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"DOLLARIZATION IN LATIN AMERICA:
GRESHAM'S LAW IN REVERSE?"

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ABSTRACT

Since the 1970s, a number of high-inflation Latin American countries have experienced a persistent process of "dollarization". To interpret some of the stylized facts, this paper presents a simple model in which dollarization reflects the fact that there are costs involved in switching the currency denomination of transactions. The transaction costs of dollarization define a band for the inflation differential within which there will be no incentive to switch between currencies. Above the upper value of the band, the local currency gradually disappears as the economy becomes fully dollarized; below the lower value, de-dollarization occurs.

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I. Introduction

The possibility of portfolio holders substituting different currencies in their portfolios in response to differentials in rates of return (inflation rates) has been widely analyzed in the literature. A common feature of the early studies on currency substitution (see, for instance, Kouri (1976) and Calvo and Rodriguez (1977)) is that they were based on an asset view of monetary holdings. Under this approach, demand for the different monies is a stable function of conventional variables such as income, wealth, and their respective opportunity costs, measured by inflation rate differentials or, alternatively, by the nominal interest rate differential, corrected by the change in the relative price between currencies. Basically, these models placed the phenomenon of currency substitution on a par with that of optimal portfolio composition in a world with capital mobility. Currency holdings and flows were thus treated identically as foreign asset holdings and as capital flows in general.

More recent studies (see, for instance, Liviatan (1981), Calvo (1985), Boyer and Kingston (1987), Guidotti (1989), Végh (1989), and Sturzenegger (1990)) have emphasized the role of currency substitution at the level of the transactions demand for money. In these studies, therefore, the demand for domestic and foreign money is motivated more explicitly by a transactions motive, abstracting specifically from the store of value motive and from portfolio composition considerations. However, a crucial assumption common to all of these studies is that foreign and domestic money are imperfect substitutes. This assumption implies that the derived money demand functions have the same qualitative properties of those obtained from portfolio considerations.

Among high inflation Latin American countries, at least since the 1970s, something along the lines of currency substitution has been going on under the name of "dollarization". In several of these countries-- Argentina, Bolivia, Peru and Uruguay among the most visible--the U.S. dollar has gradually but persistently been replacing national currencies in the performance of all types of monetary services. Not only have dollars replaced "pesos" in the local portfolios but, more importantly, dollars are often being used for settling current transactions and as a unit of account.

The standard approach to currency substitution views dollarization as a phenomenon that is easily reversible once the relative rates of return on the alternative monies are changed. This follows directly from the fact that the standard approach to currency substitution relies on the existence of stable money demand functions, in particular, of interest rates or inflation. For example, if domestic inflation increases, then the public will shift into dollars, and the reverse process will occur as soon as domestic inflation is lowered. However, this process is not what has been observed in the highly dollarized Latin American economies during the last two decades. Rather, what has been observed is a systematic tendency of money demand to fall while inflation has fluctuated widely. True, higher inflation rates are associated with lower real cash balances, but at the

same time countries subject to dollarization episodes have experienced a significant fall in real cash balances that cannot be accounted for by changes in inflation rates or in income. ^{1/} In addition, there have been several instances where dollarization, as well as the changes in money demand, appear to be unrelated to changes in inflation or in interest rates

In this paper, we present the view that this unexplained fall in real money demand is due to an ongoing dollarization process that depends not on a rising inflation rate but on a high inflation rate that gradually induces more and more transactions to be transferred to the dollar system. What is observed does not appear to be exclusively the result of a portfolio composition decision but rather a wider process through which markets are gradually changing the currency in which transactions are denominated and settled. Contrary to Gresham's Law that applies to currencies with intrinsic value (such as coins minted from precious metals), for paper currencies it is the good money that displaces the bad money.

Dollarization is modeled as a process which reflects the fact that there are costs involved in switching the currency denomination of transactions. Choosing the currency with which to make transactions is an all-or-nothing decision and there are economies of scale in using a single currency. Once the peso has been adopted by a particular fraction of the market, the decision to switch to dollars depends on which currency is the cheapest in terms of opportunity cost and the transaction costs involved in switching to a different currency. Some significant inflation differential may be necessary to induce a move from pesos to dollars. Once the switch is made, a fall in peso inflation may not necessarily imply that the peso will be used again; this will depend on the nature of the once and for all transaction costs that will be incurred in the process. The transaction costs of dollarization will define a band for the inflation differential within which there will be no incentive to switch between currencies. Transactions being made in pesos will continue being so if the peso inflation changes but remains within the band. Above the upper value of the band, the local currency gradually disappears as the economy becomes fully dollarized; below the lower value, de-dollarization occurs and all transactions are carried out in local currency as the local currency is clearly superior to the dollar. Within the upper and lower bounds, the local inflation rate may vary without inducing any changes in the degree of dollarization, since the benefits from switching from the high-opportunity-cost currency to the low-opportunity-cost currency will not compensate, at the margin, for the transaction costs involved.

Our approach to dollarization suggests a different type of money demand than that suggested by standard currency-substitution models. Our approach

^{1/} This unexplained fall in the demand for money has sometimes been interpreted as "financial innovation". Arrau, De Gregorio, Reinhart, and Wickham (1991) provide an extensive empirical investigation of this phenomenon for a sample of ten developing countries.

by no means implies that there may not be many other valid reasons for money demand to be a stable and elastic function of the inflation rate. We do add, however, the possibility that above a certain inflation rate, a dollarization process may start, through which all transactions in the economy will gradually be transferred into foreign currency. We will therefore observe that increases in the velocity of circulation of money not only are positively associated with increases in the inflation rate but also with the *level of the inflation rate*. From this last perspective, a very high inflation country may experience an ever-rising velocity of circulation rather than just a high level for velocity as suggested by conventional models of currency substitution.

The possibility of dollarization imposes serious constraints on the nature and the objectives of stabilization policies. Basically, it means that small reductions in inflation rates need not imply any significant increase in the degree of monetization of the economy. Thus, if the objective of policymakers is to reverse an ongoing dollarization process, then they should not settle with "livable" inflation rates; rather, reversing an ongoing dollarization process will require making the domestic currency the better alternative so that, initially, the required domestic inflation rate must be even lower than that of the dollar.

The paper is organized as follows. Section II provides some background on the process of dollarization observed in a number of Latin American countries. Some stylized facts, based mainly on the experiences of Bolivia, Mexico, Peru, and Uruguay, are presented. Section III presents a simple model of dollarization that is able to provide an interpretation of the stylized facts presented in Section II. Section IV discusses the policy implications of the model. Section V contains some concluding remarks.

