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SIMULATING AN OPTIMIZING MODEL OF CURRENCY SUBSTITUTION*

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Abstract:

This paper reports simulations based on the parameter estimates of an intertemporal model of currency substitution under nonexpected utility obtained by Bufman and Leiderman (1991). Here we first study the quantitative impact of changes in the degree of dollarization and in the elasticity of currency substitution on government seigniorage. Then, wen examine whether the model can account for the comovement of consumption growth and assets' returns after the 1985 stabilization program, and in particular for the consumption boom of 1986-87. The results are generally encouraging for future applications of optimizing models of currency substitution to policy and practical issues.

1. Introduction

The precursor to this paper (Bufman and Leiderman (1991)) developed and estimated an intertemporal model of currency substitution under nonexpected utility. Implementing that model, which disentangles parameterization of behaviors toward risk and toward intertemporal substitution, on quarterly data for Israel for the period from 1978 to 1988 produced the following main results. First, the parameter estimates supported the notion that liquidity services enter the representative agent's objective function. Second, for most cases the evidence rejected the hypothesis of expected utility. Third, we found

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that the elasticity of intertemporal substitution is less than one, relative risk aversion is about seven, and the elasticity of currency substitution is greater than the intratemporal elasticity of substitution between consumption and liquidity services. Fourth, the model's overindentifying restrictions could not be rejected at standard signifcance levels for a whole variety of specifications.

The purpose of this paper is to use subsets of the estimated parameters in order to quantitatively assess two important issues. First, we study the impact of changes in the degree of dollarization and in the elasticity of currency substitution on government seigniorage. While we treat the elasticity of currency substitution as a preference parameter, the degree of dollarization is modeled through a productivity parameter attached to foreign money balances in a production function of liquidity sevices. As such, this dollarization parameter can change in response to those changes in policy which alter the institutional features that determine the attractiveness of domestic vs. foreign monies from agents' perspective. In this context, we quantify the extent to which a decrease in dollarization, as e.g. after a disinflation, changes the relation between seigniorage and the rate of inflation. Second, we examine whether the model accounts well for the comovement of consumption growth and assets' returns after the 1985 stabilization program, and in particular for the consumption boom of 1986-87. The fact that in both these applications the model produces useful insights enhances, in our view, the interest in using optimizing models of currency substitution for dealing with other practical issues and for evaluating the effects of alternative policies.

While most previous empirical wok on currency substitution consisted of estimating simple regression equations for domestic and foreign money as functions of the yields on these monies[1], our basic framework departs from that work in two main dimensions. First, we follow Calvo's (1985) methodology of endogenizing consumption decisions and therefore we analyze the joint determination of consumption and money holdings. That this is important has been demonstrated by Calvo (1985), who showed that the full effect of a change in monetary policy depends not only on the degree of currency substitution but also on the degree of substitution between consumption and liquidity sevices[2]. Second, we analyze currency substitution in an intertemporal optimizing framework under nonexpected utility. Within this framework it is possible to quantitatively assess the effects of changes in fundamental parameters such as the degree of risk aversion, the intertemporal elasticity of substitution, and the elasticities of substitution between consumption and liquidity and between domestic and foreign money. Thus, and in contrast to the earlier reduced-form approach to currency substitution, the present framework is not subject to the Lucas (1976) critique.

The specific currency substitution that serves as the main focus for this paper is that between holdings of domestic M2 money and Patam accounts in Israel. Patam accounts are bank deposits denominated in foreign currencies. From a domestic currency perspective these accounts are indexed to the exchange rate: a devaluation results in a one-to-one increase in the account balance expressed in domestic currency. These accounts provided partial hedging against both inflation and devaluation, and were viewed as representing an important degree of dollarization of the Israeli economy in that most of them are denominated in dollars and are liquid assets. Estimation of the model's parameters in Bufman and Leiderman (1991) took explicitly into account two important policy measures that, other things equal, made Patam holdings less attractive to the public. These are the introduction of certificates of deposit and of short term Treasury bills, in the last quarter of 1982, and the raise to one year in the minimum holding period for these accounts, in the third quarter of 1985.

Table 1 provides broad evidence on the fluctuations in consumption, in holdings of M2 and of Patam, and in the rate of inflation over the period from 1978 to 1988. A salient feature of the data is their wide variability over the years. For example, as inflation accelerated from 51 percent in 1978 to 374 percent in 1984, the share of Patam in total M2 + Patam holdings increased from 49 percent to 76 percent. This share then decreased to about 25 percent in 1987-88. Private consumption also exhibited marked fluctuations. In particular, there was a sharp rise in consumption during the attempted stabilization of 1981-82 as well as in the aftermath of the 1985 inflation stabilization program.

TABLE 1

BASIC DATA: ISRAEL, 1978-1988

Year	Consumption Growth (% per year)	Shares of M2 + Patam: M2 (%)	Shares of M2 + Patam: Patam (%)	Inflation (% per year)	Devaluation (% per year)
1978	6.7	51	49	51	67
1979	3.6	40	60	78	46
1980	0.8	31	69	131	102
1981	7.7	30	70	117	123
1982	5.7	30	70	120	112
1983	5.7	31	69	146	132
1984	−1.2	24	76	374	421
1985	3.0	35	65	305	302
1986	7.1	59	41	48	26
1987	8.6	73	27	20	7
1988	4.0	78	22	16	1

Notes: Consumption growth is measured by the percentage change in private consumption of nondurable goods and services. Inflation is measured by the percentage change in the CPI. Devaluation is the percentage change of the exchange rate of the New Israeli Sheqel against the U.S. dollar. See text for further explanations.

