new equilibrium capital stocks in the first period and, because of the lag between capital formation and output, to new stationary state levels of all other variables in the second period.

For purposes of streamlining the analysis further, the tax system is limited to one parameter--a tax rate on the production that takes place within national boundaries. The implications of imposing taxes on income (from both domestic and foreign sources) rather than production will also be discussed, but consumption taxes, import tariffs, or other

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1/ As will be discussed below, the degrees of relative price and exchange rate variability are sensitive to this assumption, but the qualitative nature of the main results are not.

2/ The only role that government securities play in the analysis is to shift consumption intertemporarily between private agents and governments. The results would be essentially unchanged if government securities were denominated in tradable goods.

3/ The rationale for suppressing financial assets is provided in subsection 2 below.

taxes that distinguish between different goods are not considered. It should be noted that because the model abstracts from labor, the tax on production is borne entirely by the owners of physical capital.

The budget constraints and income definitions of private sectors, and the budget identities of governments, can be written as:

$$(1)\quad p_x c_x + p_n(c_n+\Delta k_{n1}+\Delta k_{x1}+\Delta b_1) + sp_n^*(\Delta k_{n1}^*+\Delta k_{x1}^*+\Delta b_1^*) = y$$

$$(2)\quad p_x^* c_x^* + p_n^*(c_n^*+\Delta k_{n2}^*+\Delta k_{x2}^*+\Delta b_2^*) + (1/s)p_n(\Delta k_{n2}+\Delta k_{x2}+\Delta b_2) = y^*$$

$$(3)\quad y = (1-\tau)(p_x f_{x1}+p_n f_{n1}) + s(1-\tau^*)(p_x^* f_{x1}^*+p_n^* f_{n1}^*) + p_n r b_1 + sp_n^* r^* b_1^*$$

$$(4)\quad y^* = (1-\tau^*)(p_x^* f_{x2}^* + p_n^* f_{n2}^*) + (1/s)(1-\tau)(p_x f_{x2} + p_n f_{n2}) + p_n^* r^* b_2^* + (1/s)p_n r b_2$$

$$(5)\quad p_x g_x + p_n g_n + p_n r b = \tau[p_x(f_{x1}+f_{x2}) + p_n(f_{n1}+f_{n2})] + p_n \Delta b$$

$$(6)\quad p_x^* g_x^* + p_n^* g_n^* + p_n^* r^* b^* = \tau[p_x^*(f_{x1}^*+f_{x2}^*) + p_n^*(f_{n1}^*+f_{n2}^*)] + p_n^* \Delta b^*$$

In these equations:

p denotes price,

c denotes consumption,

k denotes a stock of physical capital,

b denotes a stock of government securities,

f denotes output produced from capital,

y denotes private after-tax income,

τ denotes the tax rate on production,

r denotes the own rate of return on securities, and

s denotes the exchange rate.

Variables without (with) a superscript * refer to country 1 (country 2); for assets, this superscript indicates where physical capital is located or by which government the securities have been issued. Subscripts x and n refer to tradables and nontradables, respectively. Subscripts 1 and 2 denote the country whose private sector owns the relevant capital stocks, securities, or output levels. And Δ indicates the difference between stocks of physical capital or securities that will generate income in the next period and the corresponding stocks that generate income in the current period.

The exchange rate corresponds to the ratio of the price of tradables in country 1 to the price of tradables in country 2

$$(7) \quad s = p_x / p_x^*$$

The existing stocks of securities are held entirely by the two private sectors

$$(8) \quad b_1 + b_2 = b$$

$$(9) \quad b_1^* + b_2^* = b^*$$

The balance of payments identity, expressed from the perspective of country 1, is:

$$(10) \quad p_x(f_{x1}+f_{x2}-c_x-g_x) + s[(1-\tau^*)(p_x^* f_{x1}^* + p_n^* f_{n1}^*) + p_n^* r^* b_1^*]$$

$$- [(1-\tau)(p_x f_{x2} + p_n f_{n2}) + p_n r b_2] = s p_n^* (\Delta k_{x1}^* + \Delta k_{n1}^* + \Delta b_1^*)$$

$$- p_n(\Delta k_{x2} + \Delta k_{n2} + \Delta b_2)$$

The first term in this identity represents the trade surplus of country 1 (all terms are valued in the unit of account of country 1); the second term represents after-tax income from production abroad and from claims on foreign governments; the third term represents after-tax income payments to nonresidents; and the two terms on the right of the equality sign represent investments by domestic residents in both tangible assets abroad and foreign securities, and investments by nonresidents in both physical capital in country 1 and securities issued by the government of country 1.

It may be instructive to note that this framework will allow inferences to be drawn about the implications of growing internationalization in asset markets. With no internationalization in asset markets (i.e., with $b_1^* = b_2 = k_{n1}^* = k_{x1}^* = k_{n2} = k_{x2} = 0$), there would be no investment flows and no net investment income payments among countries, and trade imbalances could not occur. The model does not focus on internationalization associated with the production of different types of tradable goods in different countries.

