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Issues in Interest Rate Management and Liberalization

SÉRGIO PEREIRA LEITE and V. SUNDARARAJAN*

The transition strategy from administratively set interest rates to market rates is discussed. Despite worldwide trends toward financial liberalization, few monetary authorities are prepared to accept as reasonable any interest rate level that is market determined. The paper suggests some helpful indicators to assess the adequacy of interest rates and discusses factors that contribute to a smooth liberalization process. The main conclusion is that interest rate liberalization is not synonymous with laissez-faire policies, but requires the replacement of the administratively set interest rates by indirect monetary management techniques that operate through the market. [JEL 311]

MODERN ECONOMIC thinking generally acknowledges the important role of interest rate policy as a demand management technique to achieve both internal and external balance and to ensure the efficient allocation of financial resources in an economy. Interest rates influence the demand for and supply of investable resources and the decisions of economic agents to invest or consume. They are at the center of any policies that the monetary authorities may choose to undertake to influence business conditions and economic activity. They affect exchange rate and capital movements as well as inflation.[1]

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[1] For an elaboration of these points, see International Monetary Fund (1983).

Despite the importance of this variable, many countries have chosen to maintain interest rates at unrealistic levels. A large number of developing countries have traditionally followed a policy of low and unchanging interest rates. These policies are normally the result of three factors: (1) the desire to increase the level of investment; (2) the desire to improve the allocation of investment among sectors; and (3) the desire to keep financial costs down so as to avoid possible inflationary effects of interest rate liberalization. A vast body of literature appeared in the 1970s to refute the validity of these considerations.

The belief that low interest rates stimulate investment and growth has been vigorously attacked by McKinnon (1973) and Shaw (1973), among others. They have shown that if real interest rates are reduced below market equilibrium levels, demand for investment will no doubt increase, but actual investment will decrease, since at low interest rates insufficient savings will be generated to finance these investments. Moreover, the excess demand for investment will require the rationing of existing resources among all competing investors willing to borrow at that rate. Where there is rationing and controlled lending rates, it is unlikely that financial intermediaries will choose to provide funds according to a ranking of rates of return on investment. Most likely, other factors, such as the capacity to provide collateral and political influence, will also play an important part in the decisions of financial intermediaries. Consequently, a policy of low interest rates not only inhibits investment, but also tends to reduce the average rate of return on investment below the maximum attainable rate.

Attempts to improve the allocation of resources are also an important factor behind the use of low interest rate policies by the authorities of many countries who assume that selective reductions of interest rates to preferred sectors of the economy will significantly improve the allocation of resources. Available evidence tends to contradict this assumption. In most cases in which this hypothesis was tested, results showed that the effect of selective credit policies on growth and investment was minimal. The key problem was the fungibility of money, which makes it very difficult to ensure that funds are in fact used for their original purposes (Johnson (1975) and Khatkhate and Villanueva (1978)).

The third reason often mentioned in defense of low interest rate policies is the possible inflationary impact of interest liberalization. There is no doubt that there will be some short-term price effects resulting from interest rate liberalization. However, the direction of these effects is a complex empirical issue that cannot be easily resolved on a priori grounds. In any case, the possible inflationary effects of interest rate liberalization tend to be somewhat overplayed by defenders of the status quo. Available estimates of the ratio between financial costs and total production costs in several countries indicate that it seldom exceeds 10 percent. Thus, the direct effect of an increase in interest rates on production is likely to be small. Moreover, this increase will not necessarily be completely passed on to consumers, because interest rate increases should reduce demand.[2] Finally, interest rate increases are likely to reduce the hoarding of goods, thereby increasing aggregate supply.

The purpose of this paper is to emphasize some key elements that have proved important in the process of interest rate management and liberalization. This process, while relatively straightforward in the abstract, has a few pitfalls that can perhaps be avoided by learning from the experience of the several countries that have moved toward market-related interest rates in the last decade.

The first step in the process of interest rate management and liberalization should be an assessment of the appropriateness of the prevailing interest rate levels and structure. Section I discusses a number of indicators that can be used to gauge the appropriateness of prevailing interest rate levels.

Section II presents a discussion and assessment of the interest rate structure. If the level and structure of rates are found to be adequate, the only concern of the monetary authorities should be to ensure that they are flexible; that is, that changes in underlying economic conditions will be fully reflected in interest rate changes so as to keep them always adequate. However, if rates are not at acceptable levels, a strategy needs to be designed to move them to more realistic levels.

Section III discusses the transition from fixed to market-determined interest rates. For many countries, this transition can be traumatic if not properly managed. Thus, the monetary authorities should plan the proposed liberalization path carefully, so as to achieve this goal with minimal side effects to the economy.

Section IV examines government intervention in the economy and its relevance for interest rate policies, focusing on the impact of government financing on interest rates and on the financing of the rest of the economy. Section V presents concluding remarks.

I. Adequacy of Interest Rates

Determining the most adequate interest rate level is not a simple task, since there is no clear-cut method of assessing its appropriateness (see

[2]To the extent that higher interest rates shift savings from goods into financial instruments, the rate of inflation would decelerate.

Leite (1982)). However, there are a number of indicators that together can help the policymaker judge whether the prevailing interest rate is grossly out of equilibrium. These indicators are discussed below.

Positive Real Rates

Saving instruments should bear a positive expected real interest rate; otherwise, there would be a strong tendency to substitute hoarding of goods and self-investment for financial saving. Clearly, not all real interest rates on financial instruments need to be positive. In most countries, demand deposits (and currency holdings) do not pay interest. However, up to a point, the services and convenience resulting from the use of these deposits make them attractive to hold. Nevertheless, in all cases, and specifically in hyperinflation situations, it is highly unlikely that under competitive conditions, the average real rate of return on saving instruments would be negative. Consistently negative returns are thus likely to be due to a lack of competition or to government ceilings on interest rates. This is even more so when real lending rates are negative. Occasionally, the real interest rates observed in the economy may be negative, even when rates are free and competitively determined. For instance, if the inflation rate is volatile, people may underestimate the future rate of inflation. This underestimation is likely to result in relatively low nominal interest rates that will turn out to be negative in real terms ex post. Also, the combination of bank-specific credit ceilings and unfettered growth in reserve money may lead to market-determined interest rates that are negative even in competitive banking systems.

Positive real rates give only a floor on nominal rates; other indicators would have to be used to assess how far above that floor interest rates should be. Moreover, a few caveats should be kept in mind when positive real rates are being used as a guide for interest rate policies. First, when there are price controls the calculated inflation rate is likely to underestimate underlying inflationary pressures. Therefore, calculated real rates may be overstated because of the artificially low measured inflation. Second, calculations of expected inflation rates are difficult without long, consistent time series, and even then may not be reliable. Third, the most appropriate deflator of interest rates is a broad-based price index that takes into account the prices of current consumption goods as well as the prices of assets that would produce future consumer goods (capital goods) (Brown and Santoni (1981)). Finally, taxation of interest incomes should also be taken into account when expected real interest rates are calculated (Tanzi (1980)).

World Interest Rates

If two economies are totally open to capital movements, the differential between their domestic interest rates will tend to be equal to the expected movements in the exchange rate between their currencies.[3] Although most developing countries have some form of control on capital movements, these controls have limited effectiveness, resulting in different degrees of openness to capital movements. Consequently, a country's leeway in determining domestic interest rates is limited, since failure to take foreign interest rates into account is likely to result in destabilizing capital movements. In particular, the ability to determine interest rates independently of international rates is limited if (1) there are no effective capital controls; (2) the currency is freely convertible; (3) the currency is widely accepted outside the country; (4) there is a thriving black market for foreign exchange; and (5) foreign firms have a large role in the domestic economy.

In cases where there is some but not perfect capital mobility, the interest rate differential, after allowance is made for exchange rate expectations, should not be too large so as to avoid destabilizing capital movements. For this purpose the relevant "world" interest rates are those of the countries to and from which capital movements are more likely to take place. Note also that if a country is hoping to attract foreign private capital flows, domestic rates should exceed world rates, in order to compensate foreign investors for the increased risks of international lending.

Rates of Return on Investments

Rates of return on investment projects should exceed the interest rate charged on the funds used to finance them. Therefore, one way of assessing the adequacy of interest rates could be to estimate the economy's overall rate of return—probably on the basis of completed projects—and to compare prevailing interest rates to that overall rate.

The difficulty with this approach is that in most countries factors of production are not perfectly mobile, and there are special constraints to entry into the high return sectors. Also, there is no overall rate of return on investment for the economy, but rather a spectrum of rates. Moreover, to the extent that real interest rates have been kept below equilibrium levels because of regulation ("financial repression"), the rates of

[3] However, some other country-specific variables such as political risk or reserve requirements may also play a role.

return of some of the projects undertaken exceed the actual lending rate but are below the maximum rates of return attainable under more competitive conditions. Those projects are clearly suboptimal. These facts have led to the suggestion that the lending interest rate be guided by the rate of return on the "modern" sector of the economy (see Galbis (1977) and Khatkhate (1980)). The problem with this approach is how to define the modern sector. Nevertheless, some guidance can be obtained by ranking the rates of return of different sectors and trying to gauge which lending rate would reduce the number of investment projects to a level that can be financed within the available resources (see Dasgupta, Sen, and Marglin (1972)).

Perhaps more interesting is to compare the rate of return on potential investments with the lending rate. If lack of financial resources seems to hamper the chances of a project being implemented even if its rate of return substantially exceeds the prevailing lending rate, the lending rate is probably artificially low and credit is likely being allocated according to other criteria ("credit rationing"). This is especially so if the rate of return on these potential projects also exceeds the rates of return on a number of completed projects.

Interest Rates in Informal Markets

In many countries interest rates in informal markets are substantially above the rates prevalent in the organized financial system. Unfortunately, it is doubtful that interest rates in these markets could be used as a guide to the proper level in the organized market. Although by their nature informal markets are unregulated, there is no evidence that they are always more competitive than organized markets. Also, informal markets handle high-risk loans and consequently require a higher premium to cover their expected losses by default (Wai (1956), Bottomley (1963), and Badhuri (1977)). Consequently, interest rates on informal markets, although contributing an additional piece of information, can only provide an upper bound for the rates prevailing in the organized market. Movements in these rates, however, may parallel required changes in the rates in the organized market.

Relative Price of Capital and Labor

Interest rates can be viewed as a component of the relative price of capital to labor.[4] This relative price is the ratio of the rental price of

[4] For a discussion of the empirical relevance of this variable in assessing the impact of interest rate policy, see Sundararajan (1987).

capital to the nominal wage rate, with the rental price of capital defined as the product of the price of capital goods and the real (or nominal) interest rate. Therefore, the real interest rate could be chosen so as to restore this relative price to a target level, taking into account developments in the price of capital goods and the wage rate. This approach assumes that the authorities have some opinion on the adequate level of the relative price, perhaps based on past experience when interest rates were at adequate levels. Unfortunately, all this method can do is to say how the prevailing interest rate levels need to be changed so as to restore the relative prices of capital and labor to some target level. It is therefore not very helpful in situations in which the authorities have no idea of what the proper relative price between capital and labor is.

II. Structure of Interest Rates

The structure of interest rates also needs to be examined when the appropriateness of a system of interest rates is being evaluated. However, ready and easy rules on interest rate structure have yet to be devised, since so much depends on the specifics of each market. Interest rates on saving instruments (and lending rates as well) should differ according to their intrinsic characteristics, such as their riskiness, maturity, liquidity, and convenience of their use. Yields on saving instruments (and loan rates) should be positively related to their riskiness and negatively related to their liquidity. A term structure of interest rates that offers insufficient returns to longer maturity deposits could reduce the availability of term finance for investment.

Under competitive conditions the spread between lending rates and the average cost of loanable funds (that is, funds obtained by the financial intermediaries to on-lend) should be just enough to cover costs, risks, and "normal" profits. Large spreads common in many developing countries indicate, in many cases, the lack of competitiveness or government intervention in the financial markets.[5] Sometimes they reflect high intermediation costs, often resulting from a large portfolio of nonperforming loans or high operating costs. Whatever their cause, these spreads will most likely result in low deposit and high lending rates, with an inappropriate division of risk.

Against this background, any strategy to improve the interest rate structure should start by abolishing the most obvious causes of the initial distortions. Steps to be taken include the introduction of policies to

[5]Most often, high reserve and liquid asset requirements that are not adequately remunerated contribute to widening the spread, particularly in times of high inflation.

reduce interest subsidies based on an assessment of their incidence and effectiveness in redirecting resource flows. Also, policies to streamline and monitor the cost-of-funds calculations of financial institutions should be introduced. Other policies that are likely to improve the interest rate structure include reduction and unification of liquidity requirements for various groups of financial institutions; the introduction of a prime rate or a base lending rate system; measures to monitor and improve the operating efficiency of financial institutions; and legal, regulatory, and institutional changes to minimize the incidence of bad debts. The use of indirect instruments of monetary control instead of direct credit controls is also likely to improve the interest rate structure.

Another possibility would be to use the interest rate differentials prevailing in some other countries as a basis for a first approximation of the relationships between interest rates in the domestic markets. One should be aware, however, of country characteristics and government intervention that could influence these relationships. Differences in country regulations that affect the operating costs of the financial intermediaries such as liquidity ratios, reserve requirements, and access to a rediscount window, will result in different interest rate structures. In sum, although international comparisons are useful, one should take these differences into account when assessing the appropriateness of a given interest rate structure.

One measure to minimize the complications of setting up an appropriate interest rate structure is to reduce the number of interest rates by eliminating (or at least streamlining) selective credit policies that artificially create new interest rate categories.[6] Another possibility is to increase the integration of the financial markets, for example by moving toward universal banking—as opposed to narrowly defined specialized institutions.

Freeing all interest rates from government regulation is often advocated as a way to achieve an initial approximation of an equilibrium level and structure of interest rates.[7] In practice, the conditions for optimality of this strategy are unlikely to hold strictly. However, many policymakers would argue that the application of this strategy would at least approach the optimal solution. That said, some concern remains about the speed with which this strategy can be implemented in the presence

[6] Selective credit policies aim at granting credit to designated sectors (for example, agriculture or exports) under more favorable conditions (for example, amount, interest rate) than they would get in the absence of such policies.

[7] This requires that certain conditions obtain, namely the existence of perfect competition, absence of externalities and government intervention, well-behaved risk distributions, and full information.

of macroeconomic imbalances and weak bank supervision. Given proper safeguards, it is, nevertheless, one of the best ways to eliminate the most important interest rate distortions.

III. Financial Liberalization Strategy

If a country's interest rate system is inappropriate, and until conditions for free interest rates obtain, some kind of interest rate management policy may be necessary. This management can take various forms. The following are some alternatives.

The savings deposit rate can be used as the minimum basic rate and all other rates can be tied to it. The government would then intervene in the financial market by adjusting the savings deposit rate in line with the various criteria discussed earlier, while monitoring its effects on the interest rate structure.

Some governments have set a minimum deposit rate (or a structure of minimum rates by type of deposit) and a maximum lending rate, and over time adjusted the floor and ceiling rates to bring about a gradual liberalization of the system.

An alternative used in some countries is to set interest rate ranges for the deposit rates and lending rates separately, and allow the commercial banks to set rates within these ranges. The authorities then widen these ranges over time so as to phase in the liberalization of the rates.

An alternative that relies more heavily on market forces is for the government to fix the maximum spread between the average cost of funds to the financial intermediaries and their lending rate, while allowing them to determine the level of their interest rates. If the spread allowed by the authorities takes into account normal intermediation costs, risks, and profits (but not excessive monopolistic profits), the result, even in the presence of oligopolistic structures, could be an interest rate structure similar to the equilibrium rates under competitive conditions.

In any case, any move toward a more liberal interest rate regime should be associated with the development of appropriate monetary policy instruments that are capable of influencing the rates indirectly to reflect monetary policy objectives, such as containing credit expansion or ensuring that divergences from world rates are not excessive (resulting in large capital flows). In this regard, the appropriate choice of operating techniques of monetary policy becomes important to ensure that monetary control does not exert an undue impact on growth, and to promote further development of financial markets. For example, raising the level of interest rates and containing credit expansion through increases in unremunerated reserve requirements would result in a larger spread between deposit and lending rates and greater distortions in credit allocation than alternative methods of containing credit expansion such as open market operations.

Interest rate liberalization has a better chance of success if the following key questions are addressed at the outset of the liberalization process.

Will there be adequate competition?

To ensure adequate competition, the interest rate liberalization would have to be accompanied by a properly phased freeing and homogenization of various portfolio regulations. In particular, as stated above, various selective credit policies based on below-market interest rates would either have to be eliminated or reduced in scope. In addition, policies toward mergers, licensing, and branching would have to be modified, taking into account possible economies of scale. Also, it is important to provide adequate incentives to induce borrowers to behave in an interest-sensitive fashion by eliminating "soft" budget constraints that often apply to state enterprises or enterprises that are closely linked to banks. Insolvent banks are another obstacle to competition. Government banks are often not as competitively minded as private banks. Rehabilitation and restructuring of banks may be an important step to increase competition in the banking system. Without such a range of policy changes to improve competition, interest rate liberalization could produce significant distortions in the level, structure, and responsiveness of interest rates.

Are the money market and monetary policy instruments adequate to influence the marginal cost of funds to banks?

The issue of instrument adequacy takes on particular importance in the context of interest rate liberalization. Typically, such liberalization would have to be accompanied by, or preferably preceded by, measures to strengthen the money and interbank markets and to improve the effectiveness of monetary policy instruments. In particular, developing the technical ability to monitor the money market and intervene to stabilize and influence money market rates would become important, insofar as these rates serve as the marginal cost of funds to banks. In the absence of well-developed money markets, the authorities would have to develop and streamline primary issues of central bank or government securities and the rediscount mechanisms, so that the primary issue yields or the rediscount rates can serve as the marginal cost of funds to banks.[8]

The development of market-based instruments of monetary control and a fostering of money markets are mutually supporting processes. Therefore, the introduction of market-based monetary control instruments should be paralleled by measures to strengthen money and interbank markets—such as reforms of laws governing issuance and transfer of short-term securities, introduction of new instruments, and the development of well-capitalized and supervised dealers. Often, the clearing and settlement system for payment transactions needs to be strengthened to support an active money market. As money markets evolve, the indirect monetary control procedures can be progressively refined, and day-to-day money market intervention can become over time the primary means of both defensive and dynamic monetary policy implementation.

Will the market-determined lending and deposit rates respond rapidly to shifts in monetary policy and to developments in international interest rates and exchange rates?

A key factor to be considered in addressing this question relates to the relative importance of domestic and international factors in the determination of domestic interest rates. The relative weight of these two factors is likely to undergo a significant change following the liberalization, and this change must be closely monitored to judge the extent of monetary independence. To the extent that monetary policy can play a role in influencing interest rates—depending on the degree of openness to capital flows and other structural features—the speed of response of interest rates to monetary policy can become a critical issue.

In some countries, following interest rate liberalization, the authorities have introduced significant monetary reforms to develop money markets and strengthen monetary policy instruments. As a result, they have achieved the technical ability to influence money market rates or, more generally, the marginal cost of funds to banks. Nevertheless, the response of banks in adjusting the lending and deposit rates in line with the marginal cost of funds has been rather slow. Even if some of the lending rates respond rapidly, a wide range of lending rates and even deposit rates may respond sluggishly, often leading to large spreads, and in some

[8]For a survey of developing country experiences in adapting such market-related policy instruments, see Johnston and Brekk (1989).

cases to excessively and persistently high lending rates. This can frustrate policymakers and cause doubts as to the wisdom of liberalization.

Based on the recent experience of countries undertaking interest rate liberalization efforts, key factors that cause such sluggish response include inappropriate prudential limits on interbank borrowing; too restrictive limitations on the range of instruments and participants in the money market; the oligopolistic structure of the banking industry; significant differences in the maturity structure of assets and liabilities; excessive fluctuations in money market rates; and the inelastic demand for credit owing to a large share of nonperforming loans, highly leveraged borrowers, and weak bank supervision. Measures that can speed up the responsiveness to monetary policy are appropriate changes in money market regulations; changes in policies on licensing banks, mergers, takeovers, and branching so as to promote greater competition; a strengthening of defensive monetary policy operations so as to stabilize money market rates; and policies to reduce segmentation in the loan markets (for example, loans to related firms and discriminatory regulations on credit). In some cases, a financial restructuring of banks, supported by a strengthening of prudential regulations, may become necessary to ensure the effectiveness of interest rate liberalization based on active competition.

Is the banking system sufficiently sound to face interest rate competition? Is the bank supervision mechanism sufficiently strong to anticipate the effects of liberalization and react to it in a timely and efficient manner?

If many institutions are too weak—with a large share of nonperforming loans and high operating costs—then, without adequate bank supervision machinery, unexpected failures of individual units can lead to systemic crises following liberalization. Moreover, a large share of nonperforming loans in the system can significantly reduce the interest elasticity of credit demand, because if interest rates rose, nonperforming loans would tend to grow automatically, insofar as banks tried to keep these loans current by capitalizing interest; the resulting increase in nonperforming loans could offset any decrease in demand for performing loans as a result of the rise of interest rates. As a result, the flow demand for credit becomes fairly inelastic, leading to excessive increases or fluctuations in interest rates. These considerations suggest that a close review of the soundness of the banking system and adequacy of bank supervision and rapid reforms in these areas are critical for the effectiveness of interest rate liberalization.

A related issue in the liberalization of interest rates is the liberalization sequence for various segments of the market. Many countries liberalize segments of the financial system in steps. The sequence in which liberalization of nonbank institutions, private banks, state-owned banks, and government securities has proceeded varies from country to country. The appropriate sequence would depend on the initial regulatory and institutional features. For example, some countries may initially liberalize only parts of the loan or deposit markets (for example, short-term deposits) or free the rates of a select group of financial intermediaries (for example, nonbank financial institutions). After they are assured of the soundness of these financial institutions and of their ability to be competitive, the authorities liberalize other markets. In some socialist countries, interest rates in the enterprise deposit and loan markets have been liberalized first, and the household and enterprise markets are integrated in the second stage. However, a gradual approach to liberalization may introduce distortions of its own and raises the question of the political sustainability of the process.

Another issue is possible imbalances resulting from maturity transformation by financial institutions. Institutions that lend long term at fixed rates but whose funds are mostly short term can be caught in the liberalization process. If interest rates increase, their cost of funds will increase while interest income will change much more gradually. During the liberalization process, the monetary authorities will have to pay close attention to this problem to avoid the possibility of a financial crisis. To reduce exposure to interest rate risk, financial institutions that engage in maturity transformation should be encouraged to actively promote adjustable-rate loan contracts. However, these contracts should be designed in such a way as to avoid unduly increasing the risk borne by borrowers and, thereby, default rates. Some of these techniques, such as interest caps, have been used in many countries and may help strike the right balance between the interest risk borne by lenders and borrowers. The institutional solutions to the problem of long-term loans at fixed rates should ultimately deal with the question who should pay for the implicit subsidies following the liberalization of interest rates.[9]

IV. Government Intervention

Government intervention poses special problems, because while some types of government intervention can improve the allocation of resources, other forms might be the dominant reason behind the misalloca-

[9] Similar problems may result from large changes in exchange rates, which often accompany or precede the financial reforms.

tion of resources. It is therefore important to separate those policies that may cause a distortion in interest rates without a corresponding improvement in the allocation of resources from those that may be beneficial.

Monetary policies are an important part of the array of policies a government can undertake. Thus, in most countries, even those that are market oriented, interest rates are influenced by the monetary authorities. It is important to note, however, that although in the past many countries chose to fix the interest rate by fiat, there has been a growing tendency for governments to influence interest rates indirectly through two main mechanisms: (1) financing of government deficits at market-determined rates;[10] and (2) open market policies directed at influencing trends in monetary and credit aggregates to achieve given economic targets.

Government Deficits and Interest Rates

Government budget deficits are financed either from the financial markets or by recourse to the central bank.[11] If the funds are raised in the financial market on equal terms with the private sector, and insofar as the social return on the government's program financed by these funds exceeds the market rate, there need not be a misallocation of resources. A misallocation can arise more easily when the central bank accommodates the government's credit needs directly or when special incentives are given to hold government debt—such as tax incentives or use of these government liabilities to fulfill liquidity requirements.

If the central bank provides the credit accommodation, purchasing power is redistributed in favor of the government, which results in the crowding out of the private sector, particularly if there is a concomitant increase in prices. The crowding out is even more pronounced when quantitative credit limits on private sector borrowing are simultaneously imposed to correct existing inflationary tendencies. The same is true when the crowding-out effect is achieved through an increase in liquidity requirements to levels above those that might be needed for prudential reasons, with the objective of tapping resources from the financial system at below-market rates.

[10] Although in this case the government allows interest rates to be market determined, it still can have a substantial impact on these rates because of the size of its financing operations.

[11] In this section, we concentrate on the effects of government deficits on interest rates. The opposite effect is also relevant. Interest rate movements, by their effect on the cost of funds to the government, alter the financial flows and may force compensatory adjustments in taxation or inflation.

Finally, in a number of countries, part of the government deficit is reflected in central bank losses that have the same inflationary effects as central bank financing of the deficit. These central bank losses often result from the government transferring to the central bank its foreign exchange risks, or from the central bank failing to charge proper interest rates on its loans to the government or preferred sectors of the economy. These policies clearly distort interest rates.

Open Market Policies

Open market operations can be conducted either in the primary market or in the secondary market. Many countries have used primary sales of some government securities—either central bank securities or treasury bills—as an instrument of monetary policy. By varying the timing and the volume of primary issues and by issuing them at market rates, it is possible to influence bank reserves and interest rates in the short run; this practice has provided an attractive alternative technique for influencing short-run interest rates and monetary developments, in the absence of active secondary markets in these securities. It has also served as a transitional device for fostering the development of secondary markets. Once a genuine secondary market develops, monetary policy can be implemented by operating in these markets. However, to the extent that budget deficits are large, requiring massive financing, primary sales of government securities tend to be the dominant influence in the financial markets, seriously limiting the use of open market operations as an effective short-run policy instrument and, at the same time, distorting the level and structure of interest rates.[12]

An appropriate level and structure of interest rates can therefore be brought about only if the government gradually reduces its budget deficit to a level that would permit it to borrow directly from the financial market in competition with the private sector, without crowding out the latter and without recourse to special regulations, such as high liquidity requirements. The elimination of such regulations and the move from captive to active markets in government securities call for a comprehen-

[12] Large fiscal deficits would constrain the scope of open market operations by resulting in unacceptably high levels of interest rates for the specific debt instruments used in such operations. This is likely to be the case when the domestic debt management is not well developed and relies on a limited range of debt instruments. Also, a large and rising volume of treasury debt held by the nonbank sector could be associated with significant substitution away from bank deposits, with consequences for demand for reserve money and for the level and structure of interest rates.

sive approach to strengthening public domestic debt management that is well coordinated with monetary management.

Moreover, the government's intervention should be limited to the financing of expenditures with (social) rates of return above the market interest rate.[13] Unfortunately, this basic rule is of limited practical utility, since the authorities do not normally know what the socially optimum interest rate is. Dasgupta, Sen, and Marglin (1972) suggest that since the overall social rate of return is unknown, the government should estimate the internal rate of return on each proposed government project. Over the years, the accumulated experience of comparing the internal rates of return of individual projects and having to choose among them would slowly evolve into a basic agreement among policymakers about the smallest internal rate of return that would justify a project. This rate, when a consensus is finally developed, will be the socially optimum interest rate.

Open market policies can also be used to maintain interest rates constant without having to resort to direct regulation of financial intermediaries. Such a strategy would imply allowing the monetary and credit aggregates to find their own levels. What criteria could guide the authorities' choice between interest rate and monetary (or credit) aggregate targeting? The generally accepted view is that interest rates should be the preferred short-run and intermediate target when the dominant source of instability in the economic system is the financial sector (for example, shifts in money demand due to financial innovations). The targeting of a monetary or credit aggregate should be preferred when real sector disturbances are more important (for example, shifts in terms of trade, or fluctuations in real demand for goods and services). In practice, of course, no simple rule of policy intervention can ensure economic and financial stability. In an economy that may be simultaneously subject to multiple disturbances of varying intensities on which there is imperfect information, policymakers may prefer to adopt a policy of discretionary adaptation by continuously reviewing the settings of policy targets in the face of the most recent information. Although it would still be necessary to choose between interest rate or money supply targets at any point in time, this choice would generally be subsidiary to the more important task of setting the consistent target levels for these variables. Thus, even in a liberalized interest rate regime, the authorities

[13] The social rate of return may differ from the rate of return that a private investor might attribute to a project. For the social rate of return, all the benefits and costs of the projects are computed, even those that do not accrue to the owner of the project.

must constantly hold a view of the appropriate level of the interest rate and strive to achieve it. In addition, central banks generally attempt to smooth out short-term fluctuations in interest rates around their "fundamental" trends, partly to ensure that changes in trends are not obscured by day-to-day volatility. Such "defensive" monetary policy operations help to speed up the transmission of the effects of monetary policy and enable smooth functioning of the financial markets.

V. Concluding Remarks

Both in market and in centrally planned economies, it is important to avoid distortions in relative prices, if only to ensure the optimum allocation of resources. For this reason, an interest rate reform should be a component of any policy package aimed at improving the performance of these economies.

First, it should be well understood that lower interest rates will not lead to additional investment unless savings are forthcoming. Second, expected real interest rates must be positive in order to prevent unproductive hoarding of goods or the financing of economically unsound projects. Third, interest rates, after allowing for exchange rate expectations, should be set with due consideration to interest rate differentials vis-à-vis world financial markets, taking into account the economy's degree of openness to capital movements. Fourth, whenever public sector dependence on the financial markets is due largely to fiscal imbalances, the servicing requirements of the government debt become a major stumbling block in the path of interest reform. Interest liberalization will thus have to go hand in hand with an improvement in the financial position of the government. Only after its borrowing requirements are reduced to manageable levels will the government be able to engage in a meaningful interest rate policy. Fifth, in centrally planned economies, as well as in countries where the public sector is a major borrower, it is important that the government projects that are carried out yield (social) rates of return that exceed those of the projects (private and government) that are refused financing. The calculation of internal rates of return for each project can assist policymakers in making rational choices among competing projects. In market economies, the socially optimum rate might be assumed, as a first approximation, to be equal to the rate that the market would freely determine in competitive conditions. The government has an important role in promoting competition, and also in ensuring that its financing operations do not distort market rates.

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Interest Rate Policy in a Small Open Economy

The Predetermined Exchange Rates Case

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An important obstacle encountered in analyzing interest rate targeting is that standard models usually lead to indeterminacy of the price level or the inflation rate. This paper develops a simple framework that avoids such problems, because the bonds whose interest rate is controlled provide liquidity services. This framework is used to examine interest rate policy in a small open economy under predetermined exchange rates. A permanent increase in the interest rate has no real effects, whereas a temporary increase in the interest rate leads to higher consumption and a current account deficit that worsens over time. [JEL 431]

THE INTEREST rate enjoys a unique position among macroeconomic adjustment policies. Historically, it played a central role during the gold standard era (despite the insistence of economic theory on specie-flow mechanisms).[1] Currently, it is one of the most watched variables

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[1] Hume (1752) provided the classical exposition of the price specie-flow mechanism. Governments' frequent disregard for the "rules of the game" under the gold standard is the focus of Bloomfield (1959). At the time, observers were well aware of the active use of interest rates by central banks. Keynes (1924, p. 19), for instance, argued that one of the main characteristics of the British monetary system under the gold standard was "the use of the bank rate for regulating the

among the Group of Seven industrial countries.[2] In developing countries interest rates have been manipulated, among other things, to provide cheap credit to the government, to increase saving and investment, and to try to quell raging inflation.[3]

The high reputation that interest rate policy enjoys among economic practitioners contrasts sharply with the one it has among their more academic peers. Wicksell (1965) thought that pegging the interest rate, for example, might lead to instability of the inflation rate—a conjecture that also emerges from standard adaptive-expectations models—while the theory of rational expectations demonstrates the possibility that, unless there is some additional nominal anchor, an interest rate policy may lead to indeterminacy of the price level or of the rate of inflation (see Sargent and Wallace (1975), McCallum (1981, 1986), Calvo (1983), and Gagnon and Henderson (1988)).[4] Determinacy can be recovered, though, by simultaneously setting money supply targets.[5] For the system not to become overdetermined, however, the interest rate and money supply targets cannot be set independently, which makes it difficult to distinguish the effects of interest rate policy from those of money supply policy.[6]

Given the importance that policymakers sometimes attach to controlling interest rates in order to achieve certain objectives, it might be worthwhile to develop an analytical framework within which interest rate policy can be analyzed. This paper is an attempt in that direction; it develops a model in which interest rate policy is not subject to the above-mentioned indeterminacy or instability problems. More important—and in contrast to the approaches mentioned above—the effects of interest rate policy are much easier to identify because the interest rate target can be changed without modifying the money supply target.

balance of immediate foreign indebtedness (and hence the flow, by import and export, of gold)."

[2] Batten and others (1990) examined the implementation of monetary policy in the Group of Five industrial countries and concluded that monetary authorities focus on influencing key short-term interest rates.

[3] See Fry (1988) for a discussion of interest rate policies in developing countries.

[4] McCallum (1986) distinguishes between price level "indeterminacy" (the model does not determine the value of any nominal magnitude) and "nonuniqueness or multiplicity" of price level solutions (there are multiple paths of real money balances).

[5] See, among others, McCallum (1981, 1986), Calvo (1982), Canzoneri, Henderson, and Rogoff (1983), Goodfriend (1987), Barro (1989), and Reinhart (1989).

[6] See Calvo and Végh (1990c) for a discussion.

The key feature of the model is the assumption that the interest rate that is controlled by the central bank is, in fact, not a *pure* rate, but rather the interest rate borne by bonds that possess some of the characteristics of domestic money.[7] It is shown that just a "pinch of liquidity" in the assets whose interest rate is controlled by the central bank is in general enough to restore full monetary determination. This is an interesting result because it exhibits the relative weakness of the rational expectations case against interest rate policy, given that central banks usually deal with government assets that are not substantially different from high-powered money (see, for example, the discussion in Bryant and Wallace (1979)). This is the paper's first message.

The analysis concentrates on a small open economy under predetermined exchange rates in which price flexibility and full employment prevail. In addition, and to abstract from other well-known effects, we make sufficient assumptions to guarantee inflation super-neutrality and Ricardian equivalence. These assumptions are strong and prevent the emergence of almost all effects from monetary policy (see Calvo (1989b)). The assumptions are responsible in part for the absence of real effects stemming from *permanent* changes in the interest rate controlled by the central bank.[8] These assumptions, however, help to highlight the role of *temporary* policies—what almost all actual policymaking is about—because temporary policies are shown to have real effects, even under those strong proneutrality conditions. This is the paper's second message.

A simple model is developed, which provides an understanding of some of the basic issues raised by interest rate policy. The discussion is carried out in terms of a representative consumer subject to a liquidity constraint. To introduce the liquidity component into domestic bonds, we assume that the consumer "produces" liquidity by means of high-powered money and bonds (which we identify with interest-bearing checking accounts). In the present context, therefore, increasing the interest rate on bonds is equivalent to offering a higher return on money (defined as the sum of high-powered money and interest-bearing checking deposits). Hence, it should not come as a big surprise that an interest rate hike could have expansionary effects, which is contrary to the predictions of more ad hoc models. This is the third message of the paper. We feel that this lesson could be very relevant for countries that attempt to influence aggregate demand by increasing the rate of interest.

[7]The term "pure rate" refers to the interest rate borne by a nonliquid bond.
[8]The expression "real effects" refers to effects on consumption—which determine welfare. Permanent policies, however, will affect the real money supply.

This policy tends to reduce the cost of holding liquid assets and could, therefore, exert no downward pressure on aggregate demand.[9]

It is shown that a temporary increase in the rate of interest is equivalent to a temporary *decrease* of the rate of devaluation. They are both expansionary because they reduce the opportunity cost of holding money, and consequently tend to stimulate consumption. The resulting increase in money demand induces an initial accumulation of reserves at the central bank. The current account, however, deteriorates from the first moment, and reserves are eventually lost. The country is ultimately poorer and, more surprisingly, the representative individual also feels poorer from the very start. The policy, therefore, has no redeeming social value.

The paper proceeds as follows. Section I develops the basic model and shows that permanent changes in the nominal interest rate have no real effects. Section II studies the effects of a temporary increase in the nominal interest rate. Section III relates the analysis developed here to interest rate policy in more complex models.

I. The Model

Consider a small open economy that operates under predetermined exchange rates. There is only one (nonstorable) good in the world whose price is given and equal to unity. The representative consumer is endowed with a constant flow of the good, denoted by y.

The utility function of the representative consumer is given by

$$\int_0^\infty u(c_t)e^{-\beta t}dt, \tag{1}$$

where the instantaneous utility function, $u(\cdot)$, is assumed to be increasing, twice-continuously differentiable, and strictly concave; c_t denotes consumption; and β is the positive and constant subjective discount rate.

The consumer is subject to a "liquidity-in-advance" constraint. The requirement that a liquid asset (money) be used in order to purchase goods is by now a common feature of monetary models.[10] A more novel feature introduced into the present analysis—which explains the use of the term "liquidity-in-advance"—is that the consumer is posited to use

[9] Another independent, and more familiar, reason for the counterproductive nature of an interest rate hike in high-inflation countries is that in many cases the government is one of the main borrowers. Thus, the policy tends to worsen the fiscal situation even further.

[10] The use of the cash-in-advance constraint in continuous-time models is discussed in Feenstra (1985).

two distinct liquid assets to carry out his or her purchases. In addition to cash (H), the consumer makes use of demand deposits (Z) that earn interest at a rate i (for instance, NOW or Money Market Accounts).[11] This formulation is intended to capture, in a simple way, the stylized fact that consumers usually resort to both types of assets to carry out their transactions.[12] Specifically, the liquidity-in-advance constraint is given by

$$c_t \leq l(h_t, z_t), \qquad l_h > 0,\ l_z > 0,\ l_{hh} < 0,\ l_{zz} < 0,\ l_{hz} > 0, \tag{2}$$

where h_t and z_t stand for real balances of cash and demand deposits, respectively; and $l(\cdot)$ is a concave, homogenous of degree 1, twice-continuously differentiable function, which can be viewed as a liquidity-services production function.[13,14] The liquidity-in-advance constraint (2) requires that consumption not exceed the liquidity services produced by the use of both cash and demand deposits.

The consumer also holds an internationally traded bond, f, whose rate of return is given and equal to r. The consumer's lifetime budget constraint is therefore

$$a_0 + \int_0^\infty (y + \tau_t)e^{-rt}\, dt = \int_0^\infty [c_t + I_t h_t + (I_t - i_t)z_t]e^{-rt}\, dt, \tag{3}$$

where $a_0 = f_0 + h_0 + z_0$ denotes initial real financial assets; τ_t stands for government lump-sum transfers; and $I_t = r + \pi_t$ (π_t being the rate of inflation) stands for the *pure* nominal interest rate.[15] I_t and $I_t - i_t$ (both

[11] The sum of cash and demand deposits will be referred to as "money" (M); that is, $M \equiv H + Z$.