The paper is organized as follows. Section 2 describes the basic analytical framework. Section 3 provides simulations of the impact of changes in the degrees of dollarization and of currency substitution on the relation between inflation and seigniorage. An assessment of the fiscal revenue implications of various tax schemes on income from Patam accounts is also provided in that section. Section 4 examines the extent to which the model accounts for the comovement of consumption and assets' returns, and in particular the consumption boom, observed in the aftermath of the stabilization program of 1985. Section 5 concludes.

2. Basic Framework

As in Bufman and Leiderman (1991), an infinitely-lived representative agent is assumed to derive utility from the consumption of a single good and from the liquidity services provided by holdings of domestic and foreign money. The agent's consumption and holdings of domestic and foreign money are deterministic at time t, but future consumption and liquidity are uncertain. Faced with this uncertainty, the agent is assumed to from a certainty equivalent of random future utility using his risk preferences. Intertemporal utility is assumed to have a CES recursive structure:

$$U_t=\left\{\left[(\mu C_t^{\sigma}+(1-\mu)L_t^{\sigma})^{\frac{1}{\sigma}}\right]^{\rho}+\beta\left[E_t U_{t+1}^{\alpha}\right]^{\frac{\rho}{\alpha}}\right\}^{\frac{1}{\rho}}, \quad (1)$$

where U denotes utility; C denotes consumption; L denotes liquidity services; U_{t+1} is utility from period t + 1 onward, which is random from time t's standpoint; and E_t is the expectations operator conditional upon information available at time t. The notation for the various parameters can be introduced by considering their interpretation for the case when future utility is certain [see Weil (1990a)]. In that case, β is the subjective discount factor; ρ is a parameter that reflects intertemporal substitution, in that $\frac{1}{1-\rho}$ is the elasticity of intertemporal substitution of broadly defined consumption (i.e., including consumption of liquidity services); α is a risk aversion parameter such that 1 – α is the coefficient or risk aversion for timeless gambles; σ is a parameter that measures the degree of substitution between consumption and liquidity services such that $\frac{1}{1-\sigma}$ is the corresponding intratemporal elasticity of substitution; and μ is the weight of consumption of goods and services in the broad consumption aggregate.

This recursive representation of preferences is related to the earlier formulations by Koopmans (1960) for a deterministic case and by Kreps and Porteus (1978) for a stochastic setting. It extends the specification used by Epstein and Zin (1991) to the case in which liquidity services enter the utility function. Equation (1) assumes that the representative agent uses risk preferences to compute a certainty equivalent of random future utility U_{t+1}, and that this certainty equivalent is combined with current consumption and liquidity via a specific aggregator function to yield current period utility. This representation allows for separate parameterization of attitudes toward risk and toward intertemporal substitution[3].

Domestic and foreign real money balances, denoted by m and f respectively, provide liquidity services, denoted by L_t, as follows:

$$L_t=\left[\delta' m_t^{\theta}+(1-\delta')f_t^{\theta}\right]^{\frac{1}{\theta}}, \quad (2)$$

were θ measures the degree of currency substitution, and δ' measures the effectiveness of each of these assets in producing liquidity services. In a deterministic case, the elasticity of substitution between domestic and foreign money is $\frac{1}{1-\theta}$ (where θ < 1). Institutional changes that alter the relative liquidity characteristics of domestic and foreign money will be modeled by changes in δ'. Accordingly, policy measures that reduce the effectiveness of foreign money in producing liquidity services, and thus result in a decrease in the degree of dollarization, will be represented by an increase in δ'.

The budget constraint for the representative agent is given by

$$A_{t+1}=(A_t-C_t)R_t, \quad (3)$$

where A is the real value of agent's assets and R is one plus the random real rate of return on the portfolio. The consumer is initially endowed with A_0 resources which can

be consumed or saved. We assume that in addition to domestic and foreign money, the agent holds in his portfolio stocks and linked bonds. The gross real return on the portfolio is measured by $R_t=\Sigma\zeta_{it}R_{it}$, where ζ_{it} denotes the weight of asset i in the portfolio, and R_{it} is one plus the random real rate of return on holdings of asset i[4].

An attractive feature of the model consisting of equations (1)–(3) is that is encompasses various specifications used in previous work. Thus, the special case α = ρ corresponds to an expected–utility specification of preferences. In such case, the degrees of risk aversion and intertemporal substitution are reciprocals. It can be shown that the case α = 0 and ρ ≠ 0 corresponds to logarithmic risk preferences under nonexpected utility and the configuration α = ρ = 0 yields the logarithmic expected utility model. The case α < ρ implies that the early resolution of uncertainty is preferred [in the sense of Kreps and Porteus (1978)]. Most specifications used in previous work on currency substitution are also included in the basic model. For example, by setting β = μ = 0 and treating C_t as predetermined one obtains the static case analyzed by Miles (1978) and Bordo and Choudri (1982). Recall that $\frac{1}{1-\theta}$ is the elasticity of currency substitution. The case in which intertemporal utility depends only on direct consumption, as in Epstein and Zin (1991), obtains under μ = σ = 1.