The assumptions about production should also be noted: the model disaggregates capital stocks and production not only by country and sector, but also by ownership within sectors. The assumption that the production opportunities available to different private agents in different sectors of different countries are all independent (in the technological sense that one agent's output depends only on his own capital stock) is simply a variant of the paradigm of many competitive firms.

The Appendix specifies and solves the optimization problem for a representative private agent under the assumption that these agents are risk-neutral price takers who maximize the present discounted values of their utility streams subject to budget constraints and initial endowments, with period utility levels $U(c_x, c_n)$ or $U^*(c_x^*, c_n^*)$ and discount factor β, and with perfect foresight of fiscal policy parameters and other variables. The first order conditions are familiar:

$$(11) \quad \frac{\partial U/\partial c_n}{\partial U/\partial c_x} = \frac{\partial f_{xi}/\partial k_{xi}}{\partial f_{ni}/\partial k_{ni}} = \frac{p_n}{p_x} \qquad \text{for } i = 1,2$$

$$(12) \quad \frac{\partial U^*/\partial c_n^*}{\partial U^*/\partial c_x^*} = \frac{\partial f_{xi}^*/\partial k_{xi}^*}{\partial f_{ni}^*/\partial k_{ni}^*} = \frac{p_n^*}{p_x^*} \qquad \text{for } i = 1,2$$

$$(13)\quad (1+\hat{p}_n)(1+r) = (1+\widehat{sp}_n^*)(1+r^*) = 1/\beta$$

$$(14)\quad (1+\hat{p}_n)[1+(1-\tau)\partial f_{ni}/\partial k_{ni}] =$$

$$(1+\widehat{sp}_n^*)[1+(1-\tau^*)\partial f_{ni}^*/\partial k_{ni}^*] = 1/\beta \qquad \text{for } i = 1,2$$

where $\hat{p}_n = \Delta p_n/p_n$ and $\widehat{sp}_n^* = \Delta(sp_n^*)/sp_n^*$.

Conditions (11) and (12) require that marginal rates of intratemporal substitution between nontradables and tradables in consumption, *and marginal rates of intratemporal transformation through production*, must equal the relative prices of the goods. The intertemporal conditions (13) and (14) require that all assets yield the same after-tax returns at the margin, which must be equal to the rate of consumer time preference as measured by the reciprocal of the discount factor. These conditions imply, in turn, that any equilibrium in which both real variables and prices are stationary will have the properties that the marginal products of capital in the nontradable goods sectors (i.e., the capital-goods sectors) depend only on the discount factor and the tax rates on production

$$(15)\quad \frac{\partial f_{ni}}{\partial k_{ni}} = \frac{(1-b)}{\beta(1-\tau)} \qquad \text{for } i = 1,2$$

$$(16)\quad \frac{\partial f_{ni}^*}{\partial k_{ni}^*} = \frac{(1-b)}{\beta(1-\tau^*)} \qquad \text{for } i = 1,2$$

while the stationary-state levels of interest rates on securities depend only on the discount factor

$$(17)\quad r = r^* = (1-\beta)/\beta$$

Note, also, that in a model with nontradable goods as numeraires, such that $p_n = p_n^* = 1$, condition (13) implies that interest rates in every period satisfy the familiar uncovered interest rate parity approximation

$$(18)\quad r - r^* \approx \hat{s}$$

2. The interpretation of the price system

One of the significant pieces that the model is missing is an exogenous nominal quantity (or some other nominal rigidity) that is capable of pinning down the absolute level of prices. For present purposes, it is desirable to leave that piece missing, since the focus initially is on the implications of nonmonetary shocks, 1/ and since it seems preferable to avoid the controversy over how to incorporate money in a general equilibrium model. 2/ Accordingly, for the remainder of this section, price levels will be "tied down" simply by treating the nontradable goods as numeraires

$$(19)\quad p_n = p_n^* = 1$$

A second limitation of the model is that the menu of goods from which consumers may choose includes only nontradables and tradables that obey the law of one price. Apart from structures, most consumer goods in reality are tradables that do not obey the law of one price and whose prices (relative to prices of nontradables) fluctuate much less than those of law-of-one-price commodities. In light of this point, a variant of the model that has considerable appeal--but that this paper does not attempt to work out formally—is based on a production framework in which goods are produced with other goods along with nontradable factors (e.g., labor and land) and primary commodities. If nontradable factors are scarce relative to primary commodities (which can be imported), then any shock that shifts production toward country 1 and away from country 2 will bid up (down) the price of nontradable factors relative to the price of primary commodities in country 1 (country 2). Moreover, to the extent that efforts by monetary authorities to stabilize the prices of goods have the effect of keeping the wages of nontradable factors much more stable in absolute terms than the prices of primary commodities, such a model would be consistent with the observation that in reality the prices of manufactured goods and nontradable factors are much less variable than primary commodity prices and nominal exchange rates. In such a monetary model, any shock that shifts production toward country 1 will tend, in the short run, to push

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1/ The focus on nonmonetary shocks can be justified by the fact that monetary models of exchange rates haven't worked. As Dornbusch and Frankel (1987, p. 10) observe: "If exchange rate changes were in truth explainable by changes in money supplies, ... we would have much better results in our regressions than we do."