II. Dollarization: Background and Stylized Facts

As mentioned in the introduction, a gradual process of currency substitution--under the name of dollarization--has been going on in a number of high-inflation Latin American countries over the past two decades. This section will focus, in particular, on the experiences of Bolivia, Mexico, Peru and Uruguay, but many of the qualitative features of the analysis also apply to other country experiences, such as that of Argentina.

Dollarization goes to the very nature of money and of the monetary system. Even though we still may not be totally able to define what money is, it is quite easy to recognize when one currency is being replaced by another *in all of its basic functions*. If the observed trends are to continue, one may well see that, in the future, the national monies in some of the above-mentioned countries will just be used to carry out small change transactions and those that the governments may still want to reserve for themselves (collecting taxes, settling judicial fees, paying salaries of public employees, etc.).

What is being discussed under the heading of dollarization is the survival of national monies in the face of the competitive challenge being placed by other "superior" currencies such as the dollar. At the level of "store of value", several national monies have already lost the battle. It is very hard to justify among the countries mentioned above, any holdings of non-interest earning money on the basis of their being stores of value. The minimal holdings of non-interest bearing domestic money are almost exclusively used for transaction purposes and even then have to compete with dollars as these are also used for the same purposes in a wide and expanding variety of transactions. All of the mentioned countries have widespread systems of foreign exchange houses (designed to serve nationals, not tourists as one might initially think) and also street vendors, who in some cases, would even change currencies to automobile drivers as well as inside buses or trains (particularly in Peru and to a lesser extent in Argentina and Uruguay).

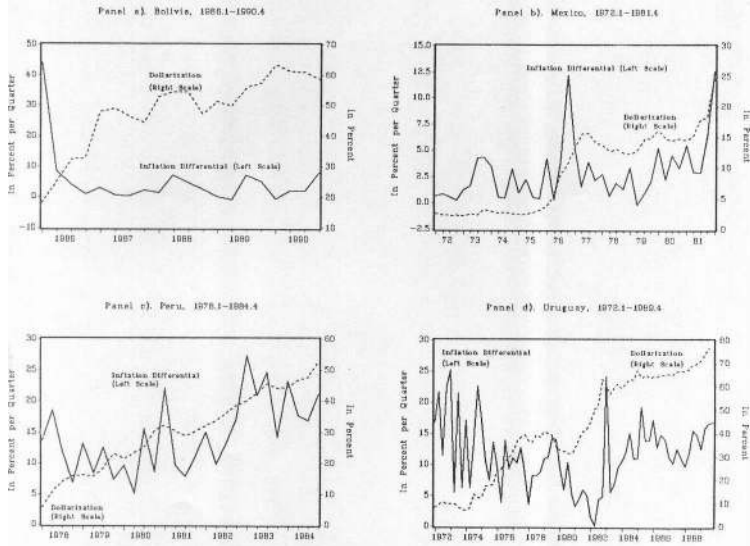
The process of dollarization described above was certainly allowed to happen by the much greater freedom granted to the financial and currency markets since the 1970s. The elimination of foreign exchange controls and the authorization to hold foreign exchange to residents has allowed dollarization to expand from its ever-present role of "store of value" to the less conventional ones of unit of account and medium of exchange. In all of the countries mentioned, transactions for real estate, automobiles, electric appliances, private schools fees, among others, are openly denominated in and actually settled with dollar bills. In the case of Peru by mid-1991 the highest denomination domestic bill was equivalent to \$7, making it easy to imagine that most high value transactions are actually being settled with dollar bills.

One of the striking features of the process of dollarization in Latin America is the persistence of the phenomenon, despite wide fluctuations in inflation and interest rates. Figure 1 shows the evolution of dollarization--measured by the ratio of foreign currency deposits to the sum of M2 in domestic currency and foreign currency deposits--and the differential between the domestic and the U.S. inflation rates during four dollarization episodes: Bolivia (1986.2-1989.4); Mexico (1972.1-1981.4); Peru (1974.1-1984.4); and Uruguay (1972.1-1986.4). ^{1/} (Quarterly data are used in Figure 1, so that 1986.2, for example, denotes the second quarter of 1986.)

Of the four episodes presented, Bolivia and Uruguay are the ones where the process of dollarization most strikingly displays the features described above. In Bolivia, the dollarization episode starts with a stabilization

^{1/} A similar picture would be obtained by considering alternative definitions of "dollarization" (see, Savastano (1990)). Given that data on the amount of dollar bills held outside the financial system are not available, the measure used in Figure 1 has to be regarded only as a proxy for the real extent to which the economy is dollarized.

Figure 1. Dollarization and Inflation



plan that was implemented in August 1985 to fight hyperinflation. At that time, dollarization of the Bolivian economy was relatively low, because of the de-dollarization scheme that was implemented in November 1982. Under the scheme, foreign currency deposits held by the private sector were effectively subject to confiscation by the government (more on this later). 1/ After the implementation of the 1985-stabilization plan (see Morales (1988)), there was a period of sharp dollarization at a time when domestic inflation was still very high: between the third quarter of 1985 and the first quarter of 1987, dollarization increased from near zero to almost 50 percent. 2/ In the following years, until end-1990, the process continued, although at a much slower pace, despite a rapid drop in inflation, averaging 3-4 percent per quarter. Overall, Bolivia provides an example of dollarization that has increased markedly in periods of stable or even decreasing inflation. By the end of 1990, Bolivia displayed a very high degree of dollarization; for instance, even at the level of demand deposits, foreign currency deposits accounted for almost one half of the total. Moreover, by the end of 1990, about 80 percent of the financial system's assets and liabilities were denominated in foreign currency.

In Uruguay, the process of dollarization has displayed a remarkable persistence over a period of two decades, despite large fluctuations in inflation. During the first decade--from 1972 to 1982--the degree of dollarization increased steadily despite a falling inflation differential. Overall, while the quarterly inflation differential has fluctuated within a band of 0 and 25 percent, dollarization increased from near-zero levels in 1972 to over 70 percent by the end of 1989. Since 1974, the process of dollarization has been promoted by a system of free currency convertibility and a financial system in which deposits can be made in either domestic or foreign currency at market-determined interest rates. Furthermore, in 1976, foreign exchange received the status of legal tender, when the government allowed commercial and financial transactions to be denominated and settled using foreign currency.

