NBER Working Paper #4232
December 1992

CURRENCY SUBSTITUTION

ABSTRACT

This paper reviews the extensive theoretical and empirical literature on currency substitution. After discussing the ambiguity surrounding the definition of currency substitution, the paper illustrates the causes of substitutability of different currencies using a cash-in-advance model and a model where money yields liquidity services. The effects of currency substitutability on exchange rates, international adjustment and the inflation tax are discussed. The paper also reviews the empirical facts on the size of currency substitution in developed and developing countries. Whereas currency substitution is found to be sizable in some developing countries and on the rise in the European Community, estimates of the ability to substitute foreign for domestic currency are often found to be unreliable due to data, methodological and conceptual problems. Policy implications of currency substitution for international monetary cooperation and inflationary finance are explored.

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NBER WORKING PAPER SERIES

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Working Paper No. 4232

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 1992

Paper written for the Handbook in Open Economy Macroeconomics, edited by Frederick van der Ploeg. We are grateful to Jaime Marquez and Miguel Savastano for helpful comments and to Benedict Clements and Miguel Savastano for providing some of the data. We acknowledge financial support from the Belgian National Science Foundation and Columbia University (travel grant). This paper is part of NBER's research program in International Finance and Macroeconomics. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

1 Introduction

The concept of currency substitution is one of the most ambiguous in economics. Indeed, our dissatisfaction with it has tempted us to discard it completely. We keep on referring to currency substitution because we do not want, in this paper, to reject altogether a literature that, despite its vagueness, has provided a number of important insights and valuable contributions. Our aim, therefore, is to provide a way to read this vast literature, and make sense of an often ill-defined concept. The most important constraint we are working under is of course the state of monetary theory. As Tobin (1983) vehemently put it:

> Why fiat currency, intrinsically useless paper, has positive real value at all and how its value is determined are questions that continue to puzzle economic theorists ... A fortiori, the determination of the relative prices of several fiat currencies seems to be a subject on which the utility technology-resource endowment paradigm of basic microeconomic theory has nothing to say.

We disagree with Tobin on the view that "the utility technology-resource endowment paradigm of basic microeconomic theory has nothing to say" on the determinants of the demands for different currencies, and indeed our discussion below makes use of that paradigm and does, in our opinion, illuminate the issues to some extent. However, we think that Tobin raised an important point. The difficulties of monetary theory are in some sense multiplied when one attempts to understand the demand for different currencies.

Our confusion on the definition of currency substitution has been shared by many authors. McKinnon (1985) states that "currency substitution is also treacherous semantically because people differ on its proper interpretation". In his review of Canto and Nickelsburg (1987), Cuddington (1989) refers to"the imprecision regarding the definition of currency substitution [which] plagues... most of the previous work on the topic". Canzoneri and Diba (1990) admit that they do not have a "deep theory of currency substitution".

A closer look at the way currency substitution has been defined in the literature brings little clarity. Its definition has varied from

a very narrow to a broad view of the role of money. At one extreme, Calvo and Végh (1992), following Cuddington (1989), limit currency substitution to the use of different currencies as media of exchange. At the other end of the spectrum, McKinnon (1985) solves the "semantic problem" by distinguishing between direct and indirect currency substitution. "*Direct currency substitution* means that two (or more) currencies compete as a means of payment within the same commodity domain.... *Indirect currency substitution* refers to investors switching between non-monetary financial assets...". As has been pointed out (among others, Spinelli (1983)), the latter form of currency substitution is hardly distinguishable from the concept of capital mobility. In between these two poles, one finds all sorts of variations. Gros and Thygesen (1992), Clements and Schwartz (1992), Agénor and Khan (1992), El-Erian (1988) and Fasano-Filho (1986) define currency substitution as a situation in which foreign money substitutes for domestic money in its three traditional roles. Others—e.g. Handa (1988), Kim (1985) and Elkhafif and Kubursi (1991)—limit their interpretation to the store-of-value role of money. McKenzie and Thomas (1984) talk about the substitutability between domestic and foreign primary securities.

Many authors abstract from this discussion althogether and define currency substitution as a situation in which domestic money demand is influenced by foreign economic variables. Most often, the relative opportunity cost of holding both currencies is treated as the crucial variable—see Bana and Handa (1990), Marquez (1985a, 1985b, 1992), Neldner (1987), Rogers (1990), Poloz (1984) and Tanzi and Blejer (1982). Miles (1978) stresses the importance of the responsiveness of the demand for both currencies to other economic variables, cautioning that "the mere ownership of foreign currency-denominated balances by domestic residents is not a sufficient condition for currency substitution to occur". Ramirez-Rojas (1985) defines currency substitution as the demand for foreign fiat currency by domestic residents. Khan and Ramirez-Rojas (1986), alternatively, define currency substitution as "the ability of domestic residents to switch between domestic and foreign fiat money". In an end note, they mention that "in actual fact, the definition of currency substitution covers a wide variety of possibilities, such as foreign currency

deposits in the domestic financial system, deposits held abroad by domestic residents, and foreign currency notes circulating within the boundaries of the country".

A similarly broad range of different interpretations characterizes the definition of *dollarization*, a concept often used to refer to currency substitution in a Latin American context. Lamdany and Dorlhiac (1989) define dollarization as a "replacement, by the monetary authorities, of the national currency with a reserve currency (for example), the dollar, as legal tender", stressing its institutional aspects. Melvin (1988), in contrast, sees dollarization as a market-enforced monetary reform, a somewhat contradictory term referring to "demand-based substitutions away from domestic currency into foreign currency". He defines dollarization as the use of U.S. dollars by Latin Americans in place of domestic currency. Ortiz (1983b) defines dollarization as "the degree to which real and financial transactions are actually performed in dollars relative to those performed in domestic currency" and links it to currency substitution. Calvo and Végh (1992) exclude dollarization, as used in most studies, from their definition of currency substitution since it primarily deals with the unit of account and store-of-value function of money. Hence, "Currency substitution is normally the late stage of the dollarization process".

The first problem of currency substitution is the use of the term "substitution," which is rather uncommon in economics. Webster's 7^{th} New Collegiate Dictionary confirms our concerns. *Substitution* is there defined as the noun corresponding to the verb *to substitute.* The latter is, according to the dictionary, "1: to put in place of another: exchange 2: replace." In particular, it is not clear from the term substitution whether it refers to a characteristic of currencies—in which case "substitutability" is to be preferred—or to an equilibrium outcome—in which case "substitution" could be acceptable. Interestingly, the two alternative concepts lead to opposite kinds of research. The study of currency substitutability would naturally explore its potential effects, domestically and internationally, on variables of interest to economists and policymakers. By contrast, the study of substitution would explore the size and the potential causes of the (partial) replacement of one currency with another, and from

them, extract a better understanding of the mechanics of money demand.

In this paper we want to discuss both the concept of substitutability and the phenomenon of substitution, its origins and consequences. This separation makes sense because there are no reasons to believe that substitutability implies substitution, or vice versa.[1]

Consider now the determinants of currency substitutability. For that purpose, it is useful to distinguish among the three traditional functions of moneys: unit of account, provider of transactions services and provider of store-of-value services.

Little is known about the unit of account function of moneys, except for the fact that making calculations of relative prices using different units of measurement is always a very cumbersome task. Anybody who has travelled to a foreign country knows this problem very well. We suspect that habit, both in its spatial (that is market thickness) and temporal dimensions, is an important factor determining the substitutability of unit of account services. The more people are used to operate in different currencies to settle transactions, the more these currencies' unit of account services will be substitutable. Similarly, the longer people have been used to operate in different currencies to settle transactions, the more these currencies' unit of account services will be substitutable.

Store-of-value substitutability is one of the key theoretical issues in the paper. It is well known that, as stores of value, currencies are usually dominated by interest-bearing nominal assets, and also by real assets. Yet, non-interest-bearing currencies often take up significant shares of portfolios, ostensibly for store-of-value purposes (the money-under-the-mattress phenomenon). In order to explain this phenomenon, we need to discuss in great detail liquidity services. Since the seminal contribution of Tobin (1958) it is well understood

[1] We do not expect, a priori, that high currency substitutability necessarily implies large fluctuations in holdings of domestic and foreign currency by the public: we come to this conclusion having in mind the standard demand-and-supply diagram (where, as customary, higher substitutability means flatter demand curves), and observing that in such diagram large fluctuations in quantities, even when demand (or relative demand) curves are highly elastic, can only be produced by the right combination of shocks. Of course, at this stage we are unable to argue which price, or relative price, belongs to the diagram, and what are the determinants of supply functions and—for that matter—demand functions. This is indeed the whole problem that we want to tackle in the paper. Conversely, it is possible to observe large movements in domestic and foreign currency holdings, without highly substitutable currencies.

that only if money provides liquidity services it will be held in portfolios together with interest-bearing and other assets.

Such liquidity services, however, are likely to be very different from country to country, and to depend on the degree of financial sophistication and capital market liberalization that is present in each country. As we will note in our discussion below, the concept of store-of-value substitutability is often intimately linked with the concept of international capital mobility. We think that this linkage has very often led to undue confusion, and we attempt in this paper to clarify as much as possible the distinction between the two concepts.

Medium of exchange substitutability is what economists have most often in mind when discussing currency substitution, if anything because of the previous observation, that money is often dominated by other assets as a store of value.

In discussions of money's transactions services externalities are often mentioned. A currency is more acceptable when more individuals use it as a means of settlement of private transactions. Indeed, the theory of vehicle currencies in international financial markets (see below) has relied on the concept of substitutability of medium-of-exchange functions of money to explain the establishment of an internationally acceptable money.

Section 2 of this paper will attempt to clarify the mechanics of the substitutability of transactions and store-of-value services of different currencies. It will also discuss the macroeconomic implications of currency substitution. Section 3 both reviews the evidence on currency substitution—by discussing the data on circulation of foreign moneys during the historical episodes of hyperinflation in Germany and in Russia, in Latin American countries, and in Western European countries—and surveys the econometric studies which have attempted to estimate the substitutability of different currencies. Section 4 explores the implication of currency subsitutability and substitution for economic policy. Finally, section 5 contains a few concluding observations.

2 Theoretical Models

A discussion of the theoretical underpinnings of currency substitution is just a discussion of the theory of money demand in a multi-currency economy—a country where different currencies circulate, or different countries where several currencies can circulate in each.

The models of money demand that have been developed can be catalogued into 3 major classes: cash-in-advance models, transactions-costs models and ad-hoc models (that is, models in which the demand for different currencies and the nature of their substitutability is specified *a priori*). In what follows, we discuss in some detail the first two classes of models. Using a cash-in-advance model we ask the basic question: what determines the substitutability of two currencies? This question is further refined using a transactions-costs model, which is suitable to illustrate liquidity services of money.[2]

The discussion of the theoretical models leads us to a review of the implications of currency substitutability. Currency substitutability affects the stability of monetary aggregates, the dynamics of exchange rates, and the government revenue from inflation. Each of these effects raises questions for economic policy, which are discussed in the following section.

2.1 Cash-in-Advance Models

The simplest cash-in-advance model can be used to ask the most basic question of currency substitution. Agents maximize utility subject to a budget constraint—which we do not need to specify—and a cash-in-advance constraint.[3] How should the cash-in-advance constraint be specified? Suppose we just stack two closed-economy cash-in-advance constraints:

$$\frac{M}{P} \geq C \tag{1}$$

$$\frac{M^*}{P^*} \geq C^* \tag{2}$$

[2] A version of the cash-in-advance model could generate the same liquidity effects.

[3] See, for example, Lucas (1982). Boyer and Kingston (1987) employ a similar model which incorporates cash and credit goods to analyze the effects of currency substitution on exchange rate volatility and the transmission of inflation.

This assumption does not allow any substitution between the two currencies for the purpose of acquiring the two goods in the consumption basket. In this model, the cash-in-advance constraint always binds (agents do not want to employ resources to accumulate an asset, money, which is dominated by all other assets), and therefore the domestic and foreign price levels are determined by the quantity equations, obtained by replacing the inequalities in (1) and (2) with equal signs.

The relative price of the two goods is determined by goods market equilibrium. For simplicity assume exogenous supplies of the two goods and a representative agent. Under these assumptions the marginal rate of substitution is an exogenous variable fluctuating with the output of the two goods and so is their relative price:

$$\frac{eP^*}{P} = \frac{U_1(C, C^*)}{U_2(C, C^*)} \tag{3}$$

where subscripts 1 and 2 indicate, respectively, the partial derivatives of the utility function U with respect to its first and second argument.