[12] The incorporation of demand deposits into the cash-in-advance constraint can be found in Walsh (1984). Brock (1989) assumes that both assets reduce transaction costs or "shopping" time. Englund and Svensson (1988) distinguish between "cash" and "check" goods, both of which are subject to liquidity constraints. Demands for both cash and demand deposits have been derived in a Baumol-Tobin context by Santomero (1979) and Whitesell (1989). Given the different costs of using cash versus debitable accounts, cash is used for small transactions and debitable accounts are used for large transactions (see Whitesell (1989)).

[13] A subscript on a function denotes the partial derivative with respect to the subscripted variable.

[14] The assumption $l_{hz} > 0$ is equivalent to ruling out perfect substitutability between h and z. (Notice that if $l_{hz} = 0$, then, by Euler's theorem, $l_{hh} = l_{zz} = 0$, in which case $l(h,z)$ is a linear function.) As discussed below, the analysis still applies to the case of perfect substitution, but it involves a corner solution in which only demand deposits are used.

[15] The rate I will be referred to as the *pure* nominal interest rate, because it is the rate of return borne by a pure bond—in the sense that the bond does not yield liquidity services. The rate borne by demand deposits, i, will be referred to simply as the nominal interest rate.

of which will be assumed to be positive) represent the opportunity cost of holding cash and demand deposits, respectively.

The consumer chooses paths of c_t, h_t, and z_t to maximize the utility function (1), subject to constraints (2) and (3). In addition to constraint (2), holding with equality, and intertemporal budget constraint (3), the other first-order conditions for this problem are

$$u'(c_t) = \lambda[1 + I_t/l_h(h_t,z_t)] \tag{4}$$

$$l_z(h_t,z_t)/l_h(h_t,z_t) = (I_t - i_t)/I_t, \tag{5}$$

where λ is the (time-invariant) multiplier associated with constraint (3).[16,17] Equation (4) has the familiar interpretation that the marginal utility of consumption equals the marginal utility of wealth times the price of consumption. The relevant "price" of consumption in this model—which will be referred to as the *effective* price of consumption—is given by the term in square brackets on the right-hand side of equation (4). The effective price consists of the market price, unity, plus the marginal cost of producing the liquidity services needed to purchase a unit of consumption, $I_t/l_h(h_t,z_t)$. Intuitively, note that one additional unit of liquidity services is needed to purchase an additional unit of consumption. The production of a unit of liquidity services requires $1/l_h(h_t,z_t)$ units of h, whose cost is $I_t/l_h(h_t,z_t)$.[18]

Equation (5) indicates that, at an optimum, the marginal rate of substitution between demand deposits, z, and cash, h, is equated to the ratio of their opportunity costs. Note that because $l(h,z)$ is homogenous of degree 1, $l_z(h,z)$ and $l_h(h,z)$ are homogenous of degree 0. Therefore, equation (5) implicitly defines the demand for demand deposits relative to cash as a decreasing function of the opportunity cost of demand deposits, $I - i$, relative to that of cash, I:

$$z_t/h_t = \phi[(I_t - i_t)/I_t], \tag{6}$$

where

$$\phi'[(I_t - i_t)/I_t] = \frac{l_h(1,\phi)}{l_{zz}(1,\phi) - [(I_t - i_t)/I_t]\, l_{hz}(1,\phi)} < 0. \tag{7}$$

[16] It has been assumed that $\beta = r$ to ensure the existence of a steady state. This implies that there are no intrinsic dynamics in the model, so that all dynamics will result from the implementation of temporary policies.

[17] The constraint (2) holds with equality at an optimum, because it has been assumed that the opportunity cost of both cash and demand deposits is positive.

[18] This follows from differentiating equation (2)—holding with equality—and setting $dz = 0$ to obtain $dh/dc = 1/l_h(h,z)$.

An increase in I (that is, an increase in $(I-i)/I$), which raises the opportunity cost of demand deposits proportionately more than that of cash, induces the consumer to reduce the ratio of demand deposits to cash. An increase in i (that is, a decrease in $(I-i)/I$), which *lowers* the opportunity cost of demand deposits, increases the ratio of demand deposits to cash.

Combining the liquidity-in-advance constraint (2)—holding with equality—with equation (6) yields the demand for cash, demand deposits, and money, which is defined as the sum of cash plus demand deposits (see Appendix I):

$$h_t = \psi^h[\underset{+}{c_t}, \underset{+}{(I_t - i_t)/I_t}] \tag{8}$$

$$z_t = \psi^z[\underset{+}{c_t}, \underset{-}{(I_t - i_t)/I_t}] \tag{9}$$

$$m_t = \psi^m[\underset{+}{c_t}, \underset{-}{(I_t - i_t)/I_t}], \tag{10}$$

where $m \equiv h + z$ and a sign under an argument denotes the sign of the corresponding partial derivative. An increase in the nominal interest rate, i, reduces the demand for cash (equation (8)) and raises the demand for demand deposits (equation (9)), as one would expect. The effect on the demand for money of a higher nominal interest rate is positive (equation (10)). In other words, the reduction in the demand for cash is more than offset by the rise in the demand for demand deposits. The intuition is as follows. Since the opportunity cost of demand deposits, $I-i$, is lower than the opportunity cost of cash, I, the marginal productivity of demand deposits is, at an optimum, lower than that of cash (that is, $l_z(h_t,z_t) < l_h(h_t,z_t)$, as indicated by first-order condition (5)). Therefore, for a given level of liquidity services, a rise in the nominal interest rate, i, implies that cash must decrease by less than demand deposits increase, because cash is more productive, at the margin, than demand deposits. Thus, the demand for money (that is, the demand for cash *plus* demand deposits) increases as a result of a higher nominal interest rate.

The function $\phi(\cdot)$, given by equation (6), can be used to express the effective price of consumption (p), given by the term in square brackets on the right-hand side of equation (4), as a function of I and i:

$$p(I_t,i_t) = 1 + \frac{I_t}{l_h\{1,\phi[(I_t - i_t)/I_t]\}}, \tag{11}$$

where

$$p_I(I_t,i_t) = \frac{l_h(1,\phi) - l_{hz}(1,\phi)i_t\phi'/I_t}{l_h^2(1,\phi)} > 0 \qquad (12)$$

$$p_i(I_t,i_t) = \frac{l_{hz}(1,\phi)\phi'}{l_h^2(1,\phi)} < 0. \qquad (13)$$

Equation (12) indicates that an increase in the pure nominal interest rate, I, raises the effective price of consumption, because it increases the opportunity cost of both cash and demand deposits. Less familiar, but critical to the whole analysis, is the way in which a rise in the nominal interest rate, i, affects the effective price of consumption. As follows from equation (13), a rise in i *decreases* the effective price of consumption, because it becomes less costly to hold interest-bearing demand deposits, which are used to produce liquidity services.[19]

The other actor in this economy is the government. To keep the model simple, we abstract from the banking system and assume that the government issues two nominal liabilities: high-powered money, H, and interest-bearing demand deposits, Z. There is no government consumption, so that any revenues left after paying interest on demand deposits are transferred back to the consumer in a lump-sum fashion. Formally, the present value of government transfers is given by

$$\int_0^\infty \tau_t e^{-rt}dt = k_0 + \int_0^\infty [\dot{h}_t + \dot{z}_t + \pi_t(h_t + z_t) - i_t z_t]e^{-rt}\,dt, \qquad (14)$$

where k_0 stands for government's initial holdings of bonds, and a dot over a variable denotes its time derivative. The government collects revenues from the creation of both high-powered money $(\dot{h}_t + \pi_t h_t)$ and demand deposits $(\dot{z}_t + \pi_t z_t)$.

The government is assumed to control the interest rate paid on demand deposits, i, by giving up the control over the *composition* of its liabilities, H and Z.[20] Thus, the composition of the government's liabilities is demand determined. In order to use this model to think about the real world, it is useful to keep in mind the following interpretation. The

[19] Notice that if $l_{hz} = 0$, equation (13) does *not* apply because h and z would be perfect substitutes, as indicated earlier. In that case, the consumer uses only demand deposits because they have a lower opportunity cost than cash. The effective price of consumption is $1 + I - i$ (assuming $l(h,z) = h + z$), so that an increase in i decreases the effective price of consumption.

[20] Alternatively (as shown below), the authorities can be viewed as issuing only high-powered money and determining the interest rate paid on demand deposits by controlling reserve requirements.

government issues bonds (for instance, treasury bills) yielding a rate i, which are entirely acquired by financial institutions. Financial institutions, in turn, issue demand deposits to consumers, which, in a competitive equilibrium with costless banking, will also yield i. It is as though the financial institutions "broke up" the government bonds into small pieces and sold them to consumers as NOW or money market accounts. This is the channel through which the nominal interest rate determined by the government affects the nominal yield of a portion of the consumer's money holdings and, thus, the consumer's consumption path.

The combination of equations (3) and (14) yields the economy's lifetime resource constraint (provided, naturally, that the transversality conditions $\lim(h_t e^{-rt}) = 0$ and $\lim(z_t e^{-rt}) = 0$, as $t \to \infty$ hold):

$$b_0 + \int_0^\infty y e^{-rt}\, dt = \int_0^\infty c_t e^{-rt}\, dt, \tag{15}$$

where $b_0 = f_0 + k_0$ are the economy's initial bond holdings. Equation (15) simply says that the present value of consumption equals the present value of tradable resources.

To derive the *equilibrium* path of consumption, assume, for computational simplicity, that $u(c) = \log(c)$.[21] Making use of equations (4) and (15), the expression for the *equilibrium* value of the multiplier follows:[22]

$$\lambda = \frac{1}{y/r + b_0} \int_0^\infty \frac{e^{-rt}\, dt}{1 + I_t/l_h\{1, \phi[(I_t - i_t)/I_t]\}}. \tag{16}$$

Substituting equation (16) into equation (4) yields the equilibrium consumption path:

$$c_t = (y + rb_0) \frac{\dfrac{1}{r\displaystyle\int_0^\infty \frac{e^{-rt}\, dt}{1 + I_t/l_h\{1, \phi[(I_t - i_t)/I_t]\}}}}{1 + I_t/l_h\{1, \phi[(I_t - i_t)/I_t]\}}. \tag{17}$$

This expression is key to the whole analysis. The ratio on the right-hand side (that is, the factor that multiplies $y + rb_0$) can be viewed as the *equilibrium* marginal propensity to consume (MPC) out of permanent income, $y + rb_0$. As will become clear below, the numerator of this ratio can be interpreted as the average effective price over the interval $[0,\infty)$. Therefore, the equilibrium MPC is the ratio of the average effective price to the current effective price. In equilibrium, all that matters is the

[21] See, for instance, Obstfeld (1983, 1985) for a similar research strategy.
[22] For notational simplicity, no superscripts are introduced to denote equilibrium values.

average effective price *relative* to the current effective price, because changes in the effective price of consumption have no wealth effects, so that only substitution effects remain. Hence, if the effective price path is constant over time, the equilibrium MPC is unity for all t and consumption is constant over time and equal to permanent income; that is, $c_t = y + rb_0$ for all t.[23] The constancy over time of the effective price of consumption implies that there are no incentives to engage in intertemporal consumption substitution. In contrast, if the effective price is lower today than it will be in the future, today's equilibrium MPC is above unity—because the average effective price is higher than the current effective price—and hence today's consumption is above $y + rb_0$. Future consumption, therefore, will be below $y + rb_0$. The fact that the effective price path is not constant over time induces intertemporal consumption substitution.

Finally, the equilibrium current account path can be derived as follows. Private asset accumulation is given by

$$\dot{f}_t + \dot{h}_t + \dot{z}_t = y + rf_t + i_t z_t + \tau_t - \pi_t(h_t + z_t) - c_t. \tag{18}$$

The government's flow budget constraint indicates that the excess of revenues over spending results in asset (or reserve) accumulation:

$$\dot{k}_t = \dot{h}_t + \dot{z}_t + \pi_t(h_t + z_t) + rk_t - i_t z_t - \tau_t. \tag{19}$$

Combining equations (18) and (19) yields

$$\dot{b}_t = y + rb_t - c_t. \tag{20}$$

As expected, the accumulation of net foreign assets (that is, the current account balance) is equal to the difference between income and consumption.

To derive the equilibrium path of reserves, it is necessary to specify the domestic credit rule. As usual, it is assumed that domestic credit expansion just compensates the consumer for the real depreciation of money balances. Therefore, the level of transfers adjusts endogenously, so that the time derivative of domestic credit (measured in real terms) equals $\pi_t(h_t + z_t)$:

$$\tau_t = rk_t + \pi_t(h_t + z_t) - i_t z_t. \tag{21}$$

[23] Note that a constant path of the effective price constitutes the only case in which the equilibrium MPC is unity for all t. If the effective price varies over time, the equilibrium MPC may be unity for *some* t, but it cannot be unity for *all* t.

If the domestic credit rule (equation (21)) is substituted into the government's flow budget constraint (19), it follows that $\dot{k}_t = \dot{m}_t$ (recall that $m \equiv h + z$). Thus, all changes in reserves are associated with changes in real money balances.

It can now be shown that a permanent change in the nominal interest rate has no real effects. For this purpose, assume a constant devaluation rate, so that π_t is constant at π and, thus, $I = r + \pi$.[24] It is assumed here—and throughout the paper—that, prior to the disturbance (which takes place at $t = 0$), the economy is in a stationary state. At the initial steady state, $i_t = i^l$. Then it follows from equation (17) that $c = y + rb_0$; namely, consumption equals permanent income. Consider an unanticipated and permanent increase of i from i^l to i^h at $t = 0$.[25] It can be readily verified from equation (17) that consumption remains unchanged at the permanent income level, $y + rb_0$. The intuition follows from the interpretation of equation (17). Recall that a change in i, whether temporary or permanent, has no wealth effects in equilibrium, as can be seen from equation (15).[26] Therefore, consumption will change only as a result of intertemporal price substitution effects. The permanent change in i, however, does not affect the equilibrium MPC, which continues to be unity, because the average effective price decreases by the same amount as the current effective price does. The fact that the effective price path remains flat—even if at a lower level because the rise in the nominal interest rate reduces the effective price of consumption—implies that there is no change in consumption.

The rise in the interest rate increases the demand for demand deposits by more than it decreases the demand for cash; that is, the demand for money rises, as follows from equation (10). This implies that there is a gain in reserves as the consumer exchanges bonds for money at the central bank.

Although there is no change in the pure real interest rate, $I - \pi$, the rise in i increases the real interest rate on the liquid bond, $i - \pi$. Thus, in the present context, there is no necessary connection between the real interest rate on the liquid asset and real economic activity.

[24] Because foreign inflation is zero, the rate of devaluation is also the rate of inflation.

[25] Throughout the paper, superscripts "l" and "h" will be used to denote "low" and "high" values, respectively, of any given variable.

[26] If cash and demand deposits were modeled as reducing transaction costs, as in Brock (1989), then changes in i would affect available resources. In this paper, by adopting the liquidity-in-advance specification, we abstract from such effects in order to concentrate exclusively on intertemporal price speculation effects.

II. Temporary Increase in the Interest Rate

This section focuses on the central experiment of the paper: a temporary increase in the nominal interest rate, i.[27] Suppose that at time 0 (the "present"), the interest rate is temporarily increased from i^l to i^h. At time T, the interest rate is brought back to i^l. More formally, for some $T > 0$,

$$i_t = i^h \qquad 0 \leq t < T \tag{22a}$$

$$i_t = i^l \qquad t \geq T, \tag{22b}$$

where $i^h > i^l$. Initially (that is, before time 0), consumption is at its permanent income level, given by $y + rb_0$. Substituting equations (22a) and (22b) into equation (17) yields the consumption path for $t \geq 0$:

$$c_t = (y + rb_0)\frac{\dfrac{1}{(1/p^l)(1 - e^{-rT}) + (1/p^h)e^{-rT}}}{p^l} \qquad 0 \leq t < T \tag{23a}$$

$$c_t = (y + rb_0)\frac{\dfrac{1}{(1/p^l)(1 - e^{-rT}) + (1/p^h)e^{-rT}}}{p^h} \qquad t \geq T, \tag{23b}$$

where

$$p^h \equiv 1 + I/l_h\{1, \phi[(I - i^l)/I]\}$$

$$p^l \equiv 1 + I/l_h\{1, \phi[(I - i^h)/I]\}.$$

For notational convenience, p^h and p^l—where $p^h > p^l$—stand for the effective price of consumption associated with i^l and i^h, respectively. Since a higher nominal interest rate implies a lower effective price of consumption—recall equation (13)—the effective price of consumption decreases at time 0 from p^h to p^l, and it increases back to p^h at time T. In order to make clear that, as already suggested, the term $1/[(1/p^l)(1 - e^{-rT}) + (1/p^h)e^{-rT}]$ in equations (23a) and (23b) can be interpreted as the average effective price, equations (23a) and (23b) can be rewritten as

$$c_t = (y + rb_0)\frac{p^l\Phi(T) + p^h[1 - \Phi(T)]}{p^l} \qquad 0 \leq t < T \tag{24a}$$

$$c_t = (y + rb_0)\frac{p^l\Phi(T) + p^h[1 - \Phi(T)]}{p^h} \qquad t \geq T, \tag{24b}$$

[27] Since permanent changes in the nominal interest rate have no real effects, this section's results also hold for an anticipated decrease in the nominal interest rate.

where $0 < \Phi(T) < 1$; $\Phi(T \to 0) \to 0$; $\Phi(T \to \infty) \to 1$; and $\Phi'(T) > 0$ (see Appendix II). The average effective price is thus a weighted average of p^l and p^h, with the weight being determined by the length of the period during which each effective price will prevail. Hence, equations (24a) and (24b) illustrate the notion that the equilibrium MPC is the ratio of the average effective price to the current effective price.

The consumption path that results from policy (22a) and (22b) follows from equations (24a) and (24b). When the nominal interest rate is increased at time 0, there is a once-and-for-all reduction in the average price. The fall in the average price, however, is more than offset by the reduction in the current price. Therefore, the equilibrium MPC increases above unity (as can be verified from equation (24a)), which raises consumption. The fact that the current effective price remains unchanged until $t = T$ implies that consumption stays constant as well. At $t = T$, the current price increases back to p^h, which decreases the equilibrium MPC below unity, so that consumption jumps downward at that point. This anticipated discontinuity in the consumption path is feasible under predetermined exchange rates, because with the price level, and hence the exchange rate, given at $t = T$, there are no profit opportunities.[28] The consumer exchanges money for bonds at the central bank to achieve the desired level of real money balances.

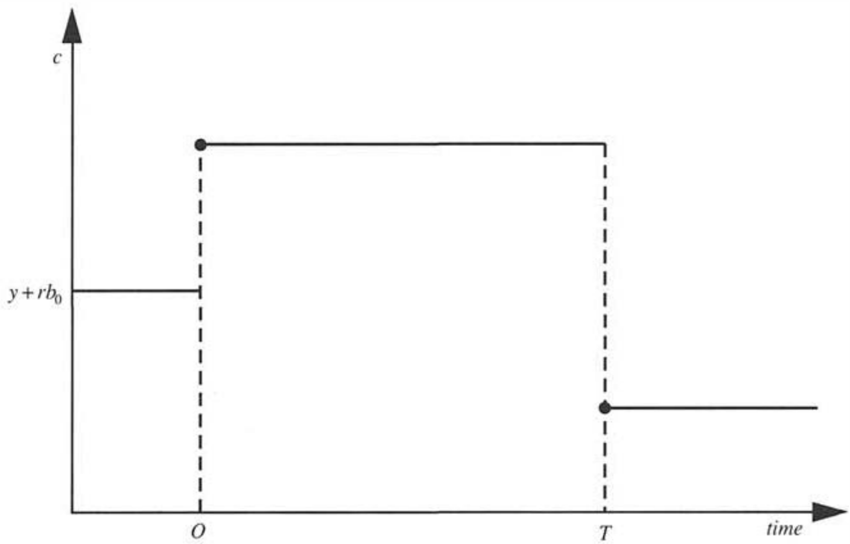
Figure 1 illustrates the consumption path that results from the policy described by equations (22a) and (22b). Initially (that is, before time 0), consumption is at its permanent income level, given by $y + rb_0$. When the policy (equations (22a) and (22b)) is announced at time 0, consumption jumps upward and remains constant up to time T. At time T, consumption jumps downward and remains constant thereafter at a level below initial permanent income.

The path of the current account—which is illustrated in Figure 2—is given by equation (20), taking into account equations (24a) and (24b). Due to the increase in consumption at $t = 0$, the current account jumps into deficit. It then deteriorates steadily between time 0 and T, even though the trade deficit (that is, $c_t - y$) remains constant, because interest payments on net foreign assets decline throughout. At $t = T$, the current account jumps into balance and the stock of foreign assets stops declining. In the new steady state, net foreign assets are lower than they were initially.

As far as the stock of reserves is concerned, note that both the rise in the nominal interest rate and the rise in consumption increase money de-

[28] In the context of anticipated devaluations, an anticipated discontinuity is possible only if there is no capital mobility (see Calvo (1989a)).

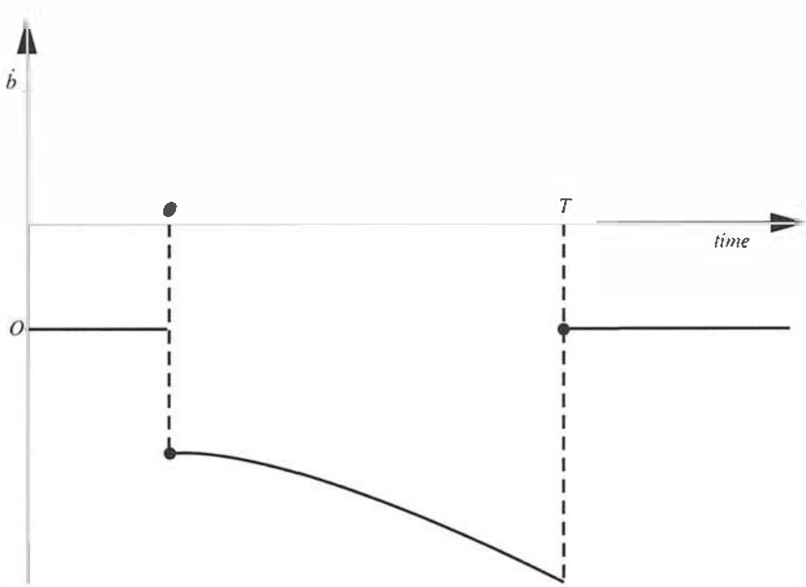
Figure 1. *Consumption Path*



mand (recall equation (10)). Therefore, there is an initial gain in central bank reserves at $t = 0$. Reserves remain constant between time 0 and time T, but when time T arrives there is a sharp drop in reserves (because both the interest rate and consumption fall), which will more than offset the initial gain. This follows from the fact that the steady-state stock of reserves decreases. The reason is that, in the new steady state, the interest rate is back at its initial level but consumption is lower, which implies, by equation (10), that real money demand is lower. Since changes in real money supply reflect changes in reserves, the lower steady-state real money supply implies that the level of reserves is also lower in the new steady state.

This policy experiment illustrates even more sharply the lack of necessary relationship between the real interest rate on the liquid asset and economic activity. Since the effect of the policy described by equations (22a) and (22b) is independent of the level of the nominal interest rate, i, at time 0, the real interest rate on the liquid asset could have gone up or down during $[0, T)$, and the real effects would still be the same. It is not, therefore, the *level,* but the *expected change* of the real (or nominal) interest rate on the liquid asset that really matters.

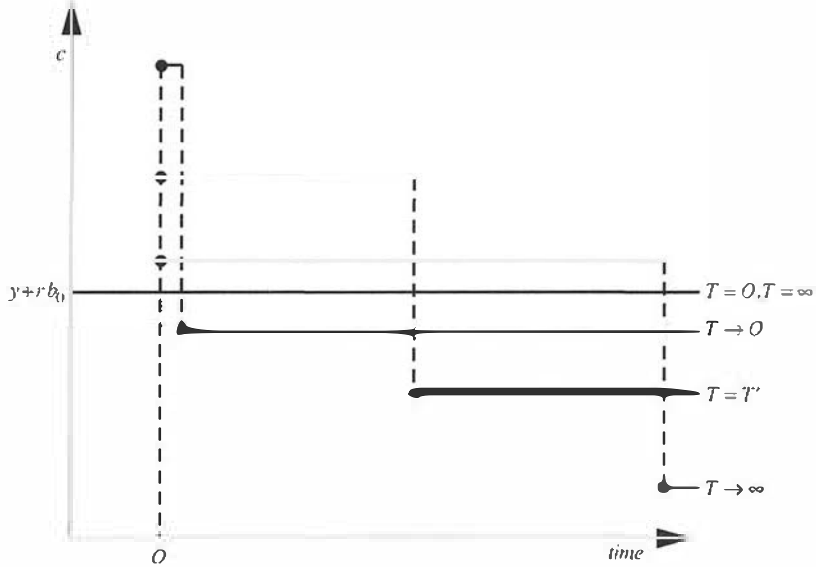
Figure 2. *Current Account Path*



Equations (24a) and (24b), together with the earlier finding that permanent changes in i do not affect consumption, may be used to examine the role played by T. The parameter T measures the time during which the interest rate remains at the higher level; namely, the degree of "temporariness" of the policy. Figure 3 depicts the consumption path for different values of T. Clearly, if $T = 0$ (that is, there is no change in the interest rate), $c_t = y + rb_0$. The same is true if "$T = \infty$" (that is, the increase in i is permanent).

To examine the initial jump in consumption (and, hence, the level of consumption for $0 \leq t < T$) for a positive and finite T, consider equation (24a) as a function of T. It follows from equation (24a) that $c(T)$ is discontinuous at $T = 0$, because as $T \rightarrow 0$, $\lim[c(T)] = (y + rb_0)(p^h/p^l)$. Furthermore, $c(T)$ is a decreasing function of T, and as $T \rightarrow \infty$, $\lim[c(T)] = y + rb_0$. Thus, when the degree of temporariness gets arbitrarily large, consumption before T tends to its permanent (as of $t = 0$) income level. Equation (24b), as a function of T, yields the level of consumption for $t = T$ (and hence for $t \geq T$) for those cases in which $T < \infty$. It follows from (24b) that (1) consumption at T is a decreasing function of T; (2) as $T \rightarrow 0$, $\lim[c(T)] = y + rb_0$; and (3) as $T \rightarrow \infty$,

Figure 3. *Consumption Path for Different Degrees of Temporariness*



$\lim[c(t)] = (y + rb_0)(p^{l}/p^{h})$. Note that the latter limit does not coincide with the value of consumption when "$T = \infty$" (that is, when the rise in the interest rate is permanent); this situation is analogous to the discontinuity of $c(T)$ at $T = 0$.

Thus, as Figure 3 illustrates, the shorter the period of time during which the rise in the interest rate remains in effect ($T \to 0$), the larger the initial increase in consumption (and hence the larger the initial current account deficit) and the higher the level of consumption after T. Intuitively, the price path is flat except for a very short period of time, which implies that the effects of intertemporal price speculation alluded to above are exacerbated. In contrast, the longer the high interest rate remains in place ($T \to \infty$), the smaller the initial increase in consumption and the lower the level of consumption after T. The path of consumption for an intermediate value of T, such as T', lies somewhere in between the paths for $T \to 0$ and $T \to \infty$.

To illustrate the effects of a higher ratio of demand deposits to cash on the response of the effective price of consumption (and thus of consumption) to a rise in the nominal interest rate, consider the case in which

$l(h, z)$ exhibits fixed proportions.[29] Formally, let the liquidity-in-advance constraint be given by

$$m_t = \alpha c_t \tag{25a}$$

$$h_t = q m_t, \qquad z_t = (1 - q) m_t, \tag{25b}$$

where

$$\alpha > 0, \qquad 0 \leq q \leq 1.$$

The effective price of consumption is then (taking into account the policy described by equations (22a) and (22b))

$$p(I, i^h) = 1 + \alpha[qI + (1 - q)(I - i^h)], \qquad 0 \leq t < T \tag{26a}$$

$$p(I, i^l) = 1 + \alpha[qI + (1 - q)(I - i^l)], \qquad t \geq T. \tag{26b}$$

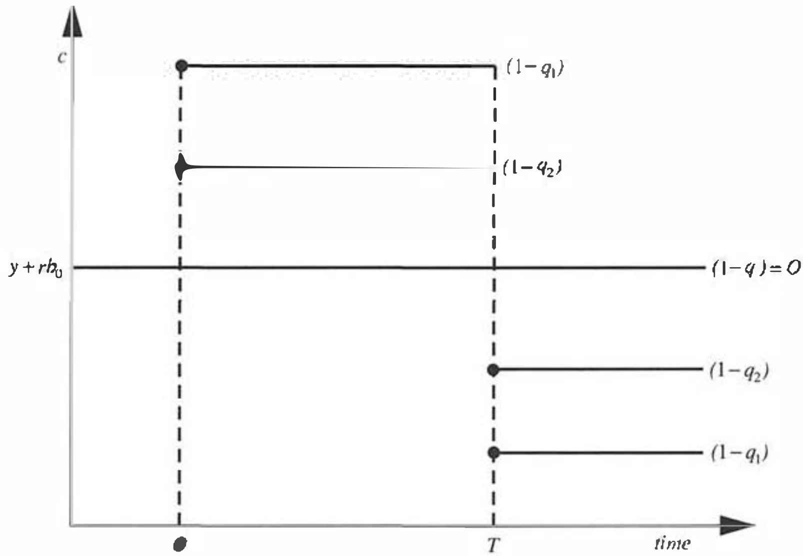
Figure 4 illustrates the effects of a rise in the interest rate for different values of $1 - q$. Clearly, if $1 - q = 0$, there is no channel through which the interest rate can affect the effective price of consumption, so that the consumption path remains flat. A given increase in the nominal interest rate results in a lower effective price the larger is $1 - q$. Thus, a larger $1 - q$ leads, other things being equal, to higher consumption between 0 and T and a correspondingly lower consumption after T. This suggests that economies in which interest-bearing liquidity plays an important role will exhibit a larger response to temporary interest rate increases.[30]

Consider now the welfare implications of a temporary rise in the interest rate. To begin with, observe that such a policy is not Pareto-optimal: a planner interested in maximizing the utility function (equation (1)), subject to the economy's resource constraint (equation (15)), would choose a constant level of consumption equal to permanent income. Therefore, the optimal policy is to choose a *constant* interest rate—*the level is irrelevant*—that induces the consumer to choose the Pareto-optimal consumption path. It seems intuitively clear that the welfare cost of a given temporary rise in the interest rate increases with the proportion of demand deposits held by the consumer. The reason is that, as

[29]The liquidity services production function needs to be specified for this exercise because third derivatives are involved.

[30]In the Cobb-Douglas case ($c = h^{\theta} z^{1-\theta}$), it can be shown that $p_i(I,i) = -(z/h)^{\theta}$; that is, the fall in the effective price of consumption as a result of a rise in the interest rate is an increasing function of the ratio of demand deposits to cash. Therefore, a higher initial ratio z/h—because of a higher initial value of $I/(I - i)$—implies a larger fall in the effective price of consumption and therefore a larger increase in consumption.

Figure 4. *Consumption Path as a Function of the Proportion of Demand Deposits Held*



Note: $(1-q_1)>(1-q_2)$.

argued above and illustrated in Figure 4, a higher initial ratio of demand deposits to cash results in a "less smooth" consumption path and would—one would expect—lead to higher welfare losses. (Simulations of the model suggest that this is indeed the case.) In contrast, welfare does not change monotonically with T because of the following. First, recall that consumption remains unchanged when $T=0$ or "$T=\infty$"; second, the welfare loss converges to zero when $T\rightarrow 0$ or $T\rightarrow\infty$; and third, the welfare loss is positive for all T, such that $0<T<\infty$.[31] Therefore, there exists a $T\in(0,\infty)$ at which the welfare loss reaches a maximum.

It should be noted that this setup could be used to examine a temporary stabilization program under predetermined exchange rates (that is, a temporary reduction in the devaluation rate), as in Calvo (1986).

[31] Naturally, the discontinuity of $c(T)$ at $T=0$ does not imply that the welfare loss is discontinuous at that point. In technical terms, the integral is continuous if the integrand is *piecewise*-continuous.

Suppose that π is reduced during the period from $t = 0$ to T. It follows from equations (12), (13), and (17) that a reduction in π (which reduces I) is equivalent to an increase in i, because both affect consumption through the same (and only) channel; that is, by lowering the effective price of consumption. Therefore, the same effects on consumption and the current account obtain for a temporary decrease in the rate of devaluation.

Finally, note that the authorities could control the interest rate paid on demand deposits by manipulating reserve requirements.[32] To show that this policy is equivalent to the one studied above, note that, under competitive and costless banking, the zero-profit condition implies that

$$i_t = (1 - \gamma)I_t, \tag{27}$$

where $0 < \gamma < 1$ denotes the required reserve ratio. Since I is exogenously given, controlling γ is tantamount to controlling i. Thus, a temporary reduction in γ—by temporarily reducing the effective price of consumption—has an expansionary effect on consumption.

III. Conclusions

Policymakers have frequently manipulated nominal interest rates in order to achieve different macroeconomic goals. An analytical obstacle that has hindered studies of the effects of such policies in the context of rational expectations models has been that interest rate targeting usually results in indeterminacy of the price level or the inflation rate. This paper provides an analytical framework in which a meaningful examination of interest rate policy is feasible. The key feature is that the authorities control the interest rate borne by a liquid bond—which we identify as interest-bearing demand deposits—rather than the rate of the nonliquid bond. In this context, raising interest rates lowers the cost of holding money. If the rise in the interest rate is unexpected and permanent, there are no real effects because the effective price of consumption remains constant over time. If the rise in the interest rate is temporary, the effective price of consumption is lower today compared to the future, and the increase thus has an expansionary effect on consumption.

We have isolated one specific—and often disregarded—channel through which higher nominal interest rates may work. This is an important first step, from a conceptual point of view, toward understanding

[32] This equivalence would not hold under flexible exchange rates, however, because the pure nominal rate is not exogenously given.

the effects of interest rate policy in more realistic (and thus more complex) models. Even in considerably more complex models, this channel will still be present.

We have dealt with the simplest possible scenario: a small open economy with full employment, flexible prices, and predetermined exchange rates. The simplest extension is to consider the case of flexible exchange rates and analyze the effectiveness of raising interest rates in fighting inflation (see Calvo and Végh (1990b)). In that context, it is still true that only temporary changes in the interest rate have any real effects on the economy. The inflation rate always increases on impact as a result of a temporary rise in the interest rate, and increases exponentially thereafter. Consumption may increase or fall on impact. The reason consumption may fall on impact is that the higher inflation rate—which tends to increase the effective price of consumption—may more than offset the effect of the higher interest rate—which tends to decrease the effective price. The conclusion, therefore, is that raising interest rates seems hardly appropriate in the context of a flexible-prices model as a means of fighting inflation.

The expansionary effects that may result from an increase in the interest rate in the flexible-prices models run counter to conventional wisdom, according to which raising interest rates should be contractionary. This has led us to examine interest rate policy in a sticky-prices model. In Calvo and Végh (1989, 1990c), we analyze interest rate policy in a closed economy, staggered-prices model. The main message is that the conventional (that is, contractionary) effects re-emerge in that context. Inflation is brought down—at the cost of a sharp fall in output—both when the interest rate is raised temporarily and when it is raised permanently. When the rise is temporary, however, the initial fall in inflation is followed by an upsurge in inflation over and above its initial level. The expansionary effect of a higher interest rate isolated in this paper is still present in the sticky-prices model, in the sense that the consumer might want to increase consumption. The key difference, however, is that the increased consumption cannot be effected because the real money supply cannot increase instantaneously, since (1) the economy is closed, and (2) the price level cannot jump.

Since the absence of capital mobility might be crucial to the results obtained in the closed economy, staggered-prices model, the next logical (and final) step in our quest for understanding interest rate policy is to open the sticky-prices model to trade in goods and assets. The conjecture is that—in the Mundell-Fleming spirit—predetermined exchange rates coupled with perfect capital mobility would dramatically affect the results. To this effect, we plan to use the open economy, staggered-prices model developed in Calvo and Végh (1990a) to study interest rate policy. One would expect that, under predetermined exchange rates, the expansionary effects reappear—even in the presence of sticky prices—because the public may increase its real money holdings through the central bank window. Therefore, a temporary increase in the interest rate may have expansionary effects in both the traded and nontraded goods sector. Under flexible exchange rates, however, one would expect to find that the traded goods sector may expand while the nontraded goods sector contracts. Once again, flexible exchange rates prevent the public from increasing real money balances (in terms of nontraded goods).

APPENDIX I

Derivation of Demand for Cash, Demand Deposits, and Money

From equation (2), holding with equality, and equation (6), it follows that

$$h_t = \psi^h[c_t,(I_t - i_t)/I_t] \equiv c_t/l\{1,\phi[(I_t - i_t)/I_t]\} \tag{28}$$

$$z_t = \psi^z[c_t,(I_t - i_t)/I_t] \equiv c_t\phi[(I_t - i_t)/I_t]/l\{1,\phi[(I_t - i_t)/I_t]\} \tag{29}$$

$$m_t = \psi^m[c_t,(I_t - i_t)/I_t] \equiv c_t\{1 + \phi[(I_t - i_t)/I_t]\}/l\{1,\phi[(I_t - i_t)/I_t]\}. \tag{30}$$

Clearly, all three functions are increasing in c. Differentiation of equations (28)–(30) yields (denoting $(I - i)/I$ by R)

$$\psi^h_R(c_t, R_t) = \frac{-c_t l_z[1,\phi(R_t)]\phi'(R_t)}{l^2[1,\phi(R_t)]} > 0 \tag{31}$$

$$\psi^z_R(c_t, R_t) = \frac{c_t\phi'(R_t)\{l[1,\phi(R_t)] - \phi(R_t)\, l_z[1,\phi(R_t)]\}}{l^2[1,\phi(R_t)]} < 0 \tag{32}$$

$$\psi^m_R(c_t, R_t) = \frac{c_t\phi'(R_t)\{l[1,\phi(R_t)] - [1 + \phi(R_t)][l_z(1,\phi(R_t))]\}}{l^2[1,\phi(R_t)]} < 0. \tag{33}$$

The sign of the numerator of equations (32) and (33) follows from Euler's theorem and the fact that, by equation (5), $l_h > l_z$.

APPENDIX II

Derivation of $\Phi(T)$

To illustrate the idea that the equilibrium MPC can be thought of as the ratio of the average effective price to the current effective price, the function $\Phi(T)$ was used in equations (24a) and (24b). This function and its properties are now derived. Let the function $\Phi(T)$, $0 < T < \infty$, be defined in implicit form by

$$p^l\Phi(T) + p^h[1 - \Phi(T)] \equiv \frac{1}{(1/p^l)(1 - e^{-rT}) + (1/p^h)e^{-rT}}, \quad (34)$$

where the right-hand side is the numerator of the ratio that multiplies $y + rb_0$ in equations (23a) and (23b). For notational simplicity, denote the denominator on the right-hand side of (34) by $\Gamma(T)$. Using (34), $\Phi(T)$ can be solved for

$$\Phi(T) = [1/\Gamma(T) - p^h][1/(p^l - p^h)]. \quad (35)$$

Clearly, $\Phi(T)$ is continuous for $T \in (0,\infty)$ since $p^l \neq p^h$. Recalling that $p^l < p^h$, it follows from (35) that (1) $\Phi(T) > 0$; (2) $\Phi'(T) > 0$; (3) as $T \to 0$, $\lim[\Phi(T)] = 0$; and (4) as $T \to \infty$, $\lim[\Phi(T)] = 1$. Hence, $0 < \Phi(T) < 1$.