The case of Mexico provides an interesting example of hysteresis (or irreversibility) in the process of dollarization. In the early 1970s, the differential between the domestic inflation rate and the foreign inflation rate (as measured by the U.S. inflation rate) was low and stable,

1/ The de-dollarization scheme applied in Bolivia amounted to confiscation because foreign currency deposits were exchanged for domestic currency deposits at a below-equilibrium exchange rate and were later sharply reduced in real value by the inflationary process which culminated in the hyperinflation of 1985.

2/ The increase in the level of dollarization of the Bolivian economy partly reflects, during the second half of 1985 and during 1986, the deposit into the financial system of dollar bills previously circulating in the economy. Therefore, for that period, the measure of dollarization used in Figure 1 underestimates the extent of "true" dollarization of the Bolivian economy.

oscillating around an average of 1.5 percent per quarter. During this period the level of dollarization was both low and stable over time. As domestic inflation increased significantly in 1976-77--following the 1976 nominal devaluation and subsequent switch from a fixed to a floating exchange rate regime--the process of dollarization accelerated. When the differential between domestic and foreign inflation fell back to pre-1976 levels, the level of dollarization did not fall. 1/ In fact, it remained fairly stable until 1981, when domestic inflation and dollarization levels rose again. In the case of Mexico and Peru, the ending point for the dollarization episodes, as illustrated in Figure 1, is set at three quarters preceding a forced de-dollarization. The rationale for stopping three quarters prior to the de-dollarization is to abstract from the effect of anticipation of such government measures. As discussed by Savastano (1990), the anticipation of de-dollarizations prompted a run from foreign currency deposits in both Mexico and Peru. (More detail on the de-dollarization episodes appears below.)

The case of Peru also provides an example of persistent dollarization--going from less than 5 percent at the beginning of 1978 to over 50 percent by the end of 1984--despite wide fluctuations in inflation. 2/ The case for a stable inflation rate, however, appears more difficult to make, as depicted in Figure 1, since the inflation differential appears to display a mildly positive trend over the 1978-84 period. The Peruvian episode, thus, invites a closer look at the data.

Figure 1 suggests that dollarization and the inflation differential may have different time series properties. In particular, while dollarization appears to be a nonstationary process in all four countries, the inflation differential appears to be stationary. To examine the validity of this conjecture in more detail, we tested for the presence of a unit root in the time series process of dollarization and of the inflation differential. In

1/ The liberalization of the Mex-dollar deposit rate in the third quarter of 1977 is also considered to have had an impact on the level of dollarization in that period (see Ortiz (1983)). Previously, the Mex-dollar interest rate was controlled by the Banco de Mexico and, even though the authorities adjusted the rate to keep the Mex-dollar interest rate in line with foreign interest rates, significant differential between the two rates often emerged. However, the largest source of fluctuations in the differential rates of return between domestic and foreign currency deposits in the 1976-77 period was due to the changes in the rates of devaluation and inflation rather than to the dollar rate.

2/ From December 1977 until the de-dollarization of August 1985, Peruvian banks were allowed to issue fully-convertible foreign currency certificates of deposits issued in U.S. dollars at market interest rates (see Rojas-Suarez (1990) for a study of currency-substitution in Peru).

all cases, the version of the Dickey-Fuller test used allowed for a time-varying drift. 1/ Table 1 summarizes the results.

Table 1. Unit Root and Cointegration Tests

	Dickey-Fuller t-statistic	MacKinnon Critical values		
		1%	5%	
A. Augmented Dickey-Fuller Unit Root Test				
	Inflation Differential	Dollarization		
Bolivia (86.2 - 90.4)	-6.71	-2.94	-4.53	-3.67
Mexico (72.1 - 81.4)	-4.50	-2.71	-4.20	-3.52
Peru (78.1 - 84.4)	-6.68	-3.43	-4.32	-3.58
Uruguay (72.1 - 89.4)	-6.03	-2.17	-4.09	-3.47
B. Engle-Granger Cointegration Test				
Bolivia (86.2 - 90.4)	-3.09		-5.36	-4.39
Mexico (72.1 - 81.4)	-2.26		-4.76	-4.04
Peru (78.1 - 84.4)	-3.87		-4.97	-4.17
Uruguay (72.1 - 89.4)	-2.18		-4.56	-3.92

In all four cases, at the 1 percent and 5 percent significance levels, there is evidence that the dollarization proxy has a unit root, while the inflation differential is stationary. Since the two series are not integrated of the same order, it follows that dollarization and the inflation differential are not cointegrated. This was verified by the results of the Engle-Granger cointegration tests reported at the bottom of the table. The cointegration test applied the Augmented-Dickey-Fuller test to the residuals of a linear regression of the dollarization proxy against the inflation differential and a time trend. 2/ These findings suggest: 1) that shocks affecting the dollarization proxy have permanent effects, and 2) that dollarization cannot be fully described by a function of the current inflation or interest rate differential, as would be implied by traditional currency substitution models.

1/ In the case of the inflation differential, we also tested for the presence of a unit root without a time-varying drift. Results were qualitatively the same as those reported in Table 1.

2/ The same results obtain if the time trend is excluded.

As was mentioned earlier, two of the four dollarization episodes examined--those of Mexico and Peru (in August 1982 and July 1985, respectively)--ended with a forced de-dollarization. In addition, Bolivia experienced a forced de-dollarization in November 1982, which marked the end of a previous dollarization episode that had started in the early 1970s (see Savastano (1990)). In all of these cases, de-dollarization took the form of a *de facto* conversion of foreign currency deposits held by the private sector into domestic currency. In all cases, the de-dollarizations implied effectively a confiscation, since the exchange of foreign currency deposits into domestic currency was accompanied by large nominal exchange rate devaluations. In addition, de-dollarizations were accompanied, in all cases, by the imposition of capital and exchange controls, designed to impede any rapid reconstitution of private foreign assets holdings. Foreign currency deposits were allowed back in Bolivia in 1984 and in 1990 in Peru. The fact that dollarizations have been reversed only through confiscation schemes, suggests a stylized fact in itself: dollarization appears to be, to a large extent, an irreversible phenomenon.

III. Dollarization: A Simple Model

Consider a one-good economy, in which domestic money is used along with foreign money to carry out transactions. The representative individual maximizes the following lifetime utility function:

$$U = \int_0^{\infty} u(c_t) e^{-\rho t} dt,$$

where c_t denotes consumption at time t . It is assumed that a portion c_{mt} of total consumption is subject to a domestic-cash-in-advance constraint, while the remaining portion, denoted by c_{ft} , is subject to a foreign-cash-in-advance constraint. Formally,

$$m_t = \alpha c_{mt}, \quad c_{mt} \geq \bar{c}_m$$

$$f_t = \alpha c_{ft},$$

$$c_t = c_{mt} + c_{ft},$$

where m_t and f_t denote real balances of domestic and foreign currencies, respectively, and α is a (positive) parameter. Equations (2)-(4) describe an economy where there is a "dollarized" sector, in which transactions must be carried out using foreign currency, and a domestic sector, in which transactions must be carried out using the domestic currency. In equation (2), it is assumed that there is a minimum amount of transactions, \bar{c}_m , which

requires domestic currency (possibly, because of government regulations). (Eventually, \bar{c}_m could be equal to zero.) This assumption will impose a ceiling on the process of dollarization.