How can we talk about currency substitution in this model? While the two cash-in-advance constraints do not allow any substitution, the way the two goods enter the representative agent's utility function affects, though indirectly, the substitutability of the two currencies. If the utility function is constant elasticity of substitution, with elasticity parameter σ, the relative price of the two goods is:

$$\frac{eP^*}{P} = \left(\frac{y}{y^*}\right)^{\frac{1}{\sigma}} \tag{4}$$

Substituting the quantity equations, we find an expression for the nominal exchange rate:

$$e = \left(\frac{y}{y^*}\right)^{\frac{1-\sigma}{\sigma}} \frac{M}{M^*} \tag{5}$$

An increase in domestic output, y, brings about an increase in money demand, which calls for an appreciation of the national currency—a decrease of e. At the same time, however, the relative price of

domestic goods falls, with elasticity $1/\sigma$. The larger the elasticity of substitution of the two goods, the smaller the change in their relative price in response to a change in their supply. In particular, if σ is greater than 1, the money-demand effect on the nominal exchange rate prevails: an increase in domestic output brings about a nominal exchange rate appreciation.

As pointed out before, the specification of the cash-in-advance constraint in this model is very special, and difficult to justify: why could agents not use any currency to purchase any one of the two goods? After all, transactions costs in international money markets are a fraction of transactions costs in goods markets. In this model, the arbitrariness of the version of the cash-in-advance constraint used matches the arbitrariness of the cash-in-advance constraint itself. Nevertheless, it is useful, in this context, to ask what determines the substitutability of the two currencies.

Substitutability can here be determined by two things: the parameter of the utility function and the specification of the cash-in-advance constraint. Consider the utility function first. If the two goods become ever more substitutable, the two currencies become themselves more substitutable, since the goods they purchase become indistinguishable in agents' tastes. What happens when the two goods are more substitutable? For a given covariance matrix of exogenous shocks, equation (5) implies that a higher value of σ, when $\sigma > 1$, increases the volatility of the nominal exchange rate.

That occurs because when the two goods are highly substitutable a change in their supplies brings about pressure on the exchange rate through the money demand effect, but relative prices are insensitive and hence do not provide the dampening effect described above.

What happens when we change the specification of the cash-in-advance constraint? Consider the extreme case where either currency can be used to buy either good. but—like before—currencies are always needed to buy goods. The cash-in-advance constraint is now:

$$\frac{M}{P} + \frac{eP^*}{P}\frac{M^*}{P^*} \geq y + \frac{eP^*}{P}y^* \qquad (6)$$

Figure 1 illustrates the determination of equilibrium in this case. The two functions used in the figure. f and g are, respectively, the relative price of foreign (starred) goods and the value, in domestic

currency terms, of output at home and abroad, i.e. the value of total purchases (the right-hand-side expression in equation (6)). Both are functions of just domestic and foreign output, which are assumed exogenous. This model has an infinity of equilibria, represented in the figure by the points on the downward sloping schedule, each one characterized by a certain triplet (P, P^*, e). This triplet is determined by the intersection of the array crossing the origin and the curve. The slope of the array equals the known function f divided by the exchange rate. Hence each of the infinite equilibrium triplets is characterized by a different value of the nominal exchange rate.

The multiplicity of exchange rates displayed in this model is the result of Kareken and Wallace (1981), who obtained it in a different setup. The result highlights the potential instabilities caused by currency substitution. In this model, like in Kareken and Wallace's, the implications of exchange-rate indeterminacy are however limited, for two reasons. First, indeterminacy is mirrored by the equivalence, from a welfare viewpoint, of all equilibria. Agents do not care about the different exchange-rate equilibria. Second, multiple exchange rates are in this model a knife-edge property, in the sense that an arbitrarily small constraint on the use of national moneys would immediately pin down the exchange rate. In this respect, an especially realistic constraint is the one adopted by Giovannini and Turtelboom (1992), who postulate that taxes have to be paid with the currency of the government which levies them.[4]

These problems, however, are in part an artifact of the assumption of a single, representative agent that characterizes the model used here. King, Wallace and Weber (1992) demonstrate that the exchange rate indeterminacy result can be obtained in a model where a fringe of agents does not face cash-in-advance -type constraints. In their model, characterized by the presence of three

[4]Girton and Roper (1981) also find this exchange rate indeterminacy when currencies are perfectly substitutable. However, when they endogenize monetary policy, the result on the variability is reversed. Giovannini (1989) also finds increased exchange rate volatility in a currency substitution model. Canzoneri and Diba (1992), however, find that currency substitution will have a stabilizing effect on exchange rates in the European Community. For other studies on the relation between currency substitution and exchange rate volatlity, see Boyer and Kingston (1987), Canzoneri, Diba and Giovannini (1990), Chand and Onitsuka (1985), Daniel (1985), Henderson (1989), Isaac (1989), King, Putnam and Wilford (1978), Koustas and Ng (1991), Lapan and Enders (1983), Marquez (1984), Park (1987) and Saurman (1986).

types of agents (one type being the speculative fringe and each of the other two types bound to the use of a particular currency), the multiple exchange-rate equilibria can have real effects, to the extent that financial markets are not complete. This result is intuitive, since complete financial markets are often regarded as the dual of the representative-agent assumption. With incomplete markets, random exchange-rate fluctuations generate redistribution of wealth among the three agents, which affect welfare.

2.2 Transactions Costs Models

The simple cash-in-advance model discussed in the previous subsection helps to illuminate a number of questions regarding the concept of substitutability of different currencies but does not explain how different moneys can work as stores of value. Every instant, agents can costlessly acquire the cash they need for their purchases. For this reason they will never want to carry "idle" cash balances in their portfolio. Whatever cash they need to purchase goods they can obtain immediately by liquidating part of their portfolio of bonds or other assets. Indeed, in the model described in the previous subsection, money does not serve as a store of value.

Casual empiricism, however, suggests that—to different degrees in different countries—money still has an important role as a store of value. This role stems from the transactions costs incurred in transforming other assets instantaneously into goods, or into money. These transactions costs make money more "liquid" than other assets.

To illustrate the store-of-value services of money, we use a model where such transactions costs are described as follows: money facilitates purchases of goods, and every period agents need to acquire the cash balances they plan to use next period for goods purchases.[5] The inability of agents to instantaneously acquire cash to facilitate goods purchases makes money more liquid than other assets. Once again we resort to the useful concept of a representative agent. The

[5]See, for example, Marshall (1987). Poloz (1986) also uses a transaction cost model.

agent solves the following problem:

$$\max \sum_{t=0}^{\infty} \beta^t U(C_t, C_t^*) \tag{7}$$

subject to:

$$\begin{aligned} &\frac{B_{t+1}}{P_t} + \frac{e_t B_{t+1}^*}{P_t} + \frac{M_{t+1}}{P_t} + \frac{e_t M_{t+1}^*}{P_t} = y_t + \frac{e_t P_t^* y_t^*}{P_t} - \\ &C_t - \frac{e_t P_t^* C_t^*}{P_t} - \Phi(C_t, C_t^*, \frac{M_t}{P_t}, \frac{M_t^*}{P_t^*}) + \frac{B_t(1+i_{t-1})}{P_t} + \\ &\frac{e_t B_t^*(1+i_{t-1}^*)}{P_t} + \frac{M_t}{P_t} + \frac{e_t M_t^*}{P_t} + \frac{Z_t}{P_t} + \frac{e_t Z_t^*}{P_t} \end{aligned} \tag{8}$$

where y and y^* are the endowments of the two goods, B and B^* are domestic and foreign bonds, and Φ represents transactions costs. The function Φ is increasing in C and C^* and decreasing in the stocks of real money balances , M/P and M^*/P^*. We do not impose any other constraints on Φ, since they are not needed for what follows, but would want to note here that the nature of the substitutability of currencies depends crucially on the form of the Φ function. Z and Z^* are exogenous transfers of domestic and foreign cash balances. Every period t, the agent chooses the amount of bonds B_{t+1} and B_{t+1}^* maturing at time $t+1$ and cash M_{t+1} and M_{t+1}^* he wants to hold. A domestic bond maturing a time $t+1$ has a known interest rate, i_t.

Let λ_t represent the Lagrange multiplier associated with the budget constraint. The first-order conditions with respect to C and C^* yield the following:

$$U_C(C_t, C_t^*) = \lambda_t [1 + \Phi_{t,C}] \tag{9}$$

$$U_{C^*}(C_t, C_t^*) = \frac{e_t P_t^*}{P_t} \lambda_t \left[1 + \frac{P_t}{e_t P_t^*} \Phi_{t,C^*}\right] \tag{10}$$

The subscripts to the symbol Φ_t denote partial derivatives of the Φ function, evaluated at time t, with respect to the variables in the subscripts. Equations (9) and (10) show an important feature of this model. The presence of liquidity costs induces a potential wedge between the marginal rate of substitution of the two goods, and the

marginal rate of transformation, represented by their relative price (the real exchange rate). This wedge depends on the form of the liquidity function. It could equal 0 if the two partial derivatives were identical: this would happen, for example, if the C and C^* were perfectly substitutable in the function Φ.

Taking derivatives with respect to the two moneys and the stock of domestic bonds we get:

$$\frac{\lambda_t}{P_t} = \beta E_t \left[\frac{\lambda_{t+1}}{P_{t+1}} (1 - \Phi_{t+1,M/P}) \right] \tag{11}$$

$$\frac{e_t \lambda_t}{P_t} = \beta E_t \left[\frac{e_{t+1} \lambda_{t+1}}{P_{t+1}} (1 - \frac{P_{t+1}}{P^*_{t+1} e_{t+1}} \Phi_{t+1,M^*/P^*}) \right] \tag{12}$$

$$\frac{\lambda_t}{P_t} = \beta E_t \left[\frac{\lambda_{t+1}}{P_{t+1}} (1 + i_t) \right] \tag{13}$$

Equations (11), (12) and (13) are the traditional first-order conditions from asset-pricing models. They yield the usual "beta representation" of ex-ante rates of return, whereby the return on an asset, in excess of the riskfree rate, equals the excess return over the riskfree rate of a benchmark asset, times a factor of proportionality determined by the covariance of the individual asset with the benchmark portfolio. In this model, the benchmark portfolio is perfectly conditionally correlated with the multiplier associated with the budget constraint, λ.[6] Consider the first-order condition with respect to domestic-currency bonds. Rearranging it we get:

$$1 = (1 + i_t) \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} \right) \tag{14}$$

Since the nominal interest rate is known at the time the one-period bond is acquired, the familiar relation between the expectation of a product of random variables and the product of their expectations implies that the return on the domestic-currency bond is determined by the covariance between the rate of deflation and the rate of growth of the marginal utility of wealth (λ).

Notice that, in the case of the domestic and foreign money, the payoff is determined by the liquidity services that they offer, represented by the partial derivative of the liquidity function with respect

[6] See Richard (1981) and Hansen, Richard and Singleton (1981).

to the real money stocks (the sign of that partial derivative and the minus sign in front of it cancel each other out).

After imposing a specific functional form on the function Φ, one can solve the system (11), (12) and (13), augmented with the first-order condition with respect to the foreign bond, and obtain demand correspondences for domestic and foreign money. We do not undertake this exercise because the final result is, not surprisingly, entirely determined by the assumed functional form for the liquidity function. Alternatively, one can obtain portfolio-balance-like equations (relating demand for bonds and moneys, domestic and foreign, to wealth and expected returns), by finding the functional form relating λ to the representative agent's wealth. This is straightforward in a two-period setting, and yields the static CAPM as well as the traditional portfolio-balance asset demand equations,[7] but is much less straightforward in the infinite-horizon model discussed here.

In summary, the model of liquidity discussed in this section has shown that the demand for domestic and foreign currency is determined by their expected liquidity services, and that agents trade off moneys and other assets in their portfolio by comparing their expected returns and their covariance matrix. These liquidity services, however, are not directly related to rates of return on bonds, but are determined—at least in the specific model used here—by the amount of consumption purchases and the amount of real balances available to consumers.

The liquidity model of money demand illustrates the determinants of the demand for different currencies for store-of-value purposes. It is of crucial importance, especially for those countries where the liquidity services of money are significant because underdeveloped financial markets do not permit easy purchases and sales of financial assets by individuals. With illiquid financial assets, the liquidity services of moneys increase and so does the demand for money for store-of-value purposes. If the domestic currency has low expected returns (as it is the case in high-inflation countries), the foreign currency becomes a significant liquid investment for domestic residents.

[7] Since wealth is just the value of the holdings of different assets, asset demand equations can be obtained solving the first-order conditions.

The liquidity model is also suited to illustrate another important aspect of the substitution and the substitutability of different currencies, sometimes referred to—in the international economics literature—as the "vehicle currency" phenomenon (see Krugman (1980), Black (1991) and Matsuyama, Kiyotaki and Matsui (1991)).[8]

Suppose that the optimization problem of this subsection pertains to one atomistic individual, identical to all others in the economy, and that the liquidity cost function is not only defined over the holdings of real cash balances and the flows of consumption by the individual, but also over the shares of domestic and foreign currency in the total stock of money balances in the economy. The bigger the aggregate share of the domestic currency, the more likely it is for a consumer to find a counterparty willing to accept it in payment for a good or a service. Thus, the cross-partial derivative of the liquidity function with respect to, say, domestic real money balances and the aggregate share of domestic real money balances in the economy is negative.