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Economic and Monetary Integration and the Aggregate Demand for Money in the EMS

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Aggregate demand for M1 in the countries participating in the exchange rate mechanism (ERM) of the European Monetary System is shown to be a stable function of ERM-wide income, inflation, interest rates, and the ECU-dollar exchange rate. Particularly noteworthy is the rapid dynamic adjustment, in contrast to the implausibly slow adjustment implied by most single-country estimates. These results, if robust, suggest that, even at the present stage of economic and monetary integration, a European central bank might be able to implement monetary control more effectively than the individual national central banks. [JEL 311, 423]

THIS PAPER examines the determinants of the aggregate demand for narrow money (M1) in the countries participating in the exchange rate mechanism (ERM) of the European Monetary System (EMS).

The motivation for this study is twofold. First, the increasing degree of stability in exchange rates and the process of liberalizing capital movements within the ERM area are likely to have increased the substitutability of money and other assets denominated in the various participating currencies. As a result of this development and of the increased degree of integration of the ERM economies, the demand for money in

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individual countries may have become more volatile, while at the same time the demand for money in the ERM area as a whole may have become more stable. Russo and Tullio (1988) and others have argued that this new stability may have made the ERM-wide money stock a more important determinant of inflation in the ERM than the domestic money stocks, which might help justify centralizing monetary policymaking at a European level.

Second, irrespective of whether the aggregate demand for money in the ERM is more stable than its counterparts in the individual countries, the present discussion about a single monetary policy for the EMS (implemented by a European central bank, or by coordination among the national central banks[1]) poses the question of whether an aggregate demand for money function can be identified that could serve as a guide for such a policy.

The estimation of a money demand function for a group of countries with different currencies adds several aspects, both of a conceptual and of a practical nature, to the aggregation issues normally encountered in modeling macroeconomic money demand. Conditions that may justify and make worthwhile an analysis of money demand at the level of ERM-wide aggregates are discussed in Section I.

If it can be assumed that such conditions are satisfied, then a more practical problem remains: which exchange rates to use in aggregating to the ERM level the national variables appearing in the money demand function. Three alternative conversion rates are juxtaposed in Section II; namely, current exchange rates, fixed base-period exchange rates, and purchasing power parity (PPP) rates. The first approach, using current nominal exchange rates, would be appropriate if exchange rates were irrevocably fixed, but its merit is less obvious in the case of the ERM, given that exchange rates have remained adjustable. This approach has been applied by Gray, Ward, and Zis (1976) in a study of world money demand during the Bretton Woods era. The second method, using fixed base-period exchange rates, has been used by McKinnon (1982, 1984) and Spinelli (1983) to study the determination of money and prices at the world level under flexible exchange rates, and by Bekx and Tullio (1987) in an analysis of the demand for money in the ERM. It renders the measurement of aggregate variables impervious to nominal exchange rate changes. The third approach, using PPP rates, shares this feature

[1] Coordination might include arrangements whereby one central bank, such as the Deutsche Bundesbank, sets monetary policy taking account of monetary and general economic conditions in the EMS as a whole, including the reactions of the other central banks.

with respect to real variables. The first and third approaches would of course be equivalent if exchange rates were maintained consistent with PPP on a continuous basis, the second and third if all ERM countries had identical inflation rates, and the first and second if exchange rates were fixed.

The econometric specification of money demand presented in this paper is the result of an examination of the data generated by all three methods of aggregation, as well as econometric experimentation with the second and third (base-period and PPP) approaches. The third approach, based on PPP, has some particularly attractive properties: for one thing, since money stocks and incomes are converted to a single currency in proportion to the purchasing powers of the currencies in which they are originally measured, the weight of each country in the ERM aggregate reflects the size of its real economy. As a result, the growth rate of aggregate real gross national product (GNP) and other variables properly reflects the growth rates of the corresponding national variables.[2] Another desirable feature of the PPP approach in studying the demand for narrow money, held largely for transactions purposes, is that it reflects the money's purchasing power in the country in which it is spent—which, in the ERM countries, is still primarily the country in which the money is issued. Supporting this approach, exploratory work suggests that a money demand equation using base-period exchange rates, namely that of Bekx and Tullio (1987), is not well specified; results presented in Appendix I show that their money demand function suffers from parameter instability.[3]

Estimating a money demand function using data based on aggregation at PPP yields more satisfactory results. Section III applies the error-correction model developed by Hendry (1985, 1986), Engle and Granger (1987), and others, drawing a careful distinction between long-run developments and short-run fluctuations in the ERM-wide demand for real M1. It is found that the demand for real narrow money in the ERM can be expressed as a stable function of ERM-wide real income, inflation, interest rates, and the exchange rate of the European Currency Unit (ECU) vis-à-vis the U.S. dollar. The long-run relationship between these variables is stable and well determined: a unit income elasticity,

[2] As brought out in the figures that follow, this property is not shared by ERM variables aggregated at current nominal exchange rates and expressed in deutsche mark. Similar difficulties could persist if the aggregates were expressed in a basket currency (European currency unit (ECU), say), though perhaps to a lesser degree.

[3] This probably reflects other features of their model as well, notably the absence of dynamics.

negative elasticities with respect to inflation and the level of interest rates, and a positive elasticity with respect to the strength of the ECU exchange rate vis-à-vis the U.S. dollar. Short-run fluctuations in the demand for real M1 can be expressed as a stable function of changes in real income, changes in interest rates, and disequilibrium feedback from deviations of the real ERM money stock from its desired long-run position. An interesting feature, discussed theoretically in Section I, is the relatively rapid elimination of such disequilibria; this contrasts with most earlier econometric work on individual countries, which found slower adjustment. The model satisfies a broad set of diagnostic tests for possible misspecification and fits the data at least as well as the money demand functions customarily estimated for individual ERM countries (for example, Atkinson and others (1985) and von Hagen and Neumann (1988)).

I. Theoretical Aspects of Aggregation

In this study not only is it found that a stable and well-behaved money demand function can be specified for the ERM as a whole, but this function also appears to have properties that are more satisfactory than those of similar estimates for single countries. Because this finding is perhaps counter-intuitive, the gains and losses from aggregating across the ERM countries must be explored.

In determining how aggregation affects estimates of the demand for money, two kinds of biases can be distinguished (see Pesaran, Pierse, and Kumar (1989)). First, aggregation bias can arise to the extent that different countries in the group have different money demand relationships; as a result, aggregate estimates may not converge to a "true" money demand relationship in any one country, or even to an appropriately weighted average. Second, specification bias can occur to the extent that there are omitted variables, errors in the measurement of the explanatory variables, or other errors in the equation's specification. The specification bias could be reduced through aggregation, for example, if the bias reflected the omission of aggregate variables from the individual country equations. Thus, taking both aggregation and specification bias into account, it is possible that aggregate estimates actually perform better than single-country ones.[4]

[4] This possibility, which applies to the aggregation of economic relationships in general, was first examined by Grunfeld and Griliches (1960). Zellner (1962) addressed the aggregation issue in his development of the seemingly unrelated regression equations (SURE) approach. Pesaran, Pierse, and Kumar (1989) provide a useful recent treatment.

In an examination of the demand for money in a relatively integrated financial area such as that corresponding to the ERM, there are two obvious potential sources of specification error in single-country equations. First, there may be currency substitution, with individuals or firms resident in any country holding transactions balances located in more than one country and denominated in more than one currency.[5] This would imply that money holdings in a given country's currency would depend not only on income and interest rates in that country, but also on incomes and interest rates in other countries. Moreover, with currency substitution, a shock to money demand in one country may be correlated either positively or negatively with shocks to money demand in other countries. To the extent that these shocks are associated with irregularities in payments and receipts in trade, the correlation may be negative; for example, someone's delayed receipt is someone else's delayed payment, so that one person's money holdings may temporarily be less than planned and the other's temporarily greater. The same holds for unexpected changes in spending plans; for example, if rainy Mediterranean weather keeps German tourists at home, this could lead to a temporary positive shock to Germans' money balances accompanied by a temporary negative shock to Italians' balances. Such would also be the case if there are unobserved changes in the anticipated relative returns on money balances held in different currencies; for example, the public may base its expectations of exchange rates on data, such as political developments, that are not taken into account by the econometrician-observer. Money demand shocks that correspond to common changes in transactions technology or preferences, however, tend to be correlated positively across countries.

In addition to currency substitution, international portfolio diversification (of which currency substitution is a special case) more generally implies that individuals may hold domestic as well as foreign assets, and thus may take the rates of return on foreign assets into account as part of the opportunity cost of holding money. In this case, and especially given the existence of capital controls, which create imperfect asset substitutability and thus imply that interest rate differentials do not merely correspond to anticipated exchange rate movements, interest rates in other countries, especially other ERM countries, would affect the demand for money in individual ERM countries (see, for example, Brillembourg and Schadler (1979)).

[5] Currency substitution often refers to a more specific concept, namely that expected exchange rate movements affect the demand for money in opposite directions in different countries. Here, we use the term in the broader sense that individuals can satisfy their demand for money by holding balances in more than one currency.

In empirical estimates of the demand for money, dynamic specification is particularly important from both an econometric and a theoretical and policy perspective. Empirical money demand equations typically either include a conventional lagged dependent variable or use an error-correction specification; either of these formulations implies that money balances adjust gradually toward their equilibrium relationship with explanatory variables such as income and interest rates. Empirical studies of the demand for money in many countries have estimated partial adjustment or error-correction coefficients that imply a speed of adjustment that is implausibly slow—especially to the extent that, in an economy as a whole, income, interest rates, and prices, rather than individual money holdings, adjust to equate actual and desired money balances (for example, Laidler (1982) and Lane (1990)). Goodfriend (1985) showed that specification error may account for the implausibly slow adjustment speeds that emerge from many empirical studies.[6] If this explanation were valid, then reducing specification error would be expected to give rise to higher—and therefore arguably more plausible—implied adjustment speeds.

In this paper, the demand for money is examined within a two-step error-correction framework,[7] which entails first estimating a static equation, often interpreted as the long-run or equilibrium relationship among the variables. Subsequently, a dynamic equation is estimated in which the lagged residual from the static equation is included as an explanatory variable representing disequilibrium feedback. The coefficient on the residual, the error-correction coefficient, is interpreted as a measure of adjustment in response to deviations from the equilibrium relationship (see Salmon (1982)). Because of the two-stage nature of this error-correction framework, measurement or other specification errors affecting the static equation are reflected in the first-stage residual, which may in turn bias the error-correction coefficient (as well as other coefficients) in the dynamic equation. Kremers and Lane (1989) showed that if the

[6]Using the partial adjustment framework, Goodfriend (1985) showed that measurement errors may bias the coefficient on the lagged dependent variable toward unity; similarly, Kremers and Lane (1989) showed that, in the error-correction framework, such specification errors may bias the error-correction coefficient toward zero.

[7]The use of this framework is appropriate if both real money balances and the explanatory variables are $I(1)$, and a co-integrating relationship between these variables can be found such that the residuals from this relationship are $I(0)$. Under these circumstances, consistent estimates of the co-integrating relationship can be obtained using ordinary least squares (OLS), without requiring the usual assumptions about the orthogonality of the explanatory variables to the disturbance term. See Granger (1986) and Engle and Granger (1987).

measurement error results primarily from the exclusion of foreign income from each country's money demand equation when there is currency substitution, as discussed above, the error-correction coefficient will be biased toward zero, wrongly implying a slow adjustment toward equilibrium in money balances.

Aggregation across ERM countries replaces one set of restrictions with another; that is, the exclusion of foreign income from each country's demand for money is replaced with the restriction that the money demand of all countries has roughly the same structure, and that the weight of any country's income in influencing another's demand for money is roughly proportional to the weight of that country's money in aggregate money. Whether misspecification is reduced under this alternative set of restrictions is an empirical question. One way of tackling this question is by considering whether one can identify, for the ERM as a whole, an error-correction money demand model that passes a range of specification tests. An additional issue, as already discussed, is whether the ERM-wide money demand estimation yields an error-correction coefficient that is larger than has typically emerged from single-country studies. To anticipate the results, the answer to both of these questions is "yes."

II. Derivation of the Aggregate Data

In this section the aggregate data are presented and their salient features discussed.[8] Seven countries are included in the analysis: Belgium, Denmark, France, the Federal Republic of Germany, Ireland, Italy, and the Netherlands. This comprises the entire ERM except Luxembourg, for which not all of the required data are available.

For this study of the demand for narrow money (M1), it is preferable to use data encompassing the total monetary asset holdings of domestic residents, held domestically as well as abroad, in both domestic and foreign currency. In light of the requirement that the data should be comparable across countries, the study is based on narrow money as defined in the International Monetary Fund's *International Financial Statistics* (*IFS*). This measure of money includes, for each country, currency outside banks as well as demand deposits in domestic currency of the domestic private nonbank sector with domestic banks. The measure unfortunately does not include the nonbank private sector's demand deposits in foreign currency held either in domestic or in foreign banks. Deposits

[8]Exact source references for all the data are relegated to Appendix II.

held by ERM residents in offshore markets are therefore not included in the analysis, but, given that these are largely held in time deposits rather than demand deposits or currency, this is probably not a serious omission. Domestic notes and coins in the hands of foreigners are included, however, which is likely to be an advantage, since a large part of each of the ERM countries' currency held by foreigners is probably held elsewhere within the ERM area.

The income variable is, depending on availability, either real GNP or real gross domestic product (GDP) (in 1985 prices). For Germany, France, and Italy, the income variable is available at a quarterly frequency; for the other countries, annual data are interpolated according to the quarterly pattern of industrial production. The income variables, as well as the money stocks, are seasonally adjusted at the national level.

Both the short-term interest rate and the long-term interest rate play a role in the empirical analysis. The former is represented by the short-term interbank money market rate, and the latter by the government bond yield.[9] The consumer price index (CPI) is used to deflate nominal money and to measure the rate of inflation.

The ERM-wide aggregate for the income variable is derived in three alternative fashions: namely, using current nominal exchange rates, fixed base-period nominal exchange rates, and PPP rates. The average nominal exchange rates for 1979 (the first year of the EMS) underlie the second method. The third method is based on the PPP rates published by the Organization for Economic Cooperation and Development (1989), which are designed to correspond to PPP for the entire GDP. They rely on a large-scale international survey conducted in 1985; the parity rates for the years before and after 1985 (which is near the middle of the EMS sample) are computed by utilizing changes in the GDP deflators in the various countries. In order to maintain the national relativities between money and income in the ERM aggregate, the money stocks are added up at the same exchange rates as are the income variables.

The average ERM interest rates are computed as weighted averages of the national rates, using as weights the shares of the national currency in the ECU in 1989 (Ungerer and others (1986, Table 4)), redefined to exclude the United Kingdom and Luxembourg. These shares are intended to reflect the relative importance of the various ERM economies

[9]The use of interest rates to measure the opportunity cost of holding money may, in principle, be confounded by the payment of interest on deposits. However, although demand deposits bear interest in some ERM countries during some or all of the sample period, rates were generally low and varied little, so this issue is likely to be of little concern in estimating the demand for M1.

and the role of their currencies in the international financial marketplace. The aggregate CPI is computed as a weighted average of the national indices, the weights being the shares of the real income variables in the ERM aggregate computed either at current nominal exchange rates or at PPP rates.[10]

The resulting data set is presented in Figures 1 through 6.[11] Figure 1 shows aggregate real GNP in the ERM, expressed in deutsche mark and derived on the basis of the three alternative methods discussed above. The pattern of nominal appreciation of the deutsche mark is clearly reflected in the downward movement of aggregate real GNP based on current nominal exchange rates. It is also apparent from Figure 1 that the aggregation at base-period exchange rates produces a pattern similar to that resulting from aggregation at PPP rates. In the latter measure Germany has a slightly smaller weight than in the former, whereas, among the other ERM countries, Italy in particular is weighted more heavily. This disparity of weights is reflected in a slightly faster growth of the ERM aggregate on the latter measure. Figure 1 illustrates these divergences in a comparison of German growth with ERM growth derived at PPP rates.

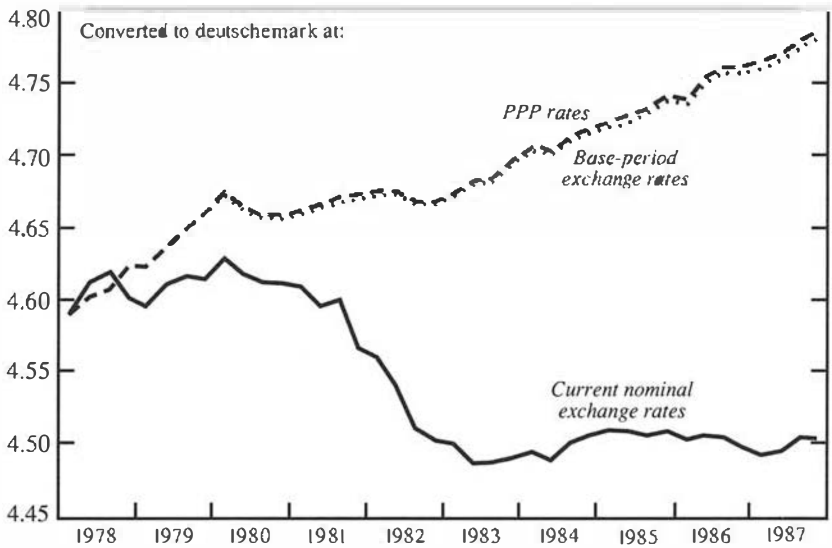
Figure 2 depicts the corresponding series for the nominal money stock in the ERM and Germany; and Figure 3 shows these series deflated by the matching CPI indices. The behavior of the nominal series derived at base-period exchange rates is again quite similar to that based on PPP rates; Figure 2 shows that, from 1979 through 1987, nominal money growth in Germany was considerably more restrained than in the ERM. In contrast, as Figure 3 shows, real money growth (based on PPP rates) was faster in the ERM than in Germany in 1979–81, about equal in 1982–84, and considerably faster in Germany in 1985–87. This pattern is also reflected in the liquidity ratio, defined as the ratio of real money over real GNP (Figure 4). This variable, which will play an important role in the empirical analysis in Section III, fell more rapidly in Germany in the first half of the EMS period, but this fall was followed by a relatively steep rise in the second half.

The process of inflation reduction and convergence in the ERM is documented in Figure 5. Finally, Figure 6 displays short-term and long-term interest rates.

[10]Bekx and Tullio (1987) based their ERM-wide CPI on the 1979 ECU weights, and that procedure will be followed for the estimates replicating their model (see Appendix I).

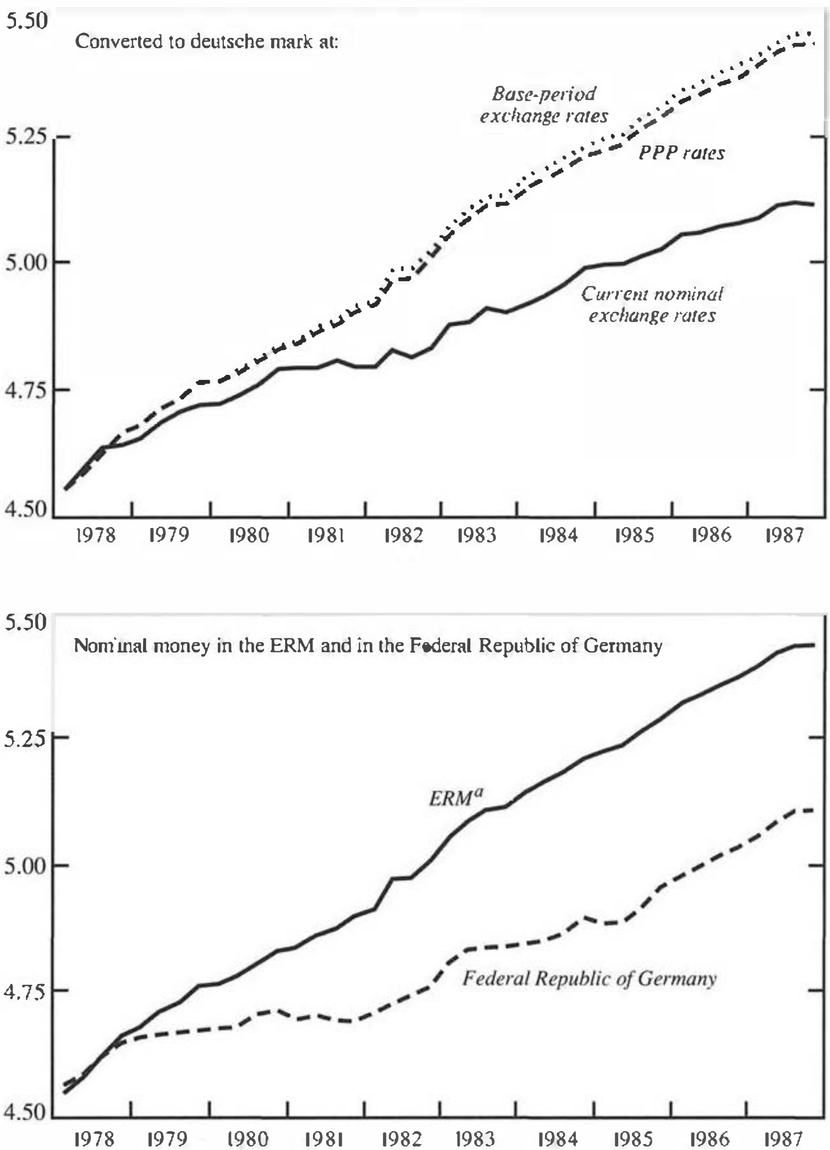
[11] In charts that are in natural logarithms, the vertical axes can be used to gauge changes and differences in percentages of levels of the original variables. Due to scaling and indexing of components of some original series, levels should be interpreted with caution.

Figure 1. *Real GNP in the ERM*



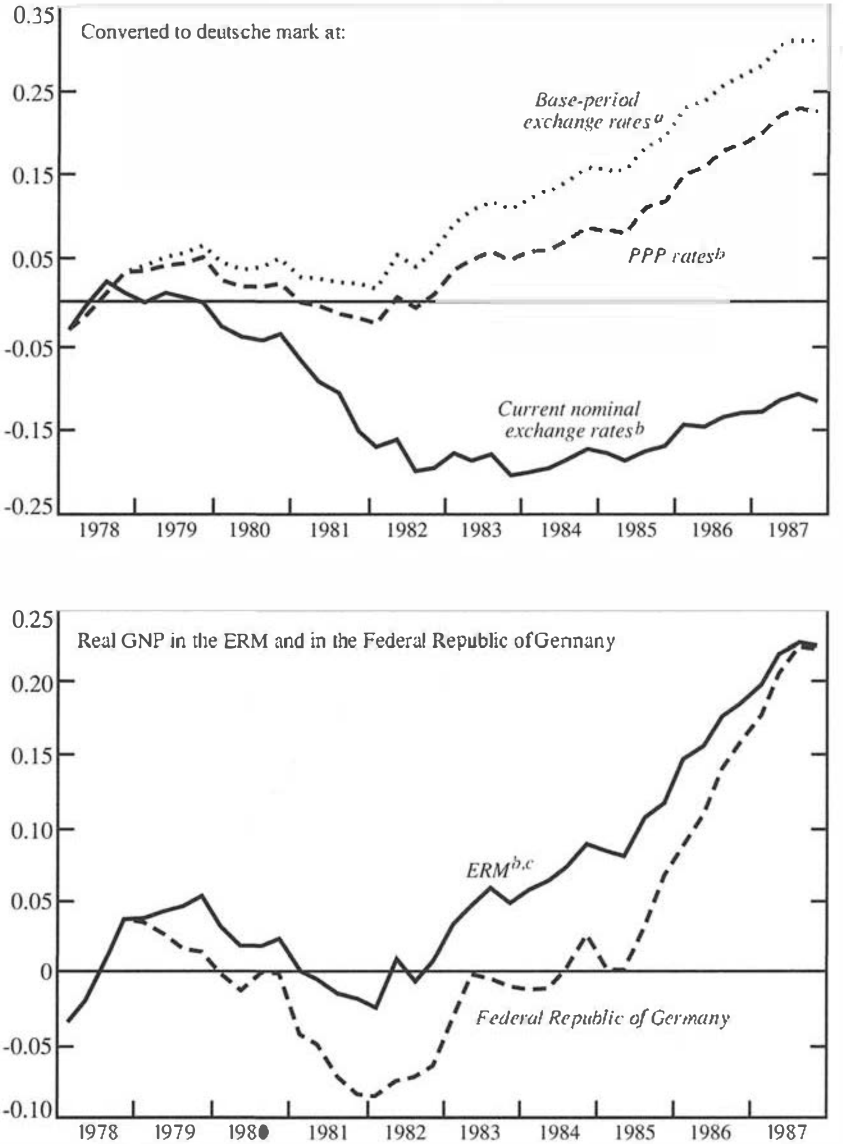
Source: Appendix II.
Note: Natural logarithm of real GNP, in deutsche mark at 1985 prices (indices scaled to 1978 = 100).
[a] Converted to deutsche mark at PPP rates.

Figure 2. *Nominal Money in the ERM*



Source: Appendix II.
Note: Natural logarithm of nominal M1, in deutsche mark (indices scaled to 1978 = 100).
[a] Converted to deutsche mark at PPP rates.

Figure 3. *Real Money in the ERM*



Source: Appendix II.

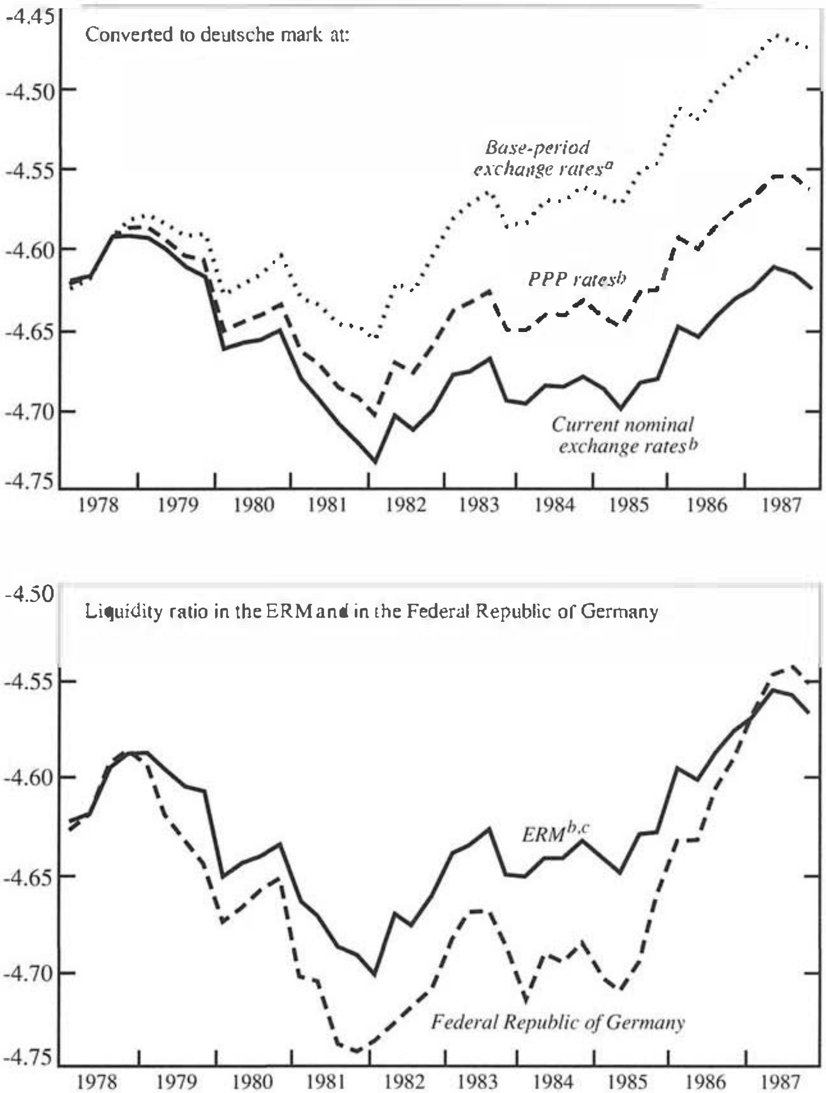
Note: Natural logarithm of nominal M1 deflated by CPI, in deutsche mark (indices for M1 and CPI scaled to 1978 = 100).

[a] CPI based on ECU weights.

[b] CPI based on real GNP weights.

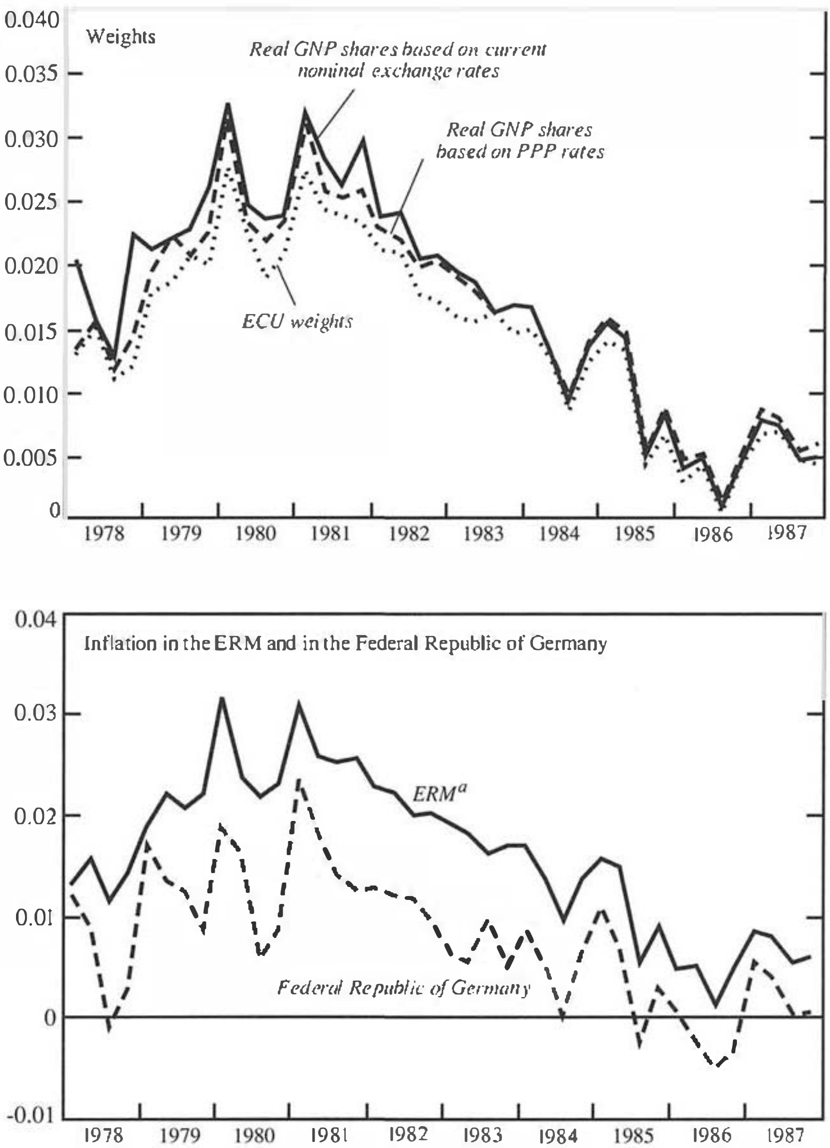
[c] Converted to deutsche mark at PPP rates.

Figure 4. *Liquidity Ratio in the ERM*



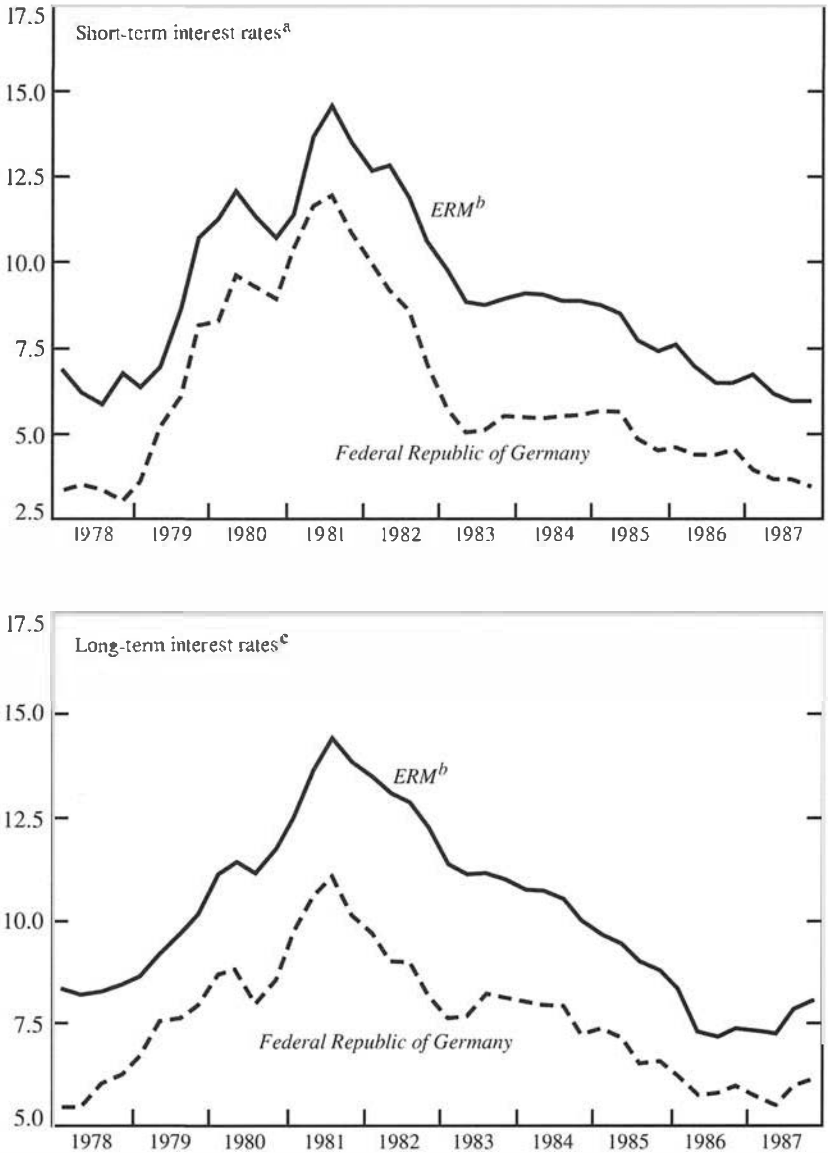
Source: Appendix II.
Note: Natural logarithm of real M1 (nominal M1 deflated by CPI) divided by real GNP in 1985, in deutsche mark (indices for M1, CPI, and real GNP scaled to 1978 = 100).
[a] CPI based on ECU weights.
[b] CPI based on real GNP weights.
[c] Converted to deutsche mark at PPP rates.

Figure 5. *Inflation in the ERM*



Source: Appendix II.
Note: Quarterly change in the natural logarithm of CPI indices.
[a] Weights based on real GNP shares relying on PPP rates.

Figure 6. *Interest Rates*



Source: Appendix II.
[a] Short-term interbank money market rate, annual return.
[b] Based on ECU weights.
[c] Long-term government bond yield, annual return.

III. Empirical Results

Given the considerations advanced above, the demand for money in the ERM was analyzed employing aggregate data and relying either on fixed base-period exchange rates or on PPP rates. As a benchmark for the investigation, the model proposed by Bekx and Tullio (1987), which relies on base-period rates, was scrutinized (see Appendix I) and found to be misspecified. An alternative model is presented here that relies on PPP rates and has a richer dynamic structure; this model turns out to be satisfactory.

The Bekx-Tullio model is unusual in that it excludes any dynamics. It thus resembles the kind of relation that may exist between money, prices, income, and interest rates in the long run. Indeed, the recent literature on co-integration has recommended static regressions as a vehicle for uncovering long-run economic relationships. The idea underlying co-integration is to study the behavior of variables moving apart in the short run but brought together again by market forces or government policy, or both, in the longer run.[12] A variable is defined to be integrated of order 1 (denoted $I(1)$) if it must be differenced once to induce stationarity (denoted $I(0)$). A set of variables, each $I(1)$, is said to be co-integrated if a linear combination of them is $I(0)$ (that is, if they move together in the longer run).

The practical merit of the empirical methods that have been developed in connection with co-integration is that they provide a way of distinguishing empirically between short-run and long-run features of economic time series. Since we are interested in disentangling the long-run tendencies of money demand in the ERM from its short-run fluctuations, we will use the theorem, established by Engle and Granger (1987), that co-integration between a set of variables implies that their short-run dynamics are influenced by feedback returning them to their long-run equilibrium. The converse is also true: if such feedback exists, then the variables must be co-integrated.

Specifically, it will first be determined whether the residuals from a static regression of the ERM money stock (denoted m_t)[13] on the price level (denoted p_t), real GNP (denoted y_t), the interest rate, inflation, and the exchange rate of the ECU (excluding the United Kingdom and Luxembourg) vis-à-vis the U.S. dollar are stationary. Based on the results of some alternative regressions not reported here, a short-term,

[12] See Granger (1986), Hendry (1986), and Engle and Granger (1987) for introductions to co-integration.

[13] All lowercase variables are in natural logarithms.

rather than a long-term, interest rate is specified (denoted RS_t); this is consistent with the idea that narrow money is held largely for transactions purposes and that the time horizon relevant for decisions regarding the amount held is accordingly rather short.[14]

The nominal exchange rate of the ECU in terms of U.S. dollars, ecu_t, is also included in the static equation.[15] This is consistent with the Deutsche Bundesbank's (1988) finding that the strength of the deutsche mark has tended to be associated with a stronger demand for German money (especially notes and coins), and with similar results found for the ERM by Bekx and Tullio (1987). This link between the exchange rate and the demand for money may reflect currency substitution.[16] For example, the exchange rate may embody information about the future course of monetary policy and other fundamentals affecting the future exchange rate, and any new information would be incorporated in the exchange rate as well as affecting the demand for money. An anticipated easing of monetary policy in Europe, for instance, would lead to an expected depreciation of the ECU and would thus lead immediately to a lower ECU; the same expectations could also lead the demand for European money to decrease due to currency substitution, and perhaps also via the effect of anticipated inflation. The "long-run" demand for money will be affected if the new information is "permanent"; that is, if it is as likely to be revised in one direction as the other; this would be the case under rational expectations.[17] In the absence of an explicit model of expectations, this interpretation of the role of the exchange rate in money demand functions remains, of course, a tentative one.

Other specific features of the model are as follows. The aggregate data are based on PPP rates. The rate of inflation is included as a (negative) return on money. Preliminary estimates also suggested that imposing the assumption of long-run homogeneity of money demand in the price level and restricting the income elasticity to unity does not significantly raise

[14] See for example, Laidler (1977), pp. 108–109. In principle, the yields on assets of all maturities may enter the money demand equation, regardless of the relevant time horizon, because these will embody interest rate expectations; however, interest rate expectations are of less relevance if holdings of money can be altered at short notice at little cost.