2/ It should be recognized, of course, that in many models the monetary policy reactions to nonmonetary shocks can be very important in transmitting the effects of the shocks to real variables. To this extent, the omission of the monetary sector distorts the analysis of relative prices and other real variables.

down (up) the absolute price of primary commodities in country 1 (country 2) and, consistent with the law of one price for primary commodities, to appreciate the currency unit of country 1.

3. Effects of unanticipated changes in fiscal variables

The next step is to use the formal model to analyze how exogenous changes in different types of fiscal variables can influence exchange rates, international payments imbalances, and other variables. This material will serve as the core for subsequent attempts to think about a world in which fiscal authorities adjust--and are expected to adjust--their policy variables in an endogenous manner, and in which there are monetary authorities who "react" to exchange rates.

The model described by conditions (1)-(19) has a stationary state equilibrium in which the values of relative prices and other real variables depend on production technologies, consumption preferences, the policy settings of the fiscal authorities, and the distribution of security holdings. The settings of fiscal variables include tax rates, the quantities of goods that governments purchase, and the outstanding stocks of government securities. Given that the analysis has been simplified by treating private sectors as risk neutral with perfect foresight, for present purposes the distribution of security holdings is treated as exogenous. 1/

Because the only lag in the model is a one-period lag between capital formation and production, the effects of an unanticipated shock on the equilibrium values of real variables can be viewed as the result of adjustments that take place over two time periods. In the first period following the shock, production levels are predetermined by the capital stocks that existed prior to the shock, and market prices must be consistent with allowing capital stocks to adjust to whatever levels prevail in the new stationary state equilibrium, which is assumed to be reached in the second period. The solution procedure is first to derive the new equilibrium values of relative prices and other real variables and then to derive the first-period "impact effects" that must occur to generate the adjustment to the new equlibrium. This procedure is spelled out formally in Dooley and Isard (1988, Appendix II).

Recent contributions to the literature on fiscal policy and exchange rates have emphasized that the effect on the exchange rate of an increase in fiscal spending depends on the composition of the additional fiscal spending; similarly, the exchange rate effects of measures to increase fiscal revenue depend on how the additional revenue is

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1/ Under the risk neutrality and perfect foresight assumptions, the yields on different securities (net of any taxes) will be equal, and private sectors will be indifferent about the compositions of their portfolios of securities.

raised. 1/ To a large extent, such analysis has focused on how fiscal actions affect the level and composition of the aggregate private-plus-public demand for goods. By contrast, the model developed in this paper emphasizes that in a forward-looking framework, fiscal actions can affect the exchange rate by influencing the desired stocks of physical capital in different countries, which has implications for time paths of production, relative prices, and exchange rates. The notions that resource allocation and exchange rate movements are interrelated, and that exchange rate overshooting can result from the fact that physical capital formation takes time, have been emphasized previously by Neary and Purvis (1983).

In distinguising the effects of unanticipated changes in different fiscal variables, it is instructive to isolate the effects of changes in tax rates and debt by making the assumption that the composition of government spending on tradables and nontradables exhibits the same behavior, at the margin, as the composition of private sector spending. The effects of a change in the composition of government spending can be analyzed separately. Although the only taxes identified explicitly in the model are taxes on domestic products, the effects of a change in taxes on income earned (at home and abroad) by domestic residents can be inferred. It should be emphasized, however, that the analysis abstracts from the issue of tax avoidance and greatly oversimplifies the issue of tax incidence.

Table 1 provides summary descriptions of the effects of four different types of fiscal changes in country 1. The first line of the Table considers a reduction in the tax rate on domestic production in country 1, with neutral changes in the fiscal position of country 2. 2/ Because the tax reduction effectively raises the after-tax returns on capital located in country 1, it provides incentives for additional capital accumulation in both the tradable and nontradable goods sectors of country 1. 3/ The new stationary state levels of nontradables production in country 2--which (because capital is formed from nontradables) depend only on the discount factor and the local tax rate--will be

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1/ See Frenkel and Razin (1987a, 1987b).

2/ Since the settings of fiscal instruments must satisfy the government budget identities, any event that affects relative prices in country 1 will generally require an adjustment of fiscal policy settings in country 2. In this context, a neutral change in the fiscal position of country 2 is defined as an adjustment that holds the tax rate and stock of public debt constant while changing the composition of government spending in amounts that satisfy the budget identify and exhibit, at the margin, the same elasticities as private sector spending in response to relative price changes.

3/ The effects of production taxes would be different to the extent that the tax burden was ultimately borne by labor rather than by capital.