The representative consumer may change the proportion of his/her consumption which is financed using foreign currency. Changing that proportion, however, involves a cost, $\Psi(\dot{c}_{ft})$, which is a function of the rate of dollarization. (Since, in equilibrium, total consumption will turn out to be constant over time, what is costly in this model is changing the currency denomination of transactions. 1/) The assumption that it is costly for the individual to shift across currencies reflects the fact that once a sector, or a portion of the market, is used to dealing in one currency it has dis-economies of scale in dealing with a second currency. Moreover, shifting transactions into another currency involves a cost that is proportional to the amount of resources being shifted. 2/ Since the process of shifting from one currency to another is costly, it will happen only slowly over time. For simplicity, it will be assumed that the cost $\Psi(\bullet)$ takes the form of a transfer among individuals. 3/

The presence of the cost $\Psi(\bullet)$ may be interpreted as a form of imperfect substitutability. However, it will become clear that this form of imperfect substitutability has substantially different implications than the type of imperfect substitutability usually emphasized in the literature, which, in particular, is the vehicle to obtain stable money demands as functions of the relevant opportunity cost. Imperfect substitutability usually means that domestic and foreign currency provide, in some fundamental sense, different types of services. In this model, there are two essential elements that will drive the process of dollarization. On the one hand, there is a deep sense in which domestic and foreign currencies are perfect substitutes: both currencies represent a medium of exchange that applies to the same good. On the other hand, the two currencies are imperfect substitutes because there are economies of scale in dealing with a single currency and there are transactions costs involved in switching from one currency to another.

We assume that the marginal cost of dollarizing or de-dollarizing transactions in the economy is given by:

1/ The same results would follow if costs are a function of the time-derivative of c_f/c .

2/ Santomero (1979) and Sturzenegger (1990) provide models where there are transactions costs associated with changing the medium of exchange. In particular, these models assume that there is a continuum of goods ordered according a good-specific transaction cost.

3/ No significant changes would derive from the alternative assumption that the cost $\Psi(\bullet)$ represents a loss for the economy as a whole.

$$\Psi'(c_f) = \begin{cases} k + \phi c_f & \text{if } c_f > 0 \\ -k + \phi c_f & \text{if } c_f < 0, \end{cases} \quad (5)$$

where k and ϕ are (positive) constants. Equation (5) implies that the marginal cost of the first unit of dollarization (or de-dollarization) is positive and, furthermore, that $\Psi(\cdot)$ is strictly convex. 1/ It is useful to define:

$$z_t = \begin{cases} -c_{ft} & \text{for } c_{ft} < 0 \\ 0 & \text{otherwise,} \end{cases}$$

and,

$$x_t = \begin{cases} c_{ft} & \text{for } c_{ft} > 0 \\ 0 & \text{otherwise,} \end{cases}$$

which implies that $z_t \geq 0$ and $x_t \geq 0$. Hence,

$$c_{ft} = x_t - z_t$$

Moreover,

$$\Psi(x_t - z_t) = k(x_t - z_t) + \frac{\phi}{2}(x_t - z_t)^2.$$

The flow budget constraint of the consumer is given by:

$$\dot{w}_t = y + r w_t - c_{mt} - c_{ft} - i_t m_t - i_t^* f_t + r_t - \Psi(x_t - z_t), \quad (6)$$

where $w_t = m_t + f_t + b_t$; i_t and i_t^* denote the domestic and foreign nominal interest rates; y denotes the endowment (which is assumed to be constant

1/ We assume that $\Psi(\cdot)$ is symmetric whether there is dollarization or de-dollarization. Alternatively, one may think that the marginal cost of dollarizing the economy is higher than that of de-dollarizing it. It is straightforward to extend the analysis in that direction.

over time); r_t denotes real government transfers; b denotes the holdings of an international indexed bond that pays a fixed return of r . Perfect capital mobility and strict PPP are assumed, so that r is both the domestic and the foreign real interest rate. Henceforth, to ensure the existence of a steady-state equilibrium, it is assumed that $r = \rho$. The Fisher equation implies that $i^* = \rho + \pi^*$ and $i = \rho + \pi$, where π^* and π denote the expected (and actual, under perfect foresight) foreign and domestic inflation rates. Thus, $i - i^* = \pi - \pi^*$.

The consumer maximizes (1) subject to (2)-(6), non-negativity constraints on x , z , c_f , and the appropriate transversality condition. (Henceforth, when no risk of confusion arises, time subscripts will be dropped.) The first-order conditions associated with the consumer's problem imply that:

$$u_c(c_m + c_f) = \lambda(1 + \alpha i) \quad (7)$$

$$\dot{\lambda} = \lambda(\rho - r) = 0, \quad (8)$$

where λ , the multiplier associated with flow constraint (6), is the shadow value of wealth. Since the real interest rate equals the discount rate, λ is constant over time--as indicated by equation (8). Equation (7) is a familiar condition whereby the marginal utility of consumption is equated to the product of the "effective" price of the good and the shadow value of wealth. The effective price of the consumption good equals its direct cost (unity) plus the opportunity cost of holding α units of money required, by the cash-in-advance constraint, to purchase one unit of the good. Assuming that i is constant over time (because π is time-invariant), equations (7) and (8) imply that total consumption, c , is constant over time as well. By integrating (6) and using (2) and (3), it follows that:

$$w_0 + \frac{y - c(1 + \alpha i)}{\rho} + \int_0^{\infty} r_t e^{-\rho t} dt + \int_0^{\infty} [(i - i^*)\alpha c_{ft} - \Psi(x_t - z_t)] e^{-\rho t} dt = 0.$$

Thus, the optimal plan--i.e., that which achieves the highest consumption level--maximizes

$$\int_0^{\infty} [a c_{ft} - \Psi(x_t - z_t)] e^{-\rho t} dt,$$

where $a = \alpha(i - i^*)$. Suppose that $i > i^*$ and $x > 0$. Then, equation (10) is interpreted as the present discounted value of the net gains from dollarization. On the one hand, the term $a c_{ft}$ represents the savings in terms of differential inflation tax--at a rate $i - i^*$ --that accrue at each

point in time by holding an amount αc_{ft} of foreign currency. On the other hand, the term $\Psi(x_t)$ represents the cost associated with increasing c_{ft} at a rate x_t .