Defining the intertemporal marginal rate of substitution used by consumers to discount future returns on assets that do not provide liquidity services by

$$\Psi_{t+1}=\beta^{\gamma}\left[\frac{\mu C_{t+1}^{\sigma}+(1-\mu)L_{t+1}^{\sigma}}{\mu C_t^{\sigma}+(1-\mu)L_t^{\sigma}}\right]^{(\frac{\rho}{\sigma}-1)\gamma}\left[\frac{C_{t+1}}{C_t}\right]^{(\sigma-1)\gamma}R_t^{(\gamma-1)}, \quad (4)$$

where $\gamma=\frac{\alpha}{\rho}$, and extending the procedure in Epstein (1988) to the present case yields the following necessary conditions for maximization of equation (1) subject to equation (3), given equation (2):

$$E_t\Psi_{t+1}R_{bt}-1=0, \quad (5)$$

$$E_t\Psi_{t+1}R_{at}-1=0, \quad (6)$$

$$E_t\Psi_{t+1}\left(\frac{C_t}{L_t}\right)^{(\sigma-1)\gamma}(R_{bt}-R_{mt})\left[\frac{\mu}{(1-\mu)L_{mt}}\right]^{\gamma}-1=0, \quad (7)$$

$$E_t\Psi_{t+1}\left(\frac{C_t}{L_t}\right)^{(\sigma-1)\lambda}(R_{bt}-R_{ft})\left[\frac{\mu}{(1-\mu)L_{ft}}\right]^{\gamma}-1=0, \quad (8)$$

where R_{bt}, R_{at}, R_{ft}, and R_{mt} denote one plus the random real returns from holding bonds, stocks, foreign money, and domestic money, respectively, from period t to period t+1. Since an M2 aggregate is used as domestic money in the empirical work, its return is $R_{mt}=\xi_t\pi_t+(1-\xi_t)R_{dt}$, where π_t denotes the inverse of one plus the rate of inflation from t to t + 1 and R_{dt} denotes one plus the real return on time deposits. $(1 - \xi_t)$ is the weight of these deposits in M2 at time t. In addition, we used above the definitions

$$L_{mt} = \delta' \left(\frac{L_t}{m_t}\right)^{(1-\theta)} \quad \text{, and } L_{ft} = (1-\delta') \left(\frac{L_t}{f_t}\right)^{(1-\theta)} .$$

In Bufman and Leiderman (1991) we implemented the orthogonality conditions in equations (5) to (8) using quarterly time series data for Israel covering the period from 1978 to 1988. In that application, consumption was measured by per-capita private consumption spending on nondurables and services. The assets included in that analysis were per-capita holdings of M2 (for domestic money), of deposits linked to the exchange rate (for foreign money), of CPI-linked government bonds, and of stocks traded at the Tel-Aviv Stock Exchange. The returns on these assets were expressed in net, after tax, terms. The rate of inflation was measured by the percentage change of the price deflator for the consumption measure of above[5].

As indicated, we used bank deposits linked to the exchange rate –known is Israel as Patam accounts– as our proxy for foreign money. These accounts were made accessible to the public at large as pat of the foreign exchange liberalization of November 1977. Prior to this, the accounts were available only to licensed international traders and to recipients of reparations from Germany. As inflation accelerated throughout the early 1980s, the authorities adopted measures aimed at attenuating the shift from domestic currency assets to foreign currency assets by enhancing the liquidity characteristics of domestic M2 balances against those of Patam accounts. Two such institutional changes were mentioned in the Introduction: (i) the introduction of certificates of deposit and short term Treasury bills in the last quarter of 1982, and (ii) the raise to one year in the minimum holding period for Patam accounts in the third quarter of 1985. In order to account for the potential impact of these policy measures, the empirical work by Bufman and Leiderman (1991) specified δ' equation (2) as follows:

$$\delta' = \delta + \Omega_1 D_1 + \Omega_2 D_2 ,$$

where δ is a time invariant parameter, D_1 is a dummy variable that is equal to zero before the last quarter of 1982, is equal to one from that quarter up until the second quarter of 1985, and is equal to zero thereafter, and D_2 is a dummy variable which obtains values of zero before the third quarter of 1985 and of one thereafter. For the special case in which $\Omega_1 + \Omega_2 = \Omega$, we defined the dummy variable $D = D_1 + D_2$. The Ω-parameters attempt to capture the impact of the institutional changes under consideration on the effectiveness of the various monies in producing liquidity services. Positive values of the Ω parameters can be interpreted as signals of policy-induced decreases in the degree of dollarization.

Generalized Method of Moments (GMM) estimates of the parameters provided support to the notion that liquidity services enter the representative agent's utility function, and in most cases reject the hypothesis of expected utility. In general, we found that the elasticity of intertemporal substitution is less than one, the elasticity of currency substitution is greater than one, and relative risk aversion is about seven. We also found that estimated δ's are slightly above 0.5 and are significantly lower than 1.0. Thus, while a unit of domestic money is more effective in generating liquidity services than a comparable unit of Patam, the evidence is that the latter do enter the liquidity services function. Estimated values for the Ω parameter, applied to the D dummy variable, are positive and range from .08 to .19. This indicates that the changes in the characteristics of the various assets in late 1982 are reflected in an increase in the relative effectiveness of domestic money (compared to foreign money) in generating liquidity sevices, measured by the (δ + ΩD) coefficient. This pattern of change can be interpreted as a reduction in the degree of institutional dollarization. Last, the values of Hansen's (1982) J_T chi-square statistic, for testing the overidentifying restrictions of the model, were generally small relative to the degrees of freedom thus indicating nonrejection of the model's overidentifying restrictions.