This model displays multiple equilibria, since, in the aggregate, the cost of using either one of the two currencies is decreasing in the proportion of that currency in private portfolios. This property of the model has been used to explain the establishment of an international currency, and its lingering even after the economic conditions for it to be a vehicle currency do not anymore exist (Krugman (1980)). The externality can also be employed to explain other hysteresis-type phenomena, like for example the persistence of large holdings of foreign cash balances even after the end of inflationary episodes, documented by Guidotti and Rodriguez (1991).

2.3 Implications of Currency Substitutability

In this subsection we describe some of the implications of the coexistence of different moneys in agents' portfolios and of the substitutability among them.

The natural point of departure is the classic proposition on the effects of the coexistence of different moneys. Gresham's law, one of the best known propositions in monetary economics, says that "bad

[8] See Thomas and Wickens (1991) for an attempt at quantifying the vehicle-currency effect in the context of money demand estimation.

money drives out good", or that the less valuable currency substitutes for the more valuable currency in monetary circulation. To understand Gresham's law it is important to keep in mind that it is a description of monetary instabilities under a bimetallic standard. In a bimetallic standard the central bank freely exchanges at a fixed nominal price two metals (say gold and silver) for money. Fixing the nominal value of gold and silver coins means to fix also their relative price. Gold and silver are traded in the nonmonetary market (industrial market) as well, where also newly mined ore is originally sold. A condition of equilibrium between the monetary and nonmonetary markets is that the official parity equals the relative price of the two metals in the industrial market.

Consider now what happens when some exogenous shock (say an increase of silver ore production that tends to make silver cheaper in the industrial market—and gold more expensive) drives the relative price of the two metals away from the official parity. Private agents would find it profitable to buy gold from the central bank at the official parity to resell it in the industrial market. This would produce a progressive disappearance of gold from monetary circulation. In other words, the "bad" money has driven out the "good": hence Gresham's law.

This discussion clearly implies that Gresham's law cannot apply in a world of fiat currencies, because there is no industrial market to arbitrage national different currencies to. It is still possible, however, to consider the effects of a change in two currencies' relative valuation caused by a change in their relative monetary services: transactions services and store-of-value services. Suppose, for example, that private agents expect a devaluation to occur over some future horizon: in this case the store-of-value services of a currency increase relative to those of another. Agents would bring the "bad" currency to central banks in exchange for the "good" one. The "good" currency drives out the "bad" from monetary circulation. The same would occur with a change in transactions services originating, for example, when one currency gets increasingly used to make payments, and therefore—as we argued above—it becomes more acceptable in private transactions. Also in this case the "good" currency would drive out the "bad". Hence, the kind of shocks in

money demand that can occur in a fiat currency system imply that Gresham's law can only occur in reverse (we have taken the foregoing discussion from Giovannini (1991b)).[9] The general lesson of Gresham's law is that, whenever different currencies coexist in an integrated economy under fixed exchange rates, fluctuations of their relative valuation affect their circulation. This in turn can give rise to instabilities, usually caused by the inability of monetary authorities and the banking system to fully accommodate these demand fluctuations: there is always a limit beyond which central banks cannot run down their reserves or cannot increase their borrowing from other central banks and the banking system.

Two other questions on the effects of currency substitution have had a prominent role in the literature: the effects of currency substitution on real exchange rate fluctuations in a flexible exchange rate regime, and the effects of currency substitution on the inflation tax.

The first question was first analyzed by Calvo and Rodriguez (1977). These authors consider a model where foreign currency provides store-of-value services, presumably because financial assets are illiquid. This occurs, as we have argued in the previous section, in all those economies where financial markets, perhaps because of pervasive government regulations, are repressed or underdeveloped. Because in Calvo and Rodriguez's (1977) model foreign cash balances are the only internationally traded asset, the accumulation of foreign cash balances can only occur through current account surpluses. Hence, in their model, a change in the rate of growth of the domestic money stock leads domestic resident to want to accumulate foreign assets (foreign cash balances), which they can only accomplish through a current account surplus. The equilibrium response is a depreciation of the real exchange rate, which produces

[9] However, it is easy to verify that an increase in the monetary services of a specific currency increases its monetary circulation both under a commodity standard and under a fiat standard: see Giovannini (1991b). Indeed Bernholz (1989) refers to the opposite phenomenon—"good" money driving out "bad" money—as *Thiers' Law* after the French historian Louis A. Thiers who identified cases in which "specie, which was supposed to be hoarded or carried abroad, found its way into circulation. That which had been hidden came forth; that which had quitted France returned. The southern provinces are full of piasters, which came from Spain ..." during the French revolution (Thiers (1840), quoted in Bernholz (1989)). Bernholz also refers to other historical episodes where "good" money drove out "bad" money: USA during 1776-81, Peru in 1875-87 and Mexico in 1913-17. See also Guidotti and Rodriguez (1991).

enough of a current account surplus to permit the desired accumulation of foreign cash balances. Hence, in the model of Calvo and Rodriguez (1977), a monetary disturbance leads to fluctuations of the real exchange rate associated with the phenomenon of currency substitution.[10]

The second question regards the effects of currency substitutability on inflationary financing of government deficits. Intuitively, the higher is the substitutability of domestic and foreign currency the more difficult is for the government to finance deficits by printing money. One one hand, seigniorage is taken up by the foreign money holdings, and on the other hand the demand for domestic currency would likely become more sensitive to the inflation tax rate. Hence, for any given level of the inflation tax rate, the revenue from the inflation tax would be lower in the presence of currency substitution.[11]

3 Empirical Evidence

3.1 A first glance

There are many data problems which prevent a clean measurement of the actual amount of currency substitution. The ideal measurement would include foreign banknotes circulating as medium of exchange and store of value in the economy, as well as checking accounts and short-term deposits denominated in foreign currencies in the domestic banking system and abroad.

Given the obvious difficulties in estimating foreign currency notes in the economy, this part of currency substitution is generally excluded from its measurement. Even in industrial countries, data on cross-border credit-card and cheque payments are, to our knowledge, not publicly available. Melvin and Afcha (1989) developed a method to estimate the amount of dollar banknotes circulating in Bolivia, based on a ratio of check clearings to total demand deposits.

[10] The original result of Calvo and Rodriguez (1977) was subsequently extended and refined by various authors, including Liviatan (1981), Calvo (1985) and Végh (1988). See Calvo and Végh (1992) for a careful discussion of this strand of the literature. The interest of this literature stems also from the fact that, in the traditional Mundell-Fleming-Dornbusch model of flexible exchange rates with sticky prices, the extent of overshooting is inversely proportional to the interest-elasticity of money demand, a parameter that has often been assumed to represent the elasticity of substitution of different currencies.

[11] This discussion will be taken up further in section 3.

However, their methodology does not seem to be easily transferable to other countries. Kamin and Ericsson (1992) employ data on shipments of US dollar notes to Argentina in the latter half of the 1980s and find it to be a significant and growing component of currency substitution in Argentina.

The data on foreign currency deposits (FCD's) have to be interpreted carefully. Quite often, the maturity structure of these deposits is not available. Hence, one can only guess which part of these series actually cover the currency substitution phenomenon. Whereas data on FCD's in the domestic banking system are often available, those held by residents abroad are harder to measure. Indeed, all flows through third countries and third currencies are very hard to detect. Data on deposits held abroad in care of a non-resident—commonly used in some developing countries—are also not available. In addition, data on deposits held in off-shore banking centers are often unreliable.

To summarize, it is reasonable to treat the available data as lower bounds on the actual amount of currency substitution. This underestimation will be more severe in a situation of extreme economic instability, when the risk that the FCD's in the domestic economy will be confiscated, or their prohibition, makes them both attractive and hidden.

What do the available data tell us? Figure 2 describes the evolution of FCD's world-wide, in the industrialized world and in developing countries. These series are estimates of these deposits in major international banking centers. They should be interpreted with caution since little is known about the maturity of the deposits included. In constant U.S. dollars, the figure shows a world-wide increase from 600 billion to around 1100 billion dollars during the 1980s, an increase which was more pronounced in industrialized countries than in developing countries.

Most of the voluminous empirical work on currency substitution concentrates on Europe and the Western Hemisphere.[12] Figure 3 depicts the extent of currency substitution in Mexico, Peru, Bolivia and Uruguay. The solid line shows the proportion of FCD's, held

[12]Little is known about the extent of currency substitution in Asia and Africa, although there is casual evidence of dollarization in some African countries. Agénor and Khan (1992) give evidence for some African and Asian countries.

at home and abroad, in the extended monetary aggregate—M2 plus these FCD's (except for Bolivia, where only FCD's in the domestic banking system are included).[13] As the figure shows, these four countries have experienced, in the last twenty years, a dramatic increase in the use of foreign currency by domestic residents.[14] The degree of currency substitution appears related to macroeconomic instability. In all four countries FCD's rise with currency depreciation, although towards the end of the 1980s, they remain at relatively high levels despite the introduction of stabilization packages.[15]

Figure 4 provides more information on the breakdown of foreign currency holdings for Mexico, Peru and Uruguay, by reporting FCD's held in the domestic banking system and abroad. Notice that the substitution of FCD's at domestic banks with FCD's held abroad occurred mostly after FCD's were banned in the domestic banking system. This substitution, however, was not instantaneous.

The experience of Latin American countries shows the importance of macroeconomic instability in the development of currency substitution. It is beyond the scope of this paper to explain the differences in the degree of currency substitution in these countries but, as Savastano (1992) points out, the regulatory framework and the development stage of the financial system appear to be crucial factors.[16] This observation is consistent with our discussion in the previous section, where we argued that foreign currency is held as a store of value in countries where the financial markets' underdevelopment, perhaps coupled with pervasive controls on international financial assets' transactions, makes all financial assets—domestic and foreign—illiquid.

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[13] This explains the sudden fall of FCD's in 1982-85 in Bolivia when FCD's were outlawed. This sudden fall did not occur in the other three countries at the time when FCD's at home were outlawed, because there was a substitution between FCD's held in the domestic banking system and abroad those held abroad. See figure 4.

[14] For an in-depth analysis of the Latin-American experience, see Savastano (1992). See also Dornbusch, Sturzenegger and Wolf (1990).

[15] Guidotti (1989a, 1989b) and Clements and Schwartz (1992) deal more in depth with the limited effectiveness of stabilization policies in reversing currency substitution.

[16] One issue not addressed here is the effect of drug trade on dollarization in Latin America. The available evidence suggests that it does affect the degree of dollarization in Peru and Bolivia, but not so much in Colombia. Melvin and Ladman (1991) did find evidence of the significance of the drug trade. Loans in informal loan markets in the Cochabamba Upper Valley in Bolivia were more likely to be denominated in dollars during the coca harvest than at other times of the year.

Another natural question about the role and importance of currency substitution has to do with hyperinflation experiences. During a hyperinflation the opportunity cost of holding the national currency is so high that one expects currency substitution to be pervasive. Yet, the domestic currency does not disappear altogether. Although the German hyperinflation has been studied extensively in the literature on money demand, scant attention has been paid to the circulation of foreign currency in Germany during this period, perhaps again because of data problems. Abel *et al.* (1979) provide monthly data on the real money stock from 1921 until mid-1923. According to their data, the real domestic stock of money was, at the end of 1922, only one-fifth of its value in January 1921. In August 1923, it was only 4 percent of its value in January 1921. To what extent did foreign currency make up for this exorbitant drop in domestic real money balances? Beusch (1928) mentions estimates of foreign currency in circulation in mid-1923, which were ten times larger than the value of paper marks. Bernholz (1989) estimates that in mid-1923 there were about 4 billion gold-marks of "value-stable" money in circulation. This includes 2-3 billion gold-marks of foreign currency, and 1.1 billion gold marks of "emergency money". The rest was made up of commodity-backed money: notes representing specified amounts of rye, coal and other commodities. Together with 4 billion gold-marks of value-stable currency, Bernholz estimates a circulation of 80–800 gold-marks' worth of inflating currency after June 1923.[17]

These very dramatic fluctuations of monetary aggregates suggest two preliminary observations. First, when inflation reaches extremely high values, the economy naturally adopts substitutes to the depreciating currency. And, second, the inflating currency does not completely disappear. This stubborness of the hyperinflating money is an unexplored phenomenon. It could be due both to legal enforcement of its use for some transactions (*i.e.* taxes to be paid in cash), and/or to the hysteresis-type phenomena described in the previous section.

Russia went through a hyperinflationary cycle and stabilization

[17] As Holtfrerich (1980) points out, the adoption of foreign currency by the German economy induced the government to push ahead with a monetary reform to recapture the inflation tax. See also Dornbusch (1987).

during 1922-23. However, as Rostowski (1992) mentions, the Russian authorities introduced a second stable currency, the *Chervonets*, circulating together with the inflating currency, the *Sovznak*, 15 months before the stabilization. Figure 5 shows that the *total* real money stock had a positive trend, despite the collapse of the value of the *Sovznaki*. At the end of 1922 the stock of *Sovznak* stood at 90 millions of pre-war rubles. By the end of 1923, the total money stock—*Sovznaki* plus *Chervontsy* and transport certificates—stood at 186.7 millions of pre-war rubles. Although the real stock of *Sovznaki* had fallen to 50 million, the circulation of the new currency had more than made up for this decline. During 1924, the real value of *Sovznaki* all but evaporated, and the *Chervontsy* almost completely replaced it. The total stock kept growing rapidly throughout 1924, to reach 365.2 million of pre-war rubles in December 1924.