In order to characterize the process of dollarization, consider first the case where $a > \rho k$. This implies that the present discounted value of the difference in inflation tax between the domestic and the foreign currency multiplied by the consumption velocity--i.e., $\alpha(i - i^*)/\rho$ --exceeds the marginal cost of an infinitesimal dollarization rate, k . In this case, it can be shown that the consumer finds it optimal to set $x > 0$; i.e., there is dollarization. If $x > 0$ (which implies that $z = 0$), then the first-order conditions of the consumer's optimization problem imply that:

$$\dot{x} = \rho x + \frac{\rho k - a}{\phi}$$

Equation (11) is dynamically unstable. It relates the rate of change of the dollarization rate as a function of the dollarization rate and the interest rate differential and other parameters of the model. In particular, the higher is the interest rate differential, the lower is \dot{x} .

Since there is a limit to the process of dollarization--namely, $c_f \leq c - \bar{c}_m$ --a constant x is not optimal. It will be shown below that optimal x decreases over time, and that dollarization stops at a finite time, t^* . Thus, equation (11) can be solved to yield:

$$x_t = \begin{cases} (x_0 + \frac{\rho k - a}{\phi \rho}) e^{\rho t} - \frac{\rho k - a}{\phi \rho}, & t \in [0, t^*] \\ 0, & t \in [t^*, \infty). \end{cases}$$

It would appear from equation (12) that a higher interest rate differential implies a lower rate of dollarization. However, that conclusion would be incorrect because the initial rate of dollarization, x_0 , is a function of $i - i^*$, as will be shown later. Thus, we postpone the interpretation of equation (12) until later when the determination of x_0 is discussed. By integrating equation (12), the path of c_f is obtained:

$$c_{ft} = \begin{cases} c_{f0} + (x_0 + \frac{\rho k - a}{\phi \rho}) \frac{1}{\rho} (e^{\rho t} - 1) - \frac{\rho k - a}{\phi \rho} t, & t \in [0, t^*] \\ c - \bar{c}_m, & t \in [t^*, \infty) \end{cases}$$

Hence, from equation (13), t^* must satisfy the following expression

$$c - \bar{c}_m - c_{f0} = (x_0 + \frac{\rho k - a}{\rho \phi}) \frac{1}{\rho} (e^{\rho t^*} - 1) - (\frac{\rho k - a}{\rho \phi}) t^*. \quad (14)$$

It can be easily shown that equation (14) establishes--as one would expect--a negative relationship between x_0 and t^* . A higher initial dollarization rate implies that maximum dollarization is achieved at an earlier time.

The optimal initial dollarization rate, x_0 , is obtained by solving the following problem:

$$\text{Max}_{x_0} \int_0^{t^*} [ac_{ft} - (kx_t + \frac{\phi}{2}x_t^2)]e^{-\rho t} dt + \frac{a(c - \bar{c}_m)}{\rho} e^{-\rho t^*},$$

subject to equations (12)-(14). The corresponding first-order condition implies that:

$$-(\phi x_0 + k - \frac{a}{\rho})t^* + \frac{(1 - e^{-\rho t^*})}{\rho} (k + \frac{\phi}{2}x_{t^*} - \frac{a}{\rho}) = 0. \quad (15)$$

Equations (12) and (15) imply that $0 < x_0 < (a - \rho k) / \rho \phi$; namely, the initial dollarization rate is less than the rate that would maintain optimal x constant. By equation (12), this implies that x falls over time at an increasing rate. Next, we show that the optimal plan satisfies

$$x_{t^*} = (x_0 + \frac{\rho k - a}{\rho \phi}) e^{\rho t^*} - \frac{\rho k - a}{\rho \phi} = 0; \quad (16)$$

i.e., x is continuous at t^* .

Equations (15) and (16) imply the following relationship between x_0 and t^* :

$$t^* = \frac{1}{\rho} \left[\frac{x_0}{\frac{a - \rho k}{\rho \phi} - x_0} \right]. \quad (17)$$

The relationship implied by equation (17) is illustrated in Figure 2: on the one hand, when $x_0 = 0$, then $t^* = 0$; on the other hand, when x_0 approaches $(a - \rho k) / \rho \phi$, then t^* tends to infinity.

Similarly, equations (14) and (16) imply the following relationship between x_0 and t^* :

$$t^* = \frac{\phi x_0}{a - \rho k} + \frac{\rho \phi (c - \bar{c}_m - c_{f0})}{a - \rho k}, \quad (18)$$

which is also illustrated in Figure 2. Given that the relationship implied by equation (18) is linear, and that $t^* > 0$ when $x_0 = 0$, it is obvious that an intersection of the two schedules in Figure 2 always exists. Such intersection determines the optimal initial rate of dollarization, x_0 , and the optimal time at which the process of dollarization stops (because it has reached its maximum), t^* . Given x_0 and t^* determined by equations (17) and (18), the dynamic path of x is fully characterized by equation (12).

Equations (17) and (18) can be used to determine the effects of the different exogenous variables on x_0 and t^* . It is easy to show that, in accord with intuition, a larger inflation differential--recall that $a = \alpha(i - i^*) = \alpha(\pi - \pi^*)$ --implies a higher initial dollarization rate and a smaller t^* . Moreover, since equation (11) is dynamically unstable, a higher initial dollarization rate implies a faster dollarization at every point in time along the interval $t \in [0, t^*]$. Similarly, a larger α implies a higher x_0 and a lower t^* . Intuitively, a larger α implies that for the same amount of consumption there is a higher inflation tax base (or, alternatively, there is a higher "effective" price of consumption). Thus, for a given inflation tax differential, a higher α induces more rapid dollarization. It can also be checked that, according to intuition, higher values of k and ϕ reduce x_0 and increase t^* .

We have characterized optimal x for the case in which $\alpha(i - i^*) > \rho k$. The characterization of optimal z , for the case in which foreign inflation exceeds domestic inflation and, moreover, $\alpha(i^* - i) > \rho k$, is completely analogous to the above characterization of optimal x . ^{1/} Thus, Figure 3 shows the dynamics of dollarization, x , and de-dollarization, z , when $\alpha(i - i^*)/\rho$ either exceeds k or is lower than $-k$.