[15] The corresponding real exchange rate has a very similar pattern throughout the EMS period.

[16] Substitution between the deutsche mark and the U.S. dollar as parallel currencies in some Eastern European countries may be especially important.

[17] This interpretation implies that the exchange rate is an endogenous variable, so that the static equation does not satisfy the assumptions of the general linear regression model; however, as discussed by Granger (1986), OLS estimation yields consistent estimates of a co-integrating relationship among a set of nonstationary ($I(1)$) variables, even if some of these variables are endogenous.

the sum of squared residuals; these restrictions, essentially reformulating the long-run equilibrium in terms of the liquidity ratio, were thus imposed and subsequently tested again in the dynamic model that follows; as reported below, they could not be rejected.

Incorporating these features, the static regression is reported in equation (1).[18] Heteroscedasticity-consistent standard errors are shown in parentheses under each coefficient. Directly under the regression are reported the sample period, the multiple correlation coefficient, the estimated equation standard error, and a set of misspecification tests (for autocorrelation, nonnormality, and heteroscedasticity of the residuals, and for parameter instability—see Appendix III for brief descriptions of the tests). Test failures at a significance level of 5 percent will be indicated by asterisks.[19] All the empirical results were obtained with the program PC-GIVE by D.F. Hendry and the Oxford Institute of Economics and Statistics (see Hendry (1989)):

$$\underset{}{(m-p-y)_t} = \underset{(0.01)}{-5.92} - \underset{(0.15)}{0.67}\, RS_t - \underset{(0.53)}{1.40}\, \Delta p_{t-1} + \underset{(0.007)}{0.079}\, ecu_t \tag{1}$$

$T = 1978{:}4\text{–}1987{:}4$	$NORM(2) = 0.39\ (5.99)$
$R^2 = 0.91$	$HET(6,26) = 0.35\ (2.47)$
$\hat{\sigma} = 1.00$ percent	$ARCH(4,25) = 0.76\ (2.76)$
$AR(8)_1^8 = 3.30\ (15.51)$	$CHOW(12,21) = 1.00\ (2.25)$
$AR(4)_1^4 = 1.66\ (9.49)$	$CHOW(4,29) = 0.88\ (2.70)$.
$AR(1)_1^1 = 0.14\ (3.84)$	

That this regression can indeed be held to capture the long-run relation between money, income, the interest rate, inflation, and the exchange rate in the ERM is confirmed by a Sargan and Bhargava (1983) test rejecting the null hypothesis that the residuals of equation (1) are nonstationary (the null hypothesis maintains that they are a random walk; the test statistic is 1.86, compared with a 5 percent critical value of 1.74). This outcome indicates that a long-run relation between these

[18]The price level is the four-quarter moving geometric average of the ERM-wide CPI (the current quarterly value and the first through third lags). This smoothed measure appeared to produce the most satisfactory specification overall, particularly in the light of tests for possible misspecification; using such a moving average does not affect the asymptotic properties of the co-integration tests or the consistency of estimates of the static equation. It was confirmed that, given the current sample, the variables in the static regression are $I(1)$.

[19]The use of Δp_{t-1} rather than Δp_t should not affect the consistency of estimates of equation (1); it produces somewhat more satisfactory diagnostic test results in the relatively short sample available. This formulation is equivalent to including Δp_t in equation (1) and adding $\Delta\Delta p_t$, which is $I(0)$, to the dynamic equation (2) below, with the additional restriction that their coefficients be the same.

variables does indeed exist and that modeling the dynamic feedback toward that long-run equilibrium is worthwhile. The stationarity of the residuals of equation (1) is confirmed in the dynamic analysis that follows below.

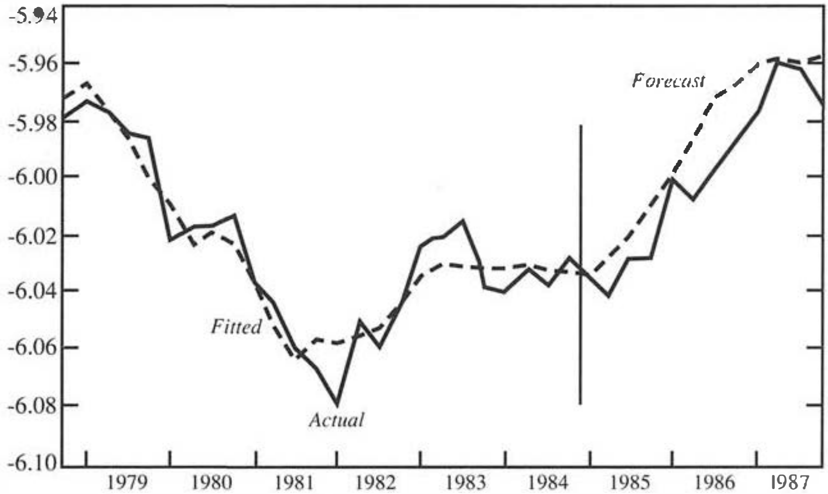
A comparison with the static regression of Bekx and Tullio (1987) (see Appendix I) shows that the estimated variance of the regression residual is reduced by more than 30 percent. Although this static regression is not intended as a well-specified model of money demand (this follows in the dynamic analysis), it is remarkable that residual autocorrelation seems to be absent; moreover, the estimated residual variance is of the same order of magnitude as that found in the money demand equations customarily estimated for the ERM countries individually.[20] The parameter estimates appear to be stable, as witnessed by the reported Chow tests. In order to illustrate this, Figure 7 displays the actual and fitted values of the liquidity ratio corresponding to the model estimated up to 1984:4, and the actual and conditionally forecast values for 1985:1–1987:4; the static model tracks the rise in the European liquidity ratio beginning in 1985 quite well.

In Figure 8 the movements in the long-run equilibrium relation are decomposed into the respective contributions of the explanatory variables. The downward movement of the equilibrium liquidity ratio in 1979–81 reflected the sharp rise in interest rates in combination with the rise in inflation and the strengthening of the U.S. dollar. The latter influence continued until 1985, but between 1981 and 1985 it was counterbalanced by the decline in interest rates and inflation. With the fall of the U.S. dollar after 1985 and the continuing decrease in inflation and interest rates, the hypothetical equilibrium of the liquidity ratio subsequently returned to a level close to that prevailing at the beginning of the EMS.

Following the procedure recommended by Engle and Granger (1987), the lagged residuals of equation (1), called EC_{t-1}, are included in a dynamic model as a representation of feedback toward the long-run money demand equilibrium. In addition, the dynamic model, formulated in terms of the rate of change of the real ERM money stock, includes as

[20]The dynamic model of the demand for M1 in the Federal Republic of Germany published by Atkinson and others (1985) had an estimated equation standard error identical to that of equation (2) (sample 1973:2–1983:1), and the dynamic model of M1 velocity in Germany published by von Hagen and Neumann (1988) produced a much larger standard error (1.27 percent, sample 1964:2–1984:4). Buscher (1984) obtained standard errors for M1 between 0.8 percent and 1.3 percent (sample 1965:1–1982:4), and Heri (1985) achieved values between 1 percent and 1.8 percent (monthly data samples varying within the period January 1966 to December 1983). All these studies were based on the national definition of M1.

Figure 7. *Liquidity Ratio: Actual Values and Long-Run Equilibrium*



Source: Equation (1) and Appendix II.
Note: In natural logarithm. Estimation period is 1978:4–1984:4; conditional forecast period is 1985:1–1987:4.

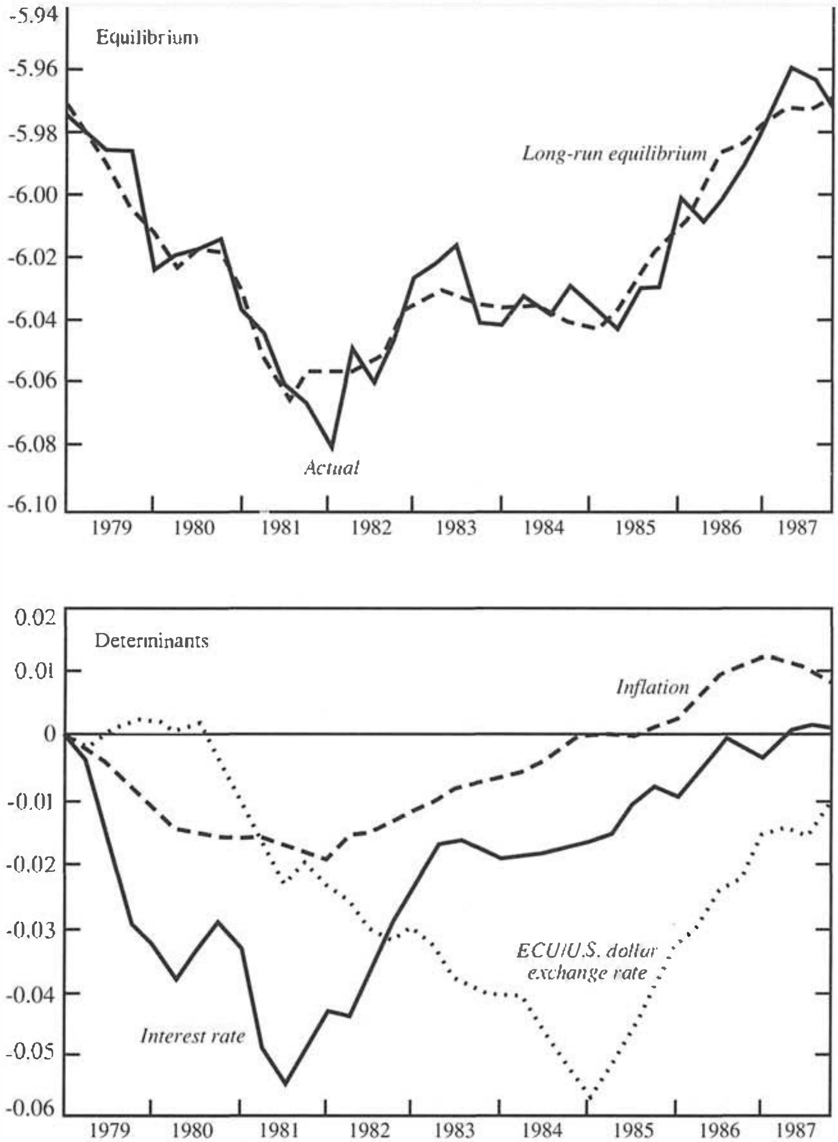
explanatory variables the rate of change of real income and changes in interest rates. The specific dynamics were chosen after inspection of more general estimates that included several lags of income growth, inflation, and changes in interest rates; lags were selected on the basis of their plausibility from a theoretical perspective and their statistical significance. This procedure yielded a relatively straightforward money demand function:

$$\Delta(m-p)_t = \underset{(0.002)}{0.002} + \underset{(0.32)}{0.67}\,\Delta y_t - \underset{(0.31)}{0.86}\,\Delta RL_t - \underset{(0.29)}{0.46}\,\Delta RS_{t-3} - \underset{(0.18)}{0.95}\,EC_{t-1} \qquad (2)$$

$T = 1979{:}1–1984{:}4$
$R^2 = 0.66$
$\hat{\sigma} = 0.82$ percent
$AR(8)_1^8 = 5.36$ (15.51)
$AR(4)_1^4 = 3.99$ (9.49)
$AR(1)_1^1 = 2.18$ (3.84)

$NORM(2) = 0.24$ (5.99)
$HET(8,22) = 0.84$ (2.40)
$ARCH(4,23) = 0.35$ (2.80)
$CHOW(12,19) = 0.82$ (2.31)
$CHOW(4,27) = 2.21$ (3.47).

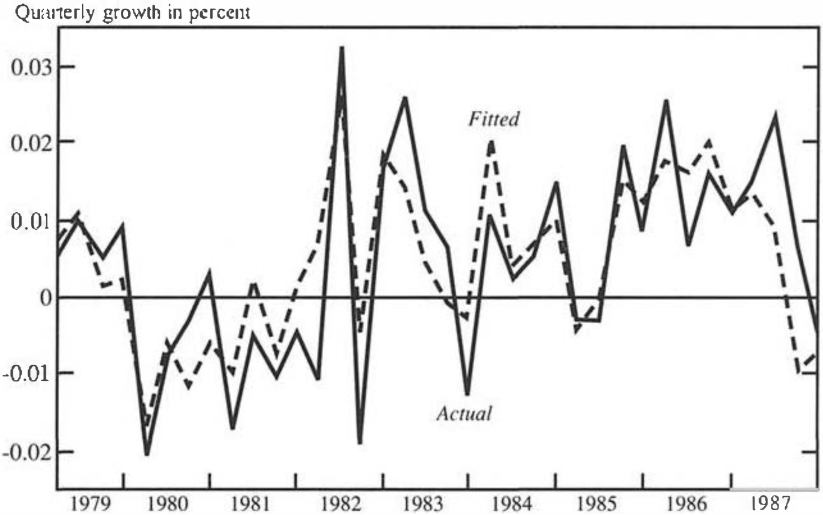
Figure 8. *Liquidity Ratio: Equilibrium and Its Determinants*



Source: Equation (1) and Appendix II.

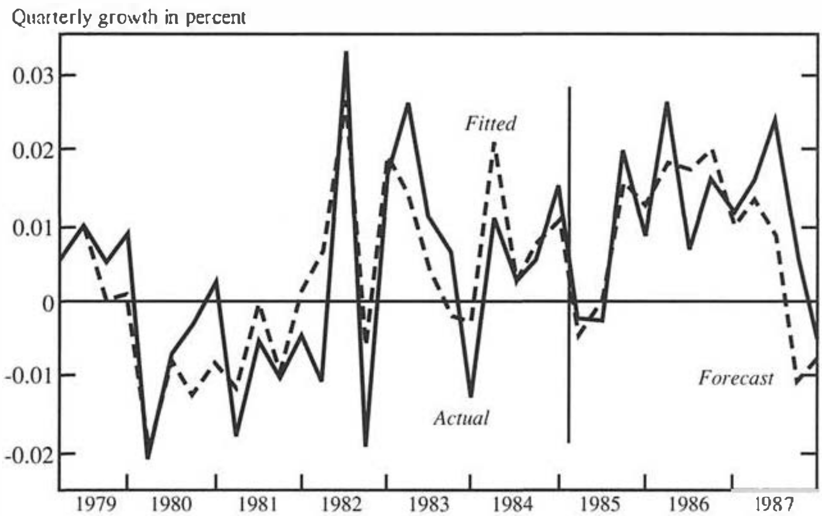
Note: In natural logarithm. Estimation period is 1978:4–1987:4. The bottom panel decomposes changes since 1979:1 of the long-run equilibrium liquidity ratio into the contribution of inflation, the interest rate, and the nominal exchange rate (variables multiplied by their coefficients in equation (1) and shifted so that the value for 1979:1 equals zero).

Figure 9. *Dynamic Model for Real Money Growth*



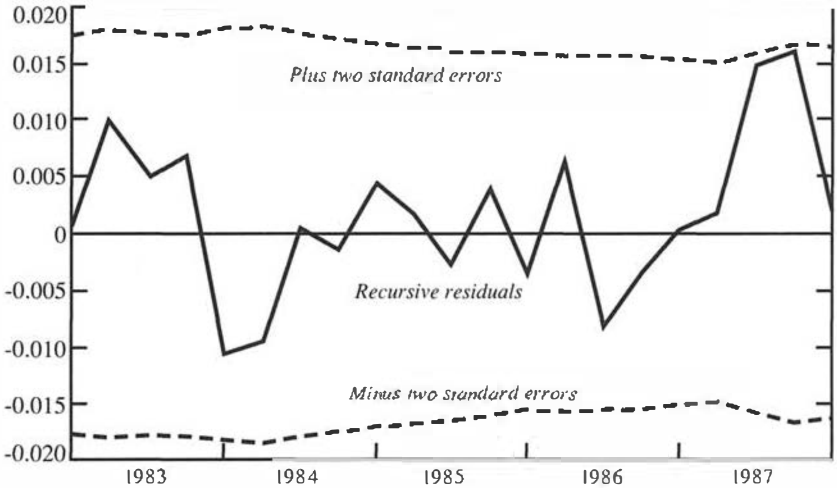
Source: Equation (2).
Note: Estimation period is 1979:1–1987:4.

Figure 10. *Dynamic Model for Real Money Growth: Stability*



Source: Equation (2).
Note: Estimation period is 1979:1–1984:4; conditional forecast period is 1985:1–1987:4.

Figure 11. *Dynamic Model for Real Money Growth: Stability of the Standard Error*



Source: Equation (2).

Note: This figure depicts the sequence of estimated equation standard errors and one-step residuals obtained by successively extending the sample by a single observation from 1979:1–1982:4 to 1979:1–1987:4 (see text footnote 21). These residuals consist of the last residual of each of the successive regressions; if they are to be normally distributed with zero mean, they must be close to zero, and 95 percent of them must lie within the band delimited by two estimated standard errors.

The unity restriction on the rate of inflation could not be rejected and was therefore imposed, linearly transforming the regression into a model of real money growth.

This money demand function for the ERM is satisfactory in several respects. First, it passes the tests for possible misspecification, and, as shown in Figure 9, it tracks real money growth rather well. Moreover, judged by the Chow tests and by the forecast performance depicted in Figure 10, it does so in a stable fashion.[21] The estimated equation standard error compares favorably with those found for the national money demand functions customarily estimated.[22]

[21] Further evidence for the stability of the parameters was acquired with the recursive regression feature of PC-GIVE, which, starting with the first few observations of the full sample, successively adds one observation and re-estimates the model, offering various graphical assessments of the stability of all the parameter estimates (including an extensive series of Chow tests—see Hendry (1989) for a comprehensive description). The sequence of recursive residuals and estimated equation standard errors is displayed in Figure 11.

[22] See the comments following equation (1) for several comparisons.

Second, the coefficient on real income growth, though not estimated very precisely, seems plausible, as do the coefficients on the changes in the short-term and long-term interest rates. The significant presence of the long-term interest rate may embody the influence of interest rate expectations on money demand.

Third, the error-correction feedback term is quite significant;[23] the linear restriction embodied in this variable (that is, the linear combination estimated in equation (1)), including the long-run income elasticity of unity, cannot be rejected (the F-test of this restriction is 1.39 against a 5 percent critical value of 2.73). The coefficient on the error-correction feedback term is large compared with estimates found in earlier econometric work on individual countries; it implies, for instance, a mean lag of about one month in the response of real money balances to real income, indicating more rapid adjustment at the ERM level than is usually found at the national level.[24]

IV. Conclusion

The empirical results presented in this paper have implications on two levels. First, they shed light on the nature of money demand in European countries. The results are consistent with the view that demand for narrow money is essentially a demand for a transactions medium, holdings of which can be varied at short notice. This view is supported by the role of the short-term interest rate as well as by the rapid adjustment speed implied by the estimate of the error-correction coefficient. The latter result is also important because of arguments that the slow adjustment implied by many single-country money demand estimates are theoretically implausible (Laidler (1982), Lane (1990)), and may reflect errors in econometric specification (Goodfriend (1985)). The apparently superior performance of ERM-wide money demand estimates may, as argued in Section I (and in more detail in Kremers and Lane (1989)), provide some evidence suggestive of currency substitution in the demand for narrow money in Europe.[25]

[23] Kremers, Ericsson, and Dolado (1989) argued that, given differences in power, it is preferable to test for non-co-integration in the dynamic error-correction framework.

[24] For example, Hendry (1985) found a value of the error 0.10 for the United Kingdom, and Baba, Hendry, and Starr (1987) found a value of 0.14 for the United States. Buscher (1984), working in a partial adjustment framework, found a mean lag of four to six months for Germany. These studies were based on national definitions of M1.

[25] Stable individual country demand for money functions with similar parameter values across countries could give rise to a stable aggregate demand function,

Second, the results also have policy implications, in connection with recent proposals for economic and monetary union in Europe. The finding that, even at the present stage of European economic and financial market integration, a well-specified ERM-wide demand for money can be identified is striking; it suggests that monetary policy guided by money supply targets would, at least in principle, be feasible for the ERM countries collectively. With further steps toward the establishment of a single economic and financial area within the European Community in the context of the 1992 Internal Market Program, the coherence of monetary behavior within this quasi-currency area would likely be further enhanced. Moreover, the fact that the ERM-wide money demand equation implies a faster adjustment speed than most single-country estimates may strengthen the case for formulating monetary policy at the European level, not only because it suggests that the aggregate estimates may be better specified than the single-country ones, but also because long lags may complicate the formulation and implementation of policy. Further examination of the evidence is clearly necessary before any firm conclusions can be advanced,[26] but the results presented here are suggestive; they indicate the possibility that a European central bank could, in principle, implement more effective monetary control than could be achieved independently by the individual national central banks.[27]

APPENDIX I

The Bekx-Tullio Model

Bekx and Tullio (1987) estimated a model of the demand for nominal money in the ERM that included the conventional variables: the price level, real GNP, and the level of long-term interest rates (denoted RL_t). They also included the deviation from purchasing power parity of the ECU exchange rate vis-à-vis the U.S. dollar (that is, the real exchange rate defined as the consumer price level in the ERM relative to that in the United States corrected for changes in the

but would not imply an aggregate equation whose performance was actually superior to that of the individual equations. The latter result would only occur if there were some specification error that could be reduced by working at the aggregate level.

[26] Moreover, the Lucas critique suggests that money demand relationships might be different if intra-EMS exchange rates were fixed for good and monetary policy conducted on an EMS-wide basis.

[27] As mentioned at the beginning of the paper, explicit policy coordination or leadership by one central bank might be alternative means of basing monetary policy on EMS-wide money demand.

nominal exchange rate of the ECU—excluding the United Kingdom and Luxembourg—vis-à-vis the U.S. dollar). This variable (denoted ecu_t) was intended to capture currency substitution effects (a large value of ecu_t indicates strength of the ECU). As noted in the main text, its behavior over the sample period is very similar to that of the nominal exchange rate used in the error correction model.

The replication of the static money demand function of Bekx and Tullio, estimated over a longer sample period, is

$$\underset{}{m_t} = \underset{(1.60)}{-4.66} + \underset{(0.06)}{1.28}\, p_t + \underset{(0.22)}{0.70}\, y_t - \underset{(0.17)}{1.57}\, RL_t + \underset{(0.22)}{0.11}\, ecu_t \qquad (3)$$

$T = 1978{:}4–1987{:}4$	$NORM(2) = 0.72\ (5.99)$
$R^2 = 0.998$	$HET(8,23) = 0.80\ (2.37)$
$\hat{\sigma} = 1.21$ percent	$ARCH(4,24) = 0.86\ (2.78)$
$AR(8)_1^8 = 10.32\ (15.51)$	$CHOW(12,20) = 2.45^*\ (2.28)$
$AR(4)_1^4 = 5.34\ (9.49)$	$CHOW(4,28) = 4.09^*\ (2.71)$.
$AR(1)_1^1 = 3.47\ (3.84)$	

Several features are noteworthy. All coefficient estimates have the expected sign. However, given that the coefficient on the price level is significantly larger than unity, this specification rejects homogeneity in the price level. The elasticity of money demand with respect to real GNP is not significantly different from unity (although the estimated standard error is large).

Turning to the misspecification tests, it appears that the Chow tests for parameter stability over the last one and three years of the sample are failed, indicating that the money demand function is unstable. This invalidates the inferences on individual parameter estimates, since these turn out to be based on a misspecified model.

APPENDIX II

Data Sources

All data are quarterly (unless noted otherwise) and taken from the International Monetary Fund, *International Financial Statistics* (*IFS*).

Variable	Definition and Source
Money	Narrow money (M1) (*IFS*, line 34)
Income	Federal Republic of Germany: GNP in 1985 prices (*IFS*, line 99a.r) France, Italy: GDP in 1985 prices (*IFS*, line 99b.r) Belgium, Netherlands: GNP in 1985 prices (*IFS*, line 99a.p). Denmark, Ireland: GDP in 1985 prices (*IFS*, line 99b.p)

Industrial production (used for quarterly interpolation of GNP/GDP)	Belgium, Ireland (*IFS,* line 66..b) Denmark, Netherlands (*IFS,* line 66..c)
CPI	Consumer price index (*IFS,* line 64)
Short-term interest rate	Money market rate (*IFS,* line 60b)
Long-term interest rate	Government bond yield (*IFS,* line 61)
Exchange rate	Computed via U.S. dollar rate (*IFS,* period average).

APPENDIX III

Test Statistics

This Appendix contains brief descriptions of the reported diagnostic tests, with degrees of freedom in brackets. Further background on these tests can be found in Hendry (1989). In the text, each reported statistic is followed (in parentheses) by its 5 percent critical value, and is starred (*) if the test is failed.

Statistic	Definition and Source
	Autocorrelation
$AR(n)_i^j$	Lagrange multiplier test for residual autocorrelation from lags i to $j(j-i+1=n)$, χ^2-form; computed by regressing the residuals on all the regressors of the original model and the lagged residuals for lags i to j, and testing the joint significance of the latter
	Normality residuals
$NORM(2)$	χ^2-test based on the estimated skewness and kurtosis of the residuals compared to their counterparts for the normal distribution
	Heteroscedasticity
$HET(.,.)$	Lagrange multiplier test for heteroscedasticity associated with squares of the explanatory variables. Computed by regressing the squared residuals on the original regressors and all their squares, and testing their joint significance
$ARCH(n,.)$	Lagrange multiplier test for nth order autoregressive conditional heteroscedasticity, F-form; computed by regressing the squared residuals on the lagged squared residuals up to lag n, and testing their joint significance
	Parameter constancy
$CHOW(n,.)$	Chow test for parameter stability over the last n observations of the current sample.

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Valuation of Interest Payment Guarantees on Developing Country Debt

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The cost of interest payment guarantees is difficult to evaluate because guarantees are a contingent obligation that become effective only if a certain condition is met (that is, the debtor fails to make a certain payment). In this paper a technique to value interest payment guarantees on developing country debt is developed and preliminary estimates are presented. Using results from option pricing theory, the market price that an interest payment guarantee would have if it were traded in financial markets is estimated from the characteristics of secondary market prices of developing country debt. [JEL 433, 521]

MANY PROPOSALS for solving the foreign debt problem of developing countries contain some kind of contract in which part of the repayment to creditor banks is insured by a third party, such as a donor country or a multilateral organization. Evaluating the cost of issuing these guarantees is more complicated than for other schemes (such as cash buy-backs) in which the actual cost is directly observable because it involves a cash payment. A guarantee on future payments, in contrast, is a contingent obligation that only becomes effective if a certain condi-

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tion is met—that is, if the debtor fails to make a certain payment.[1] This paper develops a technique to value these guarantees and provides some preliminary estimates of their cost.

The strategy that we adopt is to estimate the market price that an interest payment guarantee would have if the contract were traded in financial markets. Many other contingent liabilities with similar characteristics are traded in financial markets, most notably options, which means that we can use a number of results in finance theory. We show that an interest payment guarantee can be modeled as a portfolio of two put options. This model is then used to estimate the value of interest payment guarantees for a number of highy indebted countries.

The main problem in trying to price a guarantee is how to specify the random structure of the debtor country's payments. For a "problem" debtor, in particular, net payments to the private banking system are difficult to predict, and are probably the result of a complicated bargaining process, which is itself affected by factors such as terms of trade changes, the economic and political evolution of the debtor country, and lending policies of official creditors. Without loss of generality, we assume the existence of an unobservable state variable that determines debtor country repayments to private banks. This state variable expresses the result of the bargaining process just described. We also make the relatively nonrestrictive assumption that this variable can be modeled as a random variable that follows a certain stable stochastic time-series process. We further assume that this process would not be altered by the issuance of a guarantee on payments. This means that we are abstracting from "moral hazard" problems—both from the point of view of countries and banks—that might reduce actual payments once a guarantee has been issued, or the conceivable opposite case in which payments on guaranteed debt are higher because of the possibly stronger bargaining power of the donor country or the multilateral organization involved.

Under the above assumptions, we are able to identify the stochastic process followed by the state variable (and therefore to determine the theoretical market price of the guarantee) by using available observations on the price of developing country debt in secondary markets. This procedure minimizes the number of specific assumptions that need to be made regarding the nature of the random structure of payments to cred-

[1] The cost of a guarantee should not be confused with the maximum potential liability of the guarantor; even if that amount is required to be set aside as collateral, the true value of the guarantee is a smaller amount given by the economic cost of providing the contingent payments that might be made out of the collateral.

itor banks, or the kinds of variables that determine those payments. Previous work on this and related problems has been based on alternative approaches. Dooley and Symansky (1989) and Lamdany (1989) implicitly assume a given probability structure for debt repayments, and Claessens and van Wijnbergen (1989) assume that the price of oil is perfectly correlated with Mexico's external debt payments.[2] The advantage of the technique followed in this paper is that no such special assumptions are necessary in order to arrive at the price of the guarantee.

Another major source of risk to the issuance of an interest guarantee on floating-rate securities is interest rate volatility. To evaluate this risk along with that associated with the debtor country's uncertain repayment, we use an option model with stochastic interest rates inspired by Merton (1973). As a first step, we estimate a model of the term structure of interest rates based on Vasicek (1977) using data on U.S. Treasury bills. We then use the estimated parameters that describe the stochastic processes followed by interest rates at different maturities, together with the parameters that describe the stochastic process of the market value of debt, to obtain all the statistical moments necessary for the option price equation.

The results of the estimation indicate that the cost of hypothetical interest payment guarantees for four years would fluctuate between close to the full value of interest payments for most countries with a market price of debt at or below 30 cents on the dollar, to nearly half that amount for countries whose debt sells at about 60 cents on the dollar. Loosely speaking, the estimates indicate that the cost of guarantees is high because debt prices are low and do not have a very large variance. This implies that there is little hope that payments would be high enough to avoid a substantial use of guarantee money.

The remainder of the paper proceeds as follows: Section I warns about the risks of using a simple back-of-the-envelope calculation for pricing guarantees. Section II derives a mathematical formula for pricing guarantees, inspired by option pricing theory. Section III discusses the technique for the estimation of guarantee values on the basis of the prices of debt in secondary markets alone. Section IV presents the estimation results, and Section V contains concluding remarks.

I. Is the Market Price a Sufficient Statistic?

It is tempting to adopt a simple, back-of-the-envelope calculation to estimate the cost of guarantees on debt payments. Such a calculation

[2] For other useful insights into the pricing of guarantees, see Nocera (1989) and Clark (1990).

would use the market price of debt as the estimated probability that the country makes *each and every* payment. This calculation implies setting the value of the guarantee equal to 1 minus the market price of debt times the value of the guaranteed payments. However, the result could be far off the true theoretical price of the guarantee. Although the guarantee does not represent an independent risk in the sense that all the risk derives only from the randomness of the payments of the original debt, the random distributions of all the future cash flows of the debt contract are in principle necessary to determine the value of the guarantee. In particular, knowledge of the price at which debt is transacted is by no means sufficient to determine (or even rank) the cost of guarantees, although it is an essential piece of information; in fact, our pricing of the guarantee will be based as much as possible on the market price of debt, as opposed to using other variables.

Let us consider an example to illustrate why the market price of debt does not convey sufficient information for pricing the guarantee. Consider a two-period obligation, with equal payments due each period. To abstract from issues of asset pricing, let us assume that investors are risk-neutral and the interest rate is fixed and equal to zero. The face value of the debt is 100, and therefore the two payments are equal to 50. Suppose that the market price of debt, in this case equal to the expected value of payments, is equal to 40. There are many different random structures for the debt payments that may support the same market price for debt, but different prices for a guarantee on the first-period payment. Let us consider two of them. Country A makes, with certainty, a fraction p of every payment that is due. It is clear that the market price per dollar of face value of claims on country A is going to be equal to p, (and $p = 0.4$ in our example). The expected cost of a guarantee on the first-period debt payment for country A is going to be equal to

$$E(G^A) = (1 - p)50 = 30,$$

with certainty, because a fraction $1 - p$ will have to be paid by the guarantor.

Country B's debt has a different payoff structure. In the first period, it is known with certainty that payments are going to be equal to zero. In the second period, payment will be determined with the following probability distribution:

50 with probability Π

0 with probability $1 - \Pi$,

where $\Pi = 2p$; that is, $\Pi = 0.8$ in our example. It is clear that the certain cost of a guarantee on the first-period debt payment of country B is

$$E(G^B) = 50.$$

Therefore, the cost of the guarantee is 66 percent higher for country B than for country A, even though they both have the same market price of debt. The divergence could be even greater if the maturity of the debt were longer, because there would be more potential for different probability distributions of guaranteed payments.

There is one case in which the guarantee could be easily priced on the basis of the market price of debt—when the guarantee covers the full term of the debt. The pricing of a full guarantee would be straightforward: the guarantee would convert the risky debt into a default-free one, and its value would therefore be the difference between the price of a default-free bond and the market price of the risky debt. However, although this insight is useful, in practice it is not sufficient to price contracts that imply limited-term insurance.

Even greater variation in the value of guarantees may arise if we drop the assumption of investor risk neutrality. The proper valuation of a guarantee contract cannot be made only in terms of expected payments but must also include the risk premium associated with random guarantee payments. In other words, expected guarantee payments must be discounted by the appropriately risk-adjusted interest rates, which increases the potential for divergence in the value of guarantees for different countries with the same market price of debt but a different random structure of payments.

II. A Framework for Pricing Guarantees

We will assume that all debt takes the form of floating-rate infinite maturity contracts; that is, floating-rate perpetuities.[3] We will assume that there exists a random variable $S(t)$ that represents the state of nature and that determines the amount paid by the debtor country to the holders of its foreign debt. Each contractual payment that becomes due at time j is given by $i_j D$, and i_j is the interest rate applicable to the time j payment, and D is the contractual value (principal) of the debt. Without loss of generality, we assume that the actual payment, V_j, made by the debtor country is determined according to the following schedule:

$$V_j = i_j D \qquad \text{if } S(j) \geq D(1 + i_j)$$

[3] Although developing countr loans have fixed contractual maturities, in practice principal repayments have tended to be rescheduled. Besides, prices of long-term bonds (30 years or so) do not differ much from perpetuities.

$$V_j = S(j) - D \qquad \text{if } D \leq S(j) \leq D(1 + i_j)$$

$$V_j = 0 \qquad \text{if } S(j) \leq D.$$

Consider now a contract that guarantees a single interest payment, i_jD. At the maturity date, j, the payoff of this contract, G_j, will be

$$G_j = 0 \qquad \text{if } S(j) \geq D(1 + i_j)$$

$$G_j = D(1 + i_j) - S(j) \qquad \text{if } D \leq S(j) \leq D(1 + i_j)$$

$$G_j = i_jD \qquad \text{if } S(j) \leq D.$$

This means that the value of the contract at maturity can be written as

$$G_t = \max[0, D(1 + i_j) - S(j)] - \max[0, D - S(j)], \qquad (1)$$

which is equivalent to a portfolio of two put options written on the underlying variable S: a long position on a put with exercise price $D(1 + i_j)$, and a short position on a put with exercise price D.

If the guarantee covered only a fraction α of the interest due, the exercise price of the first put would be $D(1 + \alpha i_j)$. In the case of a partial interest guarantee, however, a better contract would be one that covered a fraction α of the shortfall in interest payments; that is, $\alpha(i_jD - V_j)$. Although incentive considerations are beyond the scope of this paper, guaranteeing a fraction of the shortfall would likely reduce the effects of moral hazard. In this case, when the debtor country makes one dollar of payment, it "loses" a fraction α from the guarantee contract, whereas in the previous case it "loses" one full dollar of potential guarantee money. In the case in which the guarantee covers a fraction α of the shortfall, it is clearly seen that its value will be equal to α times the value of the full-interest guarantee; all estimations were, therefore, done for the case of full-interest guarantee, since the value of partial guarantees can be computed easily from that basis.

Equation (1) above suggests the possibility of using option pricing theory to obtain the value of the guarantee G. However, the problem is more complicated than the standard Black-Scholes case, because the floating-rate feature makes the applicable interest rate a stochastic variable (until the time at which it is set for the next payment). This means that the exercise price itself will be a stochastic variable. However, using results by Merton (1973) on option pricing with stochastic interest rates and by Vasicek (1977) on the term structure of interest rates, it is possible to derive a formula for the first and second put options in equation (1). The details are provided in the Appendix. The derivation requires the assumptions that the rate of change of state variable S follow a continuous-time process with a constant variance per unit of time, and that the instantaneous interest rate follow an Ornstein-Uhlenbeck process.[4]

III. Measuring the Characteristics of the State Variable

The state variable S, which represents the repayment prospects by the debtor country, will, in general, depend on a number of variables. First, it will depend on variables affecting the debtor country's economic situation such as random shocks affecting gross domestic product, terms of trade changes, and government policies. Second, S will be affected by policies adopted by creditor countries or by international initiatives, such as the tax and regulatory environment for banks or proposals to deal with the debt situation. Finally, S will depend on variables affecting the outcome of the bargaining process between the country and its creditor banks, such as, for example, the state of negotiations between creditor banks and other debtor countries.

The measurement of S thus poses a significant problem. Our strategy, following the methodology developed by Marcus and Shaked (1984) and Pennacchi (1987), is to obtain a measurement of S using data on the secondary market prices for debt. We start by noting that the value of a single interest payment on developing country debt in secondary markets equals the value of a default-free payment minus the value of a contract that guarantees full payment of interest; that is

$$V_j(t) = F_j(t) - G_j(t), \tag{2}$$

where $V_j(t)$ indicates the time t value of the debtor country's interest payment that is contracted to be paid at date j; $F_j(t)$ is the time t value of a default-free, floating-rate payment of Di_j received at time j; and $G_j(t)$ is the time t value of a guarantee on this interest payment at date j, which we described previously.[5] Assuming that developing country debt can be modeled as a perpetuity, the total value of this debt, $V(t)$, can be written as

$$\begin{aligned} V(t) &= \sum_{j=1}^{\infty} V_j(t) \\ &= \sum_{j=1}^{\infty} F_j(t) - \sum_{j=1}^{\infty} G_j(t). \end{aligned} \tag{3}$$

[4]This means that the rate of return on S follows the continuous-time analogy of a random walk with a possibly stochastic drift and the short-term interest rate follows the continuous-time analogy of a first-order autoregressive process.

[5]Because of interest rate uncertainty, i_j will, in general, be random. The formula for $F_j(t)$ is given implicitly in equation (14) in the Appendix.

Given that we have a solution for the value of a guarantee for each payment, G_j, and the value of a default-free payment, F_j, then equation (3) represents a formula for the market value of developing country debt. Since each guarantee contract G_j is equal to the value of the portfolio of two put options given in equation (1), $V(t)$ will be a (nonlinear) function of S, the standard deviation of the rate of change in S, and the correlation between S and the instantaneous interest rate (see equations (14) and (15) in the Appendix).[6] In the context of deposit insurance valuation, Pennacchi (1987) has shown that it is possible to estimate those three values by solving a three-equation system: the option price formula, the expression for the variance of the price of debt, and the expression for the correlation of the price of debt and default-free bond prices. This procedure is outlined in the Appendix.