Currency substitution is an issue of interest not only in countries characterized by significant macroeconomic instabilities like the ones mentioned so far, but also in countries where, even with low rates of inflation, the opening up of financial markets, and the degree of integration with the rest of the world, make the definition of a domestic monetary aggregate a difficult exercise (with attendant difficulties in monetary targeting). This is the case in Europe, where during the second half of the 1980s many countries have opened up their financial markets to a very substantial extent, and where—as a result—the holdings of foreign currency deposits have increased noticeably. Figure 6 (from Angeloni, Cottarelli and Levy (1991)) shows the evolution of cross-border deposits (CBD's) as a percentage of a broad monetary aggregate in the European Community during 1983–90. Gross CBD's—defined as deposits held by European residents outside their own country—were fairly constant during 1983–88 at around 5 percent of the stock of broad money, but in the following 2 years they increased to about 8 percent. Net CBD's, defined as deposits held by European residents outside the EC, remained constant at around 1 percent of the aggregate broad money stock.

Figure 7 (also from Angeloni, Cottarelli and Levy (1991)) describes the evolution of CBD's in France, Germany, Italy and the United Kingdom. For each country, the figure reports 3 concepts

of CBD's: deposits held by residents with foreign banks, denominated in domestic and foreign currencies (residence of the holder); deposits with domestic banks held by non-residents in domestic and foreign currencies (residence of the bank); and finally, deposits denominated in national currency, held by nonresidents with domestic or foreign banks plus deposits denominated in national currency held by residents in foreign banks minus deposits denominated in foreign currencies held by residents with domestic banks (currency of denomination). The figure shows the importance of foreign deposits with domestic banks in a country, like the UK, with a major international financial center in it, as well as the importance of changes in regulations. In Germany the government abolished, in December 1985, the exemption for reserve requirements of short-term bank deposits, and the result was a big jump in CBD's.[18] A sizeable increase in CBD's is also observable in correspondence to the introduction of the withholding tax in January 1989, subsequently abolished in June 1989. The increase of CBD's in France and Italy occurs, for each of the two countries, after changes in regulations affecting foreign exchange controls and reserve requirements. In general, CBD's have increased after the relaxation of foreign exchange controls. In summary, while the size of CBD's for the UK dwarfs that of France and Italy, the acceleration of CBD's in the latter two countries is a very remarkable phenomenon, and possibly a more serious source of money-demand instabilities.

3.2 Econometrics

In the empirical literature currency substitutability has been defined and estimated in many different ways, often difficult to reconcile with each other or with theoretical models. Yet, three categories of empirical models can be identified.[19] In the first, demand functions for domestic and foreign moneys are part of a static (two period) portfolio balance model, where optimal holdings of domestic and foreign assets are chosen together with currencies. This strand of the

[18] For more detail, see Angeloni, Cottarelli and Levy (1991).

[19] While most of the empirical papers can be classified in the three categories that follow, some do not fit our classification method. See, for instance, Girton and Roper (1981), El-Erian (1988), and Clements and Schwartz (1992).

literature treats domestic and foreign interest rates, together with exchange rate changes, as jointly determined in a general financial equilibrium.

In the second category currency substitutability is estimated in a narrower setup. In these models, agents first decide on the optimal mix of monetary and non-monetary assets. In a second stage, they decide how to allocate the monetary assets between the different currencies in their portfolio. The latter decision is based only on the degree to which both currencies contribute to delivering money services and on the relative opportunity cost between the two currencies.

Finally, a more recent strand of literature starts from the first order conditions of a representative agent's dynamic optimization problem and, with some auxiliary assumptions, recovers the parameters of interest, which allow the estimation of the substitutability of different currencies.

Consider the two-period portfolio balance model first. Investors choose among domestic money (M), foreign money (M^*), domestic bonds (B) and foreign bonds (B^*). The derivation of the asset demand equations was pointed out in the previous section. In the first-order necessary conditions for optimization—from equations (11), (12) and (13)—the marginal utility of wealth equals, in equilibrium, the marginal utility of the end-of-period value of the portfolio, that is the sum of the holdings of each asset times the value of each asset—including its own income—at the end of the period. Hence, from these first-order conditions it is possible to solve for the desired holdings of each of the available assets.

In the illustration below, we follow Branson and Henderson (1985), where—without the explicit solution of an optimization problem — the *domestic* demand for assets is postulated to depend on their relative returns:

$$M = M(\overset{-}{i}, (i^* \overset{-}{+} e^e), \overset{-}{e^e}, \overset{+}{PY}, \overset{+}{P^c}, \overset{+}{W}) \tag{15}$$

$$eM^* = M^*(\overset{-}{i}, (i^* \overset{-}{+} e^e), \overset{+}{e^e}, \overset{+}{PY}, \overset{+}{P^c}, \overset{+}{W}) \tag{16}$$

$$B = B(\overset{+}{i}, (i^* \overset{-}{+} e^e), \overset{-}{e^e}, \overset{-}{PY}, \overset{-}{P^c}, \overset{+}{W}) \tag{17}$$

$$eB^* = B^*(\bar{i}, (i^* \overset{+}{+} e^e), \bar{e^e}, \bar{PY}, \bar{P^c}, \overset{+}{W}) \qquad (18)$$

satisfying the usual wealth constraints. The first argument in equations (15) - (18), i is the return on holding bonds denominated in domestic currency, relative to the return on domestic money (minus the rate of domestic inflation). It is assumed that all four assets are substitutes in the portfolio. Hence, an increase in i raises the demand for domestic bonds but lowers the demand for their substitutes in the portfolio. The nominal return on bonds in foreign currency is i^*. Expressed in domestic currency, this return becomes $i^* + e^e$, with e^e the expected change in the exchange rate. It affects the demand for foreign securities positively and the other asset demands negatively. Once again, this second argument is in fact a real return differential, where the return on domestic money is minus the rate of inflation.[20] Similarly, the third argument, e^e, is the return on foreign money, converted in domestic currency.[21]

The fourth argument, PY, is the home currency value of domestic output and affects demand for all assets positively. P^c is the price of the domestic consumer's consumption bundle expressed in home currency. An increase in P^c increases the demand for both moneys and lowers the demand for bonds denominated in domestic and foreign currency. The positive effect of domestic wealth W, the last argument, reflects the assumption that all assets are "normal assets".

The discussion of the theoretical models of liquidity and the demand for domestic and foreign moneys as stores of value suggests a possible source of misspecification in this model. In the portfolio-balance equations derived in the previous section the real returns from holding the domestic and foreign currencies, *i.e.* their liquidity services, have to be added to minus the rate of inflation, and

[20] Indeed, the real return on the foreign bond, in terms of domestic goods, equals the own real rate of interest on the foreign bond, plus the expected rate of change of the real exchange rate—the expected rate of change of the nominal exchange rate plus the expected foreign price inflation, minus the expected domestic price inflation. Subtracting the real return on the domestic currency, we obtain the nominal return in the equation.

[21] Again, the real return on the foreign money, expressed in terms of foreign goods, is minus the expected foreign rate of inflation. This can be transformed into a real return expressed in domestic goods by adding the expected rate of change of the exchange rate. Finally, adding the expected domestic rate of inflation (that is, subtracting the return on the domestic money stock expressed in terms of domestic goods) we are left with the expected change of the nominal exchange rate.

are distinct from the domestic and foreign interest rates and the rate of change of the exchange rate. Yet, they do not appear in the equations written above, thus raising questions about specification biases.

Indeed, in the absence of such liquidity services, it is not clear why domestic and foreign money are held at all. One potential way out is to assume that such liquidity services are constant, and thus independent of the other returns in the equations. Such assumption, however, is never invoked in the empirical papers we have surveyed.

For estimation purposes, equations (15) - (18) can be approximated in log-linear form:[22]

$$log\frac{M}{P} = \alpha_0 + \alpha_1 logY + \alpha_2 i + \alpha_3(i^* + e^e) + \alpha_4 e^e \qquad (19)$$

$$log\frac{eM^*}{P^*} = \beta_0 + \beta_1 logY + \beta_2 i + \beta_3(i^* + e^e) + \beta_4 e^e \qquad (20)$$

$$log\frac{B}{P} = \gamma_0 + \gamma_1 logY + \gamma_2 i + \gamma_3(i^* + e^e) + \gamma_4 e^e \qquad (21)$$

$$log\frac{eB^*}{P^*} = \delta_0 + \delta_1 logY + \delta_2 i + \delta_3(i^* + e^e) + \delta_4 e^e \qquad (22)$$

In the literature, currency substitutability is defined as the extent to which residents replace domestic money in their portfolio with foreign money, in response to a change in their relative rate of return.[23] In equation (19) this is reflected in the term α_4. Substitution between bonds, which McKinnon called *indirect currency substitution* is measured by γ_3 and δ_3.[24] When estimating this set of equations, the inclusion of both $i^* + e^e$ and e^e allows, according to some, to distinguish between capital mobility and currency substitutability.[25]

In addition to the conceptual problem raised above on the estimation of these money- and asset-demand equations, there are two

[22] Under suitable assumptions, described in detail in Branson and Henderson (1985), the price of the consumption bundle and nominal wealth drop out of these equations.

[23] This section looks at currency substitutability from the perspective of the domestic resident. A similar set of equations be written for the foreign resident.

[24] An intermediate case is the substitution between money denominated in one currency and bonds denominated in the other currency, measured by α_3, β_2 and γ_4. See also Thomas (1985).

[25] The most thorough application of this model that we know of is Cuddington (1983), who estimates equation (19) in this general portfolio balance framework to test for currency substitutability in the United Kingdom, Canada and Germany.

other issues that often surface in empirical work based on these equations: multicollinearity and partial adjustment. In these portfolio balance models rates of return are highly collinear (and indeed perfectly collinear when uncovered interest parity assumed by those researchers who take the expected future spot exchange rate to be proxied by the forward exchange rate[26]). Precise estimation of the parameters of interest is thus difficult. Finally, the assumption of partial adjustment (not written out in the illustration above), which amounts to introducing the lagged dependent variable on the right-hand side of the regressions, is difficult to justify, since it is hard to identify costs of adjustment of private financial portfolios. The lagged dependent variable picks up any serial correlation of the estimated residuals in the original equation. Even accepting the presence of slow adjustment due to adjustment costs, the estimated coefficients of the lagged dependent variables often indicate that these costs of adjustment are implausibly high, and imply implausibly slow adjustment.[27]

In the sequential portfolio-balance approach, the choice between the two currencies is made after the shares of monetary and non-monetary assets have been determined (Miles (1978)). In Miles's model, domestic and foreign money are both inputs in a CES function that produces money services (MS):

$$MS = (\lambda_1 \left(\frac{M}{P}\right)^{-\rho} + \lambda_2 \left(\frac{M^*}{P^*}\right)^{-\rho})^{-\frac{1}{\rho}} \tag{24}$$

This money-services function is maximized subject to the following constraint:

$$M_0 = \frac{M}{P}(1+i) + \frac{M^*}{P^*}(1+i^*) \tag{25}$$

where M_0 is the desired level of money services fixed at the previous stage of the portfolio maximization problem. The agent allocates

[26] See, for example, Cuddington (1983).

[27] In this portfolio balance approach, several different versions of equation (19) have been estimated. Marquez (1987) chose a slightly different set-up to estimate currency substitutability in Venezuela:

$$log\frac{M}{P} = \nu_0 + \nu_1 logy + \nu_2 i + \nu_3 i^* + \nu_4 e^e \tag{23}$$

again in a partial adjustment context. According to the author, ν_3 measures capital mobility and $\nu_4 - \nu_3$ indicate currency substitutability. Examples of other portfolio balance models, are in Miles and Stewart (1980) and Brittain (1981).

these money services between the two moneys depending on their relative opportunity costs (expressed in the asset constraint) and their relative efficiency in providing money services (expressed in the money services production function). The resulting first-order condition expresses the relative demand for both currencies as a function of the interest rate differential, assuming that purchasing power parity holds continuously:

$$log(\frac{M}{eM^*}) = \eta_0 + \eta_1[log(1+i^*) - log(1+i)] \qquad (26)$$

In this set-up, η_0 is the ratio of the weight of domestic real money over the weight of foreign real money in the money services function (24), λ_1/λ_2. η_1 equals $\frac{\rho}{1+\rho}$ and, according to its author, measures the degree of currency substitutability. With perfect currency substitutability, η_1 goes to infinity. This implies that ρ goes to -1 and the money services function (24) becomes the weighted sum of domestic and foreign real money.[28] In equation (26) the log difference of domestic and foreign interest rates is equal, in the presence of international capital mobility, to the forward premium (by the interest-rate-parity condition). The forward premium is in turn assumed to be equal to the expected rate of change of the exchange rate—that is, perfect asset substitutability is assumed as well. This specification could be viewed as a special case of the two-period model described above, where the expected rate of change of the exchange rate represents the relative real return of the foreign money over the domestic money.