Table 1. Effects of Unanticipated Changes in Fiscal Variables

Fiscal Change	Physical Capital Stocks	International Flows	Prices of Tradable Goods (Relative to Nontradables)	Exchange Rate 1/
1. Permanent reduction in the tax rate on domestic production (capital) in country 1, with a neutral reduction in government spending. 2/	Capital stocks in nontradables sectors increase in country 1 and do not change in country 2. In the "normal case," capital stocks in tradables sectors increase in country 1 and decline in country 2. 3/	In the short run, country 1 experiences relatively large net imports of tradable goods balanced by net outflows of claims on capital.	Declines in country 1 (perhaps considerably) in short run, then rises to around its initial level. Relatively small changes in country 2.	Currency 1 appreciates (perhaps considerably) in the short run, then depreciates to around its initial level.
2. Permanent one-time increase in the stock of outstanding securities issued by the government of country 1, with no change in tax rates.	Nothing changes in the benchmark case. 4/			
3. Permanent reduction in the tax rate on income earned (globally) by residents of country 1, with an aggregate-demand-preserving change in the stock of securities. 5/	Nothing changes in the benchmark case. 4/			
4. Permanent increase in the quantity of nontradable goods purchased by the government of country 1, offset by a reduction in purchases of tradable goods.	Capital stocks in nontradables sectors do not change. Capital stocks in tradables sectors decline in country 1 and show relatively small changes in country 2.	Relatively small changes.	Declines in country 1 in the long run. Relatively small change in country 2.	Currency 1 appreciates in the long run.

1/ Although there are no monetary assets in the model, it is convenient to use the term "currency 1" to refer to the unit of account in country 1--i.e., the nontradable good. Hence, an appreciation of currency 1 refers to a rise in the amount of tradables that can be acquired with one unit of nontradables produced in country 1 relative to the amount of tradables that can be acquired with one unit of nontradables produced in country 2.

2/ The composition of government spending at the margin is defined to be neutral when it exhibits the same relative price elasticities as private sector spending.

3/ The "normal case" is the case in which country 1 has a greater trade surplus in the long run, reflecting higher net investment income payments to the residents of country 2.

4/ The benchmark is the case in which the additional securities issued by the government are purchased by the private sector of country 1 and in which the composition of government spending at the margin is the same as the composition of private sector spending at the margin.

5/ Aggregate demand is preserved by issuing securities to accommodate the private sector's propensity to save out of its additional after-tax income.

unchanged from the pre-shock levels. The new stationary state levels of tradables production in country 2 will normally decline, since the tax rate reduction in country 1 provides incentives to shift tradables production toward country 1. For the capital accumulation to take place in country 1, private and public consumption of nontradables in country 1 must be "crowded out" in the short run by a decline in the relative price of tradables; in country 2, where capital stocks remain unchanged in the nontradables sectors and are normally decumulated in the tradables sectors, the relative price of tradables is likely to rise somewhat in the short run. Accordingly, "currency 1" will appreciate (perhaps considerably) in the short run. 1/ In the long run, after the capital accumulation and decumulation has taken place, relative prices and the exchange rate are likely to return to the vicinity of their initial levels.

In this analysis, the initial decline in nontradables consumption, and hence in the relative price of tradables in country 1, reflect the assumptions that production of nontradables cannot increase until additional capital accumulation takes place, and that the additional capital must be formed from the nontradable good. If either of these assumptions is relaxed, the initial declines in nontradables consumption and, hence, in the price of tradables will be smaller. Nevertheless, to the extent that the initial effects of the shock on capital accumulation and tradable goods prices go in the opposite direction (or are smaller in magnitude) in country 2 than in country 1, the initial decline in the currency-1 price of tradables will still be associated with an initial appreciation of currency 1.

The second type of fiscal change is an unanticipated one-time increase in the stock of outstanding securities issued by the government of country 1. As a benchmark, it is instructive to consider the case in which the additional securities are purchased entirely by the private sector of country 1, and in which the composition of the government's spending at the margin is the same as the composition of the private sector's spending. In this case the issue of securities has no effect on relative prices or other real variables (apart from the levels of public and private consumption) in either the short run or the long run. In the short run, the increase in government purchases exactly matches the reduction in private-sector consumption, both in magnitude and in composition. And in the stationary state, the reduction in the government's spending on goods, which is the counterpart of its higher interest payments, exactly matches the additional spending that the private sector finances with the increase in its interest receipts.

The same inferences can be drawn for the third type of fiscal change--a reduction in taxes on the incomes of domestic residents--provided that the government issues additional securities to

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1/ See Table 1, footnote 1.

accommodate the private sector's propensity to save out of its additional after-tax income. For the benchmark case in which the government and the private sector spend their marginal incomes in the same way, any transfer of income between them will have no affect on relative prices or other real variables (apart from the levels of public and private consumption).