Consider the panel describing the dynamics of x . The line $\dot{x} = 0$ is the locus of points which satisfies equation (11), with a constant rate of dollarization, $(a - \rho k)/\rho \phi$. The phase diagram describes the motion of x , corresponding to equation (11). There is a unique path--drawn with arrows--which, satisfies equation (11) and converges to $c - c_m$. For a given initial condition, c_{f0} , there is an initial rate of dollarization, x_0 , which places the system of that path, along which x converges to $c - c_m$ at time t^* . The panel that describes the dynamic behavior of z is obtained in an analogous

^{1/} For the case in which $\alpha(i^* - i) > \rho k$, it can be shown that optimal z satisfies

$$\dot{z} = \rho z + \frac{\alpha(i^* - i) - \rho k}{\rho \phi},$$

which the analog of equation (11).

Figure 2. Determination of t^* and x_0 .

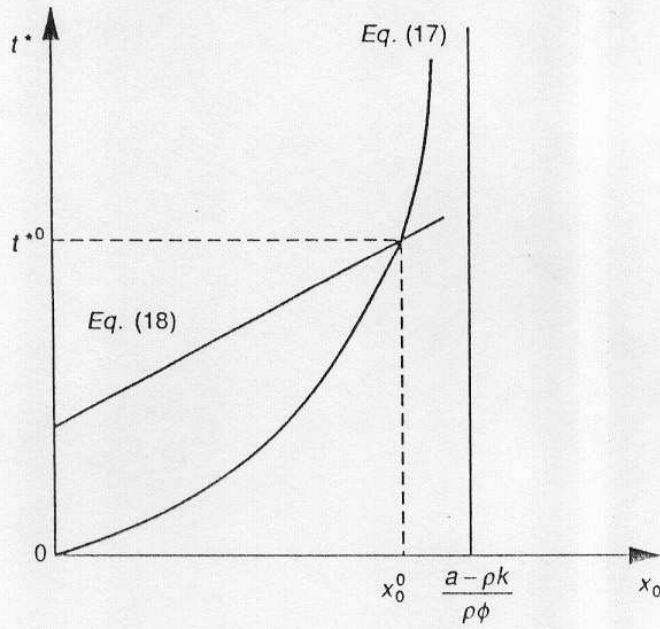
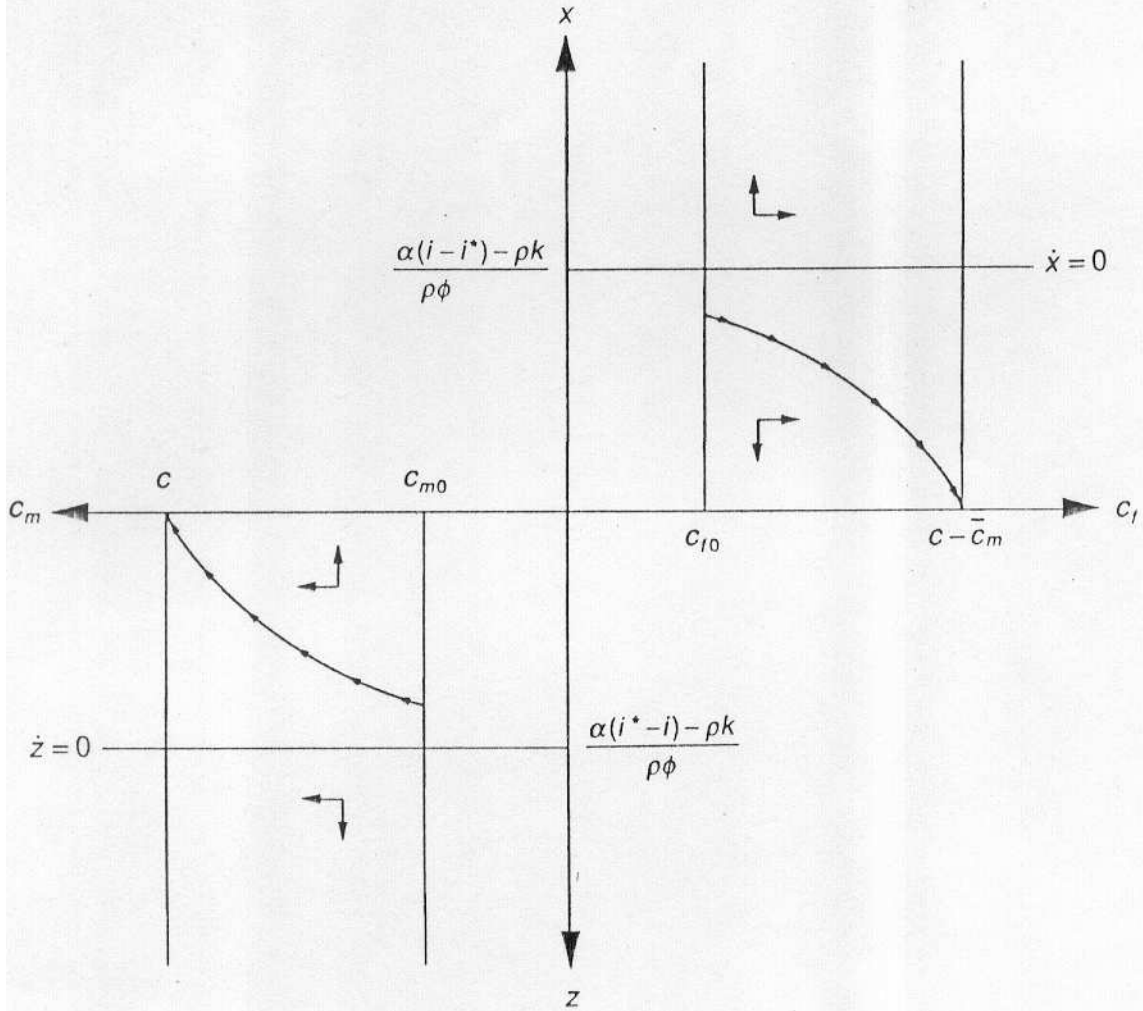


Figure 3. The Dynamics of Dollarization.



fashion. We analyze next the optimal choice of x and z when $\alpha(i - i^*)/\rho \in [-k, k]$.