IV. Estimation Results

The general indication of the estimation results is that, based on the information derived from secondary markets for developing country debt, the cost of guarantees appears to be pretty high. The reason is that debt of heavily indebted countries carries low prices with relatively low volatility (including volatility arising from the floating interest rate feature of the contracts). The low price of debt means that the situation looks bleak, and the low volatility of debt prices suggests that a sufficiently large improvement is unlikely. Table 1 presents descriptive statistics for secondary market prices of foreign debt for ten major highly indebted countries.

An identifying assumption is needed in order to proceed to the estimation. The reason is that S is not really a traded asset that would be held in an investor's portfolio and whose rate of return is determined in accordance with asset market equilibrium, but rather a state variable whose expected rate of change may differ from that of an asset with the same systematic risk. Therefore, the estimation requires an assumption regarding the expected rate of change of S, or more precisely, the difference between the rate of return on an asset with the same risk as S and the true expected rate of change in S. This parameter is denoted as c.[7]

[6]The total value of the debt, $V(t)$, will also depend on the difference between the rate of return on a marketable asset with the same risk as $S(t)$ and the expected rate of change of $S(t)$. This variable is denoted as c in the Appendix. Estimates of interest guarantees are carried out under alternative assumptions regarding the value of c.

[7]Alternative identifying assumptions are possible. We also report, below, the results from fixing the value of the volatility of S.

Table 1. *Secondary Market Prices of Debt*

Country	Market Price Mar. 2, 1989	Market Price Jan. 18, 1990	Standard Deviation[a]	Covariance with Six-Month Bond[b]
Argentina	17.25	11.75	0.3294	−1.402E-05
Brazil	26.75	27.50	0.3030	2.081E-05
Chile	55.25	64.25	0.1628	1.270E-05
Colombia	50.00	59.75	0.1425	2.034E-07
Costa Rica	13.50	18.75	0.3816	−1.597E-05
Ecuador	12.00	14.50	0.2847	6.335E-06
Mexico	33.00	38.00	0.1871	−6.407E-06
Philippines	36.00	48.00	0.1534	2.121E-05
Uruguay	57.00	50.00	0.0758	2.974E-06
Venezuela	27.25	35.25	0.2456	8.690E-06

Sources: Salomon Brothers, Inc., *Indicative Prices for Less Developed Country Bank Loans* (various issues), and International Monetary Fund, *International Financial Statistics* (various issues).

[a] Annualized standard deviation of the rate of return on the market price of debt.

[b] Covariance between the rate of return on the market price of debt and the change in the log price of six-month Treasury bills.

It is important to note that the effect of the assumed value of c over the estimated cost of guarantees is somewhat weaker than it might appear. The reason is that there is some trade-off between the assumed value for c and the estimated value for S. If one assumes a higher expected rate of growth for S—lower c—the estimate of S will be lower, partially offsetting the effect on the valuation of the guarantee.

The estimation, reported in Tables 2 to 5, was carried out for two values of c: 0 and 0.09. These are two natural assumptions of values for c. A value of 0 for c, as in Tables 2 and 4, implies that the expected rate of change of $S(t)$ equals the (unknown) expected rate of return on a marketable asset with the same risk as $S(t)$. Thus, in this case, the value of the interest guarantee can be intepreted as the difference between two put options written on an asset. A value of 0.09 for c, as in Tables 3 and 5, is an approximation for the case in which the expected rate of growth of S is zero. This is because a value of 0.09 for c only means that the expected rate of change of $S(t)$ equals that of a marketable asset with the same risk as $S(t)$ less a 9 percent annual rate of change, 9 percent being approximately equal to the risk-free interest rate. In general, the expected rate of return on an asset with the same risk as S could be higher or lower than the risk-free rate, but in the case of S representing a risk uncorrelated with other assets in the market, or in the case of a risk-neutral economy, a value of 0.09 for c would represent an expected rate of change in $S(t)$ of approximately zero.

Table 2. *Value of Interest Payment Guarantees: Pre-Brady Plan Announcement, April 7, 1987 to March 2, 1989*

(with $c = 0$)

Country	Market Price of Debt	S	σ_S	ρ_{Sr}	Value of Guarantee
Argentina	17.25	23.90	0.3369	−0.0300	36.39
Brazil	26.75	35.92	0.3125	−0.0480	35.27
Chile	55.25	61.41	0.1680	−0.0577	30.76
Colombia	50.00	54.07	0.1455	−0.0356	33.77
Costa Rica	13.50	20.45	0.3908	−0.0325	36.43
Ecuador	12.00	15.28	0.2881	−0.0166	36.79
Mexico	33.00	37.24	0.1903	−0.0233	36.19
Philippines	36.00	39.12	0.1555	−0.0270	36.32
Uruguay	57.00	58.36	0.0764	−0.0229	33.85
Venezuela	27.25	33.24	0.2509	−0.0324	36.10

Note: Guarantee refers to a four-year guarantee on a floating-rate perpetuity with semi-annual payments tied to the yield on the six-month U.S. Treasury bill rate. The initial six-month Treasury bill yield was 9.0625 percent; S is the current level of the state variable; c is the difference between the expected rate of growth of an asset with the same risk as S and that of S; σ_S is the standard deviation of the rate of growth of S; and ρ_{Sr} is the correlation of the rate of growth of S and the short-term (instantaneous) U.S. rate of interest.

Table 3. *Value of Interest Payment Guarantees: Pre-Brady Plan Announcement, April 7, 1987 to March 2, 1989*

(with $c = 0.09$)

Country	Market Price of Debt	S	σ_S	ρ_{Sr}	Value of Guarantee
Argentina	17.25	54.41	0.0543	−0.5059	36.76
Brazil	26.75	67.15	0.0624	−0.5303	35.91
Chile	55.25	92.59	0.0536	−0.7476	24.01
Colombia	50.00	88.92	0.0503	−0.7928	27.35
Costa Rica	13.50	48.24	0.0542	−0.4544	36.81
Ecuador	12.00	45.63	0.0411	−0.5720	36.82
Mexico	33.00	74.12	0.0501	−0.7115	34.75
Philippines	36.00	77.11	0.0475	−0.7787	33.89
Uruguay	57.00	93.58	0.0434	−0.9263	23.20
Venezuela	27.25	67.78	0.0543	−0.6134	35.93

Note: Guarantee refers to a four-year guarantee on a floating-rate perpetuity with semi-annual payments tied to the yield on the six-month U.S. Treasury bill rate. The initial six-month Treasury bill yield was 9.0625 percent; S is the current level of the state variable; c is the difference between the expected rate of growth of an asset with the same risk as S and that of S; σ_S is the standard deviation of the rate of growth of S; and ρ_{Sr} is the correlation of the rate of growth of S and the short-term (instantaneous) U.S. rate of interest.

Table 4. *Value of Interest Payment Guarantees: Post-Brady Plan Announcement, April 7, 1987 to January 18, 1990*

(with $c = 0$)

Country	Market Price of Debt	S	σ_S	ρ_{Sr}	Value of Guarantee
Argentina	11.75	18.51	0.4142	−0.0328	36.48
Brazil	27.50	41.04	0.3722	−0.0643	33.89
Chile	64.25	71.48	0.1644	−0.0780	26.11
Colombia	59.75	65.57	0.1549	−0.0604	29.16
Costa Rica	18.75	27.60	0.3709	−0.0423	35.91
Ecuador	14.50	20.21	0.3427	−0.0312	36.58
Mexico	38.00	45.26	0.2290	−0.0413	34.55
Philippines	48.00	54.96	0.1953	−0.0548	32.58
Uruguay	50.00	51.29	0.0813	−0.0178	35.68
Venezuela	35.25	45.44	0.2825	−0.0555	33.85

Note: Guarantee refers to a four-year guarantee on a floating-rate perpetuity with semi-annual payments tied to the yield on the six-month U.S. Treasury bill rate. The initial six-month Treasury bill yield was 9.0625 percent; S is the current level of the state variable; c is the difference between the expected rate of growth of an asset with the same risk as S and that of S; σ_S is the standard deviation of the rate of growth of S; and ρ_{Sr} is the correlation of the rate of growth of S and the short-term (instantaneous) U.S. rate of interest.

Table 5. *Value of Interest Payment Guarantees: Post-Brady Plan Announcement, April 7, 1987 to January 18, 1990*

(with $c = 0.09$)

Country	Market Price of Debt	S	σ_S	ρ_{Sr}	Value of Guarantee
Argentina	11.75	45.04	0.0532	−0.4356	36.82
Brazil	27.50	67.99	0.0718	−0.4632	35.65
Chile	64.25	97.89	0.0527	−0.7497	17.75
Colombia	59.75	95.34	0.0515	−0.7721	21.05
Costa Rica	18.75	56.60	0.0607	−0.4702	36.70
Ecuador	14.50	49.99	0.0509	−0.5051	36.81
Mexico	38.00	79.03	0.0580	−0.6413	32.94
Philippines	48.00	87.48	0.0568	−0.6983	28.26
Uruguay	50.00	88.88	0.0436	−0.9186	27.56
Venezuela	35.25	76.38	0.0646	−0.5634	33.75

Note: Guarantee refers to a four-year guarantee on a floating-rate perpetuity with semi-annual payments tied to the yield on the six-month U.S. Treasury bill rate. The initial six-month Treasury bill yield was 9.0625 percent; S is the current level of the state variable; c is the difference between the expected rate of growth of an asset with the same risk as S and that of S; σ_S is the standard deviation of the rate of growth of S and ρ_{Sr} is the correlation of the rate of growth of S; and the short-term (instantaneous) U.S. rate of interest.

The estimation was carried out with data corresponding to a date just before the announcement of U.S. Treasury Secretary Nicholas Brady's initiative (in March 1989), and after it. The reason is that the Brady plan itself, by affecting the expected return on debt, may have had a major impact for certain countries, thus distorting our estimate of the actual payment capacity of debtor countries. Therefore, Tables 2 and 3 give estimates of the value of interest payment guarantees based on market prices of debt observed just before the announcement of the Brady plan, and Tables 4 and 5 give estimates that make use of all available data. In each table, we have assumed a debt principal level of $D = 100$ and an initial U.S. six-month, default-free interest rate of 9.0625 percent.[8] Ten debtor countries with relatively more active secondary markets were selected for estimation. The first column of each table gives secondary market prices of debt quoted by Salomon Brothers, Inc. (see footnote to Table 1). The following three columns give the parameter estimates that were inferred from the market prices of this debt, the variance of the rate of return on the debt, and the correlation of the return with U.S. interest rates. Finally, the fourth column uses these parameter estimates to calculate the value of a four-year guarantee on semi-annual floating-rate interest payments, where the floating rate is equal to the yield on a six-month, default-free U.S. discount bond issued six months prior to the interest payment date.

When the expected rate of change in $S(t)$ is assumed to equal that of an asset with the same risk as $S(t)$—that is, $c = 0$—the estimated value of the guarantee is in fact close to its upper bound of 36.82 (the full amount of the promised interest payments), with the exception of the three countries with higher-priced debt (Chile, Colombia, and Uruguay).[9] When c is assumed to be equal to 9 percent, there is not a significant difference for countries with low secondary market prices of debt, but for the three with higher-priced debt the cost of guarantees falls significantly, because the larger estimated value for S makes them more likely to service their debt.

In general, the interest guarantee estimates based on secondary debt prices observed after the announcement of the Brady plan are somewhat

[8] As described in the Appendix, our estimates used the Vasicek (1977) model of the term structure, which assumes that the instantaneous (short-term) rate of interest follows a mean-reverting process. This interest rate was estimated to have a long-run mean of 8.89 percent.

[9] The figure of 36.82 is the sum of the market values of eight default-free bonds with maturities at six-month intervals. The prices of these bonds are derived from the Vasicek term-structure model whose estimation is reported in the Appendix.

lower than those based on prices observed prior to the announcement. For most debtor countries, debt prices increased after the plan was announced, and the estimated standard deviation of prices also increased. (The exceptions are Argentina and Uruguay.) In many cases, however, despite a sharp increase in market prices of debt, the value of the guarantee has not shown a significant decrease (for example, Costa Rica, Mexico, the Philippines, and Venezuela). The reason is that when the level of the state variable S is sufficiently low, increases in its estimated value do not generate significant increases in the probability of debt service by the debtor country and thus do not translate into much lower guarantee values.

It is interesting to compare these estimates with those that would be obtained by applying the rule of thumb referred to in Section I of this paper. The estimate of the value of a guarantee by the rule of thumb is simply the product of 1 minus the market price of debt times 36.82. It can be seen that although the ranking of the cost of the guarantees is roughly the same under both methods, the rule-of-thumb estimates considerably undervalue the cost of guarantees. The ranking is similar under both methods, because the statistical moments of the market prices for the different countries are roughly similar (see Table 1)—a reflection of the casual observation of substantial co-movement of prices in this market. The underestimation of the true value of the guarantee responds to a more fundamental shortcoming of the rule-of-thumb method. When payments follow a stochastic process of the kind identified through the market price of debt, there is always some probability that the debtor country will make substantial payments at some point in the future, especially for long-term debt or with rescheduling of missed payments. Therefore, low prices of debt (such as those observed for most debtor countries) can be sustained even if essentially nothing is expected to come out as payments in the short run. The rule of thumb, by ignoring uncertainty altogether, is unable to capture this effect.

To check the robustness of the results, a different specification was estimated by using a fixed value for the standard deviation of the state variable S, and estimating both the level and expected rate of change of S. This allowed us to estimate the value of the parameter c. The standard deviation of the state variable was assumed to be equal to the standard deviation of gross national product (GNP) of each debtor country, which was generally higher than the estimated variance of S in the previous exercise. The results, which are reported in Tables 6 and 7, do not differ significantly from those obtained using the original specification. The estimated values of c range between minus 3 percent and plus 6 percent, and the differences with respect to previous estimates of the value of guarantees are therefore small.

Table 6. *Value of Interest Payment Guarantees: Pre-Brady Plan Announcement, April 7, 1987 to March 2, 1989*

(with σ_S = volatility of GNP)

Country	σ_S	S	c	ρ_{Sr}	Value of Guarantee
Argentina	0.393	23.80	−0.0104	−0.0196	36.12
Brazil	0.125	48.12	0.0529	−0.2676	36.35
Chile	0.226	57.66	−0.0254	0.0311	30.13
Colombia	0.086	67.11	0.0408	−0.3890	32.71
Costa Rica	0.177	25.33	0.0390	−0.1444	36.81
Ecuador	0.168	19.12	0.0259	−0.1278	36.82
Mexico	0.200	36.61	0.0033	−0.0072	36.15
Philippines	0.129	42.45	0.0124	−0.1205	36.35
Uruguay	0.213	43.62	−0.0832	0.4800	33.46
Venezuela	0.136	41.88	0.0364	−0.2133	36.52

Note: Guarantee refers to a four-year guarantee on a floating-rate perpetuity with semi-annual payments tied to the yield on the six-month U.S. Treasury bill rate. The initial six-month Treasury bill yield was 9.0625 percent; S is the current level of the state variable; c is the difference between the expected rate of growth of an asset with the same risk as S and that of S; σ_S is the standard deviation of the rate of growth of S; and ρ_{Sr} is the correlation of the rate of growth of S and the short-term (instantaneous) U.S. rate of interest.

Table 7. *Value of Interest Payment Guarantees: Post-Brady Plan Announcement, April 7, 1987 to January 18, 1990*

(with σ_S = volatility of GNP)

Country	σ_S	S	c	ρ_{Sr}	Value of Guarantee
Argentina	0.393	18.48	0.0032	−0.0350	36.55
Brazil	0.125	53.44	0.0621	−0.2753	36.01
Chile	0.226	67.80	−0.0301	0.0125	25.58
Colombia	0.086	79.01	0.0474	−0.4236	27.25
Costa Rica	0.177	33.12	0.0398	−0.1568	36.70
Ecuador	0.168	25.57	0.0358	−0.1550	36.81
Mexico	0.200	46.88	0.0094	−0.0765	34.83
Philippines	0.129	62.40	0.0301	−0.2225	32.79
Uruguay	0.213	37.97	−0.0712	0.4648	35.26
Venezuela	0.136	55.66	0.0464	−0.2471	35.12

Note: Guarantee refers to a four-year guarantee on a floating-rate perpetuity with semi-annual payments tied to the yield on the six-month U.S. Treasury bill rate. The initial six-month Treasury bill yield was 9.0625 percent; S is the current level of the state variable; c is the difference between the expected rate of growth of an asset with the same risk as S and that of S; σ_S is the standard deviation of the rate of growth of S; and ρ_{Sr} is the correlation of the rate of growth of S and the short-term (instantaneous) U.S. rate of interest.

V. Conclusions

This paper has outlined a framework for valuing guarantees on floating-rate debt payments of developing countries. The main advantage of this method is that it derives the current level and the parameters of the stochastic process that determine repayments by using data on the market value of debt and interest rates only. It therefore requires no assumptions regarding the economic or political determinants of repayments, which, as mentioned above, could be diverse and hard to measure in any comprehensive way.

The main caveat of the technique applied here is the necessity of making an identifying assumption about the expected rate of growth of the unobservable variable that determines payments to banks. The problem arises because it is not possible to measure all the random factors affecting payments made by the debtor country, and there is no traded financial asset that is perfectly correlated with the unobservable state variable that determines a debtor country's payments. However, it is possible to compute the value of guarantees for reasonable boundaries for the value of the unknown parameter. In any event, the assumptions required by the methodology applied in this paper are certainly much weaker than those that are implicit in the application of a rule of thumb of the type discussed in Section I.

The estimated values for the guarantee contracts may perhaps appear to be on the high side, especially for the six or seven debtor countries for which the prices of debt are lower, but this is merely a reflection of the low market valuation of the debt of these countries. It opens the question however, of whether the estimated specification of the process followed by debt prices is consistent with the record of payments by debtor countries, or whether it might be too pessimistic relative to that record, possibly reflecting fears of dramatic bad news for payments to banks, arising from political or institutional considerations.

APPENDIX

Derivation of Interest Payment Guarantee Formula

The stochastic process for the state variable, $S(t)$, is assumed to take the form

$$\frac{dS(t)}{S(t)} = \alpha_s(t)dt + \sigma_s dz, \tag{4}$$

where $\alpha_s(t)$ is the (possibly time-varying) instantaneous expected rate of change of $S(t)$; dz is a standard Wiener process; and σ_s, the instantaneous standard deviation of $S(t)$, is assumed to be a constant. We will also assume that $\alpha_s(t)$ may differ from the expected rate of return on a marketable asset with the same risk as $S(t)$. The difference between the rate of return on this marketable asset and $\alpha_s(t)$ is assumed to equal a constant, c.

Let the price at time t of a default-free discount bond that pays \$1 at time $t + \tau$ be given by $P(t, \tau)$. As in Merton (1973), we assume this bond price has the following dynamics:

$$\frac{dP(t,\tau)}{P(t,\tau)} = \alpha_p(t)dt + \sigma_p(\tau)dq, \qquad dzdq = \rho dt, \tag{5}$$

where $\sigma_p(t)$ is a function only of the bond's time to maturity.

We further assume that interest rates are described by Vasicek's (1977) model, which is consistent with the assumed dynamics for bond prices given in equation (5). This implies that the instantaneous nominal interest rate, $r(t)$, follows the process

$$dr(t) = \alpha[\gamma - r(t)]dt - \sigma dq. \tag{6}$$

The parameter γ is the steady-state mean of $r(t)$, and σ^2 represents its instantaneous variance. The parameter α measures the magnitude of mean reversion in the short-term interest rate.

Given equation (6), and assuming the market price of interest rate risk is a constant, ϕ, Vasicek (1977) showed that the equilibrium price of a default-free discount bond is of the form

$$P(r(t),\tau) = A(\tau)\exp\left[-\frac{1}{\alpha}(1 - e^{\alpha\tau})r(t)\right], \tag{7}$$

where

$$A(\tau) = \exp\left[\left(\frac{1 - e^{-\alpha\tau}}{\alpha} - \tau\right)\left(\gamma + \frac{\sigma\phi}{\alpha} - \frac{\sigma^2}{2\alpha^2}\right) - \frac{\sigma^2}{4\alpha^3}(1 - e^{-\alpha\tau})^2\right].$$

Using Ito's lemma, the standard deviation of this bond's rate of return is given by

$$\sigma_p(\tau) = \frac{\sigma}{\alpha}(1 - e^{-\alpha\tau}). \tag{8}$$

Now consider the value of a guarantee on a single floating-rate interest payment, where the interest payment is tied to the yield on a default-free discount bond with a maturity τ_r. It is assumed that the interest reset date of the floating-rate debt is also exactly τ_r periods prior to the interest payment date. More specifically, the debt interest payment equals a spread, s, plus the yield on a default-free bond with a maturity τ_r that was issued τ_r periods prior to the interest payment date. Under these assumptions, the maturity value of the interest guarantee is given by equation (1) in the text where the promised interest payment is

$$1 + i_{t+\tau} = \frac{e^{s\tau_r}}{P(t + \tau - \tau_r, \tau_r)}. \tag{9}$$

A straightforward extension of Merton's (1973) work on valuing options when interest rates are stochastic yields the value of the guarantee, $G_{t+\tau}(t)$:

$$\begin{aligned} G_{t+\tau}(t) = {} & e^{s\tau_r}\, DP(t, \tau - \tau_r)\, N(-d_{12}) - e^{-c\tau}\, S(t)\, N(-d_{11}) \\ & - DP(t, \tau)\, N(-d_{22}) + e^{-c\tau}\, S(t)\, N(-d_{21}), \end{aligned} \tag{10}$$

where

$$d_{11} = \ln \left(\frac{e^{-c\tau} S(t)}{e^{s\tau_r} DP(t, \tau - \tau_r)} \right) \Big/ T_1^{1/2} + \frac{1}{2} T_1^{1/2}$$

$$d_{12} = d_{11} - T_1^{1/2}$$

$$d_{21} = \ln \left(\frac{e^{-c\tau} S(t)}{DP(t,\tau)} \right) \Big/ T_2^{1/2} + \frac{1}{2} T_2^{1/2}$$

$$d_{22} = d_{21} - T_2^{1/2},$$

and where

$$T_1 = \int_0^{\tau_r} \sigma_s^2 + \sigma_p^2(\omega) - 2\rho\sigma_s\sigma_p(\omega)\, d\omega$$

$$+ \int_0^{\tau - \tau_r} \sigma_s^2 + \sigma_p^2(\omega) - 2\rho\sigma_s\sigma_p(\omega)\, d\omega$$

$$T_2 = \int_0^{\tau} \sigma_s^2 + \sigma_p^2(\omega) - 2\rho\sigma_s\sigma_p(\omega)\, d\omega.$$

Using the expression for $\sigma_p(\omega)$ from equation (8), the integration in the formulas for T_1 and T_2 can be easily carried out.

Estimation of Parameters of the Term Structure

Let $B(t) = \ln P(r(t),\tau)$; that is, the log of a given maturity bond price. Then, using equation (7) and Ito's lemma, one can show that $B(t)$, given a constant maturity τ, will follow the process

$$dB(t) = (\alpha \ln A(\tau) - \gamma(1 - e^{-\alpha\tau}) - \alpha B(t))dt + \frac{\sigma}{\alpha}(1 - e^{-\alpha\tau})dq \tag{11}$$

$$\equiv (K(\tau) - \alpha B(t))dt + \frac{\sigma}{\alpha}(1 - e^{-\alpha\tau})dq.$$

This continuous time process has a discrete time $AR(1)$ representation of the form

$$B(t + \delta) = K'(\delta) + e^{-\alpha\delta} B(t) + \nu_t(\delta), \tag{12}$$

where ν_t is normally distributed with mean zero and variance equal to

$$\text{var}(\nu_t(\delta)) = \frac{\sigma^2}{2\alpha^3}(1 - e^{-\alpha\tau})^2 (1 - e^{-2\alpha\delta}). \tag{13}$$

Using equations (12) and (13), maximum likelihood estimation of the parameters α, σ, γ, and ϕ can be carried out. This was done using end-of-month prices of 30-, 90-, 180-, and 345-day Treasury bills over the period 1970 through 1986. The estimates and standard errors are

α	σ	γ	ϕ
0.1961	0.0452	0.0889	0.3146
(0.1210)	(0.0032)	(0.0525)	(1.1329)

Estimation of the Parameters of the State Variable $S(t)$

In this section we describe a technique that allows us to estimate the level of $S(t)$, its rate of return variance, σ_s^2, and the correlation parameter ρ, using data on secondary market prices of developing country debt. The developing country debt is assumed to be equal to a floating-rate perpetuity. Let $V_{t+\tau}(t)$ equal the value of time t of a single floating-rate payment to be received in τ periods that is subject to default risk; that is, it is not guaranteed. Then its value must equal the value of a default-free, floating-rate payment, less the value of the guarantee on this floating-rate payment:

$$\begin{aligned} V_{t+\tau}(t) &= e^{\pi\tau_r} DP(t,\tau-\tau_r) - DP(t,\tau) - G_{t+\tau}(t) \\ &= D(e^{\pi\tau_r} P(t,\tau-\tau_r)N(d_{12}) - P(t,\tau)N(d_{22})) \\ &\quad + e^{-\epsilon\tau} S(t)(N(-d_{11}) - N(-d_{21})). \end{aligned} \tag{14}$$

Therefore, the market value of this floating-rate perpetuity, V, is given by

$$V(t) = \sum_{\tau t}^{\infty} V_{t+\tau}(t). \tag{15}$$

Using Ito's lemma, we can solve for the instantaneous variance of $V(t)$, as well as its covariance with the rate of return on a t-period discount bond.

$$\sigma_V^2 = \left(\frac{\partial V}{\partial S}\sigma_s \frac{S}{V}\right)^2 + \left(\frac{\partial V}{\partial r}\frac{\sigma}{V}\right)^2 + 2\rho\frac{\partial V}{\partial S}\frac{\partial V}{\partial r}\sigma_s\sigma\frac{S}{V^2} \tag{16}$$

$$\sigma_{V_r} = -\frac{\partial V}{\partial S}\rho\sigma_s\frac{\sigma}{\alpha}(1-e^{-\alpha\tau})\frac{S}{V} - \frac{\partial V}{\partial r}\frac{\sigma^2}{\alpha}(1-e^{\alpha\tau})\frac{1}{V}, \tag{17}$$

where $\partial V/\partial S$ and $\partial V/\partial r$ are evaluated in a straightforward (but lengthy) manner using equations (15) and (14). By using secondary market prices of developing country debt as well as prices of U.S. Treasury bills, we can observe $V(t)$ as well as estimate σ_V^2 and σ_{V_r}. Given these estimates, equations (15), (16), and (17) are a system of three nonlinear equations in the three unknowns, $S(t)$, σ_s, and ρ. Numerical methods can then be used to solve this system.

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Monetary Indexation and Revenues from Money Creation

The Case of Iceland

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The effects of monetary indexation on revenues from monetization in Iceland are discussed, and the factors behind the sharp fall in monetization revenues following the introduction of indexation in 1979 are evaluated. The fiscal consequences are then examined, given that revenues from monetization have traditionally made up a substantial part of government revenues in Iceland. Different policy options are simulated using as a framework the public finance approach to inflation. The simulations focus on the relation of fiscal deficits to inflation, output, growth, and internal and external debt. [JEL 122, 311]

WITH THE passage of the Economic Management Act in 1979, Iceland introduced a comprehensive system of monetary indexation. Bank deposits and loans were linked to price developments, while the Central Bank of Iceland indexed the corresponding portion of required reserves. Indexation had important effects on the revenue derived from money creation, a revenue source on which the Icelandic authorities had relied heavily. With a substantial part of base money now being insulated, the Government's ability to derive revenues by responding to the inflation-induced demand for base money diminished. The tax base on which the inflation tax could be levied shrank substantially, as currency

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in circulation remained the only part of base money that was an interest-free liability of the public sector, and which could cover real expenditure through the issue of nominal liabilities. However, as a result of the indexation of financial assets in the banking sector, real interest rates increased significantly. With relatively higher opportunity costs of holding cash, the demand for currency decreased, thus further diminishing the inflation tax base.

The greater willingness of the public to absorb broad money and the subsequent increase in financial savings in the domestic economy did, however, translate into more seigniorage for the authorities. But since the inflation tax effect exceeded the seigniorage effect, total revenues from money creation declined.

This decrease in monetization revenues had important consequences for fiscal policy, which will be studied in greater detail in the framework of the public finance approach to inflation. Although, in principle, monetary indexation can affect the economy in various ways,[1] the analysis will be carried out under restrictive assumptions. For example, the implication that monetary indexation might have for the government's costs of nonbank borrowing—which could well aggravate the fiscal deficit—will be ignored. The offset provided by the possible increase in profits in the banking sector resulting from higher yields on required reserves, which leads to higher income tax revenues, will also be ignored.[2]

These limitations should be kept in mind, especially with regard to the policy simulations presented in this paper. The simulations are preceded by a description of the evolution of monetary indexation and of the present situation in Section I. Section II discusses the measurement of revenues from money creation. The analytical framework is presented in Section III. Section IV provides empirical results on the effects of indexation on the demand for money, Section V presents some policy simulations, and Section VI contains the conclusions.

I. Evolution of Monetary Indexation in Iceland

Monetary indexation in its present comprehensive form was institutionalized by the Economic Management Act of 1979, although there had been some earlier moves in this direction.[3] In fact, the origins date

[1] See, for example, Baer and Beckerman (1980), Kapur (1982), and World Bank (1989, pp. 63–68).

[2] The income tax effect also depends on whether the tax system includes corrective mechanisms for inflation. See Tanzi (1976, 1989, pp. 647–51). For a description of the Icelandic tax system, see Kolbeinsson (1982) and Organization for Economic Cooperation and Development (1988).

[3] For details, see Iceland Ministry of Finance (1988).

from the mid-1970s when a policy of raising the cost of credit and revenues from monetary assets was introduced. In 1976 special interest premium accounts—with interest premiums to be regularly considered in view of price developments—were initiated, and since 1977, a price compensation factor based on the cost of living and building cost indices has been added to bank lending and deposit rates. However, because these arrangements provided for only partial ad hoc adjustments of interest rates to inflation, which started to accelerate at the end of 1977, bank deposits continued to fall in relation to gross domestic product (GDP), while the demand for credit rose unabated.

In order to lessen the disincentives to save associated with negative real interest rates, the Government announced a system of general price indexation of savings and credit in April 1979 to be implemented before the end of 1980. Whereas earlier legislation explicitly prohibited the general use of indexation, the Economic Management Act of 1979 provided for full and automatic adjustment of interest rates to inflation.

The first steps toward positive real interest rates were taken during the remainder of 1979 when nominal interest rates were raised three times. Banks were given permission to grant fully indexed loans carrying a positive real rate of interest, with the loan principal indexed to the credit terms index.[4] The minimum loan maturity was initially set at four years, shortened to two-and-one-half years in early 1981, and to six months in 1983. The real interest rate on indexed loans was initially set at 2½ percent. On the deposit side, banks began to offer fully indexed two-year time deposits carrying a real interest rate of 1 percent in 1980, and in 1981 the minimum maturity was reduced to six months. Three-month indexed deposits with a zero real interest rate were also made available in 1982.

Real interest rates were initially set by the Central Bank (as were the nominal rates on nonindexed instruments), but since 1984, market forces have been given an increasing role in interest rate determination. To maintain competitiveness, the banks introduced "switching-term deposits" in 1984; these were deposits whose terms switched between ordinary and indexed rates according to which was more favorable to the depositor. The Central Bank Act of 1986 left commercial banks free to

[4] Originally, the credit terms index was calculated monthly on the basis of the cost of living index (with a weight of two thirds) and the building cost index (one third). In February 1989 the composition of the index was changed; the wage index was added with a weight of one third, and the weight of the cost of living index was reduced to one third.

set practically all their own interest rates. The deregulation of interest rates caused deposit and lending rates to rise, as banks increasingly competed among themselves and with other institutions for financial savings (Figure 1). The ratio of total deposits to GDP increased considerably in response to higher real interest rates, with switching-term deposits proving particularly popular (Figure 2).

Overall, indexation has had predictable effects, as depositors have responded to the more favorable terms by increasing their financial savings.[5] Index-linked borrowing has also gained in popularity. At end-1988, 56 percent of all bank deposits were linked to the credit terms index, 7 percent were linked to foreign exchange,[6] and 37 percent were nonindexed. On the credit side, 35 percent of bank loans were linked to the credit terms index, and about 31 percent were linked to foreign exchange, leaving about 34 percent nonindexed. For the financial system as a whole, only about 15 percent of loans were nonindexed. Moreover, almost all treasury bonds were indexed, as were most private sector bonds.

Since 1988, however, the Government has attempted to reduce financial indexation. In July 1988 it banned direct indexation of the principal value of financial instruments with maturities shorter than two years, and set the minimum maturity for indexed bank deposits at six months. In June 1989 the Central Bank announced that indexation of switching-term deposits would only apply to the unused amount in each savings account in each six-month period.

When indexed time deposits were introduced, similar accounts were opened in the Central Bank for required reserves of deposit money banks. Although originally only the portion of required reserves corresponding to the banks' indexed deposits was indexed,[7] in February 1987 it was decided to index all required reserves at a zero real rate of interest.[8] However, since March 1988, required reserves have earned a real interest rate of 2 percent.[9]

[5]The deregulation of interest rates also contributed to this development.

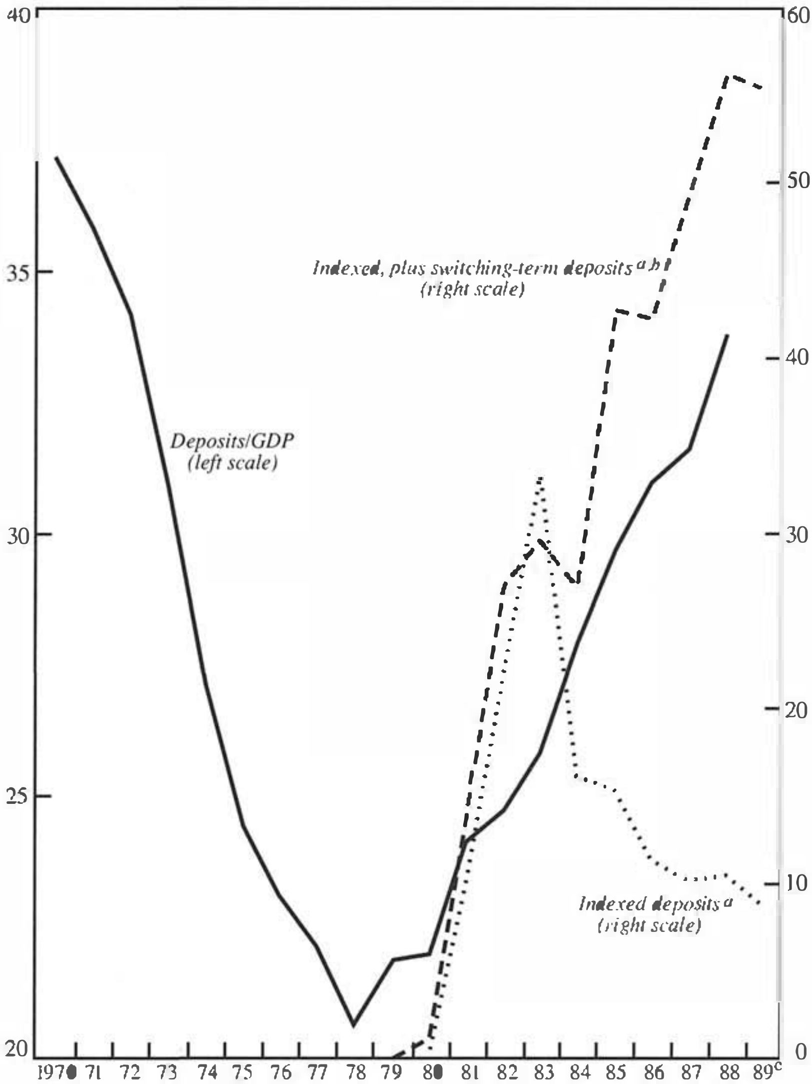
[6]In 1987 the Government considered using the exchange rate as an element in the credit terms index, but decided against it. Instead, exchange rate-based indexation has been authorized, allowing financial assets to be linked either to the credit terms index or to the SDR or the European Currency Unit (ECU).

[7]However, all required reserves earned interest.

[8]The indexation adjustments are included in reserve money at the end of each month, but the banks have access to the funds only at the end of the year.

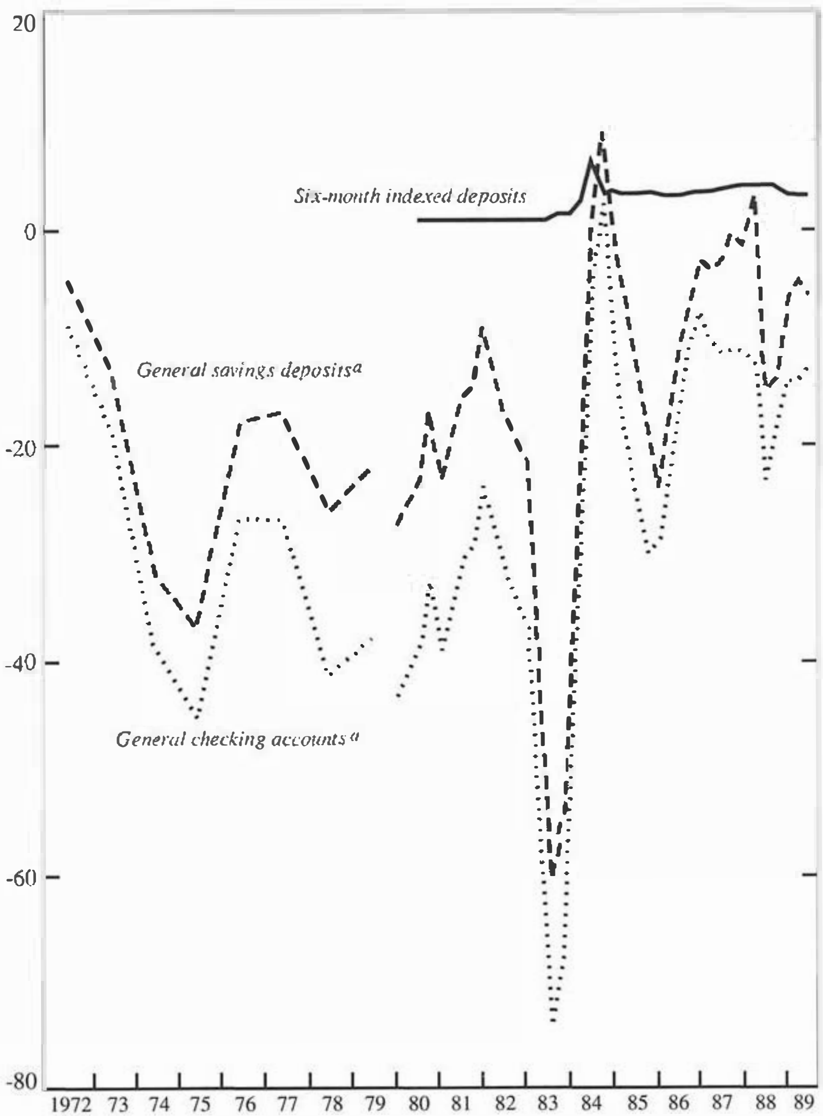
[9]The decision to pay real interest on required reserves was made in December 1988 to facilitate a reduction of interest rates in deposit money banks. This change was made retroactive to March 1988.