The fourth type of fiscal change is an unanticipated permanent increase in public spending on nontradables in country 1, offset by a reduction in public spending on tradables (holding constant the tax rate and the stock of securities). In this case there are no effects on nontradables production in either country (recall condition (15)), so the higher public spending on nontradables in country 1 must crowd out private consumption of nontradables. This requires a decline in the country-1 price of tradables in the long run, and an associated appreciation of currency 1. The decline in the long-run relative price of tradables in turn induces a decumulation of capital in the tradable goods sector of country 1. 1/

The analysis of these cases indicates that the effects on real variables and exchange rates of any type of fiscal shock depend on the extent to which capital is formed from nontradable goods, and depend as well on how quickly it is possible to shift capital between tradables production and nontradables production. 2/ It should be emphasized, however, that even if it were assumed that capital was formed only partly from nontradables and partly from tradables, rather than entirely from nontradables, the summary descriptions in Table 1 would remain valid; only the magnitude of the effects in lines 1 and 4, and not the directions, would be modified. An increase in the demand for capital goods in country 1, or an increase in the government's demand for nontradables, would still require a decline in the relative price of tradables to "crowd out" the private sector from nontradables consumption.

4. The variability of exchange rates and the implications of growing internationalization

Table 1 provides a useful starting point for addressing the sources of exchange rate variability and the implications of growing internationalization. The message of Table 1--or the view of the world

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1/ The crowding out of private consumption of nontradables will be less in the short run than in the long run (and, indeed, need not even occur in the short run) to the extent that the supply of nontradable goods is increased in the short run by capital decumulation from the tradable goods sector of country 1. For the same reason, currency 1 will appreciate more in the long run than in the short run (and could even depreciate in the short run).

2/ In the model presented in subsection 1, such capital shifting takes the same amount of time (i.e., one period) as the lag between capital formation and production.

that is incorporated into the underlying model--is that relative prices and exchange rates are particularly sensitive to the types of fiscal changes that affect the relative attractiveness of accumulating capital in different countries. For the benchmark cases considered in lines 2 and 3--when private domestic residents and the government have identical consumption patterns at the margin--relative prices and exchange rates are completely insensitive to increases in government spending that are financed either by issuing debt or by raising taxes that apply uniformly to the incomes that domestic residents earn at home and abroad. This analysis of these cases presumes, however, that private agents do not conceal their incomes from the tax authorities. 1/ Moreover, whenever the composition of government spending is systematically different at the margin from the composition of private sector spending, any fiscal policy measures that result in changes in government spending will have systematic effects on relative prices and exchange rates. 2/

In reality, tax laws and issues of tax incidence are complicated, and the relative attractiveness of investing in different countries may not be related to tax parameters in the simple and clear-cut way that the model presents. No oversimplified model can provide persuasive support for the argument that exchange rates are particularly sensitive to fiscal changes that affect the relative attractiveness of accumulating capital in different countries. Independently of this proposition, however, the view of the world that is incorporated into the model emphasizes two general points. The first proposition is the old notion that exchange rates move to re-equilibrate goods markets--i.e., to facilitate whatever adjustments in the relative prices of goods, and whatever international transfers of goods, are required to maintain equilibrium in the wake of unanticipated shocks to the economy. The second point is that the fiscal authorities are major players in the economy whose actual and expected behavior needs to be spelled out more extensively and integrated into any analysis of exchange rate determination.

These arguments do not exclude the possibility that much of the observed behavior of exchange rates may be unrelated to fiscal variables or other fundamental factors. Moreover, it should be recognized that modification of the model would modify the effects of exogenous changes in different types of fiscal variables. In a model that did not impose a constant marginal rate of time preference, increases in government spending would influence the discount factor (β) and, hence, the

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1/ In practice, the income that domestic residents earn in foreign countries may be easier to hide from domestic tax collectors than income earned domestically, so that an increase in the tax rate on the income of domestic residents may actually increase the relative attractiveness of accumulating capital in foreign countries.

2/ This can be inferred from lines 2-4 of the table.

levels of capital stocks at which the marginal products of capital were in equilibrium, even if the composition of government spending was no different than the composition of private sector spending. In a model in which capital goods were formed from a mix of tradables and nontradables, changes in tax rates that increased the incentives to accumulate capital in a given country would still require an initial rise in the relative price of nontradables in that country in order to induce a shift away from nontradables in private and government consumption. Similarly, in a model in which consumers could choose from more than two goods, and in which different consumption goods embodied different proportions of inputs of nontradable domestic factors of production and inputs of tradable raw materials (i.e., law-of-one-price commodities), an increase in incentives to accumulate capital in a given country would still require an initial rise in the shadow prices of the nontradable domestic factors in order to free those factors for producing more capital goods by inducing a shift in consumption patterns toward goods that embodied the nontradable factors in smaller proportions. 1/

The model described earlier, and the discussion surrounding Table 1, provide an important insight into the effects of growing internationalization. In particular, it should be apparent that the magnitudes of the changes in exchange rates and international payments imbalances that result from unanticipated shifts in fiscal parameters are positively related to the degree to which the equilibrium stocks of physical capital change in response to the shifts in fiscal parameters. This suggests that, other things being equal, the variability of exchange rates is positively related to the extent to which physical capital is internationally mobile in an ex ante sense--i.e., the degree to which decisions on where to locate new plant and equipment are made with an international horizon. 2/

1/ In this context, it can be argued that if attempts are made to expand the streamlined model presented in Sections II.1 and II.2 into a framework that is useful for large-scale macroeconometric modeling, the "two goods" in the streamlined model should be interpreted as primary factors of production--i.e., nontradable labor or land and tradable primary raw materials--rather than goods that are consumed directly. Production could be viewed as a process of producing goods with other goods along with the two types of primary factors.