It is shown in the Appendix that, if $a \leq \rho k$, then optimal $x=0$. An analogous proof shows that, if $a \geq -\rho k$, then optimal $z=0$. Thus, if $\alpha(i - i^*)/\rho \in [-k, k]$, then no dollarization or de-dollarization occurs; namely, the marginal cost k defines an "inaction" band. In terms of the interest (or inflation) rate differential, the band is defined by $[-k\rho/\alpha, k\rho/\alpha]$; i.e., the inaction band is wider the larger are k or ρ , and narrower the larger is α . The intuition behind the effects of changes in ρ is the following. An infinitesimal dollarization saves to the individual the *discounted present value* of the inflation tax differential. Thus the higher is the discount rate, ρ , the lower are the gains from dollarization or de-dollarization, and, hence, the wider is the inaction band. Similarly, as discussed earlier, the higher is α the larger are the gains from dollarizing or de-dollarizing and, hence, the narrower is the inaction band. The intuition behind the effects of changes in k on the inaction band is straightforward, since k is the marginal cost of the first unit of dollarization or de-dollarization.

Figure 4 illustrates the inaction band by drawing initial dollarization and de-dollarization against the nominal interest rate differential. Within the band $[-\rho k/\alpha, \rho k/\alpha]$, there is no incentive to switch between currencies. As soon as the inflation differential increases above $\rho k/\alpha$, dollarization starts; as shown before, x_0 increases as $i - i^*$ increases. An analogous analysis applies to the determination of z .

Up to this point, we have characterized optimal consumer behavior. It is easy to show, however, that the analysis applies also at the aggregate level for the economy as a whole. To characterize the general equilibrium, the model is closed by considering the government budget constraint. Assuming that the economy operates under a crawling peg regime, the government budget constraint is given by:

$$\tau = (\epsilon + \pi^*)m - g + \rho R, \quad (19)$$

where g denotes government spending, $\epsilon (= \pi - \pi^*)$ is the devaluation rate, and R is the stock of interest-bearing foreign exchange reserves. (Note that we assume that, as usual, the path of domestic credit is such that the consumer is compensated for the inflation tax; this implies that $R=m$ -i.e., the change in real cash balances equals the change in foreign exchange reserves.)

In order to focus sharply on the process of dollarization described above, we make the simplifying assumption that the domestic economy receives a rebate of the inflation tax paid on the holdings of foreign currency, i^*f ,

so that there are no aggregate wealth effects associated with dollarization. ^{1/} Since $\Psi(\bullet)$ represents a transfer among individuals, it washes out in the aggregate. Thus, under perfect capital mobility, the economy has no intrinsic dynamics (Obstfeld and Stockman (1985)) and is in a steady-state equilibrium where:

$$c = y - g + \rho(b + f + R), \quad (20)$$

where $b + f + R = (b + f + R)_0$. The process of dollarization implies that foreign currency holdings increase over time, while reserves fall over time reflecting a reduction in the demand for domestic currency. Since, by equation (20), consumption is time invariant, equation (2)-(4) imply that changes in foreign currency holdings are offset exactly by changes in reserves. ^{2/}

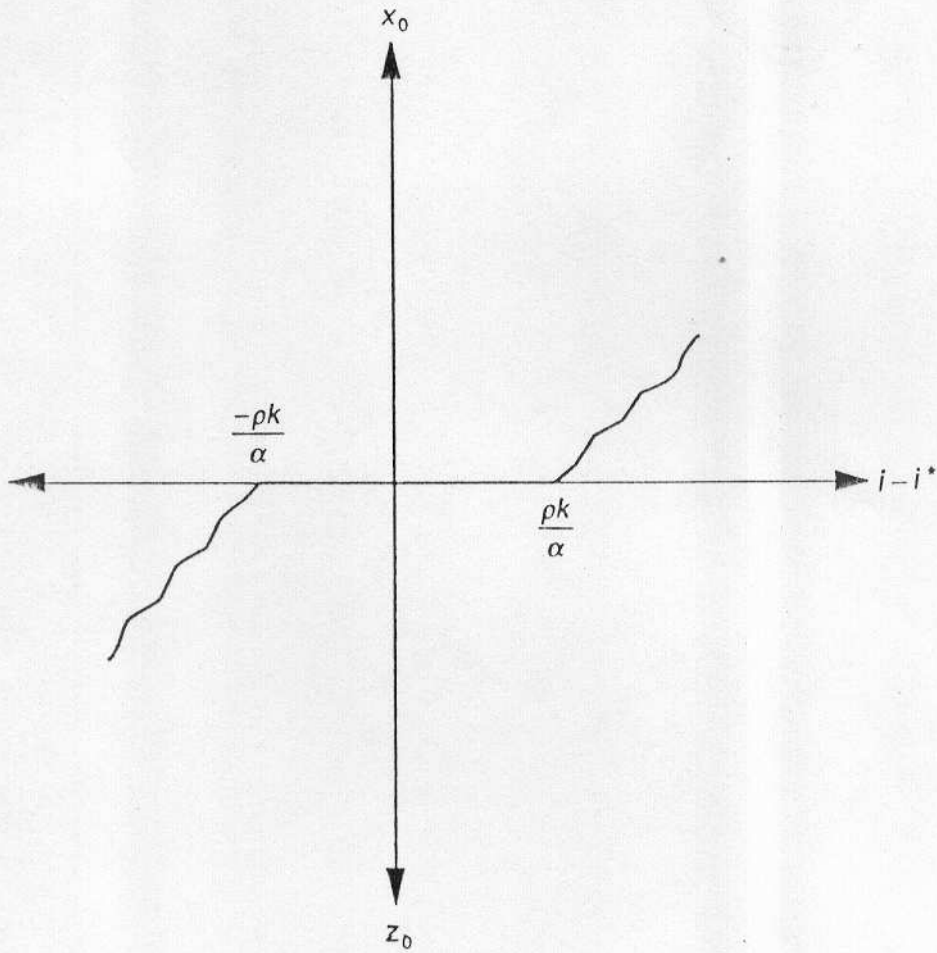
IV. Policy Implications

The model of dollarization presented in Section III provides a number of interesting policy implications. First, the presence of an inaction band implies that the phenomenon of dollarization displays irreversibility (or hysteresis); namely, *transitory* changes in inflation may have *permanent* effects on the degree of dollarization of the economy--as the cases of Bolivia and Mexico exemplify. In order to illustrate the nature of the irreversibility of the dollarization process, consider an initial situation characterized by a non-dollarized economy with a domestic inflation rate differential, $\pi - \pi^*$, sufficiently low so as to make it unattractive for

^{1/} It is straightforward, but not particularly interesting for the issues at hand, to consider these effects. The presence of wealth effects would imply the existence of current account imbalances, which would be financed by capital flows. The presence of these imbalances, however, does not alter in any significant way the analysis of dollarization presented, because aggregate consumption would remain constant over time under this alternative scenario.