Bordo and Choudri (1982) modify the model of Miles by adding output to the maximization problem. Hence output also enters the equations to be estimated. For variations on Bordo-Choudri's model, see Neldner (1987), Bana and Handa (1990) and Batten and Hafer (1984). Other authors use different variables to measure the opportunity cost of money.

Abel *et al.* (1979), studying the German hyperinflation, use a

[28] Numerous authors have built upon this specification. Ortiz (1983a, 1983b) estimated a partial-adjustment version for Mexico, incorporating foreign exchange risk and political risk. Ramirez-Rojas adapted equation (26) to study currency substitutability in Argentina, Mexico and Uruguay. Other extensions can be found in Rojas-Suarez (1992), Elkhafif and Kubursi (1991), Savastano (1992), Joines (1985), Bergstrandt and Bundt (1990), Melvin (1988), Boon, Kool and de Vries (1988) and de Vries (1988).

proxy for expected inflation (actual inflation, instrumented) instead of the domestic interest rate. Frenkel (1977) uses the forward premium as a measure of anticipated inflation.[29]

Finally, the the last category of empirical models of the demand for different currencies includes the dynamic models of İmrohoroğlu (1991) and Bufman and Leiderman (1992a, 1992b). Instead of directly estimating money demand equations, these authors exploit the orthogonality restrictions stemming from the first-order conditions for optimization, as well as from the assumption of rational expectations. İmrohoroğlu (1991) develops a model in which a representative agent derives instantaneous utility from consumption and from money services. The latter are produced by both domestic and foreign real money through a constant elasticity of substitution technology. The problem is to maximize the present discounted value of instantaneous utilities subject to a standard budget constraint. Among the first-order necessary conditions for optimization are a set of Euler equations, specifying the equilibrium dynamics for marginal utilities. One such Euler equation in İmrohoroğlu's model is the following:

$$U_{c,t} = U_{\frac{M}{P},t} + \beta(1+i_t)E_t[U_{c,t+1}\frac{P_t}{P_{t+1}}], \qquad (27)$$

where subscripts indicate the arguments of partial derivatives of the utility function evaluated at different time periods. Equation (27) says that the utility obtained from holding cash balances drives a wedge between the expected rate of growth of marginal utility and the expected real interest rate. That wedge is the marginal utility of cash balances. A similar result is obtainable from the model discussed in the previous section, by combining equations (9) and (13). After proper parametrization, these equations can be estimated using Hansen's GMM technique. Bufman and Leiderman (1992a) extend this framework by incorporating non-expected utility to disentangle behavior towards risk and intertemporal preferences.

Clearly, the empirical models of İmrohoroğlu and Bufman and Leiderman are much closer to the underlying theoretical models than those that have been used more frequently in the literature

[29] For similar exercises in a different context, see Agénor (1990), Agénor and Khan (1992) and Ghosh (1989).

so far. However their models, like most models of money demand, are subject to criticism on the services that domestic and foreign money are assumed to perform, and in particular, on the inclusion of money balances in agents' utility function.

3.3 Parameter Estimates

Despite the controversies that theoretical models of the demand for different moneys can stimulate, and the more bitter controversies on their empirical applications, a look at the estimated values of the parameters of the equations described in the previous section provides a more complete evaluation of the phenomenon of currency substitution. Even if these parameters might not actually give a precise quantification of the substitutability of different moneys, they provide useful information on the correlations in the data.

In order to keep the discussion manageable, we will concentrate on the "classic" case studies of currency substitution: Latin American countries and Canada.[30]

For Latin American countries, most studies claim to find significant currency substitutability. Ramirez-Rojas (1985) estimates a variant of equation (26) for Argentina, Mexico, and Uruguay. He finds the coefficient of the inflation differential *vis-à-vis* the United States to be negative and significant in the case of Argentina and Mexico, and ranging from -1.5 to -3.2. Ortiz (1983b)'s earlier work on Mexico yielded comparable results.

Canto and Nickelsburg (1987) project the rate of change in the ratio of domestic real money to foreign real money in Argentina on the change in the (log) exchange rate over the 1956–59 and 1979–81

[30] For the reader interested in specific countries, we would like to draw attention to the following studies: Argentina (Fasano-Filho (1984), Kamin and Ericsson (1992), Ramirez-Rojas (1985)), Bolivia (Clements and Schwartz (1992), Melvin (1988), Melvin and Afcha (1989)), Costa Rica (Camacho and Gonzalez-Vega (1985), Dominican Republic (Canto (1985)), Dutch Antilles (de Vries (1988)), Egypt (Boutros-Ghali (1980), El-Erian (1988), Elkhafif and Kubursi (1991)), Finland (Virén (1990a)), Germany (Baade and Nazmi (1989), Miles (1981), Miles and Stewart (1980), Laney, Radcliffe and Willett (1984), Neldner (1987)), Mexico (Laney (1981), Gruben and Lawler (1983), Ortiz (1983a, 1983b), Ramirez-Rojas (1985), Rogers (1992)), Netherlands (Traa (1991)), Peru (Beckerman (1987), McNelis and Nickelburg (1990), Rojas-Suarez (1992)), United Kingdom (McKenzie and Thomas (1984)), United States (McKinnon (1982), McKinnon and Tan (1983), Ross (1983), Radcliffe, Warga and Willett (1984, 1985), Daniel and Fried (1985), Marquez (1985b), Batten and Hafer (1984, 1986), Willett (1987), Virén (1989, 1990b)), Uruguay (Ramirez-Rojas (1985)), Venezuela (Marquez (1984, 1987)), Yemen (El-Erian (1988))

periods, obtaining coefficients that are comparable to those of the previous authors.

Canada is certainly the country which generated most controversy in the debate on currency substitutability. Miles (1978) estimated equation (26) and claimed to find high currency substitutability. His estimate of the interest rate differential was -5.4 during 1960-75. Bordo and Choudri's (1982) estimates of the coefficient on the interest rate differential were no longer significantly different from zero when they included income in Miles's equation.[31]

Other papers claiming negative results on the substitutability between US and Canadian dollars in Canada include Brillembourg and Schadler (1979) and Cuddington (1983). Similarly, İmrohoroğlu's (1991) GMM estimates of the elasticity of substitution of US and Canadian money balances range from $-.2926$ to $-.4337$ (depending on the instruments used).

4 Policy Questions

Currency substitutability has received most attention since the mid-1970s. While the breakdown of the Bretton Woods system seemed to have revived hopes of pursuing independent monetary policies, the macroeconomic instabilities following the oil shock had shattered those hopes in many industrial countries.

Exchange rates movements were far beyond what had been expected at the time Bretton Woods collapsed, and inflation rates were beyond anything seen during the Bretton Woods period. Towards the end of the 1970s, these problems were accompanied by a suspicion that traditional money demand equations were failing, because velocity had become more unstable, thus making monetary targeting a more difficult task.[32] This perceived instability in velocity functions led some authors, like Brittain (1981) and McKinnon (1982), to attribute it to currency substitution and to advocate

[31] See also Bana and Handa (1990) who extended the Bordo-Choudri model with a variable measuring the cost of switching from one currency into the other. They found more evidence of currency substitutability during the flexible exchange rate period than Bordo and Choudri did. Ghosh (1989) also found significant substitutability. Other estimates are reported by Gregory and MacKinnon (1980), de Vries (1988) and Daniel and Fried (1983) (who point to the omission of a variable measuring postal strikes in Bordo-Choudri's specification).

[32] See Goldfeld and Sichel (1990).

greater international monetary cooperation.

Figure 8 plots residuals from standard money demand equations for the US, Canada, Germany and Japan, whose estimates are reported in Table 1. We regressed real narrow money (M1) on a constant, real output, and the change in the GDP deflator in log-linear form. Our sample is quarterly and the data is from *International Financial Statistics*. The residual from money demand equation is the excess of actual real money balances over real money balances predicted from our estimated velocity function. Since—by the velocity identity—real money balances equal real income divided by income velocity, a positive residual indicates that actual velocity is less than estimated velocity, and vice versa. The "missing money" phenomenon is clearly apparent at the end of the 1970s and early 1980s in Canada and the US. There is also some increase in the volatility of the series plotted in figure 8. The standard deviation of the residuals for Canada is .049 in the 59:2 to 69:4 period, and increases to .159 thereafter. In the US the increase in the standard error of the estimated residual over the same periods is from .029 to .069. In Germany, the missing money phenomenon is not so marked. In the case of Japan, we do not observe any special pattern, but note that the inflation elasticity of money demand is positive and significant.

The very high persistence of the estimated velocity innovations (measured by the low values of the Durbin Watson statistics), the apparent correlation of velocity disturbances, as well as the increase in their volatility in the 1970s (in the case of the US and Canada), raised questions about monetary stability under flexible exchange rates. Currency substitutability emerged as a major, albeit controversial, explanation for some of these anomalies. McKinnon (1982) argued this point forcefully and suggested that, although currency substitutability makes the demand for national moneys more unstable, worldwide demand for money was more stable and hence a better predictor of domestic inflation. Based on this observation, he argued that all countries should set monetary targets compatible with zero inflation, assuming no shocks in money demand. After having set these targets, all countries would pursue a policy of symmetric nonsterilized intervention to accomodate demand

Table 1

$$\ln(\frac{M_t}{P_t}) = \alpha_0 + \alpha_1 \ln(y_t) + \alpha_2 \pi_t + \alpha_3 D_{1,t} + \alpha_4 D_{2,t} + \alpha_5 D_{3,t} + u_t$$

	α_0	α_1	α_2	R^2	D.W.
US	4.02	0.30	-5.85	0.64	0.21
	(25.01)	(14.67)	(-6.79)		
Canada	-5.82	1.20	-1.93	0.85	0.07
	(-16.18)	(26.48)	(-1.37)		
Germany	-3.72	1.13	-0.52	0.98	0.23
	(-33.39)	(82.13)	(-1.39)		
Japan	-7.34	2.26	5.37	0.96	0.40
	(-20.87)	(52.45)	(5.28)		

†The variables labelled D are seasonal dummies. T statistics in parentheses. Money is IFS line 34 (M1), y is real GDP (except for Germany, for which GNP is used), also from IFS. π is measured by the log-difference in the GDP deflator. All data are quarterly. Samples: US:59:1–92:1; Canada: 59:2–91:4; Germany 60:2–90:1 (after that date there is a break in the data due to the German unification); Japan: 59:1–91:1.

shocks. This would prevent monetary authorities from destabilizing the world money supply which could then be used to guide domestic inflation.

This idea has been discussed widely in the literature. For example, Spinelli (1983) argues that standard money demand equations with a scale variable and domestic interest rates leave little variation in money demand unexplained. Moreover, the empirical evidence we survey in the previous section is not conclusive in establishing the influence of foreign interest rates or expected exchange rate changes on domestic money demand. Where statistically significant cross-elasticities have been found, they are usually much smaller than the elasticity with respect to the domestic interest rate. Finally, even the evidence assembled here only suggests the presence of instabilities in the US and Canada: estimated residuals for Germany and

Japan do not display easily detectable breaks in the sample.[33]

McKinnon's idea has recently been explored in the context of the European Monetary System. As mentioned in section 2, cross-border deposits have risen steadily throughout the 1980s in EC countries. Kremers and Lane (1990) show that a narrow measure of money demand in the European Exchange Rate Mechanism (ERM) has a more stable relation with ERM-wide income, inflation, interest rates and the ECU-dollar exchange rate than national money demand equations.[34] Angeloni, Cottarelli and Levy (1991) estimate the information content of traditional money demand equations and those extended with cross-border deposits. They conclude that narrow monetary aggregates provide most information but that its informational contents has diminished recently. Some extended monetary aggregates dominate traditional aggregates in terms of information content.

Instead of looking for a proper redefinition of national monetary aggregates Bayoumi and Kenen (1992) went back to McKinnon's original approach and tested the hypothesis that ERM-wide money is as good a predictor of inflation as national money supplies since 1987. They ran Granger causality tests of inflation in ERM-countries and domestic and ERM-wide money over 1983-90 and 1987-90. They found ERM-wide money to Granger cause inflation in several countries for both sample periods.[35]

A more radical policy implication of currency substitutability is the one discussed and advocated by Hayek (1976):

> "the countries of the Common Market [...] mutually bind themselves by formal treaty not to place any obstacles in the way of the free dealing throughout their territories in one another's currencies (including gold coins) or of a similar free exercise of the banking business by any institution

[33] McKinnon's empirical arguments have also been reexamined. Ross (1983) points out that the evidence that McKinnon used could actually support an opposite conclusion and claims that ignoring foreign influences on domestic money is not too important. Goldstein and Haynes (1984) run "St. Louis regressions" to refute McKinnon's conjecture on the superiority of world money as a predictor of US inflation.

[34] For a similar analysis, see Monticelli and Strauss-Khan (1992).

[35] As the authors point out, these tests should be seen as indicative should be interpreted with caution. Their results show that both ERM-wide and national money seem to be weakly correlated with inflation in the Granger sense.