2/ In a model in which every agent who has opportunities to produce in any country has identical production possibilities, it seems intuitive that an increase in the proportion of agents who have opportunities to produce in foreign countries will increase the sensitivity of exchange rates to changes in tax rates on capital. The proposition may also be valid for other ways of representing an increase in the ex ante international mobility of physical capital.

More generally, this view of the world suggests that the instability of exchange rates and current account positions increases with the growing internationalization of economic decisions about real variables. It seems valid to assert that while instability is associated with the fact that physical capital is internationally mobile in an ex ante sense, and while decisions about the location of new production facilities are influenced importantly by international differences in (expected) tax rates, the extent to which such decisions are influenced by tax rates depends importantly, in turn, on the degree to which consumer tastes have become internationalized and the degrees to which technologies can be transferred and labor skills adapted internationally. As a related point, it may be noted that growing internationalization can increase instability in either a fixed exchange rate system or a flexible rate system. In a fixed exchange rate system, divergent fiscal conditions generate current account instability, and the extent of such current account instability increases as economic decisions about real variables become more internationalized. 1/ Whether or not the growing internationalization of financial markets adds to the potential for instability is not considered in this paper.

5. The role of market expectations

An issue that remains to be addressed is the role of market expectations. One important type of fiscal shock that was not included in Table 1 is the case of an unanticipated and recurrent budget deficit--a continuing increase in the outstanding stock of government securities. The analysis of this case requires an extension of the model and emphasizes the role of expectations. The difficulty that this case presents is that it cannot be analyzed formally without focusing on the issue of how and when the stock of debt will either stop expanding (in a world that converges to a stationary state) or stabilize relative to certain other variables (in a world that converges to a steady growth state). This is equivalent to the issue of how and when the fiscal authorities will react to an unanticipated budget deficit that threatens to persist.

The model described earlier should be viewed as a first step in analyzing a world in which governments react--and are expected by private sectors to react--to the numerous unanticipated shocks that

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1/ In the single currency system of the United States, for example, the extent to which physical capital is mobile ex ante among the states should have an important influence on the extent to which changes in state tax rates affect both the current account imbalances of the states and the relative prices of labor and land (i.e., "nontradable" factors) in different states. See Benson and Johnson (1986) for evidence that state and local taxes have a negative effect on capital formation and for the argument that interstate tax competition has kept state and local taxes relatively harmonized.

arise in the world economy. There are many types of shocks that require an adjustment in at least one of the fiscal parameters that enter the government budget identity; obversely, many types of shocks give rise to budget deficits or surpluses that are likely to persist until the government adjusts its tax parameters or spending levels. Thus, in a world that is frequently subjected to shocks that have significant implications for government budget positions, rational market participants will frequently reassess their expectations about the future actions that fiscal authorities may take. To the extent that market participants, in so doing, frequently revise their expectations about the relative after-tax returns on capital in different countries, exchange rates are likely to change frequently. 1/

IV. Fiscal Conditions and the Credibility and Viability of Monetary Policy Strategies

The previous section has focused on the extent to which exogenous changes in fiscal variables--or revisions in expectations about fiscal variables induced by exogenous shocks to the economy--can lead to changes in current account positions and exchange rates in a nonmonetary model. In addition, it has been emphasized that growing internationalization of decisions about real economic variables tends to increase the sensitivities of current accounts and exchange rates to exogenous shocks.

The paper has also noted that exchange rate developments have played a prominent role--as a proximate cause--in the evolution of monetary policy in the major industrial countries since World War II. During the Bretton Woods era, monetary policies were oriented toward maintaining fixed exchange rates; beginning in the mid-1970s, after the Bretton Woods system lost its viability, monetary policies became oriented toward achieving formal targets or informal objectives for the growth rates of monetary aggregates; and in recent years, following a period of wide swings in U.S. dollar exchange rates, the authorities have shifted back toward emphasizing objectives for exchange rate adjustment and stabilization.

When these two different types of perspectives are combined, they suggest that changes in fiscal conditions have played a major role in "forcing" the evolution of monetary policy. The shift to an expansionary

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1/ As it stands, the model presented in this paper can only explain a gradual appreciation of the exchange rate in terms of a series of positively correlated shocks. This feature of the model might conceivably be modified, however, by allowing for: (a) gradual adjustment of expectations about fiscal variables; (b) lags between changes in fiscal variables and investment decisions; or (c) gradual adjustment arising from missing sectors of the model, such as the monetary sector or labor markets.

fiscal stance in the United States in the mid-1960s, and the consequent rise in U.S. inflation, played a large role in undermining the Bretton Woods system. 1/ Similarly, to the extent that divergent fiscal changes in the United States and other industrial countries contributed to the wide swings in dollar exchange rates during the 1980s--which is a conjecture for which the model of Section II provides support 2/--changing fiscal conditions must also shoulder a good part of the blame for "forcing" monetary authorities in recent years to tolerate deviations from or near misses of monetary growth targets in the Federal Republic of Germany and the United States, and relatively rapid monetary growth in Japan, as an implication of placing greater emphasis on exchange rate objectives.