Figure 1. *Deposits in Deposit Money Banks*
(In percent)



Source: Information provided by the Icelandic authorities.
[a] In percent of total deposits.
[b] Switching-term deposits, introduced in 1984, are deposits whose terms switch between ordinary and indexed rates according to which is more favorable to the depositor.
[c] End-of-June data.

Figure 2. *Real Interest Rates*
(In percent)



Source: Central Bank of Iceland, *Economic Statistics Quarterly*.
Note: Data points for 1972–79 refer to annual series; 1980–89 data points are quarterly.
[a] Deflated by the change in the credit terms index during the past 12 months.

II. Measurement of Revenues from Money Creation

Domestic financial savings have increased as a result of the monetary indexation.[10] If required reserves, which have correspondingly increased, had not been indexed, revenues from money creation would have been larger than they have been. In the steady state, these revenues are equal to $(g + \pi)m$, where g denotes the growth rate of real income (assuming unitary income elasticity), π denotes the inflation rate, and m denotes real base money. Whereas gm can be interpreted as seigniorage—that is, the steady-state increase in the real value of base money—πm represents the inflation tax—that is, the amount of nominal balances that needs to be accumulated just to keep the real value of base money constant (Anand and van Wijnbergen (1988, 1989)).

Assuming that the Central Bank pays no interest on its liabilities and issues monetary assets at a rate equal to the inflation rate, it taxes money holders (the deposit money banks which pass the loss on to their depositors) at that rate (Fischer (1982)).[11] However, in the case of Iceland this assumption cannot be maintained. As noted above, all required reserves earned interest before 1979, but after the introduction of indexation that portion of required reserves corresponding to the indexed deposits of deposit money banks was also indexed.[12] From February 1987 to February 1988, all required reserves were fully indexed but received zero real interest. Since March 1988, real interest of 2 percent has been paid. Taking this into account, it appears more appropriate to use the following measure of revenues from money creation (RM):[13]

$$RM = [g + \phi\pi + (1 - \phi)(\pi - i)]m. \qquad (1)$$

Equation (1) follows an approach suggested by the Organization for Economic Cooperation and Development (OECD) (1988, p. 65), in which revenues from money creation in Iceland were calculated by the (negative of the) real interest rate paid by the Central Bank—$(i - \pi)m$. This approach does not take into account that interest is paid only on a fraction of base money—namely, required reserves $(1 - \phi)m$—whereas currency in circulation, ϕm, is an interest-free liability of the Central Bank.

[10] For an overview of other reforms see Nordal (1988) and various issues of the *Annual Report* of the Central Bank of Iceland.

[11] With positive real interest rates on deposits and negative yields on required reserves, the spread between deposit and lending rates would be considerable.

[12] Interest was paid on the nonindexed portion of required reserves corresponding to the nonindexed deposits of deposit money banks.

[13] For a discussion of alternative measures of revenues from monetization, see Barro (1982) and Gros (1989).

Calculations show that revenues from money creation have substantially decreased during the period of indexation. According to Table 1, average annual revenues were 2.96 percent of GDP in the preindexation period from 1971 to 1980, whereas in the period from 1981 to 1987 the average revenue was 1.49 percent.

There are several reasons for this decline, the most important being the move to nonnegative real interest rates on required reserves. As discussed, most base money in Iceland is not an interest-free liability of the Central Bank. Although in the 1970s interest was paid on required reserves at a rate equivalent to the interest rate paid by the deposit money banks on deposits plus a certain premium, the real interest rate on required reserves was still negative. To the extent that the inflation rate exceeded the nominal interest rate, the Central Bank received inflation tax revenues (in addition to revenues arising from the issue of bank notes and coins). When indexation was introduced, however, the portion of required reserves corresponding to the indexed deposits of deposit money banks was also linked. Thus, the base on which the inflation tax could be levied shrank, irrespective of the increase in deposits of the deposit money banks and, hence, in required reserves. When it was

Table 1. *Selected Sources of Government Revenues*
(In percent of GDP)

Year	Seignorage	Inflation Tax Revenues	Revenues from Money Creation
1971	1.45	0.64	2.09
1972	0.60	1.58	2.19
1973	0.57	2.50	3.07
1974	0.47	3.32	3.79
1975	0.03	2.80	2.83
1976	0.42	2.28	2.70
1977	0.78	1.63	2.41
1978	0.50	2.53	3.03
1979	0.47	1.87	2.34
1980	0.34	4.90	5.24
1981	0.22	2.16	2.38
1982	0.11	1.71	1.82
1983	−0.24	3.09	2.85
1984	0.23	0.90	1.13
1985	0.16	0.32	0.48
1986	0.47	0.72	1.19
1987	0.38	0.23	0.61

Source: Staff calculations.

decided in February 1987 to index all required reserves, currency in circulation and free reserves (which have traditionally been small) remained the only sources of inflation tax revenues.

When indexed deposits were introduced, the opportunity cost of holding cash rose. While financial savings in bank deposits increased, currency in circulation (in relation to GDP) declined from 2.17 percent in the period from 1972 to 1980 to 1.25 percent in the period 1981 to 1987. This substitution effect also diminished the inflation tax base, leading to a decline in revenues from monetization.

Two further effects should be mentioned. One is the reduction of the (average) reserve requirement ratio by 10 percentage points in April 1985 and by 5 percentage points in March 1987 (Table 2).[14] The other noteworthy effect was the deregulation of interest rates in the 1980s. To the extent that increasing interest rates on deposits in deposit money banks also led to higher interest rates on required reserves and, hence, to a smaller gap between nominal interest rates and the rate of inflation, the deregulation contributed to the decline of revenues from money creation.

As a consequence of this decrease in revenues from monetization, total government revenues have been smaller than they otherwise would have been. Such a diminution requires a cut in the deficit to keep the public debt from rising (Dornbusch (1988, p. 12)).

III. Money Creation and the Public Finance Approach

In this section, an analytical framework is presented in which the effects from decreased revenues from money creation can be studied in greater detail. The analysis uses the public finance approach to inflation, which was developed by Phelps (1973), Dornbusch (1977), Buiter (1983), and Drazen and Helpman (1987). Without denying that, in the short run, demand pressures or cost-push factors may be more important determinants of inflation, this approach argues that the ultimate reason for the existence of high inflation rates lies in the government's need for revenues. As Anand and van Wijnbergen (1988, 1989) have shown, the public finance approach provides a useful apparatus for evaluating the implications for fiscal policies of financial sector reforms. Although Anand and van Wijnbergen (1988) focused on changes in bank deposit

[14] In the 1970s the (average) reserve requirement ratio was gradually raised from 20 percent to 28 percent, where it remained until April 1985. More recently, the ratio was further lowered by 1 percentage point in August 1988 and again in April 1989.

Table 2. *Monetary Indicators*
(Annual changes; in percent)

				Required Reserves			Inflation	
Year	Narrow Money	Broad Money	Currency in Circulation	At constant rates[a]	At current rates	Monetary Base	Consumer price index	Credit term index[b]
1971	23.9	19.8	27.3	20.0	20.0	17.4	7.4	...
1972	22.8	18.8	23.8	17.6	17.6	24.6	14.4	...
1973	38.6	32.8	26.0	30.3	43.4	39.3	24.7	...
1974	27.8	27.6	28.2	26.2	26.2	26.8	42.2	...
1975	37.9	28.9	28.6	27.1	33.3	34.1	50.2	...
1976	21.6	32.5	28.5	28.2	39.4	36.3	33.5	...
1977	47.1	43.9	56.8	41.5	41.5	55.0	30.5	...
1978	40.2	48.8	40.0	46.3	46.3	55.3	44.5	...
1979	47.3	56.2	29.4	44.8	62.2	47.7	45.5	43.6
1980	61.6	65.0	36.9	76.4	76.4	75.4	59.1	57.5
1981	60.4	70.6	80.0	89.0	89.0	67.0	50.6	51.8
1982	29.0	58.0	30.8	70.9	70.9	48.9	51.1	49.8
1983	77.1	78.5	46.5	83.7	83.7	73.6	85.7	79.4
1984	43.2	33.5	24.5	27.9	27.9	29.1	30.3	33.8
1985	25.7	47.3	29.7	51.5	−2.6	24.6	32.7	30.6
1986	45.3	35.3	37.9	31.9	31.9	33.0	20.6	24.6
1987	31.7	35.3	29.3	49.0	7.6	10.5	18.9	17.4
1988	17.9	24.0	16.9	15.5	6.6	11.2	26.4	23.4

Source: Central Bank of Iceland, *Economic Statistics Quarterly* (various issues).
[a] In 1971 the reserve requirement was 20 percent of all deposits in commercial banks.
[b] Until February 1989 the credit terms index was composed of the cost of living index (two thirds) and the building cost index (one third). At present, the cost of living index, the building cost index, and the wage index have a weight of one third each.

rates, their model can easily be adjusted to take account of the effects of monetary indexation.

In order to derive the fiscal consequences of monetary indexation, start from the following public sector deficit identity:

$$D + iB + i^*B^*E = \Delta B + \Delta B^*E + \Delta DC_G. \tag{2}$$

The left-hand side of equation (2) shows expenses of the public sector (net of tax revenues or transfers from the central bank):[15] the noninterest deficit D, plus nominal interest payments on domestic and foreign debt. The variable $i(i^*)$ is the nominal domestic (foreign) interest rate on domestic (foreign) debt $B\,(B^*)$, and E is the nominal exchange rate. On the right-hand side are the financing items; that is, the issue of domestic or foreign debt plus central bank advances to the public sector.

Since the government can shift a part of its deficit into the central bank accounts by simple bookkeeping changes and central bank credit to the government represents a claim of one public entity on another, the debt of intergovernmental agencies can be consolidated (Robinson and Stella (1988)). According to equations (3) and (4) derived from a simplified central bank balance sheet

$$M = DC_G + NFA^*E - NW \tag{3}$$

$$M = Cu + RR, \tag{4}$$

base money is equal to currency in circulation (Cu), plus required reserves held by the deposit money banks at the central bank. Base money is issued to cover credit to the government and the central bank's accumulation of net foreign assets (NFA^*E), insofar as these are not already covered by the central bank's accumulated profits of net worth (NW).[16] Subtracting the central bank's profits (interest earnings on foreign reserves) from the budget deficit and the counterpart of the central bank profit; that is, subtracting the increase in net worth from the public sector's increase in liabilities yields

$$D + iB + i^*(B^* - NFA^*)E = \Delta B + \Delta B^*E + \Delta DC_G - \Delta NW. \tag{5}$$

[15] As mentioned above, tax revenues and other budgetary items are likely to be affected by monetary indexation.

[16] For simplicity, excess reserves, which are of secondary importance, are ignored, as is the fact that the central bank not only holds reserves from deposit money banks but also lends to them as well as to other private agents. Strictly speaking, the monetary base would have to be adjusted as follows:

$$M_{Adj} = (Cu - DC_{PVT}) + (RR - DC_{CML}), \tag{4'}$$

where DC_{PVT} and DC_{CML} denote central bank credit to other private agents and to deposit money banks, respectively.

Consolidating the change in the central bank's net foreign assets and the change in the government's foreign debt yields

$$D + iB + i^* (B^* - NFA^*)E = \Delta B + (\Delta B^* - \Delta NFA^*)E + \Delta M. \quad (6)$$

Taking into account that exchange rate changes imply capital losses or gains, which are part of the cost of servicing foreign debt, and deflating all variables, equation (7) can be reformulated as follows:

$$d + rb + (r^* + \Delta e/e)(b^* - nfa^*)e = \Delta b + \Delta[(b^* - nfa^*)e] + \Delta m, \quad (7)$$

where lowercase letters now denote real variables.

According to equation (7), the fiscal deficit, including the central bank's profit-and-loss account, but only counting real interest payments, equals changes in the real value of domestic and foreign debt and base money. If no nominal interest is paid on required reserves, Δm represents the government's revenues from money creation, which is equal to $(g + \pi)m$ in the steady state. Since this assumption cannot be maintained in the case of Iceland, Δm has to be replaced by equation (1).

In order to evaluate different policy options, it is important to know how the demand for money responds to changes in inflation and economic growth and whether these reactions are different if monetary assets are indexed. In order to separate effects on the demand for currency (C) and for deposits (D), the following partial-adjustment money demand functions will be estimated:[17]

$$\log (C_t/P_t) = \alpha_1 + \alpha_2 \log (Y_t^r) + \alpha_3 (i_t) + \alpha_4 (\pi_t) + \alpha_5 \log (C_{t-1}/P_{t-1}) + \epsilon \quad (8a)$$

$$\log (D_t/P_t) = \alpha_6 + \alpha_7 \log (Y_t^r) + \alpha_8 (i_t) + \alpha_9 (\pi_t) + \alpha_{10} \log (D_{t-1}/P_{t-1}) + \epsilon, \quad (8b)$$

where P is the GDP deflator of period (t); Y^r denotes real GDP; i is a weighted average of interest rates on demand, time, and savings deposits; π is the inflation rate; and ϵ is an error term.

Finally, it seems reasonable to assume that the alternative sources of budget deficit financing are subject to certain limitations. Here, a partic-

[17] Analysis of government revenue from monetary expansion frequently postulates an aggregate demand function for fiat money. Rarely is it recognized in these formulations that the demand for fiat money is composed of two distinct components: a direct demand for currency and an indirect demand for bank reserves derived from the public's demand for deposits and reserve requirements. However, in order to explore how bank regulations, especially reserve requirements, affect revenues from money creation, it seems more appropriate to estimate the two components of base money separately. See Fry (1981), Siegel (1981), and Anand and van Wijnbergen (1988).

ularly simple debt strategy is supposed; that is, fixed debt/GDP ratios for both internal and external debt.[18] Target values for these ratios imply that real domestic debt cannot grow faster than real output[19] and real foreign debt cannot grow faster than the product of output times the real exchange rate:

$$b = nb \tag{9a}$$

$$(b^* - nfa^*)e = (n - \Delta e/e)(b^* - nfa^*). \tag{9b}$$

Inserting equations (9a) and (9b) in (6) yields (expressed as a percentage of GDP):

$$[d + rb + r^*(b^* - nfa^*)e]/GDP = [nb + (n\Delta e/e)(b^* - nfa^*)]/GDP + \Delta m/GDP. \tag{10}$$

According to equation (10), the noninterest deficit plus real interest payments on domestic and foreign debt cannot exceed what can be financed through debt issue at the targeted debt/output ratio, plus the revenue from (steady-state) money creation.

IV. The Demand for Money: Empirical Results

Using quarterly data,[20] the partial adjustment model given in equations (8a) and (8b) was estimated for the preindexation period 1972:2 to 1980:2. The regressions produced reasonable results, which are reported in Table 3.[21]

As far as the demand for cash is concerned, all coefficients have the expected sign and are significantly different from zero, at least at the 10 percent level. All the diagnostic tests are satisfied at a significance level of 5 percent; neither residual autocorrelation, nor nonnormality nor heteroscedasticity can be detected. Similarly satisfying results were ob-

[18] As a matter of course, more sophisticated debt strategies could be implemented. As far as external debt is concerned, a weighted average of the debt/output ratio and the debt/export ratio, for example, might be more appropriate. See Cohen (1988).

[19] If government debt were not indexed—contrary to the actual situation in Iceland—an increase in the inflation rate would lead, under certain circumstances, not only to higher revenues from money creation, but also to a liquidation of outstanding debt. See Calvo (1989).

[20] Since quarterly data for GDP are not available for Iceland, annual data had to be interpolated. Moreover, seasonal dummies were included, but the results are not reported here.

[21] These results are similar to those obtained by Eggertsson (1982), who, however, used an aggregate demand function.

Table 3. *Regression Results*

Dependent Variable	Period	Constant	log Y_t^*	i_t	π	log (C_{t-1}/P_{t-1})	log (D_{t-1}/P_{t-1})	R^2	DW	$ARCH(4)$[a]	$AR(4)$[b]	$NORM(2)$[c]
		Independent Variables										
log (C_t/P_t)	1972:2	−3.481	0.4195	−0.775	−0.204	0.666	—	0.75	2.05	0.28	0.124	1.138
	1980:2	(−1.370)*	(1.543)*	(−1.507)*	(−1.609)*	(5.960)***				(0.884)	(0.328)	(5.991)
log (D_t/P_t)	1972:2	−7.509	1.069	1.051	−0.259	—	0.341	0.84	1.89	0.58	0.0318	1.123
	1980:2	(−3.171)***	(3.774)***	(2.289)**	(−3.280)***		(2.583)**			(0.684)	(0.343)	(5.991)
log (C_t/P_t)	1980:4	−9.091	1.043	—	−0.086	0.412	—	0.86	1.95	0.51	0.124	0.59
	1987:4	(−3.080)***	(3.186)***		(−1.362)*	(2.618)**				(0.729)	(0.328)	(5.991)
log (D_t/P_t)	1980:4	−9.264	1.146	0.593	−0.121	—	0.4789	0.97	2.02	0.27	0.60	2.71
	1987:4	(−4.280)***	(4.541)***	(3.444)***	(−1.925)**		(4.056)***			(0.895)	(0.665)	(5.911)

Source: Staff calculations.

Note: The figures in parentheses below the coefficients are t-statistics; R^2 is the coefficient of determination; DW is the Durbin-Watson statistic; one asterisk indicates that the coefficient is significantly different from zero at the 10 percent level, two asterisks indicate significance at the 5 percent level and three asterisks at the 1 percent level.

[a] Lagrange multiplier test for autoregression conditional heteroscedasticity; the probability value of the test statistic under the null hypothesis is shown in parentheses.

[b] Lagrange multiplier test for residual autocorrelation; the probability of the test statistic under the null hypothesis is shown in parentheses; according to further tests, the hypothesis of the nonexistence of residual autocorrelation of different orders could not be rejected.

[c] χ^2-test for normal distribution of residuals; critical values at the 5 percent level in parentheses.

tained for the demand for deposits. Again, all coefficients show the expected sign, while the t-values indicate a strong significance especially for real income and the inflation rate.

In order to evaluate the out-of-sample properties of the model, the estimations were used to forecast the demand for currency and deposits in the 1980s. The predicative accuracy was poor. Assuming that the model has been correctly specified, the predicative failure for the equations indicates that there has been a structural break in the demand for money.[22] In fact, the Chow test for parameter constancy rejected the hypothesis of parameter stability.[23] The χ^2-test[24] was applied, which confirmed the results of the Chow test. As can be seen from Figure 3, the regression for the demand for currency implies a serious overestimation of actual developments in the indexation period, whereas the demand for deposits is heavily underestimated. This indicates that the introduction of monetary indexation has caused a significant shift in portfolio preferences.

Re-estimating the model for the indexation period 1980:4 to 1987:4 produced the results also reported in Table 3. Almost all of the coefficients are highly significant and all of them have the correct sign. The diagnostic tests do not indicate that the regressions suffer from residual autocorrelation, nonnormality, or heteroscedasticity. Two points are worth noting: first, the interest rate variable that was used for the estimation of the demand for money in the preindexation period proved to be no longer significant. However, for demand for deposits, the indexed interest rate had a strong influence on time deposits.[25] In contrast, the opportunity costs of holding currency seem to be solely determined by the rate of inflation, whereas the return on alternative assets no longer appears to play a significant role. Experiments with different interest rates did not meet with success, so the interest variable was omitted. Second, on the one hand, the (semi-) elasticity of the demand for money with respect to inflation decreased significantly, both in the case of the demand for currency and for deposits. On the other hand, the elasticity with respect to real income increased considerably, especially for demand for currency.

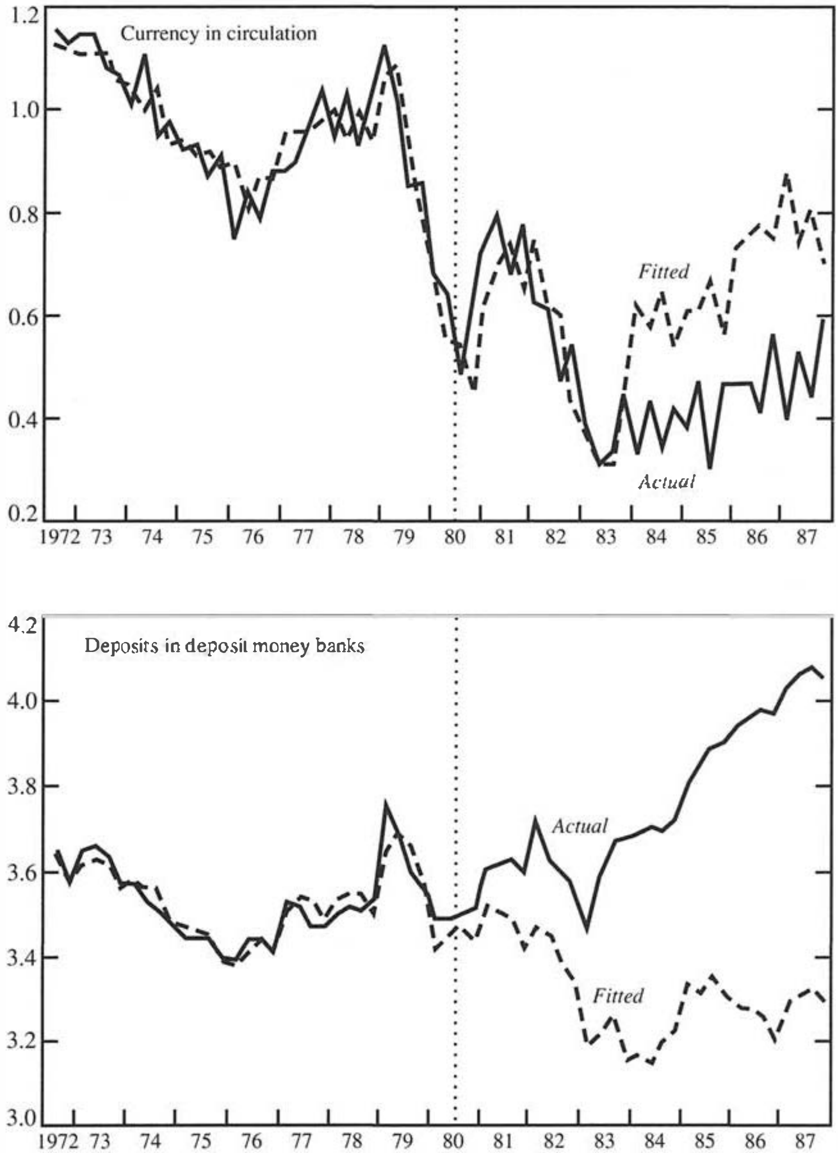
[22] A structural break in the demand for broad money was detected by Rodlauer (1984).

[23] For the demand for currency, the Chow-test value (31,27) was 2.73; for demand for deposits, the value was 1.67.

[24] The χ^2-test of whether the model parameters remain constant in the forecast period is calculated as χ^2 $(N)N$, which yields an approximate F-test. The test values significantly exceeded the critical value of 2 (for demand for currency, the value was 9.07; for demand for deposits, the value was 144.68). For the methodology, see Hendry (1989).

[25] In the regression, the implicit nominal return was used.

Figure 3. *Demand for Money: Actual and Fitted Values*
(In logs)



Source: Staff calculations.
Note: In real terms (deflated by the GDP deflator).

These regression results will now be used to estimate the demand for money and, hence, the revenues from money creation with and without indexation. This is done under alternative macroeconomic scenarios in order to evaluate different policy options.

V. Some Policy Simulations

Because indexation of base money leads to lower revenues from money creation, the so-called financiable deficit—that is, the deficit that can be financed without jeopardizing target values for internal and external debt—becomes smaller. If the government decides not to adjust fiscal policies and, hence, the actual deficit, by cutting expenditures or raising taxes, then those targets will not be attainable.

Since monetary indexation leads to a smaller base on which the inflation tax can be levied, one obvious possibility is to increase the tax rate; that is, the inflation rate. In order to evaluate this option in greater detail, let us suppose that in the indexation scenario all required reserves are fully indexed, whereas in the nonindexation scenario required reserves do not even earn interest. These assumptions, while somewhat unrealistic, help highlight the implications of indexing base money.

Under those assumptions a policy of raising inflation rates would have the following outcomes in 1985 (Table 4).[26] With money demand relatively inelastic to the opportunity cost of holding money, increased inflation generates increased revenues from monetization.[27] However, the marginal increase in revenues gradually falls as inflation rises because the demand for real balances falls.[28] Under indexation, an inflation rate

[26]The year 1985 seems particularly appropriate, since variables like GDP growth, inflation, and the budget deficit did not show the extreme values as in other years when external shocks took place; 1985 can thus be regarded as an "average" year.

[27]For dynamic considerations, see Auernheimer (1974).

[28]If the actual rate of inflation is higher than the rate at which revenues reach their maximum, an effective money demand-increasing policy might allow the government to maintain the size of its present budget deficit while reducing inflation. The policy problem, however, is to find the combination of expectations-changing policies sufficient to create the jump from the "high-inflation trap" where real money demand is lower to the "efficiently" financed deficit where money holdings are higher (Blejer and Cheasty (1988, p. 870)). It should be stressed that the inflation rate where revenues from money creation are maximized must not be interpreted as the "optimal" inflation rate. From the perspective of the theory of optimal taxation, the optimal inflation tax rate equates the marginal cost of distortions per currency unit of revenue from the inflation tax and from other distorting taxes. See, for example, Mankiw (1987) and Grilli (1989). Recent empirical studies have cast some doubt that from this point of view a positive inflation rate can be justified. See Garfinkel (1989, p. 10).

Table 4. *Revenues from Money Creation at Alternative Inflation Rates*
(In percent of GDP)

Inflation Rate	Scenario I: Nonindexation	Scenario II: Indexation
10	0.6	0.4
15	0.8	0.5
20	1.0	0.5
25	1.2	0.6
30	1.4	0.6
35	1.6	0.7
40	1.8	0.8
50	2.1	0.9
60	2.5	1.0
100	3.6	1.4

Source: Staff calculations.

of even 100 percent would cause revenues from money creation of only 1.4 percent of GDP.[29] In contrast, in the nonindexation scenario where base money is an interest-free liability of the central bank, revenues from money creation achieve this level at an inflation rate of only 30 percent. At an inflation rate of 100 percent, total revenues are more than two-and-one-half times larger than in the case of indexation. This difference would of course be even larger if required reserves received a positive real rate of interest, as has actually been the case since March 1988.

Revenues from money creation are only one source of financing. In addition, there is domestic debt issue and foreign borrowing.[30] In order to estimate the financiable deficit, all three sources have to be combined. Thus calculated, the financiable deficit can then be compared with the actual deficit, with the difference between the two measures indicating the required deficit reduction.[31] This has been done in Table 5 whereby

[29] Bomberger and Makinen (1980) have argued that in the case of Hungary indexation of financial assets was mainly responsible for the hyperinflation in 1945–46. Since index linking reduced substantially the tax base on which the inflation tax could be levied, higher inflation rates were needed to derive a given amount of revenues from money creation.

[30] See Section III; domestic debt issue and foreign borrowing are calculated in the following under the assumption of fixed debt/output ratios.

[31] Because of the lack of consolidated data the actual deficit refers to the so-called A budget of the government, which covers only the Treasury relatively narrowly defined. To take into account revaluations of indexed debt, monetary corrections have been made for accruals from those revaluations. See Tanzi, Blejer, and Teijeiro (1987, pp. 727–29). Thus defined, the actual deficit was 5 percent in 1985.

Table 5. *Required Deficit Reductions for Consistency with Various Macroeconomic Targets*

(In percent of GDP)

Target Variable	Target Scenario	Required Deficit Reduction: Nonindexation	Required Deficit Reduction: Indexation
	No real depreciation; real GDP growth, 3 percent		
Inflation	10	0.1	0.4
	20	−0.3	0.3
	30	−0.7	0.2
	No real depreciation; inflation rate, 10 percent		
Growth	2	0.8	1.1
	3	0.1	0.4
	4	−0.5	−0.3
	Real GDP growth, 3 percent; inflation rate, 10 percent		
Real depreciation	—	0.1	0.4
	2	0.9	1.3
	4	1.8	2.2

Source: Staff calculations.

the analysis focuses not only on changes in the inflation rate, but also on changes in economic growth and the real exchange rate.

As Table 5 shows, required deficit reductions are considerably higher in the case of indexation. Assuming that real economic growth is 3 percent and that the real exchange rate does not depreciate, fiscal adjustment would still be necessary at an inflation rate of even 30 percent. In contrast, if required reserves are not indexed, the financiable deficit would be equal to the actual deficit at an inflation rate of only slightly more than 10 percent. However, if economic growth accelerates, the need for fiscal adjustment decreases. At a growth rate of 4 percent, the financiable deficit exceeds the actual deficit even in the case of indexation (under the assumption that the inflation rate is only 10 percent). In turn, the need for fiscal adjustment increases if economic growth decelerates, with the required deficit reduction being relatively greater in the case of indexation.[32]

[32] It should be noted that the sensitivity of required deficit reductions with respect to economic growth critically depends on the assumed debt strategy. One might argue that fixed debt/output ratios as assumed here are too restrictive, at least on an annual basis, and that in the light of the supply shocks that periodically hit the Icelandic economy, which relies heavily on its fisheries, a

For the Icelandic economy, which is subject to severe shocks from its heavy reliance on fisheries, these results are of great interest. Suppose, for example, that as a result of an exogenous shock there is a decline in the rate of economic growth. Such a decline will, other things being equal, necessitate a compensating increase in the steady-state rate of inflation in order to keep the Government's revenues from money creation unaffected. The required increase in the rate of inflation is, however, substantially larger in the case of indexation than nonindexation. As has been shown by Melnick and Sokoler (1984), a decline in the growth rate may not only call for an increase in the rate of inflation (an increase greater than the decline in the rate of growth), but may also imply that the necessary compensating increase in the rate of inflation is a positive function of the existing rate of inflation. This will be the case if the demand for real balances is a semilogarithmic function of the expected rate of inflation, or, in other words, if the elasticity of the demand for money with respect to the expected rate of inflation increases as the rate of inflation rises.[33]

In order to prevent a deceleration of economic growth, the authorities might pursue an export strategy that relied on real exchange rate depreciation. However, such a policy would imply a greater need for fiscal adjustment by raising the ratio of foreign debt to GDP. Because of Iceland's high external debt, the required deficit reduction increases remarkably with the rate of real depreciation. Assuming real economic growth of 3 percent and an inflation rate of 10 percent, real depreciation of 4 percent would cause a gap of 1.8 percent of GDP between the financiable deficit and the actual deficit, even in the case of nonindexation. If required reserves are fully indexed, the necessary fiscal adjustment would be even larger.

medium-term strategy would seem to be more appropriate. However, the difficulty with this option is that variations in the fish catch are irregular in their amplitude and timing. Therefore, it is not possible to know how much can safely be borrowed in the slump without first knowing how much can be repaid in the boom that follows. In light of Iceland's foreign debt, which has already reached critically high levels, one could also argue that foreign debt (in relation to GDP) should decrease in any case. This would be the case, for example, if the absolute level is held constant despite an acceleration in economic growth. However, the required deficit reductions would then be higher than reported in Table 5.

[33]Such a function, proposed by Cagan (1956), is normally used when the demand for money is studied in countries that experienced high rates of inflation. See, for example, Leiderman and Marom (1988). If, however, the elasticity of the demand for money with respect to the expected rate of inflation is constant—that is, if demand for money is a linear logarithmic function of the expected rate of inflation—then the required compensating increase in the rate of inflation is a decreasing function of the existing rate of inflation.

Further simulations are conceivable, for example, to explore the consequences of changes in reserve requirements[34] or in bank interest rates (see, for example, van Wijnbergen (1985)). However, it should already be clear that monetary indexation has important budgetary implications.

VI. Conclusions

As has been shown in this paper, monetary indexation has significant budgetary consequences that are all the more important for countries like Iceland, where revenues from money creation represent a substantial part of total government revenues. Starting from the observation that revenues from money creation declined sharply after indexation was introduced, a simple framework was presented in which the consistency of fiscal deficits with other macroeconomic targets could be assessed. This framework, based on the public finance approach to inflation, made it possible to consider the relations of fiscal deficits to other targets including output growth, real exchange rate developments, and internal and external debt, with and without indexation. By simulating different policy options it can be shown that, other things being equal, monetary indexation considerably raised the need for fiscal adjustment.

This would not have been the case if only financial assets in the banking system were indexed. On the contrary, due to the increase in seigniorage associated with larger bank deposits and required reserves, required deficit reductions would have been comparatively lower. However, in the absence of base money indexation the spread between deposit and lending rates would probably increase significantly.

Recently, the Icelandic authorities have taken steps to reduce the extent of monetary indexation. As an alternative to linking monetary assets to price developments, deposits have been introduced with assets linked to the exchange rate. These schemes may provide an alternative not only to deposits indexed to the credit terms index but also to foreign exchange deposits. Although foreign exchange-linked deposits do not require the use of actual foreign currency, foreign exchange deposits normally lower the base on which the inflation tax can be levied—

[34] In principle, reserve requirements serve to control the means of payments in the economy and to secure stability in the aggregate price level, but if carried too far, they may become self-defeating as an instrument of monetary control and could seriously interfere with the banking system's intermediary role in allocating the economy's scarce resources (McKinnon (1980, p. 106)). As Eggertsson (1989) argues, Iceland has drastically reduced reserve requirements exactly for this reason. As mentioned earlier, this reduction in reserve requirements has also contributed to a decline in monetization revenues.

insofar as they provide a liquid alternative to domestic money.[35] However, in Iceland foreign currency deposits are nevertheless subject to reserve requirements, so that this potential effect is of no importance.[36]

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[35] If the rate of interest on domestic currency deposits falls below the (expected) total rate of return from foreign currency holdings (including exchange rate changes), people may satisfy at least some of their demand-for-money requirements by holding foreign currency. Apart from the fact that interest rate-induced currency substitutions may weaken monetary control, a reduction in the real stock of domestic money will, in principle, reduce the level of real revenues that the government can raise through deficit financing and money creation. See Tanzi and Blejer (1982, p. 783).

[36] However, insofar as foreign currency accounts may encourage currency substitutions, they can affect the optimal inflation tax. See Végh (1989).

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Labor Market Segmentation in a Two-Sector Model of an Open Economy

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The effects of labor market segmentation in a two-sector open economy model are examined. The model demonstrates how the structure of the labor market affects the real exchange rate, and is then used to examine the effects of two common labor market policies: increasing the degree of primary market coverage, and implementing wage restraint in the primary market. Increasing coverage increases unemployment and leads to a real appreciation. Real wage restraint, however, reduces unemployment and has ambiguous but probably small effects on the real exchange rate.
[JEL 411, 832]

THE TERM "labor market segmentation" is used here to characterize the coexistence of two different forms of market organization. In the so-called primary labor market, jobs are rationed by an above-equilibrium real wage. In the secondary market the wage is flexible and responds to excess demand conditions. Empirical evidence from developing economies (Fields (1980), Squire (1981), Heckman and Hotz (1985), and Johnson (1986)), as well as industrialized countries (Osterman (1975), Carnoy and Rumberger (1980), Reich (1984), and Dickens and Lang (1985, and the references therein)) establishes segmentation as a prevalent characteristic of the labor market.

Several theorists have studied the primary market segment and have

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suggested alternative hypotheses that explain the noncompetitive wage determination there. These hypotheses range from "job competition" models (Thurow (1979)), to "internal labor market" theories (Doeringer and Piore (1971) and Berger and Piore (1980)), the "insider-outsider" approach (Lindbeck and Snower (1986a, 1986b)), and the family of "efficiency wage" models (see the survey in Akerlof and Yellen (1986)). Others have studied the interaction of the two segments. This "dual market" approach first appeared in its present form in the work of development economists (Wellisz (1968), Todaro (1969), and Harris and Todaro (1970)), and was followed by others (Corden and Findlay (1975), Mincer (1976), Calvo (1978), and Blomqvist (1978)). The basic conclusion of these models is that, even if the secondary market is perfectly competitive, there will be a wage differential between the primary and secondary market, and some unemployment will persist at equilibrium. Moreover, expansion of labor demand or real wage restraint in the primary market or both will not restore full employment. These characteristics have made segmented market models increasingly popular tools for analyzing situations of persistent unemployment in both developing economies (Drazen (1982)) and industrialized countries (Bulow and Summers (1986) and Blanchard and Summers (1986)).

All these contributions use essentially a partial equilibrium framework; changes in the relative prices of goods are ignored because only one (single or composite) good is produced. Segmentation has not been properly studied in a two-good general equilibrium model, where the goods price is endogenous. This is all the more surprising since it has been shown (Neary (1980) and van Wijnbergen (1984)) that the open economy model with traded and home goods is very sensitive to specific assumptions about the structure of the labor market.

Introducing labor market segmentation in such a model raises two separate sets of questions. First, since segmentation causes not only output loss due to unemployment but also misallocation of labor between sectors, how is the real exchange rate (relative price of traded to home goods) affected. Second, given that many countries follow specific labor market policies (such as real wage restraint, expansion of job protection legislation, and reduction of wage differentials), often in the context of structural adjustment programs, what are the macroeconomic implications of these policies when the market is segmented.

This paper addresses these questions in a simple general equilibrium, two-sector model of a small open economy with a segmented labor market. The model is presented in the next section and the policy implications are discussed in Section II. The results are summarized in the last section.

I. The Model

Two goods, home and traded, are produced with ordinary neoclassical production functions. There is a fixed endowment of homogeneous labor, which is the only mobile factor across sectors. On the demand side, identical consumers consume both home and traded goods.

The labor market is dichotomized into a primary and a secondary part. Since the emphasis here is on the effects of segmentation on unemployment and the macroeconomy, the wage determination mechanism in the primary market is left deliberately unspecified; the primary real wage is simply assumed to be rigid at an above-equilibrium level. Any one (or any combination) of the existing hypotheses in the literature could be picked as an explanation of the real wage rigidity in the primary market without affecting the conclusions of this analysis.

General Equilibrium

Equilibrium in the labor market obtains in the following way. Before the markets open, workers decide whether or not to queue for primary jobs, based on information about the exogenously given real wage there. Since labor is assumed to be homogeneous, firms in the primary market do not discriminate between workers; they hire randomly from the queue up to the point where the product wage is equal to the marginal product of labor. The workers who do not get hired are the unemployed. The workers who decide not to queue for primary jobs are the supply to the secondary market, which, together with demand there, determines the wage so that the secondary market clears. At equilibrium the secondary wage must equal the expected gain from queuing in the primary market, which is equal to the primary wage times the probability of finding primary employment. Since hiring is random, this probability is the number of primary jobs over the number of workers in the queue. This equilibrium configuration is the one used in Corden and Findlay (1975) and is founded on a utility-maximizing model of risk-neutral workers (see Demekas (1987)).