> legally established in any of their territories." (1976, page 17)

The effect of this plan is

> "to impose upon existing monetary and financial agencies a very much needed discipline by making it impossible for any of them, and for any length of time, to issue a kind of money substantially less reliable and useful than the money of any other." (1976, page 17)

Hayek's policy proposition is predicated on the assumption that monetary authorities use their monopoly on note issuance, sustained by legal tender rules and other regulations, to maximize their own income, or the income of their governments. Increasing the competition among monetary authorities would thus eliminate this behavior, and increase economic efficiency. Hayek's proposition is extremely attractive from a theoretical perspective, but its basic premise is likely to be faulty: the objective of national monetary authorities—at least in most industrial countries—is not to maximize the revenue from inflation.

In connection with the debate on European monetary unification, the UK government (HM Treasury (1989)) has adopted Hayek's views, by putting forth a proposal for an evolutionary approach to currency unification, based on the idea of currency competition, to be achieved through "the complete removal of all unnecessary restrictions on the use of Community currencies [and] ... by tackling remaining barriers, including those affecting the development of appropriate technology, the use of relatively cheap and convenient means of payments." (HM Treasury (1989), para. 21 and 22)

The British proposal, seemingly in the same vein as Hayek's, is actually far from it. The achievement of a monetary union, even by the adoption of the most stable and efficient currency, is equivalent to the evolution from a regime of monopolistic competition to a monopoly: all the virtues of competition, under Hayek's maintained assumption, are lost. (see Giovannini (1992a), and the discussions of the British proposal in Weil (1991), Woodford (1991) and Fleming (1991)).[36]

[36] For related studies on the EMS, see Giovannini (1990, 1991a, 1991c, 1992b) and Gros and

In developing countries, the policy issues arising from currency substitutability are rather different. Two major concerns stand out. First, the effect of currency substitutability on the effectiveness of stabilization programs. Second, the effects of currency substitutability on the revenue from inflation.

Calvo and Végh (1992) discuss the effects of currency substitutability on stabilization packages. One of the difficult problems faced by countries trying to stabilize stems from the credibility of the policy change. Recently, many stabilization packages have been characterized by the fixing of the nominal exchange rate, or the establishment of a crawling peg which ensured progressive appreciations of the real exchange rate. The question is whether dollarization facilitates the stabilization, by improving credibility. In principle, credibility could be strengthened if the circulation of foreign currency in the economy largely eliminates the incentives that the government has to manipulate the national currency. In practice, however, such effect has never been tested. An additional question on the effects of currency substitutability in stabilization plans regards the choice of fixed versus flexible exchange rates. The discussion in section 2 points out, rather unambiguously, that in the presence of currency substitutability there is higher volatility of exchange rates, with potential distributional effects in the economy. These observations lead to advocate fixed exchange rates in a stabilization, whenever currency substitutability is of significant importance.[37]

The effect of currency substitutability on inflationary finance and seigniorage has been discussed above in section 2. We would like to remind here the theoretical contributions of Végh (1989a), Hercowitz and Sadka (1987) (who discuss the relation between currency substitution, the inflation tax and foreign exchange restrictions) and Khan and Ramirez-Rojas (1986), as well as the empirical work of Bufman and Leiderman (1992a, 1992b) (on Israel), İmrohoroğlu (1991) (on Canada), Savastano (1992), McNelis and Asilis (1992) and Rojas-Suarez (1992) (on Latin America) and Sturzenegger (1992)

Thygesen (1992).

[37] Some Latin-American countries promoted foreign currency deposits in their economy after the stabilization package was put into place. Note also that a big repatriation of foreign currency deposits in the domestic banking system enhances the credibility of the stabilization package. Melvin and Fenske (1992) argue, on the other hand, that the absence of dedollarization in Bolivia might be related to the low credibility of the stabilization package.

who analyses the regressivity of the inflation tax. These explorations often lead to surprising results: for example, Bufman and Leiderman find that modest increases in dollarization have a large impact on the revenue from seigniorage. Their simulations reveal that a 10 percent increase in the dollarization ratio (from 30 to 40 percent) halves the signiorage/GNP ratio for a wide variety of inflation rates (their calculations are based on the model described above, estimated on Israeli data).

Finally, currency substitutability has also implications for the optimal rate of inflation. Note that, in general, equations (9) and (10) above imply that the marginal rate of transformation between two goods deviates from the marginal rate of substitution, because of liquidity costs. Such liquidity costs, in turn, are affected by the rates of inflation in the two currencies. Hence, the model implies an optimal *relative* rate of inflation, such that the marginal rate of transformation of different goods equal their marginal rate of substitution.[38] This result, as Végh (1989a) has also pointed out, dramatically alters the analysis of the optimal inflation rate in a small country in the presence of currency substitution.[39] Given the foreign rate of inflation, the domestic rate of inflation should be chosen to minimize the distortions in relative goods prices mentioned above.

5 Concluding Observations

We conclude this survey of currency substitution with a brief list of the questions, raised in this paper, which we think represent significant challenges for future research.

The first regards the specification of the money demand equation. The boom of the empirical literature on currency substitution has shown the variety of alternative specifications of the money demand equation that could be generated by alternative theoretical models, as well as the difficulty of behavioral interpretations of its parameters. The instabilities of standard money demand equations

[38] See Canzoneri, Diba and Giovannini (1992) for a discussion of this problem in the context of a different model.

[39] See Friedman (1969), Guidotti and Végh (1992), Kimbrough (1986, 1991), Phelps (1973) and Végh (1989b).

that we have documented suggest that finding a generally acceptable and stable relation between monetary aggregates and other macroeconomic variables remains one of the main challenges of monetary theory, with major implications for monetary policy.

The second question left open by our survey regards the empirical importance of the transactions externality in money demand. Its importance is suggested by four kinds of evidence: casual empiricism *cum* introspection (for example, US dollars are generally acceptable by hotels and taxicabs in big cities outside the US), the non-disappearence of hyperinflating currencies (discussed in section 3), the persistence of foreign-currency deposits in economies that have completed stabilization programs (also discussed in section 3), and the international vehicle currency phenomenon, which we mentioned in section 2. Understanding the transactions externality, as well as its implications on the behavior of velocity and monetary management is in our view an important area for future research.

Finally, this paper has discussed in several places the effects of capital market liberalization. The traditional view on the liberalization of capital markets and of international capital flows is that it makes monetary management more difficult, since free international capital flows are highly sensitive to rate-of-return differentials and, in particular, to expectations of exchange-rate fluctuations. On the other hand, we have pointed out that restricted capital markets make financial assets illiquid, and provide a boost for the demand for money for store-of-value purposes. Whenever domestic-currency inflation is high, restricted financial markets are likely to increase the demand for more stable, foreign cash. The phenomenon of currency substitution might therefore be more pervasive in countries where financial assets are illiquid and domestic money loses purchasing power fast. Thus it is not clear what is worse for monetary management: restricted financial markets with currency substitution or free capital markets with high international capital mobility. In general, the question of whether free international capital movements are to be advocated or rejected *per se*, has not received satisfactory answers so far in international monetary theory.

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Figure 1

The Problem of Multiple Exchange-Rate Equilibria

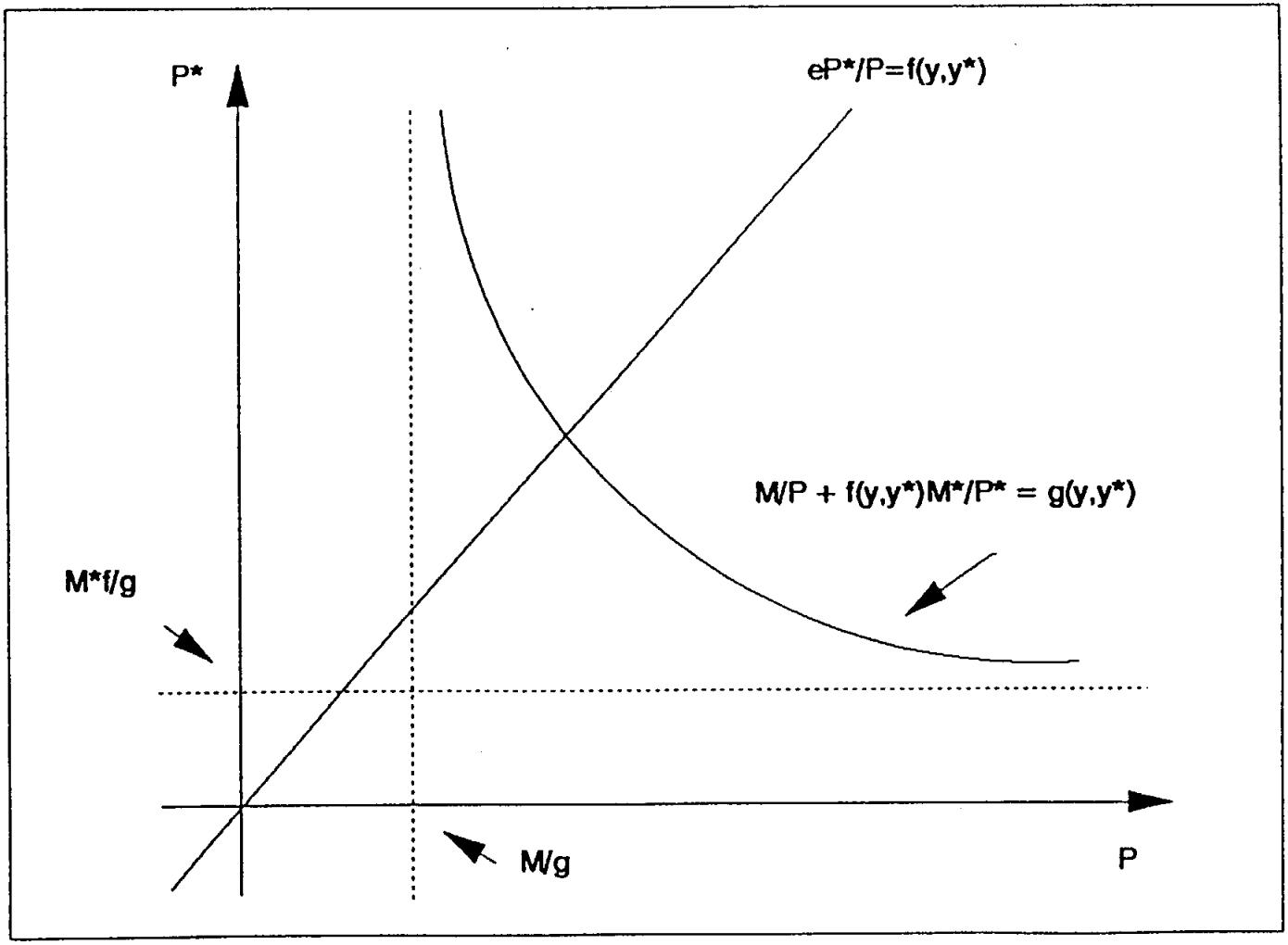
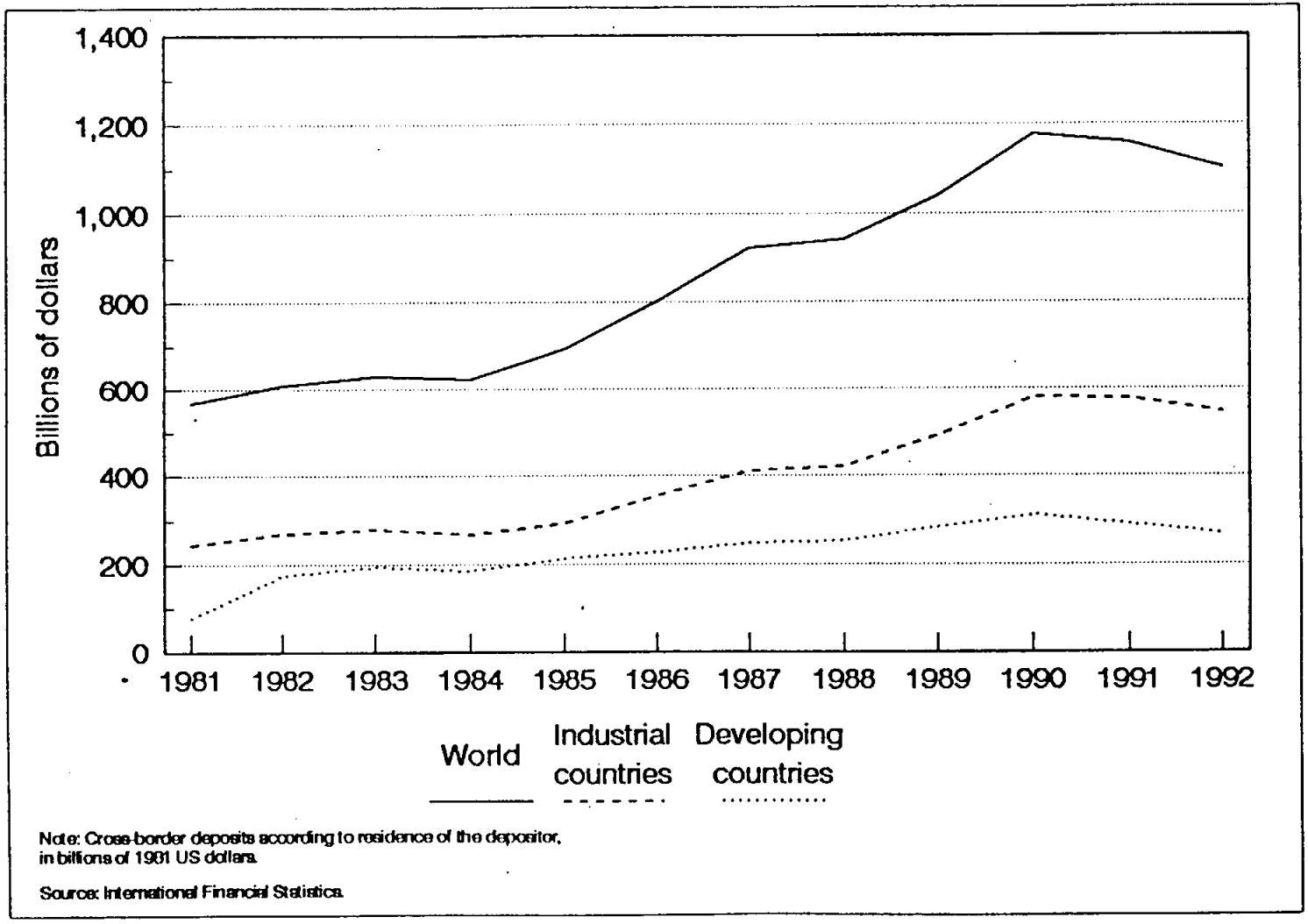