There are two points to emphasize here. One point is that changes in fiscal conditions not only can undermine a fixed exchange rate system, but also can force monetary authorities to abandon other "systems" in order to condition their policy reactions toward resisting large changes in exchange rates. The notion that monetary policy has operated independently of fiscal conditions is unrealistic, and macroeconomic analysis based on the assumption that monetary policy is exogenous may be misleading. The second point, as developed in Section III, is that growing internationalization intensifies the pressures that result from changes in fiscal conditions.

V. Conclusions

This paper provides support for the following points of view.

1. The increasing international mobility of physical capital and, more generally, the growing internationalization of economic decisions about real variables, tends to increase the instability of financial market conditions, other things being equal. The increasing integration and globalization of financial markets is not the only "cause"--and may not even be the primary cause--of the increasing volatility of financial markets.

1/ See Solomon (1977, pp. 100-104), who documents the view that the rise in inflation was linked to the rapid buildup of military outlays related to Viet Nam and the slow political process of raising taxes to finance the war.

2/ As noted earlier, this conjecture reflects the fact that the real user cost of capital in the United States was reduced considerably by the Economic Recovery and Tax Act of 1981 and was subsequently raised considerably by the Tax Reform Act of 1986. For estimates of the user cost of capital (but not of its implications for exchange rates), see Evans and Kenward (1988) and Corker, Evans, and Kenward (1988).

2. Exchange rates are particularly sensitive to changes in fiscal conditions and other factors that affect the relative attractiveness of accumulating physical capital in different countries. The relative levels of (expected) tax rates on the returns on physical capital located in different countries are particularly attractive candidates to try out as explanatory variables in empirical exchange rate models.

3. In a world that is frequently subjected to "shocks" that have significant implications for government budget positions, rational market participants will frequently reassess their expectations about the future actions that fiscal authorities may take. In such an environment, the frequency and magnitude of changes in exchange rates will depend importantly on the frequency and magnitude of revisions in expectations about the relative after-tax returns on capital in different countries.

4. The growing internationalization of economies may imply an increasing need to harmonize or coordinate policies if a deterioration in economic performance is to be avoided. Internationalization can provide economic benefits, but this generally requires a sacrifice of policy autonomy.

5. The nature of the "monetary policy reaction function" has a major influence on the nature and degree of instability in financial market conditions, but the credibility and viability of monetary policy reaction functions may depend on fiscal conditions. Changes in fiscal conditions can force monetary authorities in some circumstances to abandon a fixed exchange rate system and in other circumstances to abandon a policy strategy that allows exchange rates to fluctuate. Any form of harmonization or coordination of monetary policies among the major industrial countries may lack credibility and viability unless fiscal conditions are also harmonized or disciplined.

The endogenous nature of monetary policy, and the role of fiscal policy in conditioning the environment in which monetary policy must operate, raise issues for the design and application of macroeconometric models. Advances in computer technology and solution algorithms have made it feasible to develop multi-country macroeconometric models with model-consistent, forward-looking expectations of financial variables. 1/ These models make it feasible to conduct simulation experiments that compare the effects of different monetary policy rules under the assumption that private sectors know the rules and behave rationally. But it is important to emphasize that solutions to forward-looking models are based either on suppressing the government sector 2/--and hence ignoring the fact that governments are major

1/ See Taylor (1988) for a discussion of the empirical implementation of multi-country macroeconometric models with forward-looking, model-consistent expectations.

2/ As in Taylor (1988).

players in the economy who frequently experience budget deficits or surpluses that threaten to persist 1/--or on imposing an arbitrary fiscal policy reaction function that adjusts the level of a designated tax (or fiscal spending) parameter as the stock of public debt (or the level of debt service payments) changes relative to some appropriate scale variable. 2/ Just as the credibility and viability of any particular strategy for monetary policy in reality may depend on fiscal conditions, the performance of a given rule for monetary policy in a macroeconometric model cannot generally be evaluated independently of the specification of the fiscal policy reaction function.

1/ In this situation, private market participants will rationally form expectations of which tax or spending parameters the government will adjust and how quickly the adjustment will take place.

2/ As in the IMF's MULTIMOD; see Masson et al (1988).

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APPENDIX

First-Order Conditions for Choices by Private Agents

This appendix specifies and solves the choice problem of private agents to derive the first-order conditions (11)-(14).

At time t = 0, the representative private agent in country 1 is assumed to plan its streams of intertemporal consumption and asset holdings to maximize the present discounted value of its utility stream, $\sum_{t=0}^{\infty} \beta^t U(c_{xt}, c_{nt})$, subject to its initial endowments of assets, its period budget constraints (condition (1)), and the production technologies, tax rates, and market prices that define its income flows (condition (3)). Agents are assumed to be risk neutral with perfect foresight, 1/ and it is also assumed that private consumption decisions are not directly affected by the level or composition of government spending.