The following notation is used in the rest of the paper (throughout, subscripts i denote sectors, where n is the home goods sector, and t, the traded goods sector; and superscripts j denote segments, where p is the primary, and s, the secondary labor market):

q_i = production of good i, $i = n, t$
L_i = demand for labor in sector i
ϵ_i = elasticity of the demand for labor in sector i

$\overline{L}$ = total supply of labor
W^j, ω^j = nominal and real wage in segment j, $j = p, s$
P_i = price of good i in terms of domestic currency
$z = P_t/P_n$ = real exchange rate
θ = share of home goods in consumption
$\theta p_n + (1-\theta)p_t$ = consumer price index
Y = nominal income
$y = q_n + zq_t$ = income in terms of the home good
$D_i(y, z)$ = demand for good i
g_i = a shift parameter in the demand for good i
η_i = income elasticity of demand for good i
e = nominal exchange rate
i = domestic interest rate
D = stock of domestic credit
R = foreign reserve holdings of the central bank.

Segmentation poses an important problem in this model: what is the correspondence between the primary-secondary dichotomy in the labor market, on the one hand, and the division of production in home and traded goods, on the other? It is assumed for simplicity and tractability of results that all the firms in the traded goods sector hire their workers in the primary labor market ($L_t = L^p$), and all the firms in the home goods sector hire their workers in the secondary market ($L_n = L^s$). This conforms to the prima facie evidence that in many developing countries import-competing manufacturing industries, export industries, and export crops are under direct or indirect government control, protected by labor legislation, and usually unionized; whereas construction, family farming, retail trade, and many nontraded services belong to the so-called informal sector.

Using the assumption that $L_t = L^p$ and $L_n = L^s$, the labor market equilibrium condition discussed earlier can now be written as

$$\omega^s = \frac{L_t \omega^p}{\overline{L} - L_n}. \quad (1)$$

The product wage in the home goods sector, w, is

$$w = \frac{W_n}{P_n} = \omega^s[(\theta + (1-\theta)z)]. \quad (2)$$

Similarly, the product wage in the traded goods sector is

$$\frac{W_t}{P_t} = \omega^p\left[\left(\frac{\theta}{z} + (1-\theta)\right)\right]. \quad (3)$$

Using equations (2) and (3), the labor demand functions can be written as

$$\underset{(-)}{L_n(w)}; \qquad \underset{(-)(+)}{L_t(\omega^p, z)}. \tag{4}$$

Using equations (2), (3), and (4), the condition (1) can be rewritten as

$$\frac{w}{\theta + (1 - \theta)z} = \frac{L_t(\omega^p, z)\omega^p}{\overline{L} - L(w)}. \tag{5}$$

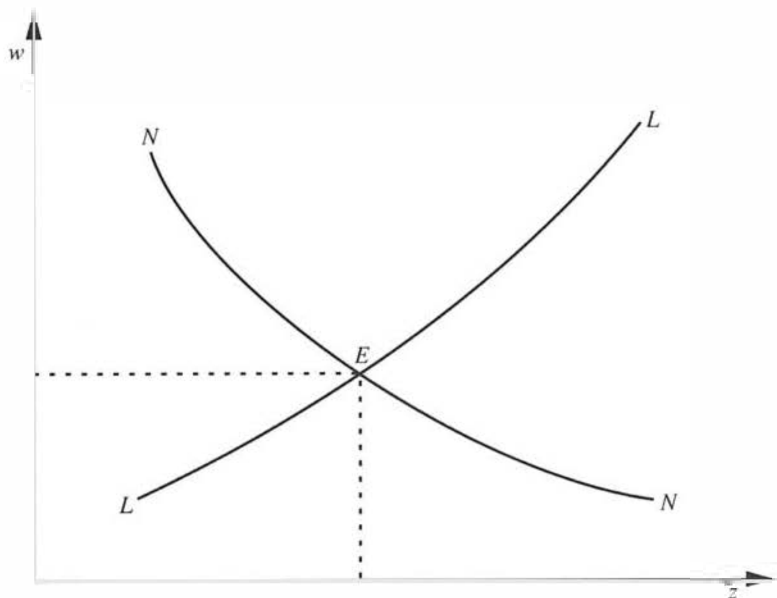
Equation (5) defines an equilibrium locus LL in the w-z space (see Figure 1) with a slope of

$$\frac{dw}{dz}\bigg|_{LL} = \frac{\omega^p L_t[(1 - \theta) + \theta|\epsilon_t|]}{\overline{L} - L_n(1 - |\epsilon_n|)}. \tag{6}$$

The condition that the elasticity of labor demand in the home goods sector be less than or equal to unity ($|\epsilon_n| \leq 1$) is sufficient to guarantee that the slope of LL is always positive. It will henceforth be assumed that this condition is satisfied.

The LL curve shifts in response to changes in the exogenous variables. An increase in total labor supply shifts the curve down, indicating that,

Figure 1. *General Equilibrium*



for any given z, the equilibrium level of w is now lower. Increases in ω^p, the primary market real wage, have ambiguous effects on the position of LL, depending on the size of ϵ_t, the elasticity of labor demand in the traded goods sector. If, on the one hand, $|\epsilon_t| \leq 1$, then increasing ω^p results in a higher wage bill in the traded goods sector, which puts upward pressure on ω^s, and the LL curve shifts up. The intuitive explanation for this is that if ω^p goes up but L_t is inelastic and does not fall much, the expected gain from queuing has risen and the secondary wage must also rise. If, on the other hand, L_t is elastic ($|\epsilon_t| > 1$), the opposite happens: the equilibrium w must, other things being equal, fall and the LL shifts down. For the rest of this paper $|\epsilon_t|$ will be assumed to be less than unity. This assumption, as well as the earlier assumption, $|\epsilon_n| \leq 1$, is supported by empirical evidence from both developing and industrialized countries, which indicates that the relevant range of labor demand elasticities is well below unity (see the surveys in Krueger (1983, pp. 25–26) and Demekas and Klinov (1987a); see also the estimates of demand elasticities in the primary and secondary labor market in Colombia in Demekas (1988)).

In the market for goods the equilibrium condition is that the market for home goods clears. In other words

$$\underset{(+)}{D_n(z},\ \underset{(+)}{y)} + g_n = q_n. \tag{7}$$

Since firms in both sectors are on their labor demand curves, equation (4) can be used to write the sectoral supply functions:

$$q_t(\underset{(-)}{\omega^p},\ \underset{(+)}{z}); \qquad \underset{(-)}{q_n(w)}. \tag{8}$$

After substituting equation (8) into (7), the equilibrium condition for the home goods market contains only two endogenous variables, w and z. An equilibrium locus NN can then be defined in the w-z space (see Figure 1) with a slope

$$\frac{dw}{dz}\Big|_{NN} = -\frac{\dfrac{\partial D_n}{\partial z} + \dfrac{\partial D_n}{\partial y}\left[q_n + \dfrac{\omega^p\theta}{z} L_t|\epsilon_t|\right]}{L_n|\epsilon_n|\left[1 - \eta_n \dfrac{q_n}{y}\right]} \tag{9}$$

The condition that home goods be neither inferior nor luxuries ($0 < \eta_n \leq 1$) is sufficient to guarantee that the slope of NN is always negative. This assumption will be maintained throughout this paper.

An autonomous increase in the demand for home goods (dg_n) tends to lower z, and shifts the NN curve to the left. An increase in the primary real wage reduces income and demand for home goods and shifts NN to the right.

The intersection of LL and NN in Figure 1 represents general equilibrium in this model. The real exchange rate and the product wage in the home goods sector are simultaneously determined, and they, in turn, provide a whole range of information about the performance of the economy. The real exchange rate and the rigid primary real wage determine the product wage, employment, and output of the traded goods sector. Employment and output of home goods depend only on w. Income in terms of home goods can then be calculated as $y = q_n + zq_t$. Unemployment is simply

$$U = \overline{L} - L_t(\omega^p, z) - L_n(w) = \underset{(+)(-)}{U(w,\ z)}. \tag{10}$$

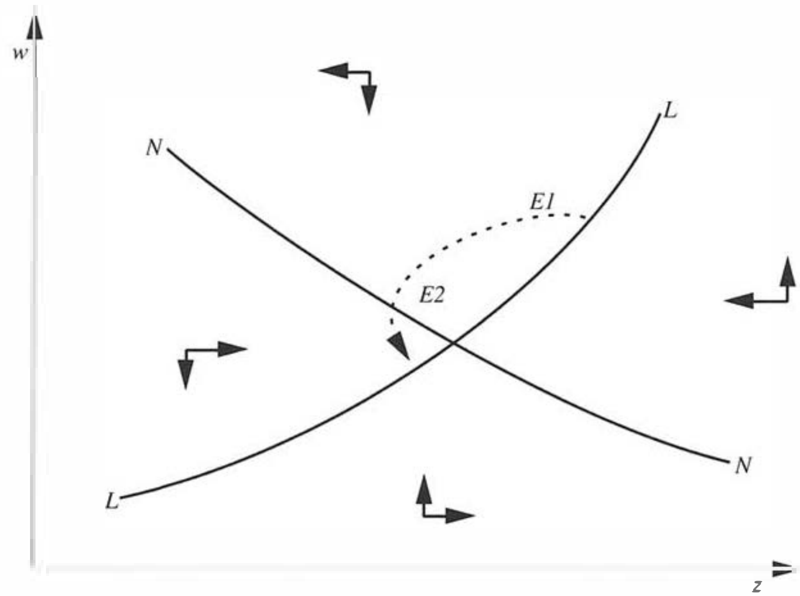
The basic model presented above is very similar to the one used by Neary (1980) and Prachowny (1984). Both assume a perfectly competitive labor market and solve the model graphically in terms of the wage and the relative goods price. Neary then goes on to examine the effects of ad hoc rationing constraints in the labor and the home goods markets. His model, however, cannot be used in the case of a segmented labor market for two reasons: first, the rationing constraints he postulates in the labor market are applied equally across-the-board to all firms; and second, his analysis does not determine a general equilibrium with rationing, but just shows where in the w-z space the equilibrium might appear, depending on to which market the constraints apply.

The model so far determines all the real variables in the system. A monetary sector can be readily added, and the implications of changes in the exogenous variables for the nominal exchange rate (in the case of a flexible exchange rate regime) or international reserves (in the case of a fixed exchange rate regime) can be easily traced. Unless, however, nominal rigidities are introduced in the system and money neutrality is abandoned, the analysis of the monetary sector is not essential for the basic results of the model. For a rigorous treatment of the monetary sector, see Demekas (1990).

Dynamic Stability

Although the previous analysis is static, the equilibrium depicted in Figure 1 can be shown to be locally stable dynamically if the product wage and the home goods price respond positively over time to excess demand in the secondary labor market and the home goods market,

Figure 2. *Dynamic Stability*



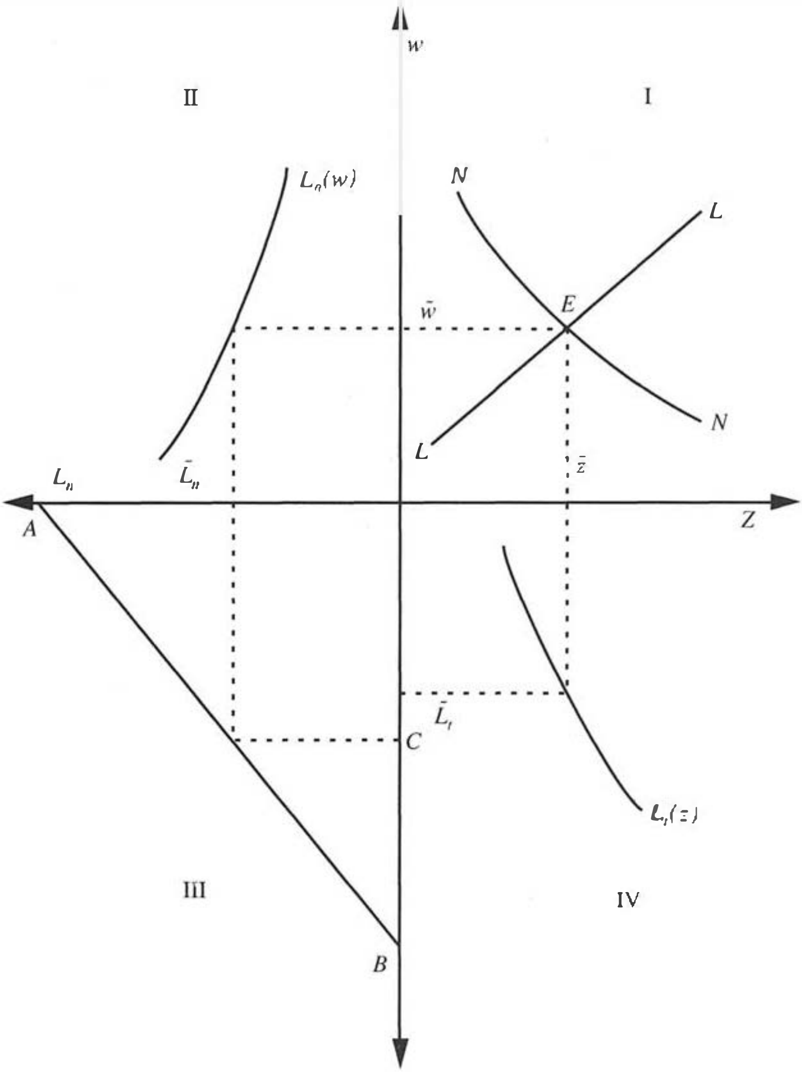
respectively. The arrows in Figure 2 depict the "laws of motion" of the economy. The adjustment path of w and z in general will be counterclockwise. An exogenous increase in the demand for home goods, for example, which, as has been seen, shifts the *NN* curve to the left, will cause the economy to follow the path depicted in Figure 2. In the course of adjustment from $E1$ to $E2$ the economy will undershoot the new equilibrium level of the real exchange rate.

The importance of this dynamic analysis should not be overestimated. Determination of the precise adjustment path for the economy would require specification of adjustment equations for z and w in a dynamic model. In a static model like the one here, the precise shape of the path is essentially a matter of speculation. Even this representation, however, can be useful as an illustration of how the economy would react to shocks that change the equilibrium (w, z) pair.

Determination of Unemployment: A Geometric Analysis

Equation (10) gives an expression for equilibrium unemployment. Figure 3 suggests an intuitive geometric interpretation. Quadrant I is

Figure 3. *Determination of Unemployment*



simply Figure 1. Quadrants II and IV contain the labor demand functions in the home and the traded goods sectors, respectively. The labor demand in the home goods sector is a function of the product wage w, whereas the labor demand in the traded goods sector is a function of z, given the level of the rigid real wage ω^p. Finally, line AB in quadrant III represents the total supply of labor. Equilibrium at E in quadrant I determines $\bar{w}$ and $\bar{z}$, which, in turn, determine $\bar{L}_n$ and, given ω^p, $\bar{L}_t$. Unemployment, then, is simply the segment $\bar{L}_tC$ in quadrant III.

Both equation (10) and Figure 3 highlight the importance of including relative goods price effects in the analysis of unemployment in segmented markets. If these effects are ignored, as in Corden and Findlay's (1975) analysis, for example, an increase in the demand for home goods would cause an increase in the demand for labor in that sector and an unambiguous decline in unemployment. Here the results are ambiguous. When NN shifts to the left, both w and z fall. The first effect tends to increase employment in the home goods sector and, therefore, reduce unemployment. The fall in the relative price of traded goods, however, increases the product wage and reduces demand for labor in that sector. The net effect on unemployment is not clear.

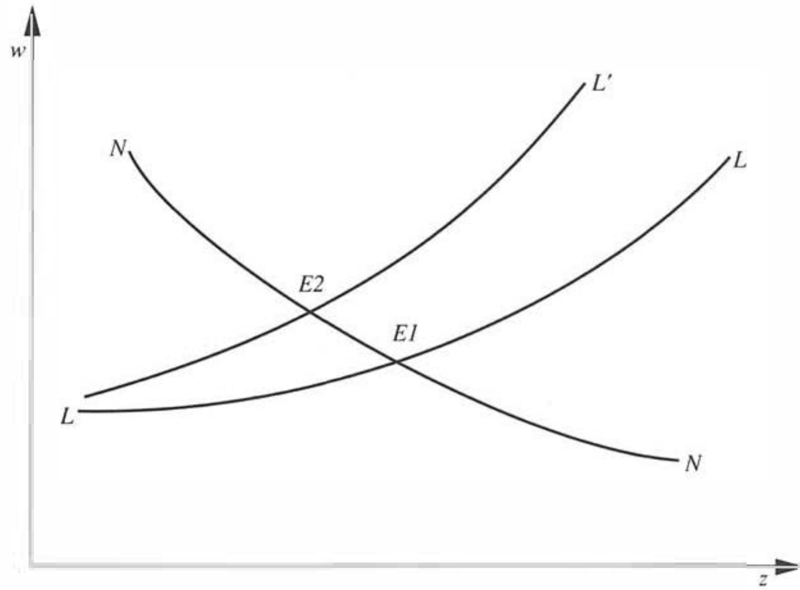
II. Labor Market Policies

In this section specific wage and employment policies are examined in a segmented market framework. Partial equilibrium models, on the one hand, cannot capture the full macroeconomic effects of such policies and, since they ignore relative price movements, may even lead to inaccurate conclusions about the final effect on unemployment. Traditional general equilibrium models with uniform labor markets, on the other hand, cannot be used to evaluate policies that aim to reduce unemployment in a segmented market.

The effects of two different sets of policies, which are common in industrialized and, especially, developing countries, will be examined. First is the expansion of such features as minimum wage laws, job protection, and nonwage labor costs to a larger number of occupations; this essentially turns secondary into primary jobs, increasing the degree of coverage of the primary market. Second is wage restraint in the primary market; in the context of the model, this can be represented by a fall in the primary real wage.

What happens when the number of primary jobs is increased? From equation (5) it follows that if an autonomous increase in L_t occurs, the LL curve shifts up and to the left (Figure 4). At the new equilibrium E_2 the secondary wage is higher and z is lower than before. This happens

Figure 4. *Changes in Primary Job Market Coverage*

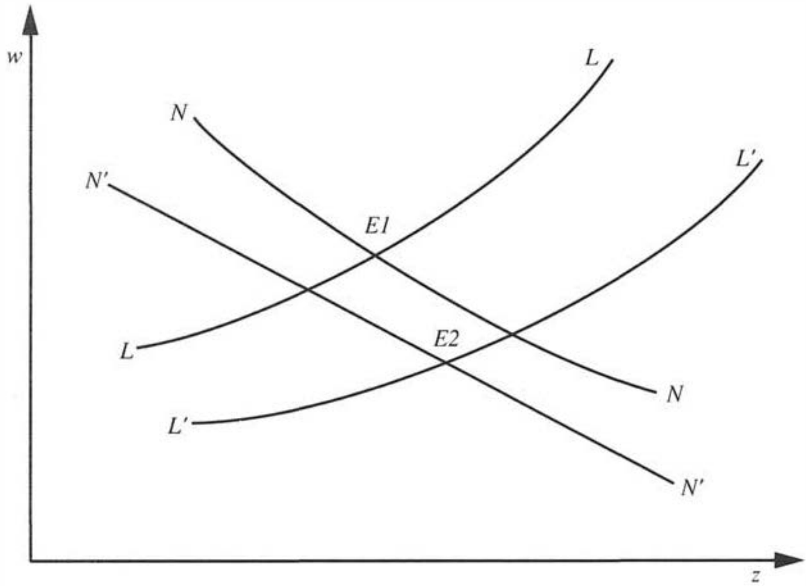


because as the probability of finding primary market employment rises, so does w. Employment and output of the home goods sector, as well as income in terms of home goods, decline. Demand for home goods, then, falls, but by less than supply, because $0 < \eta_n \leq 1$. Excess demand causes the price of home goods to rise and z to fall.

In other words, increasing the degree of primary market coverage leads initially to a higher real wage in the secondary market, a higher product wage in the home goods sector, and higher unemployment. In addition, the real exchange rate appreciates. This discourages production of traded goods, reduces demand for labor in that sector, and exacerbates the problem of unemployment. Partial equilibrium models, which do not capture this "second round" of effects, tend to underestimate the impact on unemployment of increases in the degree of primary market coverage.

Turning now to the case of real wage restraint in the primary market, it is obvious that when ω^p is reduced, both LL and NN are affected. Since the expected gain from queuing for primary jobs is reduced, LL shifts downward. At the same time, since employment and output in the traded goods sector expand, demand for home goods is increased and NN shifts to the left. As seen in Figure 5, both shifts affect the product

Figure 5. *Real Wage Restraint in the Primary Labor Market*



wage in the same direction, but the real exchange rate in different directions. The general equilibrium effects of real wage restraint in the primary market are a decline in the product wage in the home goods sector and an ambiguous (but small) change in the real exchange rate. The real secondary wage, as well as unemployment, falls.

How do these results compare with the results of partial equilibrium analysis? Partial equilibrium models predict that a decline in the primary wage reduces the secondary wage and increases employment and output in both sectors. They fail, however, to capture the income effect that increased output has on the demand for goods and, therefore, underestimate the total effect of real wage restraint on employment creation.

III. Conclusions

A simple model of a small open economy with traded and home goods was developed, with a labor market that is segmented into a primary part, where jobs are rationed, and a secondary part, where the wage clears the market. This distortion causes unemployment, misallocation of labor between the sectors, and affects the real exchange rate defined as the relative price of traded and home goods. The full extent of these effects cannot be captured in either partial equilibrium models of the segmented labor market, where the relative price of goods is taken as given, or traditional two-good general equilibrium models, where the labor market is uniform. The model developed in this paper fills an important gap, especially for the policymaker, who can now evaluate labor market policies more accurately.

The basic model is essentially an "Australian" model with a two-segment labor market, where the primary segment is subject to a rigid real wage. It is assumed, for simplicity, that the traded goods sector corresponds to the primary labor market and the home goods sector to the secondary labor market. At equilibrium, which can be given a simple geometric representation, the product wage in the home goods sector and the real exchange rate are simultaneously determined. These two variables, in turn, determine all the other real variables in the system. Moreover, although the model is static, it can be shown to be dynamically stable and its dynamic properties can be analyzed heuristically. Finally, a monetary sector can be easily added; since no nominal rigidities are postulated, however, it simply determines the price level and has no real effects.

The model is used to examine the effects of two very common labor market policies. First, it is shown that increasing the degree of primary market coverage (turning secondary into primary jobs) leads to a higher secondary wage, higher unemployment, and real exchange rate appreciation. The analysis suggests a possibility so far overlooked in traditional macroeconomic models: that labor market segmentation can be a contributing factor to an overvalued real exchange rate, as defined for the purposes of this paper.

Second, it is shown that real wage restraint in the primary market reduces the secondary wage and promotes employment creation in both sectors. Although real wage restraint cannot eliminate unemployment, its positive effects are larger than partial equilibrium analysis suggests. The effect on the real exchange rate is ambiguous but probably very small.

These conclusions fit in very well with the recent experience of some developing countries. As a result of "rationalizing" the labor markets, the application and coverage of minimum wage legislation, job protection, and nonwage labor costs have been extended to large numbers of workers. However, in order to encourage employment creation and reduce "unfair" wage differentials, governments have followed a policy of real wage restraint for high wage earners. This policy has been partly successful: wage differentials have shrunk and average real wages have remained stable or have increased less than productivity (see, for example, the surveys in Squire (1981), Johnson (1986), and Demekas and Klinov (1987b)). Unemployment, however, has persisted, and at the same time, many of these countries have experienced difficulties changing the structure of relative prices so as to promote exports and reduce external imbalances.

The combination of these events is exactly what one would expect in the model developed here if both an increasing degree of primary market coverage and real wage restraint are pursued at the same time. The two policies have opposing effects on the secondary wage, which means that wage differentials will shrink and the average wage will fall. They also have opposing effects on unemployment, which explains its persistence. The net effect on the real exchange rate, however, will probably be an appreciation. In this way, the model presented in this paper highlights the effects the structure of the labor market and labor market policies may have on the macroeconomy.

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Shorter Papers and Comments

The Risk Premium on Italian Government Debt, 1976–88

CARLO COTTARELLI and MAURO MECAGNI*

The behavior of the yield differential between government and nongovernment bonds in Italy between 1976 and 1988 is considered. The trend increase of the differential in this period was significantly influenced by the deterioration of public finances, as reflected both by an increase in the supply of government paper relative to nongovernment paper and by a worsening of selected default-risk indicators. The effect of relative supply factors, in turn, was found to be statistically more robust and quantitatively more important than that of risk indicators in explaining movements in yield differentials. [JEL 311, 313, 321]

In many countries government liabilities are considered the archetypal risk-free asset. Financial market studies therefore use the yield on government paper as a benchmark to measure against the yield of private bonds, pointing to the existence of default risks on private bonds as the reason for the frequently observed yield differential. Under conditions of high and persistent imbalances in public sector finances, however, this assumption requires some revision. As public debt increases, the market may start wondering how the intertemporal budget constraint of the government will be respected, and the possibility of government "default" may be explicitly considered.

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A case in point is provided by the Italian experience between 1976 and 1988. From the mid-1970s to the end of the 1980s public debt in relation to gross domestic product (GDP) rose from 50 percent to 100 percent. With the burden of interest payments becoming progressively heavier (reaching 80 percent of the deficit in 1989), several questions have arisen about the existence of a "debt problem" and the possible use of extraordinary measures to solve it, including forms of partial repudiation. Has the risk of default, a term which we define here as also including milder forms of repudiation, already been discounted by the market? Is that risk partially responsible for the current high level of real rates on Italian government paper? Is it perceived as being related to the size of the deficit or the debt or both?

Despite the importance of the issue, indications of the existence of a default-risk premium on the Italian Government's debt are almost exclusively anecdotal. Although increasing deficits have been shown to have a positive effect on the *level* of real rates (see Modigliani and Jappelli (1988)), this is not proof of an increase in issuer-specific risk premium, since rising deficits may affect real rates without affecting the risk premium.[1]

An increasing risk premium on government paper should be signaled by a rise in the yield *differential* between government and nongovernment assets that are comparable in terms of currency denomination, maturity, and liquidity. In order to assess the existence of a default-risk premium, we analyze the yield differential between fixed-coupon, medium-term paper (BTPs) issued by the government and by Special Credit Institutions (SCIs), the major nongovernment issuer of bonds in Italy.[2] The value of this differential, computed on bonds of equal maturity, turned from negative to positive between the 1970s and 1980s. This finding alone does not necessarily imply an increasing risk premium, however, since changes in *relative supply* can explain changes in the yield

[1] Indeed, if Ricardian equivalence does not hold, an increase in the deficit (and/or the debt) will tend to increase aggregate demand and the real interest rate for given resources and/or money. In addition, increasing deficits and debt could affect real rates by increasing the "currency-specific" risk premium; an accumulation of debt may increase the likelihood of future monetization and inflation and may push up interest rates on all assets (public and private) denominated in the risky currency.

[2] SCIs are financial intermediaries specializing in long-term credit for industrial and real estate investment. Although many of these institutions are public entities, they are largely independent from the government and have their own capital endowment and legal status; their assets are represented mainly by loans to the private sector, and their bonds are rated independently of those of the government.

differential between assets that are *imperfect substitutes.*[3] Therefore, an interpretation of the observed change in the yield differential requires a comprehensive econometric analysis allowing for separate effects of default-risk indicators, of relative supply effects, and of institutional constraints.

I. Theoretical Underpinnings and Stylized Facts

The empirical model for the yield differential considered in this paper can be derived from the mean-variance approach to portfolio choice. Under simplifying assumptions (most notably on the separability of portfolio decisions), and allowing for different propensities to accept the risk of banks and of the nonbank public, the expected yield differential between BTPs and SCI bonds can be expressed as follows (see Cottarelli and Mecagni (1990)):

$$\delta^e = \phi_0 + \phi_1 q_g + \phi_2 h + \phi_3 \frac{P^*}{B} \frac{P^*}{P^b}. \tag{1}$$

In equation (1) the differential is a function of the supply of BTPs relative to the total supply of BTPs and SCI bonds (q_g),[4] the bond distribution between the nonbank public and banks (h), and a measure of the constraint imposed on portfolio choices by the 1973–86 investment requirement forcing banks to purchase SCI bonds, $(P^*/B)(P^*/P_p)$.[5] In principle, even under the assumption of time-invariant preferences, the

[3]The hypothesis that BTPs and SCI bonds behaved as imperfect substitutes during the period under consideration is sustained here by three arguments. First, during most of the period, a portfolio investment requirement forced banks to purchase SCI bonds, thus reducing their yield and, possibly, their yield variance. Second, although the relative default risk may not have changed in the period, a constant difference in the *level* of risk is in itself sufficient to induce imperfect substitutability. Third, and most important, the imperfections of Italian bond markets are likely to have deeply influenced the relative liquidity of the two assets and the variance-covariance matrix of their returns, particularly their yield correlation.

[4]The expected yield differential δ^e required by the market increases with q_g. This increase will henceforth be referred to as "relative supply effect," although, in a mean-variance context it should be interpreted as a risk premium, since it corresponds to the increase in the expected yield differential required to move investors away from the minimum-variance portfolio—that is, to accept a higher risk; indeed, δ^e is zero only when the relative market supply of the two assets corresponds to the minimum-variance portfolio.

[5]The regulation on the investment requirement changed over time and became progressively less relevant. In equation (1) the effect of the constraint is considered to be larger, the larger is the investment requirement in relation to the total demand of SCI bonds by banks (P^*/P^b) and in relation to the size of the bond market (P^*/B).

model parameters ϕ_0, ϕ_1, and ϕ_2 should change over time, since they depend on the variance-covariance matrix of yields (which changes in time if default risks change) and on the strength of the portfolio constraints. Indeed, it can be shown that the coefficients tend to increase, in absolute value, the more binding is the portfolio constraint.[6]

In the presence of default risk, the expected yields on the two assets can be expressed as the sum of expected yields in the absence of default (r_g^{Ne} and r_p^{Ne}) minus the expected cost of default:

$$E(r_g) = r_g^{Ne} - p_g t_g \qquad E(r_p) = r_p^{Ne} - p_p t_p, \tag{2}$$

where p_g and p_p are the probabilities of default, and t_g and t_p are the costs of default, respectively, for BTPs and SCI bonds. Recalling that $\delta^e = E(r_g) - E(r_p)$, and by substituting equation (2) into equation (1), we obtain

$$\delta = \phi_0 + \phi_1 q_g + \phi_2 h + \phi_3 \frac{P^*}{B}\frac{P^*}{P^b} + p_g t_g - p_p t_p. \tag{3}$$

Equation (3) shows that δ, the yield differential computed under the hypothesis of no default ($\delta = r_g^{Ne} - r_p^{Ne}$), is a function of the expected differential cost of default ($p_g t_g - p_p t_p$). The default probabilities p_g and p_p are not observed; while we assume that p_p was constant in the period under consideration,[7] we correlate the probability of default on BTPs to a set of indicators of fiscal performance that could trigger confidence crises. Recent research (Alesina, Prati, and Tabellini (1989) and Giavazzi and Pagano (1989)) has suggested two variables that in the past may have significantly affected investors' confidence in Italian Government paper: the maturity of the debt, and the amount of debt that comes to maturity in each period.[8] It is plausible to add to these variables two fiscal policy indicators on which public opinion usually focuses: the ratio of the deficit to GDP and the ratio of the debt to GDP. We therefore assume that

$$p_g = \lambda_0 + \lambda_1 m + \lambda_2 \frac{MA}{D} + \lambda_3 \frac{DF}{Y} + \lambda_4 \frac{D}{Y}$$

$$\lambda_1 < 0,\ \lambda_2 > 0,\ \lambda_3 > 0,\ \lambda_4 > 0, \tag{4}$$

[6] Intuitively, the increase in the coefficients occurs because the demand curves for BTPs and SCI bonds become less elastic to changes in the yield differential; consequently, a larger change in the differential is required to accommodate a shift in supply composition.

[7] This is a reasonable assumption, since the profitability and capital adequacy of SCIs remained satisfactory throughout the period.

[8] In this context, the probability of a "confidence crisis" is higher when the maturity of the debt is short and when a larger amount of debt comes to maturity in each period.

where m is the average maturity of government debt, MA is the amount of debt coming to maturity in the period, DF is the deficit, Y is GDP, and D is the stock of public debt. By substituting equation (4) into (3), we obtain an equation relating the yield differential to the distribution of bonds between households and banks, to the relative supply of government paper, to the investment requirement, and to default-risk indicators:[9]

$$\delta = \phi_0' + \phi_1 q_g + \phi_2 h + \phi_3 \frac{P^*}{B}\frac{P^*}{P^b} + \phi_4 m + \phi_5 \frac{MA}{D} + \phi_6 \frac{DF}{Y} + \phi_7 \frac{D}{Y}, \qquad (5)$$

where

$$\phi_0' = \phi_0 + t_g\lambda_0 - p_p t_p \qquad \phi_4 = t_g\lambda_1 \qquad \phi_5 = t_g\lambda_2$$

$$\phi_6 = t_g\lambda_3 \qquad \phi_7 = t_g\lambda_4.$$

The sign of the coefficients is expected to be positive for ϕ_1, ϕ_3, ϕ_5, ϕ_6, and ϕ_7, and negative for ϕ_4; the sign of ϕ_2 is not determined a priori, depending on the relative propensity of households and banks to purchase government paper (that is, on their relative risk aversion).

The evidence depicted in Figure 1 is consistent with the model. As the net value of tax differential between the average yield of the outstanding stock of BTPs and SCI bonds turned from negative to positive between the 1970s and the 1980s (top panel, solid line), the relative supply of BTPs rose rapidly (central panel), and the above-mentioned risk indicators, especially the public debt and deficit ratios, deteriorated. The differential dropped in 1987–88, following the removal of the above-mentioned investment requirement (bottom panel). This decline proved to be temporary, and the differential rose again, reaching 50 basis points in the first quarter of 1990.

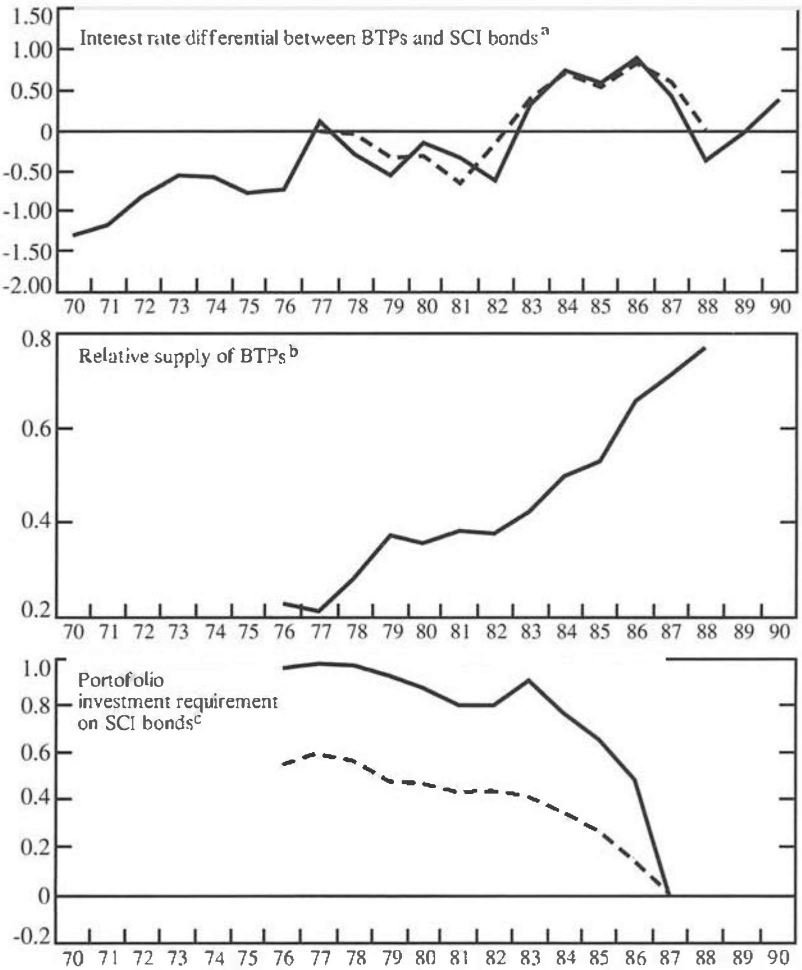
II. Econometric Estimates

Because changes in the average maturity of BTPs and SCI bonds may have heavily influenced the movements of the average yield differentials, the econometric analysis presented in this section was based on differen-

[9] We have already observed that what we call "relative supply effect" could be seen as a component of the risk premium; strictly speaking, what we call "risk factors" should be seen as factors affecting the *expected return* of government bonds, not the variance (that is, the portfolio risk).

Figure 1. *Interest Rate Differentials, Relative Supply of BTPs, and Portfolio Investment Requirement on SCI Bonds, 1970–90*

(Annual average)



Source: Bank of Italy, *Bolletino Statistico* (various issues).

[a]Yield to maturity differential between BTPs and Special Credit Institutions (SCI) bonds (industrial credit). The dashed line refers to the average differential computed on bonds of equal maturity; the figure for 1990 refers to the first quarter.

[b]Ratio of the stock of BTPs to the stock of total nonindexed bonds.

[c]The solid line refers to the minimum investment requirement in SCI bonds over total SCI bonds held by banks. The dashed line refers to the minimum investment requirement in SCI bonds over total SCI bonds and BTPs held by the market.

tials measured on bonds of the same residual maturity.[10] Our sample covers 49 quarters (from 1976:4 to 1988:4), with a total of 457 observations. The annual averages of these observations are plotted in Figure 1 (top panel, dashed line); the data adjusted for maturity differences confirm the trend increase observed on unadjusted data.

The individual observations on the yield differential, adjusted for expected inflation, were then regressed on the variables on the right-hand side of equation (5), and on the maturity of each differential. The estimated equation was

$$\delta_{nt} = X_t'\Phi + \phi_9 f_{nt} + \eta_{nt}, \tag{6}$$

where the subscript nt refers to the differential computed on the nth BTP (that is, a certain BTP issue) observed at time t; X_t' is the matrix containing, together with the constant, the seven time-varying regressors included in equation (5); Φ is the vector of coefficients on these regressors; f_{nt} is the residual maturity (in months) of each BTP issue at time t; and η_{nt} is a stochastic error term. Note that ϕ_9 cannot be signed a priori and will depend on the relative slope of the term structure of the two different types of bonds.

The estimate of equation (6) was based on a set of simplifying assumptions: first, all parameters were assumed to be time invariant, although the analysis of Section I suggested that they might be time dependent. Second, zero correlation was assumed between the error term and the regressors.[11] Finally, it was assumed that

$$E(\eta_{nt}) = 0 \quad E(\eta_{nt}^2) = \sigma_{jt}^2 = \sigma_{it}^2 \quad E(\eta_{it}, \eta_{jt}) = 0 \qquad \text{for } i \neq j \tag{7}$$

$$E(\eta_{nt}^2) \neq E(\eta_{ns}^2) \qquad \text{for } s \neq t. \tag{8}$$

[10] Although the term "maturity" will be used here for brevity, the average residual life was considered to allow for different amortization plans of BTPs and SCI bonds. The following procedure was used to derive the maturity-adjusted yield differentials: the yield of individual SCI bonds and BTPs was first collected on a quarterly basis from 1976 to 1988. A linear interpolation of SCI bond yields was then computed for each quarter. This interpolation served two purposes: first, it provided an estimate of SCI bond yields for maturities for which no SCI issue was outstanding; second, it helped to remove the high "noise" in individual SCI bond yields probably connected to market imperfections and to the small outstanding amount of each SCI bond issue. The differentials between the yield on each BTP issue and the corresponding interpolated yield were computed: thus, for each quarter, the number of available observations on the yield differential is equal to the number of outstanding BTP issues.