3. Seigniorage, Inflation and Dollarization

This section applies a subset of the previously estimated parameters to a steady state version of the model in order to quantitatively assess the relation between the rate of inflation and government seigniorage under various degrees of dollarization and currency substitution. To do so, we consider a hypothetical steady state in which there is a constant rate of growth of population, denoted by n, and per-capita consumption and assets' holdings grow at the constant rate υ. Moreover, we assume that the real return on the market portfolio, R, is invariant with respect to both time and the rate of inflation. These assumptions imply that economic agents' optimal choice of steady state domestic real money balances is given by

$$m = \left[\beta\,(\mu/(1-\mu))\phi^{(\rho-1)}\right]^{(1/(\sigma-1))} CR^{((1-\gamma)/((\sigma-1)\gamma))} \left(R_b - R_m\right)^{(1/(\sigma-1)\gamma)} \cdot \left\{\delta\left(\delta + (1-\delta)\left[((1-\delta)/\delta)Z^{(1-\gamma)}\right]^{(\sigma/(1-\sigma))}\right)^{((\sigma-\theta)/\theta)}\right\}^{(1/(1-\sigma))} , \quad (9)$$

where variables without time subscripts denote their steady state values, and where $Z \equiv (R_b - R_m)/(R_b - R_f)$ and $\phi \equiv 1 + \upsilon$.

Turning to seigniorage, note that in each period t government's revenue from monetary base creation, per capita, is given by

$$S_t = \left[(H_t - H_{t-1})/H_t\right] h_t , \quad (10)$$

where H is the monetary base and h is the per-capita real monetary base. In the hypothetical steady state considered here, the nominal value of the monetary base grows at the same rate as other assets, namely $(1+n)(1+\upsilon)\pi^{-1}$. Thus, the steady state ratio of seigniorage to GNP, denoted by SR, is given by

$$SR = \left\{1 - \left[(1+n)(1+\upsilon)\pi^{-1}\right]^{-1}\right\} \kappa \left[\frac{m}{y}\right] , \quad (11)$$

where κ is the inverse of the M2 money multiplier and y is GNP per capita. Equations (9) and (11) are used below to assess the impact of changes in the rate of inflation, in dollarization, and in the degree of currency substitution on the ratio of seigniorage to

GNP. Notice that an increase in dollarization and/or in the degree of currency substitution leads to a decrease in the base on which the inflation tax is levied, and thus calls for a change in the rate of inflation in order to maintain the same SR as before[6].

For the simulations that follow we used the following baseline set of parameter values:

$$\beta = 0.995 \;;\; \alpha = -6.0 \;;\; \sigma = -2.0 \;;\; \rho = -2.0 \;;\; \mu = 0.7\;.$$

These values are within the estimated confidence intervals for each parameter. For δ' we used three alternative values: 0.53, 0.6, and 0.7. Recall that a decrease in δ is interpreted here as indicating an increase in the degree of dollarization, because of the implied increase in the effectiveness of foreign money in generating liquidity services. Similarly, we use three alternative values for the elasticity of currency substitution [i.e., $(1-\theta)^{-1}$]: 2.0, 2.94, and 4.0. The rate of growth of population is set at 1.7 percent per year and the rate of growth of consumption per capita at 1 percent per quarter, figures that correspond to the respective averages over the sample period.

Panel 1 in Table 2 gives the relation between the rate of inflation and the ratio of seigniorage to GDP for three alternative values of δ' and for a given value (= 2.94) of the elasticity of currency substitution. There are two main features of the results. First, although at low rates of inflation the seigniorage ratio increases as inflation accelerates, there are small marginal revenue gains to government from increases in the rate of inflation beyond 10-15 percent per quarter. For example, an increase in the rate of inflation from about 10-15 percent per quarter to about 50 percent per quarter gives rise to additional seigniorage revenue of about 1 percent of GNP (for δ' = 0.6). Accordingly, the high inflation rates that prevailed in 1980-84, of about 30 percent per quarter on average, were not associated with a marked rise in seigniorage revenue. Furthermore, the evidence does not support the notion that these high rates of inflation led to a decrease in seigniorage revenue, as when the economy is on the inefficient part of the inflation tax Laffer curve [see also Eckstein and Leiderman (1992)]. Second, holding constant the rate of inflation we find that what appear to be relatively small changes in the degree of dollarization may have a sizeable impact on the seigniorage ratio. For example, a drop in δ' from 0.6 to 0.53 is accompanied, for most rates of inflation in the table, by a 50 percent decrease in the seigniorage ratio. For δ' 's of 0.53 and 0.60, it is seen in the table that the inefficient part of the inflation-tax Laffer curve is reached only when inflation rates are somewhere between 50 and 100 percent per quarter.

The foregoing features of the results are graphically summarized in Figure 1 in the form of *iso-seigniorage curves*. Each curve gives alternative pairs of δ' and of the rate of inflation that give rise to a given, fixed, seigniorage ratio. The curves indicate how relatively small changes in δ' can result in sizeable changes in the seigniorage ratio, and how the latter is unaffected by rises in the rate of inflation beyond 10-15 percent per quarter.

Panel 2 in Table 2 illustrates the impact effect of changes in the degree of currency substitution, measured by θ, on the seigniorage ratio. We find that other things equal high elasticities of currency substitution are associated with low seigniorage ratios. For example, at an inflation rate of 15 percent per quarter an increase in the elasticity of currency substitution from 2.0 to 4.0 leads to a drop in seigniorage revenues from 3.3 to 2.2 percents of GNP.