Figure 2

Foreign Currency Deposits

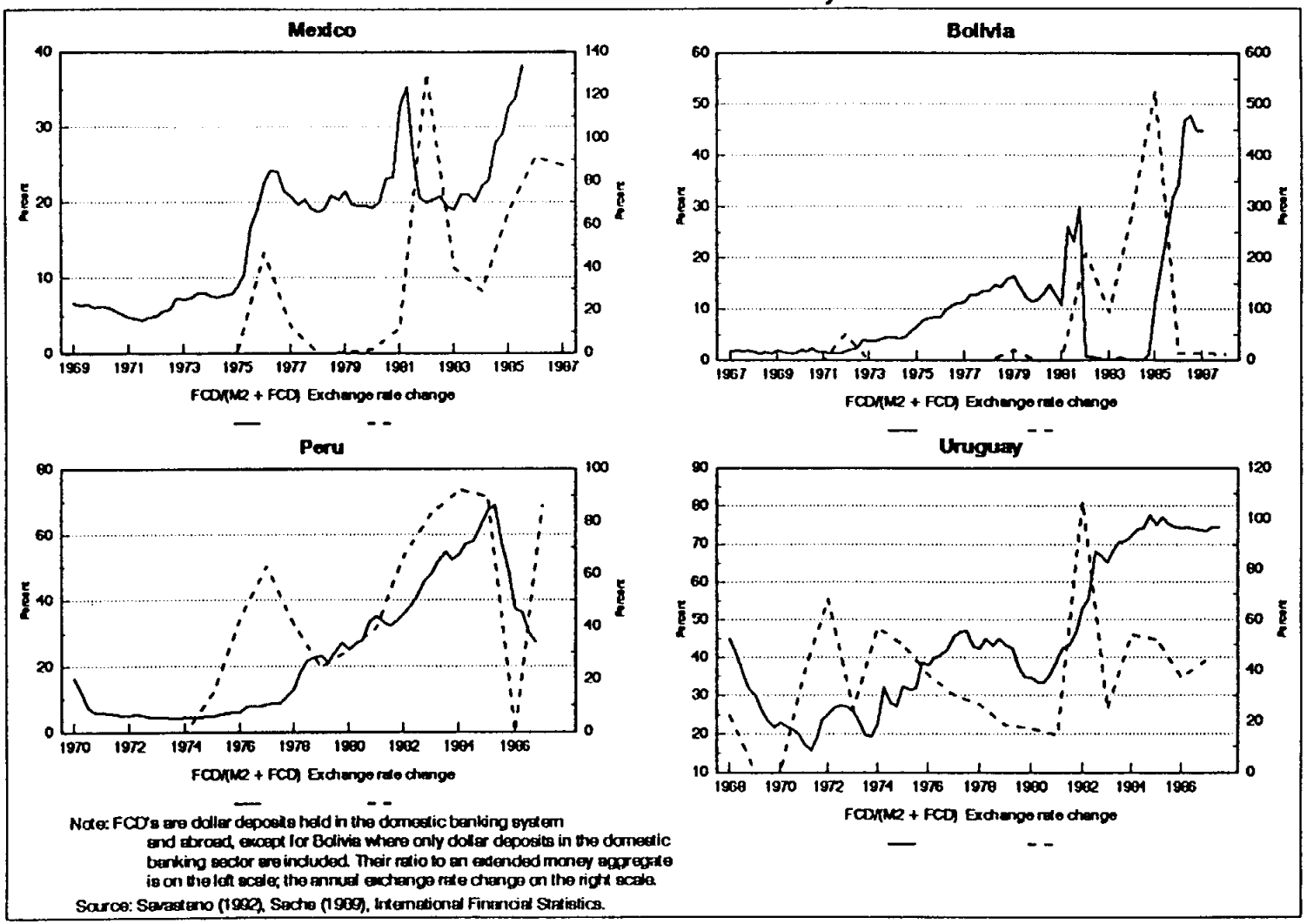


Note: Cross-border deposits according to residence of the depositor, in billions of 1991 US dollars.

Source: International Financial Statistics.

Figure 3

Dollarization and Macroeconomic Instability in Latin America

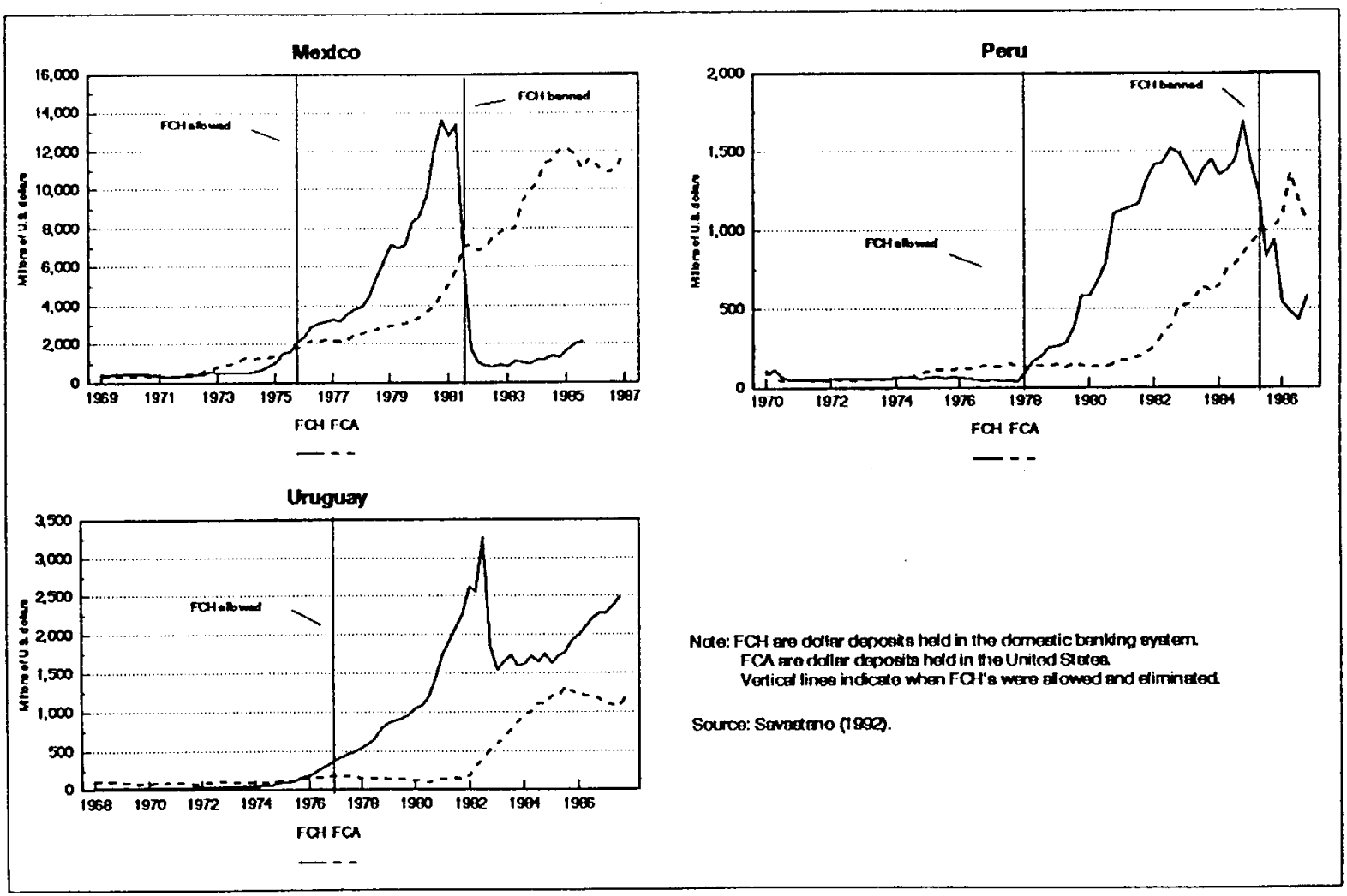


Note: FCD's are dollar deposits held in the domestic banking system and abroad, except for Bolivia where only dollar deposits in the domestic banking sector are included. Their ratio to an extended money aggregate is on the left scale; the annual exchange rate change on the right scale.

Source: Savastano (1992), Sachs (1989), International Financial Statistics.

Figure 4

Dollar Deposits in Latin America

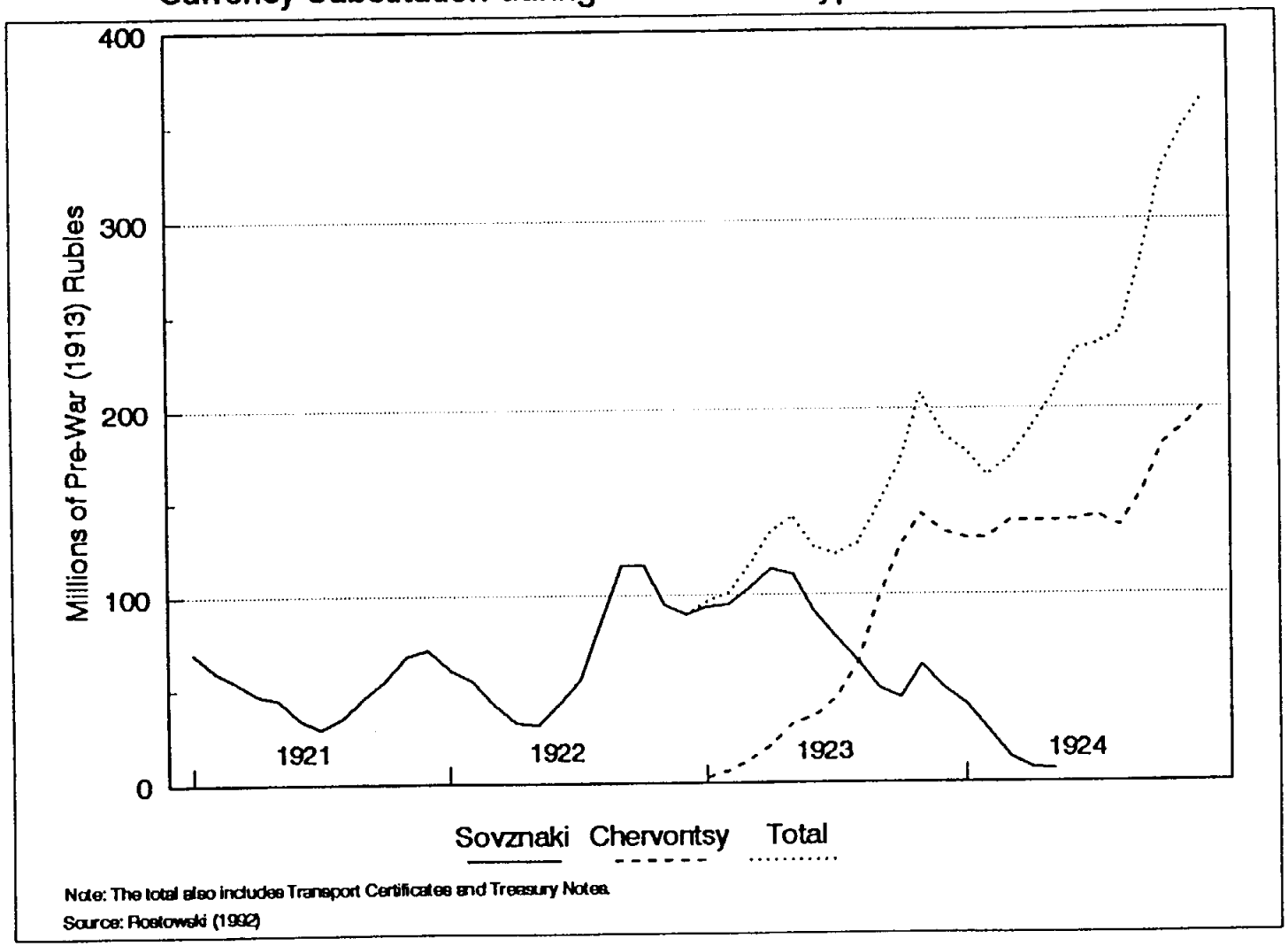


Note: FCH are dollar deposits held in the domestic banking system.
FCA are dollar deposits held in the United States.
Vertical lines indicate when FCH's were allowed and eliminated.