[11] In this respect, the main reason for the inclusion of an error term in equation (6) is associated with the existence of a random disturbance in the demand for government bonds. Therefore, unless the relative supply of government bonds (q_g) is independent of demand conditions, q_g in equation (6) is likely to be correlated with η_{nt}. Since $q_g = G/(P + G)$, even if we assume that G (the supply of

Table 1. *Panel Data Estimates of the Equation of the Real Yield Differential*

Variable	Equation (A)	Equation (B)	Equation (C)	Equation (D)	Equation (E)	Equation (F)	Equation (G)	Equation (H)	Equation (I)
Constant	−7.70	−7.68	−7.47	−7.05	−7.41	−7.81	−7.37	−4.69	−7.04
	(−23.61)	(−24.69)	(−26.50)	(−21.50)	(−22.12)	(−24.23)	(−17.91)	(−18.77)	(−22.27)
Bond distribution	0.48	—	—	—	—	3.64	—	—	—
(h)	(0.73)					(6.98)			
Relative supply	7.21	7.24	7.79	4.91	5.16	5.35	—	6.42	4.92
(q_g)	(13.33)	(15.42)	(25.83)	(10.84)	(11.25)	(11.57)		(20.81)	(11.08)
Portfolio constraint[a]	0.068	0.067	0.066	0.063	0.069	0.076	0.053	0.054	0.063
$(P^*/B)/(P^*/P^h)_{-3}$	(21.26)	(26.91)	(26.76)	(23.49)	(23.56)	(26.06)	(20.77)	(20.52)	(24.17)
Debt maturity (m)	0.32	0.33	0.36	—	—	—	—	—	—
	(7.14)	(9.99)	(12.50)						
Maturing debt	13.63	13.48	13.47	8.40	8.86	11.41	9.14	—	8.35
(MA/D)	(7.94)	(7.90)	(7.94)	(5.07)	(5.42)	(6.91)	(4.39)		(5.27)
Deficit ratio (DF/Y)	0.20	—	—	—	−2.64	—	—	—	—
	(0.24)				(−3.44)				
Debt ratio (D/Y)	0.13	0.21	—	0.89	1.03	0.28	2.01	—	0.89
	(0.84)	(1.60)		(8.51)	(8.52)	(2.20)	(19.89)		(8.85)
BTP maturity (f_n)	−0.0075	−0.0075	−0.0079	−0.0069	−0.0074	−0.0071	−0.0060	−0.0123	−0.0069
	(−7.69)	(−7.77)	(−8.56)	(−7.14)	(−7.57)	(−7.30)	(−4.80)	(−13.54)	(−7.17)
$\bar{R}^2$	0.743	0.744	0.747	0.718	0.719	0.718	0.620	0.671	0.719
Standard error	0.28	0.28	0.28	0.27	0.28	0.28	0.32	0.25	0.27
Convergence indicator[b]	16.6	5.6	0.1	0.3	0.5	11.7	0.5	0.02	0.02

Note: Estimated by GLS; 1976:4 to 1988:4; 457 observations. The figures in parentheses are t-statistics, and $\bar{R}^2$ is the adjusted coefficient of determination.

[a]The portfolio constraint index is introduced in the equations with a three-quarter lag (see Cottarelli and Mecagni (1990)).

[b]Largest percentage change of coefficients between the ninth and tenth iteration (in absolute terms). All equations (except equation (I)) include three seasonal dummies and a dummy on one BTP issue between the first quarter of 1981 and the second quarter of 1982; equation (I) includes only a seasonal dummy (in the second quarter) and the 1981–82 dummy.

These equations imply that the variance of the error term is allowed to vary over time but is assumed to be the same for all observations in the same quarter; in addition, the covariance between disturbances related to different observations is assumed to be equal to zero.

Due to the heteroscedastic nature of its stochastic term, equation (6) was estimated by generalized least squares (GLS).[12] The results presented in equation (A) of Table 1 are broadly consistent with the theoretical model of Section II, with only one coefficient (on the average maturity of the debt) having the wrong sign.[13] However, the estimates tend to converge rather slowly; as shown in the last row of the table, after ten iterations, at least one coefficient still changes by more than 16 percent. To overcome this problem, which is likely due to high collinearity among regressors, in equation (B), the two variables with lowest t-statistics (that is, the bond distribution and the deficit ratio) are omitted; the convergence indicator improves, but convergence is still not obtained after ten iterations.

Convergence is achieved in specifications (C) and (D). In specification (C) the ratio of debt to GDP is omitted without loss in terms of goodness

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BTPs) is exogenous, P (the supply of SCI bonds) is likely to be affected by the level of interest rates; finally, when the portfolio model of Section I is included in a macroeconomic model of the economy, it is clear that the interest rate levels, the yield differential, and P (and hence, q_g) are determined simultaneously, and that q_g is therefore likely to be correlated with η_{nt}. In what follows, however, we assume that at the quarterly level considered here, the composition of supply is not affected by the level of interest rates and that a random shock in the demand for government bonds is therefore entirely reflected in changes in the yield differential. This assumption is sustained by the long lags characterizing the supply response of SCI bonds to changes in the level of interest rates, due to the lagged response of investments and lengthy administrative procedures in the issue of SCI bonds.

[12]To improve efficiency in finite samples, an iterative estimation procedure was implemented. The variance-covariance matrix, initially obtained from ordinary-least-squares (OLS) residuals, was re-estimated based on the GLS estimates, producing residuals then used in a second GLS estimate; all results in Table 1 refer to the tenth iteration. Seasonal dummies were included because of the seasonality of some regressors. A dummy on the differential on one BTP issue between 1981:1 and 1982:2 was also included. The coefficient on this dummy turned out to be very high (between 200 and 300 basis points in all specifications) and was probably due to a measurement error, which was removed in the third quarter of 1982.

[13] As mentioned above, the coefficient on f_{nt} (the maturity of the BTP on which the differential is computed) cannot be signed a priori; the fact that this coefficient is always negative in the estimates implies that the term of structure of interest rates, in the sample average, rises more steeply (or declines more gradually) for SCI bonds than for BTPs. This feature may be connected to differences in the relative supply of BTPs and SCI bonds along the maturity axis. Indeed, the supply of BTPs was always relatively larger on shorter maturities.

of fit; however, the sign of the coefficient of the debt maturity is still positive. The debt-to-GDP ratio is reintroduced in specification (D), and the debt maturity is excluded, with a small decline in the adjusted R^2 and a slight improvement in the standard error of the equation. Clearly, there are no statistical grounds for preferring specification (D) over specification (C); however, the signs of the coefficients of the former are consistent with the theoretical model, and the magnitude of the coefficients also appears more plausible (see below). No improvement is obtained by reintroducing the deficit ratio (specification (E)) and the bond distribution (specification (F)): in specification (E) the deficit ratio is now significant but has the wrong sign; and specification (F) does not achieve convergence. Starting again from (D), specifications (G) and (H) were estimated to evaluate the relative importance of relative supply vis-à-vis risk indicators, by removing them in turn. Both factors seem relevant, since both equations (G) and (F) are worse in terms of goodness of fit with respect to equation (D). However, the deterioration is more evident when supply factors are removed; indeed, the specification without risk factors, although having a lower adjusted R^2 than equation (D), has the lowest standard error of all the specifications and converges rapidly. Finally, in equation (I) the statistically nonsignificant seasonal dummies included in equation (D) are removed without relevant changes in the results.

Given the characteristics of the incomplete panel data used for the regressions, the usual diagnostic tests, particularly those on residual autocorrelation, cannot be applied to the regressions presented in Table 1.[14] To circumvent this obstacle, and also as a check on the results discussed so far, equation (I) was re-estimated on aggregate data obtained by averaging the cross-sectional observations for each time period. Consistent with the specification of the error term in equation (8), the aggregate data equation was also estimated by GLS, weighting the observations with an estimate of the (time-varying) variance of the disturbances computed from the residuals of the corresponding panel data estimates. The GLS estimates (Table 2, first column) are remarkably similar to those obtained from the panel data, the main difference being the loss of significance on the coefficient on the BTP maturity; the high level of the

[14] There are n_t residuals for each period, but it is not clear what should be considered the lagged value of each residual: the residual on an interest rate differential of the same maturity in the previous period would be economically meaningful but is almost never observed, while the use of the residual on the same BTP issue observed in the previous period (that is, on the residual on the BTP characterized by a specific serial number) could hardly be explained in economic terms.

Table 2. *Aggregate Data Estimates of the Equation of the Real Yield Differential*

(1976:4–1988:4)

Variable	Equation (I)		Equation (H)	
	GLS	GLS[a]	GLS	GLS[a]
Constant	−6.39	−6.34	−4.02	−5.72
	(−4.87)	(−3.66)	(−6.99)	(−6.31)
Relative supply	4.28	8.59	5.70	7.27
(q_g)	(3.57)	(6.87)	(8.70)	(7.31)
Portfolio constraint[b]	0.056	0.070	0.047	0.063
$(P^*/B)(P^*/P^h)_{-3}$	(8.59)	(6.43)	(7.89)	(6.73)
Maturing debt	6.97	−0.46	—	—
(MA/D)	(2.54)	(−0.13)		
Debt ratio	0.86	−0.02	—	—
(D/Y)	(1.85)	(−0.004)		
BTP maturity	−0.0061	−0.0063	−0.016	−0.0038
$(1/n \, \Sigma_n f_n)$	(0.61)	(−0.47)	(−4.61)	(−0.45)
$\bar{R}^2$	0.879	0.642	0.835	0.761
Standard error	0.14	0.16	0.13	0.13
Durbin-Watson	1.29	1.96	1.17	2.04
Residual autocorrelation coefficient	—	0.68	—	0.70
		(6.45)		(6.75)

Note: Figures in parentheses are t-statistics; $\bar{R}^2$ is the adjusted coefficient of determination.

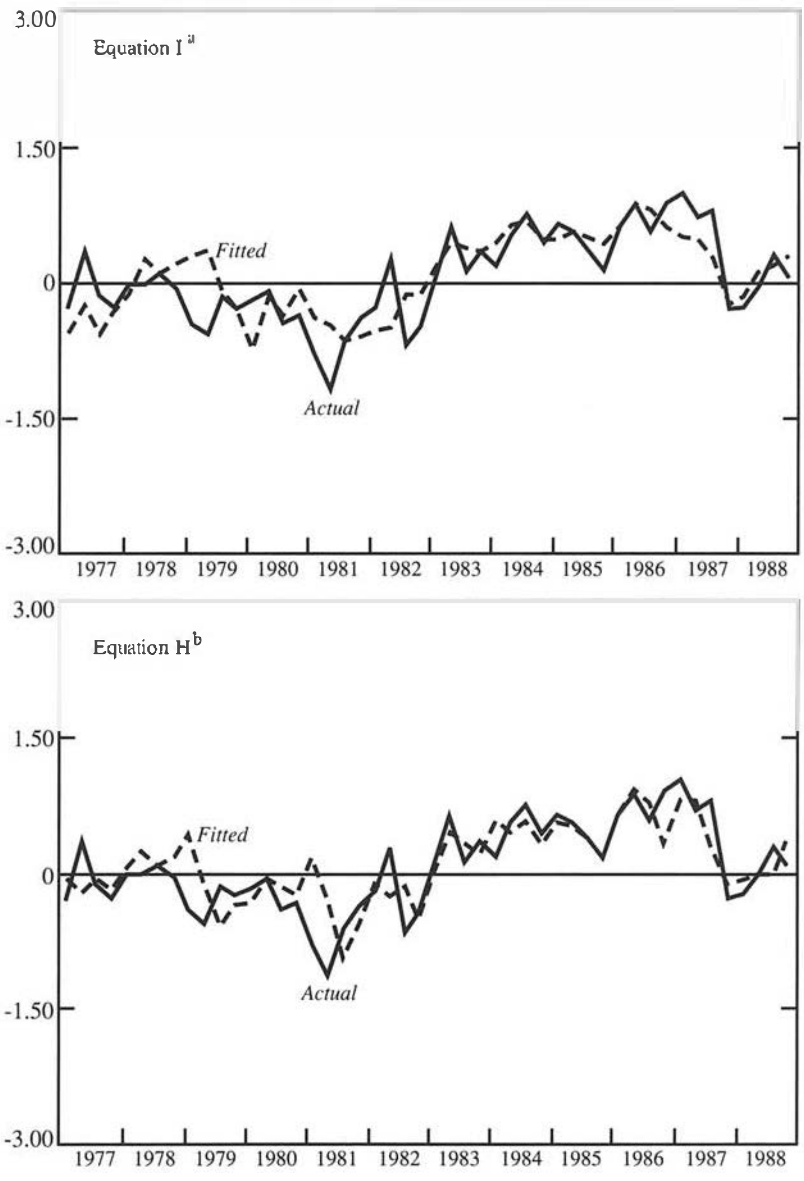
[a] Adjusted for first-order residual correlation with the Cochrane-Orcutt technique.

[b] The portfolio constraint is introduced in the equations with a three-quarter lag (see Cottarelli and Mecagni (1990)).

adjusted R^2 and the inspection of actual and fitted values (Figure 2, top panel) confirm that the model is able to reproduce the main movements of the differential. However, the Durbin-Watson (DW) test signals the presence of serial autocorrelation, which may be indicative of some misspecification.[15] As a first check, the equation was re-estimated with the Cochrane-Orcutt technique (second column); after this correction, the coefficients on the risk factors collapse, while the opposite occurs to the coefficient of relative supply.

[15] In order to check for the possibility that the autocorrelation of the residuals could be a symptom of spurious regression among nonstationary variables, Phillips-Perron unit root tests were applied to the variables used in the GLS estimation procedures. For all weighted time series, the presence of a unit root was always decisively rejected.

Figure 2. *Estimated Equations for Real Yield Differential Between BTPs and SCI Bonds, 1977:1 to 1988:4*



[a] GLS aggregate data estimates not adjusted for serial correlation.
[b] GLS aggregate data estimates adjusted for serial correlation.

On account of these results, equation (H) (which excludes the risk factors) was also estimated on aggregate data. The new estimates (Table 2, third column) show that, since the DW statistic remains low, the presence of risk factors was not the reason for the serial correlation. The adjustment for serial correlation (Table 2, last column) reduces the value and the significance of the coefficient on the BTP maturity but does not substantially alter the other coefficients, which remain close to those of the corresponding panel data estimates; actual and fitted values for this equation are plotted in Figure 2 (lower panel).

The presence of serial correlation in the OLS and GLS aggregate estimates, and possibly also in the corresponding panel data estimates, may be due to several reasons. The first is the static nature of the estimated regressions. The relevance of this factor was confirmed by computing the common factor test for equation (H) of Table 2. The value of the test statistics was 3.20 against a critical value of 9.49 of the χ^2-distribution at the 5 percent probability level. Thus, the hypothesis that the correction for autocorrelation is, in our empirical model, a convenient simplification for a more complex dynamic process cannot be rejected.

An additional reason for autocorrelated residuals may be the imposition of time-invariant parameters on a data-generating process characterized by coefficients varying over time, a concrete possibility, given the discussion in Section I. The stability of the coefficients in the disaggregated equations (I) and (H) in Table 1 was, therefore, checked by recursive GLS. Mixed indications were obtained: while both point and interval estimates for the entire sample and their profiles during the recursions remained approximately within the initial confidence intervals in most cases, for some parameters the assumption of invariance over time appeared questionable.[16] Formal Chow tests for the equality of parameters in the two subsamples 1976:4–1983:3 and 1983:2–1988:4 *rejected* the null of parameter invariance for both specifications. Although indicative, these results should be considered with caution, since the Chow-test distribution is known to be sensitive to the restrictive assumptions of nonstochastic regressors, and of normality and independence of the disturbances. The recursive estimation procedure was therefore also applied to equation (H) on aggregate data, for which the corrections for heteroscedasticity and first-order serial correlation make

[16] In equation (I) the response parameter of the real interest rate differential to the debt-to-GDP ratio was not statistically different from zero in samples until approximately the end of 1983; with the addition of the most recent information, the parameter increased in value and precision. Similarly, in equation (H), the increasing sample size coincided with a gradual increase in value of the relative supply parameter.

more appropriate the application of Chow tests. In this case, the hypothesis of parameter constancy was always *accepted* at the 5 percent level. Even in this instance, however, the addition of the most recent information was accompanied by an increasing value and significance of the relative supply parameter.[17]

In conclusion, the available empirical evidence seems to confirm the relevance of supply effects, risk indicators, and institutional constraints in explaining the movements in the yield differential between government and SCI bonds, while the relevance of the bond distribution between banks and the nonbank public is not confirmed. The evidence also suggests that supply factors were more important than risk indicators; indeed, the simple specification (H) of Tables 1 and 2, which excludes risk indicators, seems to describe adequately the behavior of the yield differential and passes the statistical diagnostic tests.

As to the multipliers implicit in the point estimates, the effect on the differential of a change in the public debt of Lit 10 trillion at the end of 1988 (around 1 percent of total debt and also of GDP), one third of which was financed by the issuance of BTPs, was computed from equations (I) and (H) of Tables 1 and 2. Although the various specifications differ in the split of the total effect between risk and supply factors, the overall effect appears to be close to *20 basis points* in all specifications. Note also that the specifications in which risk factors are present indicate that 80 percent of the overall effect is due to a change in the relative supply of assets.[18]

[17] To allow, at least partially, for time dependence of the parameters, equation (I) was re-estimated on aggregate data by entering the debt ratio in a nonlinear fashion. Indeed, the perception of risk may be connected nonlinearly to public imbalance indicators: increases in the debt-to-GDP ratio may be considered irrelevant when the ratio is low but may attract attention when the ratio is already high. In order to explore this possibility, the response parameter of the debt-to-GDP ratio was allowed to vary according to a logistic function of the level of the ratio itself. The results did not improve upon those presented in Table 2. The significance of relative supply and of the portfolio constraint was confirmed, but the estimates for the debt ratio parameter and for the parameters of the logistic curve were statistically insignificant and nonrobust to selected starting values in sensitivity analysis. Although informative, this attempt to model nonlinearities is by no means conclusive; more attention will have to be dedicated in future research to alternative estimation methods involving switching regimes.

[18] The estimate of the effect of changes in the relative supply may appear large and would imply low substitutability between BTPs and SCI bonds of the same maturity. However, as already mentioned, the estimates presented in this paper reflect the dominance in the sample of the portfolio constraint that reduced the substitutability between the two types of bonds; as a consequence, the estimates presented here tend to *overestimate* the effect on the yield differential of changes in relative supply (and indeed of risk factors as well) in the absence of a portfolio constraint. For a better appreciation of the relative importance of relative supply

III. Conclusions

This paper presented econometric evidence on determinants of the movements of the real yield differential between government and non-government paper in Italy. We showed that the increase in the differential observed between the middle of the 1970s and the end of the 1980s was heavily influenced by the deterioration of public finances. This deterioration affected the differential in two ways: first, through an increase in the relative supply of government bonds with respect to SCI bonds, in the context of imperfect substitutability between the two assets; and second, through an increase in the default-risk premium, reflected by changes in selected default-risk indicators (specifically, the ratio of debt to GDP and the share of maturing debt over total debt). However, relative supply factors were also found to be statistically more robust and quantitatively more important than risk indicators in explaining the trend increase in the differential. These conclusions appeared to be robust with respect to changes in the specification of the estimated equation, use of aggregate versus panel data, and different estimation techniques. Some caveats are nonetheless required: the analysis allowed only partially for time dependence of parameters—a likely occurrence in light of the theoretical discussion. Moreover, during the period considered in this paper, market behavior was distorted by an investment requirement on bank portfolios; since the constraint reduced the elasticity of portfolio shares to changes in the interest rate differentials in the sample period, the absolute values of the parameters reflecting the effect of supply and risk factors on the differential were probably overestimated.

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and risk factors in explaining the movements in the yield differential, the decomposition of the change in the differential between the beginning and the end of the sample period was also computed. Again, all specifications agreed that the overall effect of supply and risk factors was close to 400 basis points; when risk factors were present, they were estimated to account for one third of the overall effect, mainly as a consequence of the increase in the debt ratio. The effect on the yield differential of supply and risk factors was largely offset by the removal of the portfolio constraint, which allowed a decline in the yield differential of over 300 basis points.

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IMF *Staff Papers*
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The Effect of Government Debt on Short-Term Real Interest Rates

Comment on Findlay

PETER S. SPIRO*

IN A RECENT article in this journal, David W. Findlay reviews further empirical evidence on the effects of government deficits on interest rates. Quoting Spiro (1987) from three years earlier, Findlay concludes that these effects are as "elusive as ever" (1990, p. 438).

I would suggest that the situation is not quite as bleak as that assessment appears to make it. There is a growing realization that fiscal policy can have a variety of effects on different interest rates. A significant amount of empirical evidence indicates that current deficits do affect long-term bond yields, as noted in an exhaustive survey of the literature by Barth and others (1989, p. 55). Spiro (1989, pp. 59–62) concludes that these results are consistent with an interpretation that the government deficit affects bond yields because it is viewed by investors as an indicator of the risk of future inflation.

Even more important is a growing realization that standard economic theory does *not* predict that higher current budget deficits raise interest rates. This forgotten fact is well described in a little-known paper by Karl Brunner (1984, pp. 18–19): "Prices in markets for durable objects with comparatively low transaction costs are thus controlled, not by flows of new production and a corresponding pro-rata allocation of savings, but the interaction between the accumulated stock and the public's willingness to hold this stock. Stock demand and stock supply and not a (new) flow demand and (new) flow supply, determine the current price."

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Therefore, econometric tests should be looking for a relation between debt (not deficits) and interest rates.

The hypothesis that debt would act as a determinant of interest rates was raised as a secondary issue by Tanzi (1985, p. 560), and noted as probably being a valid factor by Spiro (1987, p. 401). In this note, I will describe some econometric evidence that provides strong additional support for the proposition that a higher total debt raises interest rates.

Barro (1989, p. 48) suggests that: "Overall, the empirical results on interest rates support the Ricardian view. Given these findings, it is remarkable that most macroeconomists remain confident that budget deficits raise interest rates." In fact, viewed in the context of Brunner's stocks model, Ricardian equivalence no longer provides any clear-cut prediction of the effect (or rather, noneffect) of government deficits on interest rates. Even if the public increased its saving exactly in line with the government deficit, it is not obvious that all of this incremental saving would be invested in government debt. If this strong assumption were violated, real interest rates would rise in response to increasing government indebtedness, since the economy's debt-to-equity ratio would rise relative to investors' desire to hold debt.

Researchers intent on demonstrating Ricardian equivalence should go directly to the issue of saving, which is what that theory is about. Since saving clearly has not risen in line with Ricardian predictions (as Gramlich (1989) has graphically demonstrated), it is not surprising that most macroeconomists continue to expect an effect of government dissaving on the cost of capital. The history of economics has shown many times that an effect can be real and important in spite of being econometrically elusive.

I. Empirical Results

We do not have direct data on the stock of liquid wealth available to the portfolio holders who are the potential purchasers of the stock of debt. However, it may be a reasonable approximation to assume that it is roughly proportional to permanent income. Hence, the cyclically adjusted government debt[1] expressed as a percentage of trend gross national product (GNP) can serve as a suitable measure of changes in the supply of government debt relative to the demand for it. Expressing it in this form also overcomes some of the problems of measuring the deficit that have been pointed out by Robert Eisner. Indeed, Eisner (1989,

[1] Using the cyclically adjusted debt improves the fit, but debt remains quite significant even when unadjusted data are used.

p. 89) has proposed that fiscal balance should be measured not by the deficit but by the ratio of debt to income.

Several alternative reduced-form regressions explaining the real interest rate are presented in Table 1. These are not necessarily meant to be the most elegant possible model of the interest rate, but to show that the debt variable is quite robust as a significant explanatory variable in a wide variety of alternative formulations and over different time horizons.

The general form of the model follows Makin (1983), including his important finding that the expected inflation rate reduces the expected real interest rate. Theoretical justification for this phenomenon has been given by Fried and Howitt (1983), among others. I have included it in most equations because it significantly increases the explanatory power, even though it remains somewhat controversial. However, omitting it does not affect the significance of the debt variable, as seen in equation (3).

In most equations, the dependent variable is the after-tax expected real interest rate, which is found to work better than the pretax rate. The presence of income tax means that inflation should increase interest rates more than one for one. This is usually known as the Darby hypothesis, but in fact the first statement of it appears to have been by Tanzi (1975). The formulation chosen here, using an after-tax real interest rate as the dependent variable, is justified by the findings of Peek and Wilcox (1984). However, the debt variable is just as effective in equation (5), where the dependent variable is the pretax real rate.

A monetary variable is included to capture the temporary liquidity effect of money supply increases on the real interest rate, and it is found to be significant in all formulations. A variable to proxy the real return on corporate capital is also included, but it is a somewhat imperfect proxy that does not always perform well. In addition, the personal saving rate is included in most of the regressions. On theoretical grounds, it is just as inappropriate an explanatory variable as the deficit itself. Therefore, it is interesting to note an analogous empirical finding—in equation (3), it has a statistically significant coefficient of the wrong sign.

The variable for the ratio of debt to GNP is introduced as a twelve-quarter distributed lag in most equations, representing the gradual and delayed effect of changes in the stock. However, in equations (1), (3), and (5), the ratio of debt to GNP twelve quarters in the past (rather than a distributed lag) is used, with equally good results. Tanzi (1985, p. 560) pointed out that "as the portfolios of individuals come to be laden with government bonds, and as debt is progressively diverted from financing capital accumulation in the private sector, the rate of return to invest-

Table 1. *Summary of Regression Results Explaining the Real Interest Rate*

	Equations							
Explanatory Variables	(1) 1958:1 to 1988:4	(2) 1958:1 to 1988:4	(3) 1958:1 to 1988:4	(4) 1959:1 to 1988:4	(5) 1958:1 to 1988:4	(6) 1958:1 to 1978:4	(7) 1979:1 to 1988:4	(8) 1970:1 to 1988:4
Constant	7.9	10.6	1.0	−0.3	10.8	4.8	21.6	22.6
	(10.4)	(7.3)	(1.6)	(−4.1)	(9.6)	(2.9)	(2.9)	(8.7)
Expected inflation	−0.53	−0.58	—	−0.64	−0.20	−0.67	−0.48	−0.76
	(−12.2)	(−11.9)		(−9.5)	(−3.2)	(−8.6)	(−4.3)	(−10.8)
Profits (−1)	0.17	0.21	0.31	—	0.20	0.22	−0.04	0.13
	(3.2)	(3.6)	(4.8)		(2.5)	(3.0)	(−0.2)	(1.3)
Money ratio (−1)	−2.56	−2.80	−2.02	−4.39	−3.48	−2.22	−4.20	−4.64
	(−8.5)	(−8.3)	(−5.6)	(−9.54)	(−7.8)	(−6.5)	(−3.0)	(−9.0)
Debt (−12)	0.27	—	0.31	—	0.37	—	—	—
	(7.4)		(7.1)		(6.9)			
Debt (−1 to −12)	—	0.25	—	0.25	—	0.26	0.19	0.24
		(7.1)		(4.9)		(5.9)	(2.0)	(5.1)
Saving rate (−1)	0.14	−0.03	−0.19	—	0.12	0.38	−0.04	0.18
	(2.1)	(−0.3)	(−2.6)		(1.1)	(4.5)	(−0.2)	(1.4)
Summary Statistics								
MA (1)	0.80	0.80	0.77	0.69	0.83	0.80	0.45	0.78
	(8.6)	(8.5)	(8.3)	(7.2)	(8.9)	(6.8)	(2.4)	(6.5)
Adjusted R^2	0.82	0.81	0.73	0.68	0.63	0.92	0.73	0.80
DW	1.50	1.58	1.22	1.99	1.53	1.91	2.00	1.98
SER	0.63	0.64	0.77	0.70	0.94	0.43	0.75	0.68
SSR	—	47.1	—	—	—	14.0	17.5	—

Note: The dependent variable is the after-tax real rate of interest on U.S. three-month Treasury bills, except in equation (5), where it is the pretax real rate; *t*-statistics are in parentheses; R^2 is the adjusted coefficient of determination; DW is the Durbin-Watson statistic; SER is the standard error of the regression; and SSR is the sum of squared residuals. An MA(1) moving average error specification is used to correct for autocorrelation.

ment in the private sector would have to go up." This would tend to imply a delayed and gradual effect, suggesting that one should be looking at distant lagged values of the government debt.

If one considers the theoretical grounds stated above—that the stock of debt influences the level of the interest rate—it would also imply that changes in the stock of debt influence changes in the interest rate. This is seen in equation (4), where all the variables are in the form of changes from the same quarter a year ago, and the distributed lag of the change in the debt ratio is a significant explanatory factor. The change in the debt ratio is equivalent to the moving average of the deficit normalized to income. This version of the deficit is in fact a significant explanatory variable, with the right sign. However, it explains the change in the real interest rate, not the level of the rate, which is what previous researchers were (inappropriately) looking for.

This model was also tried with government consumption included as an additional explanatory variable, following the reasoning of Barth and others (1989, p. 20). The government debt variable remained significant, and government consumption itself proved to be insignificant.

In view of the gradual lagged incorporation of the influence of the debt in interest rates, a causality test has to be carefully designed for this variable. Recent past values of the dependent variable will already have incorporated most of the influence of the more distant past changes in the debt ratio.[2] However, if causality is considered in the sense of a variable providing information to predict the interest rate three years in the future, then the debt ratio passes a Granger-type causality test by a large margin.[3]

The time period for equations (1) through (5) was chosen objectively. These equations cover the entire period for which data on the cyclically adjusted debt ratio have been published by the U.S. Bureau of Commerce. Equations (6) through (8) look at shorter time periods. A Chow

[2] In view of the lagged effect of the debt on interest rates, Barro and Sala i Martin's (1990) model is not well specified. They included the lagged value of the dependent variable as an explanatory variable, which makes the debt variable appear to be insignificant. The previous period's lagged value includes most of the earlier influence of the debt. Barro and Sala i Martin used stock prices as a variable explaining interest rates. Stock prices are also used by Spiro (1989, pp. 74–80), with no effect on the significance of the debt variable.

[3] The dependent variable was first predicted by a constant term and its own past value three years before. The sum of squared residuals (SSR) from this regression was contrasted with one where the dependent variable is predicted by the former plus the value of the debt ratio three years before. The improvement in predictability was substantial. The difference in the two equations was $F(1,121) = 14.8$, versus a critical value of about 3.9.

test rejects structural stability in the sample by a relatively small margin.[4] However, a comparison of the coefficients in equations (6) and (7) indicates that the main source of instability is in the response to the monetary variable. This accords with numerous findings that there has been a stronger liquidity effect in the post-1979 period.

In this 1979 to 1988 subperiod, the *t*-statistic on the debt variable declines to where it is just barely significant at the 95 percent level of confidence. This is not a function of the time period chosen but rather the shortness of the period. I found that a similar reduction in significance occurred in any ten-year subperiod chosen within the 1958 to 1988 sample. The debt ratio is a slowly changing variable with relatively little variance over short periods of time, and therefore a regression covering a short period is not able to detect the significance of its effect. This probably explains Evans's (1989) claim that the stock of debt is not a significant determinant of interest rates. He tested its influence over the very short period 1981 to 1986, when the change in the debt ratio was unidirectional and smooth. It was rising rapidly at a relatively steady rate, making it difficult to distinguish from a simple time trend. Equation (8) covers a long enough period to include both increases and decreases in the debt ratio, and it once again shows a highly significant effect of the debt ratio on the real interest rate.

II. Conclusions

A Keynesian theory with well-defined microfoundations would not in fact predict that interest rates are a function of the current government deficit or surplus. The interest rate is the rate on a large stock of assets, and it is determined by the demand versus the supply of that stock, rather than by the flow of additions to the stock. This would imply that the government debt relative to income is the variable that should be used to test the effect of fiscal deficits on interest rates.

The results described above provide strong confirmation of Tanzi's (1985) finding that a higher government debt contributes to significantly higher interest rates. It was found that this variable remains significant over a wide variety of specifications of a reduced-form interest rate equation. It appears to be the missing link in the explanation of the effect of government fiscal policies on interest rates.

[4] $F(16,124) = 3.34$, versus a critical value of about 2.2.

APPENDIX

Data Definitions and Sources

This Appendix identifies and defines the data sources used.

Debt

Cyclically adjusted U.S. government debt at par value as a percent of GNP was used (based on middle expansion trend GNP). Data were taken from the U.S. Department of Commerce's *Survey of Current Business* (March 1986, August 1988, and March 1989).

Saving

Data used comprised personal saving as a percent of GNP; Citibase GPSAV/GNP.

Profits

Corporate profits including capital cost allowance (CCA) and inventory valuation adjustment (IVA) as a percent of GNP were used; Citibase GPJVA/GNP.

Expected Inflation

Data comprised the six-month horizon semiannual Livingston survey of expected CPI increase, provided by the Federal Reserve Bank of Philadelphia. Omitted quarters are obtained by straight-line interpolation.

Money Ratio

The ratio was obtained from the monetary base (adjusted for reserve requirement changes, by the Federal Reserve Bank of St. Louis) as a percent of GNP; Citibase FMBASE/GNP.

Real Interest Rate

The three-month Treasury bill rate (FYGM3 from Citibase) was converted to an after-tax real rate. The tax rate is the variable RTPMARG from Data Resources, Inc; calculated as the nominal rate times 1-RTPMARG minus the expected inflation rate.

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Budget Deficits and Interest Rates

Reply to Spiro

DAVID W. FINDLAY*

In this issue, Spiro (1990) finds evidence that supports the hypothesis that "higher government debt contributes to higher interest rates." He also suggests that I concluded (Findlay (1990)) that the effects of deficits on interest rates remain, as Spiro (1987, p. 403) himself noted, as "elusive as ever." He further suggests that the situation is "not as bleak as my assessment *appears* [emphasis added] to make it." Apparently I was not as clear as I should have been. The purpose of this reply is to clarify my earlier conclusions and to offer several additional observations.

I did note (p. 438) that the interest rate effects of current and lagged budget deficits remain elusive. A casual observation of randomly selected articles on this relationship between the interest rate and the deficit reveals a variety of empirical estimates. Budget deficits have been found to have positive effects, no effects, or even negative effects on interest rates. (For a detailed review of this literature, see Barth, Iden, Russek, and Wohar (1989).) It was this diversity of empirical estimates that initially interested me in this area of research. In particular, I have been interested in examining which factors may have led to the different results.

I also indicated (p. 438) that the approach used by Bovenberg (1988) and Kim and Lombra (1989) is "intuitively appealing and clearly motivated." They argued that it is expected deficits that will influence interest rates. The results obtained in these two studies appear quite promising; increases in *expected* budget deficits do cause increases in the interest rate variable. The primary objective of my comment was to determine whether Bovenberg's results would be obtained for alternative specifications of the interest rate equation and for alternative mea-

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sures of the deficit variable. Barth, Iden, and Russek (1985) and Seater (1985) have argued that government expenditures must also be included in interest rate equations that include a deficit variable. When the government expenditures variable was included, the effects of expected deficits on interest rates were not as significant as those initially reported. It was not my intention then, nor is it now, to argue that deficits have no effects on interest rates. The main point that I wanted to make in the conclusion is that "additional research, like that presented by Bovenberg [and more recently, by Spiro], is needed on the formation of expectations and on the appropriate specification of interest rate equations," (p. 438).

The comment by Spiro raises an interesting question about the choice of the deficit/debt variable. In the interest rate equation studies, a number of important issues have to be resolved. First, should a deficit variable or a debt variable be included as the right-hand-side variable? If government debt is the appropriate variable, should the market value or par value be included? If the deficit variable is included, should we use real or nominal (cyclically adjusted or unadjusted) deficits? Furthermore, how does the researcher take into account deficits (or debt) created by state and local governments? A second issue focuses on the measurement of the interest rate variable (that is, before-tax or after-tax, nominal or real, or short-term versus long-term interest rates). Third, are results sensitive to the choice and construction of the expected inflation variable? Fourth, what type of theoretical model should be used to obtain the interest rate equations? There are other issues that also need to be addressed. As noted by Barth and others (1989), many of these (and other) issues have already been examined, to varying degrees, in previously published papers.

In any event, we must continue to examine the appropriate specification of the interest rate equations and to test the robustness of empirical results. The points briefly discussed above make this issue one of the more interesting (and controversial!) in macroeconomics, and it will undoubtedly continue to receive the attention of economists who attempt to disentangle the effects of fiscal actions on the macroeconomy.

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IMF Working Papers

Staff Papers *draws on IMF Working Papers, which are research studies by members of the Fund's staff. A list of Working Papers issued in 1990:3 follows; additions will be noted in future issues.*

"The 1990 Reform of United Kingdom Local Authority Finance," by Tamim Bayoumi [90/58]

"Optimal Tax/Expenditure Competition Strategy of Governments in the Presence of Time Inconsistency: The Case of Investment Tax Abatements," by Daniel P. Hewitt [90/59]

"Economic and Monetary Union in Europe and Constraints on National Budgetary Policies," by A. Lans Bovenberg, Jeroen J.M. Kremers, and Paul R. Masson [90/60]

"Targeting the Exchange Rate: An Empirical Investigation," by Shula Pessach and Assaf Razin [90/61]

"Fiscal Policy, Labor Markets, and the Poor," by Mario I. Blejer and Ke-young Chu [90/62]

"Foreign Direct Investment," by J. Saúl Lizondo [90/63]

"Risk and Capital Flight in Developing Countries," by Liliana Rojas-Suárez [90/64]

"Systemic Financial Risk in Payment Systems," by David Folkerts-Landau [90/65]

"Possible Implications of Integrating the Corporate and Individual Income Taxes in the United States," by Krister Andersson [90/66]

"The Composition and Distribution of Financial Assistance from Arab Countries and Arab Regional Institutions," by Pierre van den Boogaerde [90/67]

"The Impact of the EC's Internal Market on Nonmember Countries: The Case of EFTA," by Richard K. Abrams, Peter K. Cornelius, Per L. Hedfors, and Gunnar Tersman [90/68]

"Are Sovereign Debt Secondary Market Returns Sensitive to Macroeconomic Fundamentals? Evidence from the Contemporary and Interwar Markets," by Mark R. Stone [90/69]

"Tax Policy and Reform for Foreign Direct Investment in Developing Countries," by Tax Policy Division [90/70]

"On Noncooperative Capital Income Taxation in Open Economies," by Kenneth M. Kletzer [90/71]

"Trends and Cycles in the U.S. Economy," by Charles Adams [90/72]
"Monetary Policy in an Emerging European Economic and Monetary Union: Key Issues," by Jacob A. Frenkel and Morris Goldstein [90/73]
"Issues in the Reform of Deposit Insurance and Regulation of Depository Institutions," by Steven M. Fries [90/74]
"The Dynamics of Money Demand and Prices," by Liam P. Ebrill and Steven M. Fries [90/75]
"Fiscal Indicators for Economic Growth: An Illusory Search?" by Jack Diamond [90/76]
"Debt Overhang, Debt Reduction, and Investment: The Case of the Philippines," by Eduardo Borensztein [90/77]
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