TABLE 2

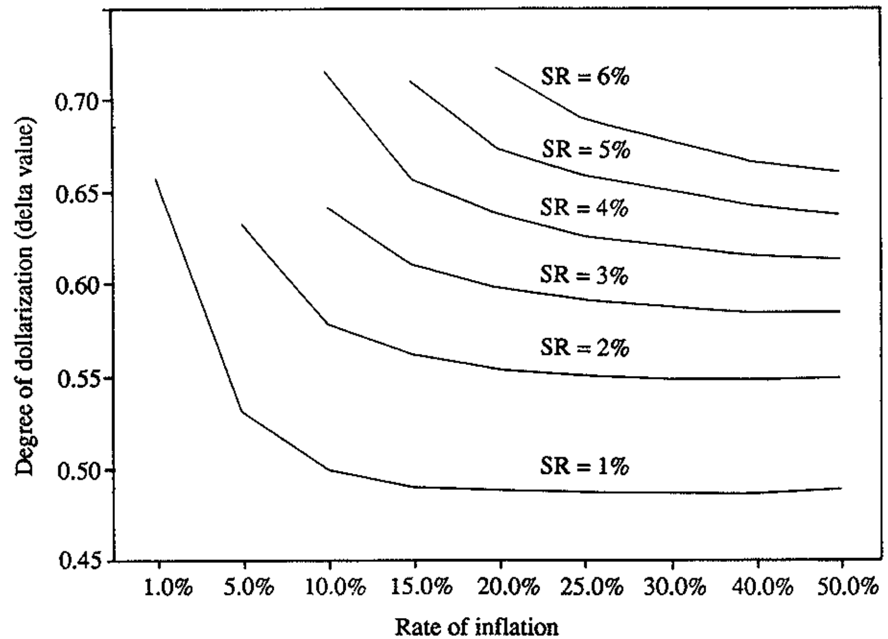
RATIOS OF SEIGNIORAGE TO GNP
(In Percents)

π	Panel 1			Panel 2		
	δ'			θ		
(%)	0.53	0.60	0.70	0.50	0.66	0.75
1	0.5	0.8	1.1	0.8	0.8	0.8
5	1.0	1.7	2.5	1.8	1.7	1.6
10	1.3	2.3	3.8	4.8	2.3	2.0
15	1.5	2.8	4.8	3.3	2.8	2.2
20	1.6	3.0	5.6	3.8	3.0	2.3
25	1.6	3.2	6.3	4.2	3.2	2.3
30	1.7	3.4	6.8	4.6	3.4	2.2
40	1.7	3.5	7.5	5.1	3.5	2.1
50	1.6	3.5	8.0	5.4	3.5	2.0
100	1.4	3.2	8.6	6.1	3.2	1.4

Notes: π denotes the rate of inflation in percents per quarter. All other entries are percents of GNP. Seigniorage ratios correspond to SR in the text. In both panels it is assumed that β = 0.995, σ = –2.0, μ = 0.7, ρ = –2.0, and α = –6.0. Panel 1 assumes that θ = 0.66 and Panel 2 assumes that δ' = 0.6. See text for further explanations.

FIGURE 1

CONSTANT SEIGNIORAGE RATIO CURVES
(For various degrees of dollarization and inflation)



It is well known that fiscal policy can play an important role in effectively determining the degree of dollarization and of currency substitution. The higher the tax rate on interest and gains from foreign assets, the smaller is the scope for substitution from domestic into foreign assets. Currently, interest earnings on Patam deposits are taxed at a rate of 25 percent at source. Table 3 explores the *impact effect* on the seigniorage ratio and on government revenues of alternative tax policy scenarios. As shown in the second column of the table, increasing the current tax rate up to 35 percent at source is shown to result in additional seigniorage revenues of 0.15 percent of GNP and in additional tax revenues of 0.06 percent of GNP. Alternatively, eliminating the prevailing tax on Patam leads to a reduction in tax revenues of about 0.7 percent of GNP. Last, we find in column (4) that replacing the prevailing tax by a 10 percent tax on both interest and capital gains due to exchange rate depreciation would result in a sizeable increase in tax revenue of 3.45 percent of GNP, most of which is due to an increase in the seigniorage ratio. It should be stressed that these are partial-equilibrium illustrative calculations of impact effects. A more comprehensive assessment would have to take into account the general equilibrium changes in the rate of inflation and in holdings of other assets that are implied by the foregoing tax policy chanes, as well as their impact on other sources of government revenue.

TABLE 3

FISCAL IMPACT OF VARIOUS TAXATION SCHEMES

	Taxation Scheme			
	(1)	(2)	(3)	(4)
R_{ft}	0.990	0.989	0.993	0.883
SR_t	3.05	3.20	2.51	5.63
DSR_t	—	0.15	— 0.54	2.58
DREV (Patam)$_t$	—	0.06	— 0.16	0.87
$DREV_t$	—	0.22	— 0.70	3.45

Notes: R_f denotes one plus the net real quarterly return of Patam deposits. Column (1) represents the existing taxation scheme of 25 percent tax on nominal foreign currency interest earnings on Patam. SR denotes the ratio of seigniorage to GNP in percents. DSR is the change in SR in a given column relative to column (1). DREV (Patam) is the change in fiscal revenue from Patam deposits compared to column (1), in percents of GNP. DREV is the total change in fiscal revenue, in prcents, of GNP, from moving from the existing system to that of any other column. Column (2) assumes that the prevailing tax of 25 percent of Patam is raised to 35 percent. Column (3) assumes that the tax on Patam income is eliminated. Column (4) assumes that both interest income and gains from devaluation of the domestic currency are taxed at 10 percent. See text for further explanations.