The choice problem can be solved in recursive form by defining the value function

$$(20)\quad V[k_{xit}, k_{nit}, k^*_{xit}, k^*_{nit}, b_{it}, b^*_{it}, \cdots] =$$

$$\text{Max} \left\{ \begin{array}{l} U(c_{xt}, c_{nt}) + \beta V[\cdot_{t+1}] \\ + \lambda_t[(1-\tau_t)(p_{xt}f_{xit}+p_{nt}f_{nit}) + s_t(1-\tau^*_t)(p^*_{xt}f^*_{xit}+p^*_{nt}f^*_{nit}) \\ \quad + p_{nt}r_t b_{it} + s_t p^*_{nt} r^*_t b^*_{it} - p_{xt}c_{xt} \\ \quad - p_{nt}(c_{nt}+k_{xi,t+1}-k_{xit}+k_{ni,t+1}-k_{nit}+b_{i,t+1}-b_{it}) \\ \quad - s_t p^*_{nt}(k^*_{xi,t+1}-k^*_{xit}+k^*_{ni,t+1}-k^*_{nit}+b^*_{i,t+1}-b^*_{it})] \end{array} \right\}$$

1/ These assumptions should be viewed as a convenient compromise. On the one hand, it is clear that the assumptions are both unrealistic and inconsistent with using the model to analyze the effects of unanticipated changes in fiscal policy parameters. On the other hand, the assmptions are fairly standard practice in comparative static analysis, the economics profession has expressed a preference for analysis based on optimizing models, and my ability to manipulate such models is limited.

where the terms inside the square brackets reflect the difference between income and expenditure, as defined by conditions (1) and (3). Differentiation of $V[\cdot_t]$ with respect to initial asset stocks yields:

$$(21) \quad \frac{\partial V[\cdot t]}{\partial k_{xit}} = \lambda_t [p_{nt} + p_{xt}(1-\tau_t) \frac{\partial f_{xit}}{\partial k_{xit}}]$$

$$(22) \quad \frac{\partial V[\cdot t]}{\partial k_{nit}} = \lambda_t p_{nt} [1 + (1-\tau_t) \frac{\partial f_{nit}}{\partial k_{nit}}]$$

$$(23) \quad \frac{\partial V[\cdot t]}{\partial k^*_{xit}} = \lambda_t s_t [p^*_{nt} + p^*_{xt}(1-\tau^*_t) \frac{\partial f^*_{xit}}{\partial k^*_{xit}}]$$

$$(24) \quad \frac{\partial V[\cdot t]}{\partial k^*_{nit}} = \lambda_t s_t p^*_{nt} [1 + (1-\tau^*_t) \frac{\partial f^*_{nit}}{\partial k^*_{nit}}]$$

$$(25) \quad \frac{\partial V[\cdot t]}{\partial b_{it}} = \lambda_t p_{nt}(1+r_t)$$

$$(26) \quad \frac{\partial V[\cdot t]}{\partial b^*_{it}} = \lambda_t s_t p^*_{nt}(1+r^*_t)$$

The derivatives of $V[\cdot t]$ with respect to the period t choice variables must vanish at an optimum (when corner solutions are ruled out), which implies:

$$(27) \quad \frac{\partial U}{\partial c_{xt}} - \lambda_t p_{xt} = 0$$

$$(28) \quad \frac{\partial U}{\partial c_{nt}} - \lambda_t p_{nt} = 0$$

$$(29) \quad \beta \frac{\partial V[\cdot_{t+1}]}{\partial a} - \lambda_t p_{nt} = 0$$

for $a = k_{x1,t+1}$, $k_{n1,t+1}$, $b_{1,t+1}$

$$(30) \quad \beta \frac{\partial V[\cdot_{t+1}]}{\partial a^*} - \lambda_t s_t p^*_{nt} = 0$$

$$\text{for } a^* = k^*_{x1,t+1},\ k^*_{n1,t+1},\ b^*_{1,t+1}$$

Half of condition (11) follows directly from conditions (27) and (28). The other half follows from conditions (21) and (22) when the two derivatives are equal, which must be the case under an optimum allocation of capital. Condition (12) follows in a similar way from solving the optimization problem for the representative private agent in country 2.

Condition (13) can be derived by updating conditions (25) and (26) and combining these with conditions (29) and (30) for $a = b_{i,t+1}$ and $a^* = b^*_{i,t+1}$, respectively, using $\lambda_t = \lambda_{t+1}$ as an implication of the assumption that utility functions have risk-neutral forms. Condition (14) can be derived by updating conditions (22) and (24) and combining these with conditions (29) and (30) for $a = k_{ni,t+1}$ and $a^* = k^*_{ni,t+1}$, respectively, again using $\lambda_t = \lambda_{t+1}$ under the assumption of risk neutrality.