Source: Savastano (1992).

Figure 5

Currency Substitution during the Russian Hyperinflation: 1921-24

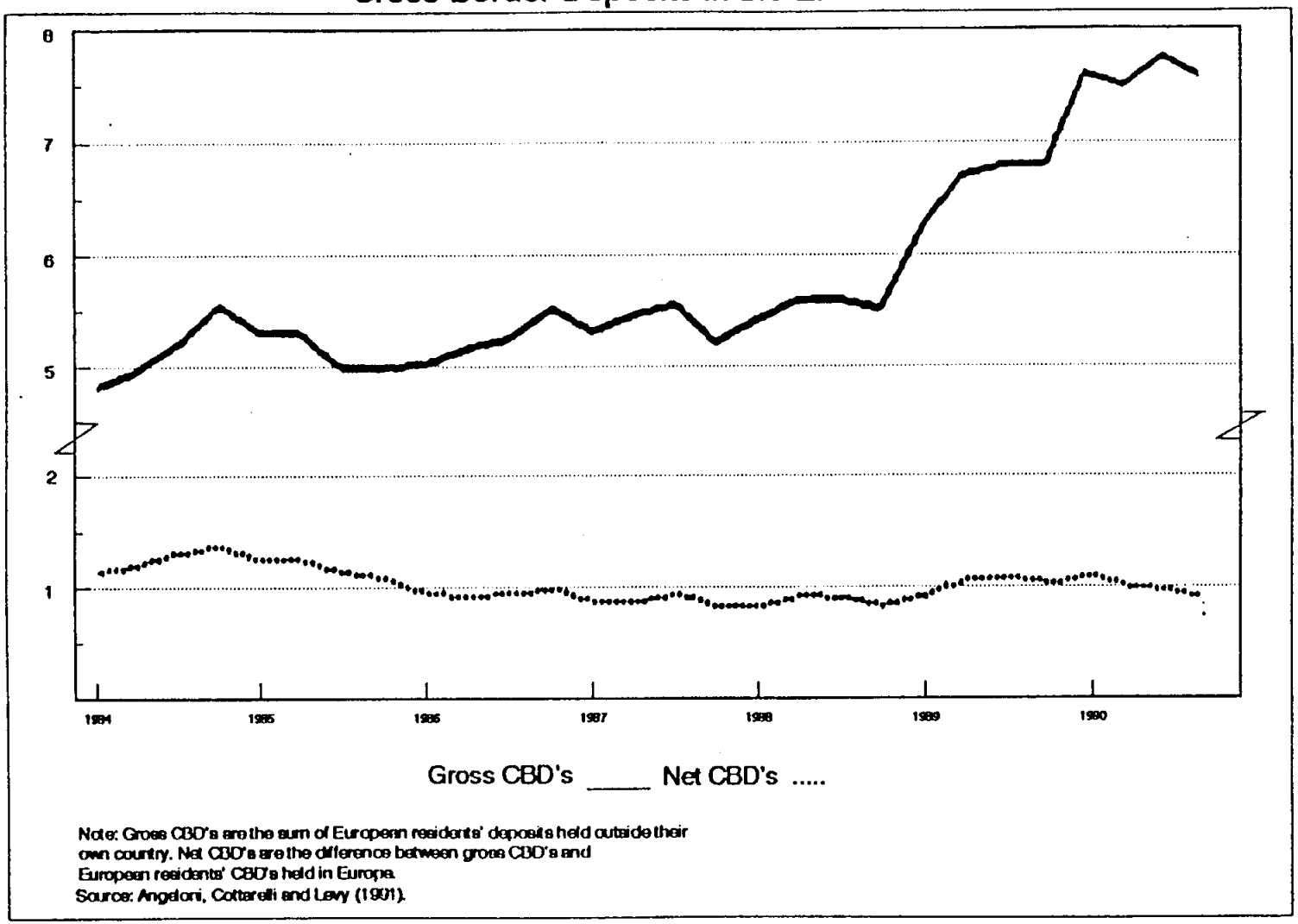


Note: The total also includes Transport Certificates and Treasury Notes.

Source: Rostowski (1992)

Figure 6

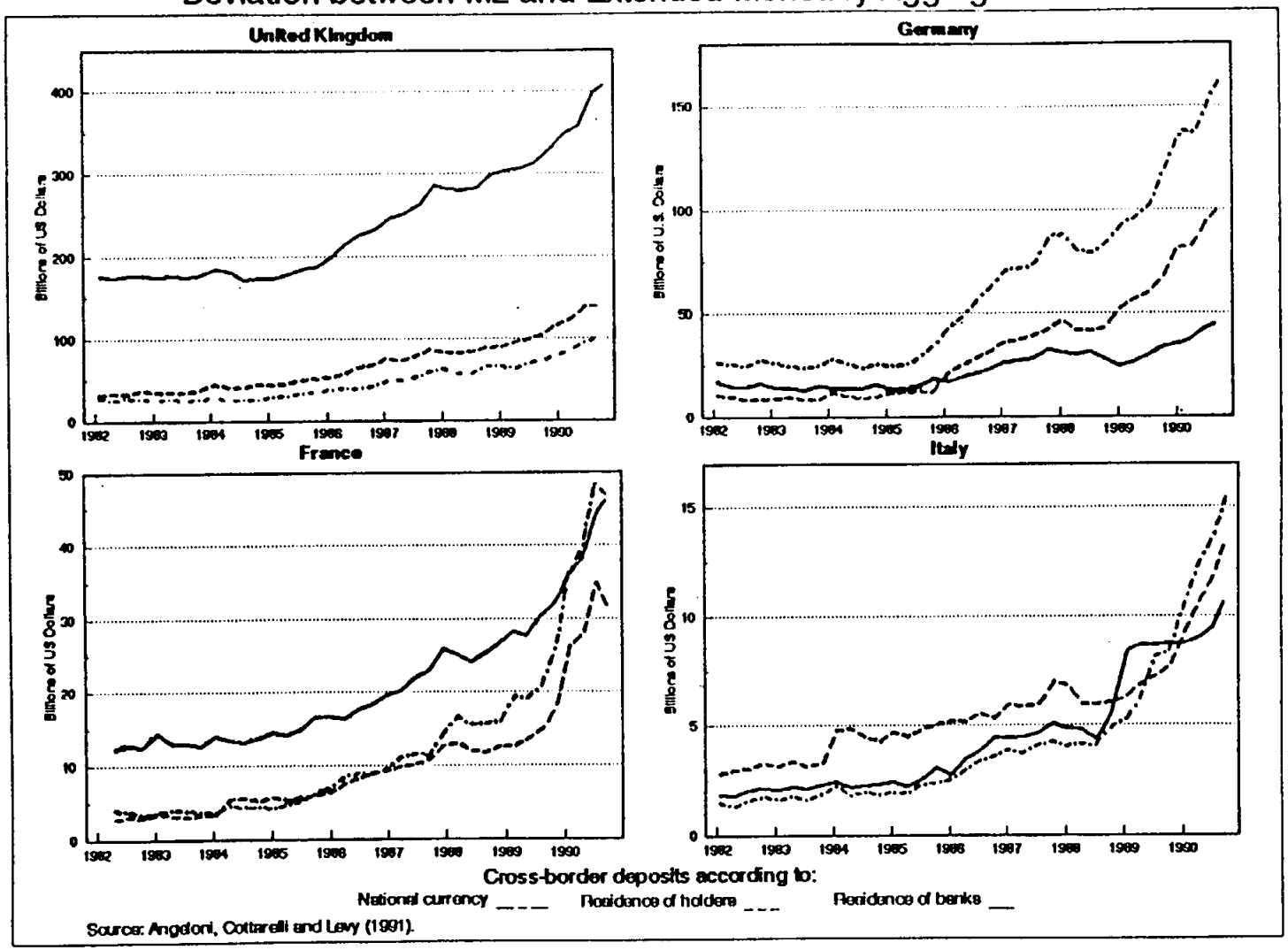
Cross-Border Deposits in the E.C.



Note: Gross CBD's are the sum of European residents' deposits held outside their own country. Net CBD's are the difference between gross CBD's and European residents' CBD's held in Europe.
Source: Angeloni, Cottarelli and Levy (1991).

Figure 7

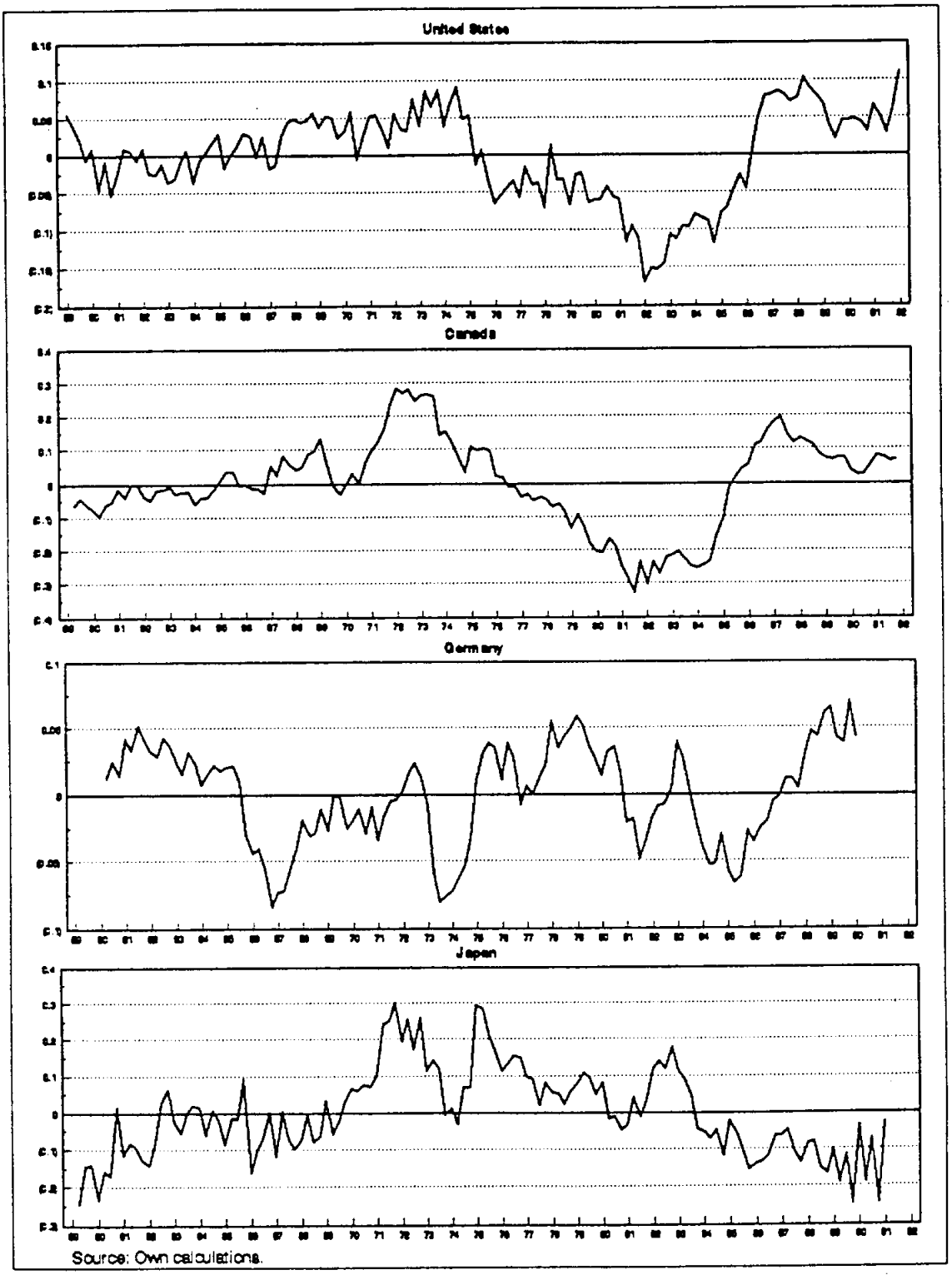
Deviation between M2 and Extended Monetary Aggregates



Source: Angeloni, Cottarelli and Levy (1991).

Figure 8

Residuals of Standard Money Demand Equations



Source: Own calculations.