4. The 1986-87 Consumption Boom

In this section we examine the extent to which the estimated model can account for the increase in private consumption after the stabilization program of 1985. This consumption-boom phenomenon has received substantial attention in that it is puzzling that abrupt disinflation was accompanied by a rise in the level of economic activity, and not by a recession as implied by simple Phillips-curve models. It can be seen from Table 1 that before the program, i.e., between 1978-84, the average rate of growth of per capita consumption of nondurables and services was 2.1 percent per year. After the program, between 1986-88, this figure jumped to 5.9 percent per year.

Several possible explanations for the consumption boom have been provided in earlier work, including the appealing hypothesis that perceived temporariness about a stabilization program can result in a drop in the current nominal interest rate relative to the future, and hence in a decrease in the relative price of present vs. future consumption. See Calvo (1986) and the empirical application of this hypothesis by Reinhart and Vegh (1992). While it is well to acknowledge that our model is not specifically tailored for accounting for the consumption boom, here we exploit the fact that the present framework implies restrictions on the comovement of consumption, assets' holdings, and assets' returns. Accordingly, we examine (in an ex-post sense) how well these restrictions accommodate a consumption-boom phenomenon for 1986-88. In order to achieve this goal, we use the firts order conditions of optimization to derive an expression for the comovement of consumption growth and the returns on the various assets. This derivation uses equations (2), (5), (7), and (8), and replaces expected values in these equations by actual values. It can then be shown, see Appendix, that one plus the rate of growth of consumption per capita is given by

$$\frac{C_{t+1}}{C_t} = \left[\beta^{\gamma} Q_{t+1} R_t^{\gamma-1} R_{bt}\right]^{\frac{-1}{\gamma(\rho-1)}} , \qquad (12)$$

$$\text{where } Q_{t+1} \equiv \frac{\mu+(1-\mu)G_{t+1}^{-\sigma}}{\mu+(1-\mu)G_t^{-\sigma}} ,$$

$$G_t \equiv \left[K_t^{\gamma(1-\theta)} \mu^{\gamma} \left[(1-\mu)\delta'\right]^{-\gamma} \left(\frac{R_{bt}-\ddot{R}_{mt}}{R_{bt}}\right)\right]^{\frac{1}{(\theta-\sigma)\gamma}} ,$$

$$K_t \equiv \left(X_t\right)^{\frac{\theta-\sigma}{\sigma-1}} \left[\frac{\mu}{(1-\mu)\delta'}\right]^{\frac{1}{1-\sigma}} \left[\frac{R_{bt}-R_{mt}}{R_{bt}}\right]^{\frac{1}{(1-\sigma)\gamma}} ,$$

and

$$X_t \equiv \left[\delta' + (1-\delta') \left[\left(\frac{\delta'}{1-\delta'}\right)\left(\frac{R_{bt}-R_{ft}}{R_{bt}-R_{mt}}\right)^{\frac{1}{\gamma}}\right]^{\frac{\theta}{\theta-1}}\right]^{\frac{1}{\theta}} ,$$

where K_t is the consumption velocity of domestic money and X_t is the consumption velocity of liquidity services. Notice that seting $\mu = \sigma = \gamma = 1$ yields equation (12)', which corresponds to the case of expected utility with no liquidity services in the objective function of the representative agent [see Hall (1978) and Hansen and Singleton (1983)]:

$$\frac{C_{t+1}}{C_t} \equiv \left[\beta R_{bt}\right]^{\frac{-1}{(\rho-1)}} \quad . \qquad (12)'$$

Assuming $\rho<1$, this equation implies a positive relation between the real return on bonds from t to t + 1 and the rate of growth of consumption from t to t + 1. Extending this specification to allow for nonexpected utility, i.e. $\gamma \neq 1$ as in Epstein and Zin (1991), yields

$$\frac{C_{t+1}}{C_t} \equiv \left|\beta^{\gamma} R_t^{\gamma-1} R_{bt}\right|^{\frac{-1}{\gamma(\rho-1)}} \quad , \qquad (12)''$$

where now consumption growth depends not only on the real return on bonds but also on the real return on the market portfolio. If liquidity services enter agents' utility function, as in the present model, then C_{t+1}/C_t is also related to Q_{t+1} –a variable that includes the ratios of real assets' returns form t+1 to t+2 relative to those from t to t+1; see equation (12).

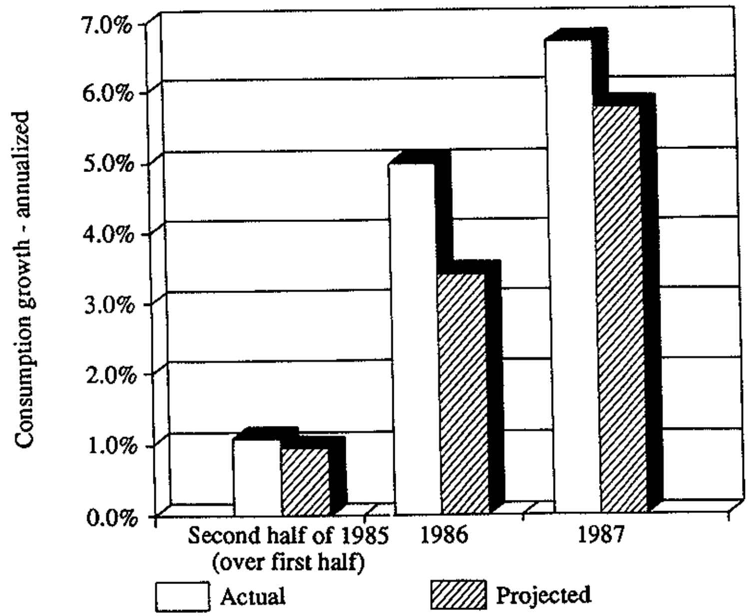
We use here the following set of parameter estimates from Bufman and Leiderman (1991):

$$\beta = 0.995 \;|\; \alpha = -6.0 \;|\; \sigma = -2.0 \;|\; \rho = -2.0 \;|\; \mu = 0.7 \;|\; \theta = 0.66 \;|\; \delta = 0.6.$$

It turns out that when these parameters are incorporated into equation (12) along with actual data on assets' returns from 1985 to 1988 the model does reasonably well in accounting for observed consumption growth. In particular, equation (12) accounts for 82 percent of actual consumption growth from the first half to the second half of 1985, for 68 percent of consumption growth from the second half of 1985 to 1986, and for 87 percent of consumption growth from 1986 to 1987. The actual and projected [i.e., using equation (12)] consumption growth rates are given in Figure 2. It can be seen that the marked growth in consumption after the 1985 stabilization program is not at variance with the predictions from the first order conditions of an optimizing model of currency substitution based on the observed movements in assets' real returns. Interestingly, it is the inclusion of liquidity services in the utility function (and not so much the notion of nonexpected utility) that especially matters for this result, in that generally equation (12)" turns out to account for much less of the observed consumption fluctuations than equation (12)'. This comparison highlights also an important element of temporariness, which was the focal point of the empirical analysis by Reinhart and Végh (1992): equation (12) includes a Q_{t+1} term that captures the ratio of asset returns' differentials in t and t+1. Had these returns moved equally in t and t+1, then there would have been no difference in the empirical performance of equations (12) and (12)". However, we know that Q has not been equal to one over time, and that the performance of equation (12) in accounting for the consumption boom is superior than that of equation (12)". Hence, some notion of temporariness is also playing a role in our results.

FIGURE 2

CONSUMPTION GROWTH, PER CAPITA
(Actual vs. projected, real terms)



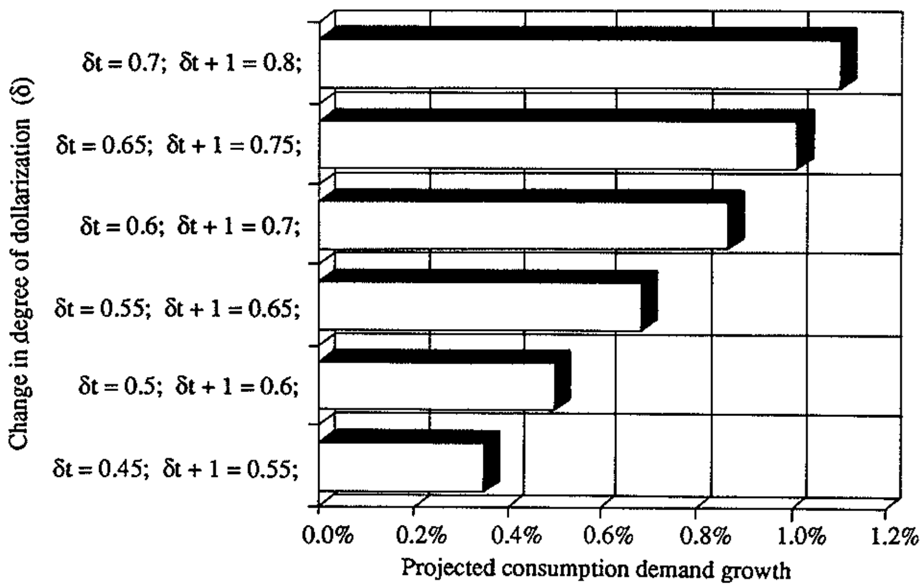
Equation (12) can be also used to asses the impact effect on consumption growth of a change in the degree of dollarization. Other things equal, a rise in δ (i.e., a decrease in the degree of dollarization) must be matched by a rise in C_{t+1}/C_t in order for equation (12) to be satisfied. This relation is depicted in Figure 3 for alternative possible changes in δ. It can be seen from this Figure that the estimated rise in δ from 0.53 to 0.70 after the stabilization progam of 1985 can account for less than one percent of the observed rise in consumption growth. Thus, from these preliminary results it appears that the change in the degree of dollarization per-se may have had a negligible role in accounting for the 1986-88 consumption boom, most of which is seems to be accounted for by fluctuations in assets' real returns after the program.

5. Concluding Remarks

Simulations of a parameterized version of an optimizing model of currency substitution under nonexpected utility using data for Israel indicated that: (i) relatively small changes in the degree of dollarization and in the elasticity of currency substitution can have a sizeable impact on government seigniorage; (ii) increases in inflation beyond rates of 10-15 percent per quarter are accompanied by negligible changes in seigniorage; (iii) the imposition of a tax on capital gains on foreign-exchange accounts, e.g. due to devaluations, could raise the base for the inflation tax and seigniorage in nonnegligible amounts; and (iv) the model's first order conditions can account reasonably well, ex-post, for the comovement of consumption growth and assets' returns and for the consumption boom that were observed after the 1985 inflation stabilization program. All in all, the analysis illustrates how optimizing models of currency substitution are or more than academic curiosity and can provide useful insights for practical and policy issues.

FIGURE 3

CHANGE IN CONSUMPTION DEMAND
(For a decrease in dollarization)



In concluding this paper, we would like to caution the reader that we reached the foregoing four conclusions based on simulations of a certainty-equivalent version of the underlying stochastic model. In practice, there may be a changing role of uncertainty over time, one which is reflected in time-varying risk premiums. Hence, our results should not be regarded as decisive, and it would be desirable in future work to verify their validity in the context of explicity stochastic simulations.

APPENDIX

Here we briefly discuss the derivation of equation (12) in the text. Dividing equation (7) by (8) and equation (7) by (5), setting expected variables equal to their actual values, and rearranging yields:

$$\left(\frac{R_{bt}-R_{mt}}{R_{bt}}\right)\left(\frac{\mu}{1-\mu}\right)^{\gamma}\delta^{-\gamma}=\left(\frac{C_t}{L_t}\right)^{-\gamma}\left(\frac{L_t}{m_t}\right)^{(1-\theta)\gamma}, \quad \text{(A1)}$$

$$\left(\frac{m_t}{f_t}\right)=\left[\left(\frac{\delta}{1-\delta}\right)\left(\frac{R_{bt}-R_{ft}}{R_{bt}-R_{mt}}\right)^{1/\gamma}\right]^{1/(1-\theta)} . \quad \text{(A2)}$$

The liquidity services function can be expressed as

$$L_t = m_t X_t , \quad \text{(A3)}$$

where X was defined on page 14 of the text.

Combining (A3) into (A1) and rearranging yields K_t, defined on page 14, which is the consumption velocity of domestic money, and G_t, also defined on page 14, which is the consumption velocity of liquidity services. These equations for velocity can be used to express m_t and L_t as functions of C_t and the various assets' returns. Substituting these expressions into equation (5) and solving for C_{t+1}/C_t yields equation (12).

Footnotes:

1 See, e.g., Miles (1978) and Bordo and Choudri (1982).

2 The potentially important role of substitutability in utility between real money balances and consumption in the context of disinflation programs has been emphasized in work by Obstfeld (1985) and Calvo (1986). For example, Calvo's (1986) analysis of temporary stabilization indicated that a temporary policy of lowering the rate of devaluation (as in Argentina in 1978-9 and Israel in 1982-3) gives rise to a temporary current deficit when money and consumption are complements. However, this effect on the current account is reversed when money and consumption are substitutes.

3 For recent empirical work based on nonexpected utility specifications, see Giovannini and Weil (1989), Bufman and Leiderman (1990), Arrau and Van Wijnbergen (1991), Epstein and Zin (1991), and Kandel and Stambaugh (1991). None of these studies dealt with the liquidity sevices of domestic and foreign monies. Imrohoroglu (1991) has independently estimated Euler equations from an intertemporal currency substitution model applied to Canadian data, yet only for the case of expected utility preferences.

4 For simplicity, it is assumed that nonasset income is zero every period. As indicated by Epstein and Zin (1991, fn 3), if nonasset income is nonstochastic and there is a riskless asset, then the initial endowment can be redefined to include the discounted value of future incomes. If nonasset income (e.g., labor income) is stochastic, then equation (3) still applies provided that A is redefined to include the stock of human capital, which is a nontraded asset, and R includes labor income as the stochastic dividend on that asset.

5 The data sources are the monthly publications of Israel's Central Bureau of Statistics and the Bank of Israel's database. The consumption aggregate used consists of nondurable goods and services purchased by Israeli households, and the consumption deflator is the price index for this aggregate. Data on these and on population were obtained from the Central Bureau of Statistics. This was also the source for indexes of net returns on linked bonds and on equitiy traded in the Tel Aviv Stock Exchange. Returns on time deposits, on short term non-linked bonds, and on Patam deposits, and data on the stocks of the various assets were obtained from the database of the Bank of Israel.

6 See also Fischer (1982).

7 For example, equation (12)" accounts for 60 percent of the increase in consumption from the second half of 1985 to 1986, and for only 15 percent of the increase in consumption from 1986 to 1987.

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DOLLARIZATION AND MONETARY REFORM
Evidence from the Cochabamba Region of Bolivia*

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Abstract:

Using data on informal market loans in the Cochabamba region of Bolivia, we test the hypothesis that monetary reform in the 1985-87 period resulted in a dedollarization of the economy. A theoretical model of the loan market suggests variables to be examined in the empirical analysis. A PROBIT model of the probability of dollar-denominated loans is estimated as a function of Bolivian inflation, exchange-rate depreciation, and exchange-rate volatility. In addition, policy reforms are modeled with dummy variables that switch on at the date of the reforms. In addition to the PROBIT estimates, we aggregate monthly average time series data for the informal market and investigate the hypotheses studied in this alternative data set. The evidence from the informal loan market suggests that the Bolivian stabilization plan was associated with an increase in dollarization rather than a decrease. Several possible reasons for this result are discussed, including a lack of credibility of the announced plan.

I. Introduction

In a recent paper, Melvin (1988) argued that dollarization may be considered a market-based monetary reform that occurs on the demand side in place of an official supply-side monetary reform. When public confidence in the domestic currency is eroded, but the government does not declare an official monetary reform, the public will substitute away from the low-confidence domestic money into a high-confidence foreign currency to the extent that such substitutions are possible.

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