^{2/} Equation (20) implies that the current account is balanced while the dollarization process is under way. If $\Psi(\bullet)$ represented a deadweight loss for the aggregate economy, instead of a transfer among individuals, then the economy would run a current account deficit while the dollarization process is in progress. When dollarization stops, and $\Psi(\bullet)$ falls to zero, the current account goes into balance. The economy's steady-state level of foreign assets would be lower than $(f+b+R)_0$ because of the current account deficits during the period of dollarization. The (possibly counterintuitive) implication that there is a current account deficit at the same time there is dollarization is a consequence of perfect capital mobility. In a model where, for example, the country faces a binding borrowing constraint, dollarization would necessarily be achieved by means of a current account surplus.

Figure 4. Initial Dollarization and Interest Rate Differential.



individuals to incur the transaction costs involved in the shifting of the marginal transaction to the foreign currency. In this context everybody has the incentive to continue using the local currency (say, the peso) unless the peso inflation rate rises--in the context of the model--above $\pi = \pi^* + \rho k/\alpha$. Suppose now that the peso inflation raises above this level. At this point transactions will start being shifted into dollars. Assume this process goes on for several months after which, say, 60 percent of the economy is dollarized and then a stabilization plan is put into effect that lowers the peso inflation rate to its initial level. At this point, even though the peso inflation has been reduced, it does not pay to change the degree of dollarization since the inflation differential does not cover the transaction cost involved.

Second, once dollarization is ongoing, reductions in inflation rates may not achieve any significant increase in the degree of monetization of the economy. Moreover, one may find that the money demand appears to behave in a "perverse" fashion, since reductions in the rate of inflation may well be associated with reductions in the demand for money. In the context of the earlier example, suppose the stabilization plan achieved a gradual reduction in inflation. Since, for some time, inflation will still be higher than the threshold $\pi^* + \rho k/\alpha$, the reduction in inflation will not achieve re-monetization; indeed, dollarization will persist despite the decreasing inflation rate.

Third, financial liberalization or, generally, the lifting of restrictions on financial activities may generate a process of dollarization even without a significant change in the rate of inflation. To envision this case in the context of our model, one may consider that financial liberalization reduces the marginal costs of adopting a second currency for transaction purposes. Thus, financial liberalization reduces k . Suppose that before there is financial liberalization, the inflation differential is such that the economy is within the inaction band. Starting from that point a fall in k , which narrows the inaction band, may well bring about dollarization at the initial inflation differential level.

These considerations show that dollarization may impose significant constraints on stabilization policies. For, in setting inflation targets, the authorities may be forced to aim at "first prize" rather than at "livable" inflation rates. First prize, in this context, means that reversing an ongoing dollarization process will require making the domestic currency the better alternative, so that from the start, the required inflation rate must be even lower than that of the competing foreign currency. In the context of the earlier example, the economy may remain at the 60 percent degree of dollarization forever, even if domestic inflation is reduced below the dollar inflation rate. For dollarization to be reversed it would be necessary, in the context of the model, to have a domestic inflation rate that is lower than the dollar rate *minus* the lower bound of the inaction band; that is, $\pi < \pi^* - \rho k/\alpha$. These considerations also may explain why, in the Latin American countries referred to in Section

II, the few de-dollarizations observed have been non-voluntary; namely, de-dollarization have been largely the consequence of confiscation schemes, rather than the equilibrium response to a reduction in domestic inflation.

V. Concluding Remarks

This paper has presented a view of dollarization that differs from traditional analysis of the phenomenon of currency substitution. Dollarization is viewed as the result of competition between different currencies, which provide, in a fundamental sense, the same type of services. Dollarization in Latin America is the product of the financial liberalization processes implemented during the 1970s and 1980s, which have allowed greater competition in monetary and financial services. It is no surprise, therefore, that we have witnessed a rising market share for the currency that provides the cheapest services.

The model of dollarization presented in this paper is highly stylized and still exploratory. In particular, we have focused more on the consequences stemming from the presence of costs associated with changing the currency denomination of transactions, rather than on the microfoundations of this process. The model's ability to shed some interesting insights on the process of dollarization and its policy implications provides encouragement to confront the much more difficult task of providing microfoundations to the economies of scale involved in the use of multiple currencies, as well as to the nature of the costs involved in adopting a new unit of account and medium of exchange. Some progress in this direction has been made by Sturzenegger (1990), where the microfoundations of currency substitution are studied in a framework similar to that proposed by Santomero (1979) for examining the role of transaction costs on the choice between currency and demand deposits.

APPENDIX

This Appendix shows that, if $a \leq \rho k$, then it is optimal to set $x_t=0$, for all $t \in [0, \infty)$; i.e., no dollarization occurs. If it were optimal to set $x > 0$, then optimal x and c_f would be given by equations (12) and (13). Moreover, the utility level associated with any given choice of x would be given by the utility associated with the consumption level attained under that choice. The consumption level, in turn, is directly related to the value of the integral in equation (10), as shown in equation (9). Hence, all that is needed is to show that, if $a \leq \rho k$, then consumption when x and c_f are given by equations (12) and (13) is lower than the consumption level that would be obtained by setting $x=0$ for all t . By using equations (10), (12) and (13), we obtain, if $a \leq \rho k$ and $x > 0$:

$$\begin{aligned} & \int_0^{t^*} [ac_f t - (kx_t + \frac{\phi}{2}x_t^2)]e^{-\rho t} dt = \\ & \int_0^{t^*} a[c_f 0 + (x_0 + \frac{\rho k - a}{\rho\phi}) \frac{1}{\rho} (e^{\rho t} - 1) - (\frac{\rho k - a}{\rho\phi})t]e^{-\rho t} dt - \\ & \int_0^{t^*} [k(x_0 + \frac{\rho k - a}{\rho\phi})e^{\rho t} - k(\frac{\rho k - a}{\rho\phi}) - \frac{\phi}{2}x_t^2]e^{-\rho t} dt + \frac{ac}{\rho}e^{-\rho t^*} = \quad (A1) \\ & \frac{ac_f 0}{\rho} - \int_0^{t^*} \{(\frac{\rho k - a}{\rho\phi})(x_0 + \frac{\rho k - a}{\rho\phi})a + [(\frac{\rho k - a}{\rho\phi})(k + at) + \frac{\phi}{2}x_t^2]e^{-\rho t}\} dt - \\ & \quad (\frac{\rho k - a}{\rho\phi}) \frac{a}{\rho} t^* e^{-\rho t^*} < \frac{ac_f 0}{\rho}, \end{aligned}$$

where $ac_f 0/\rho$ is the value that equation (10) takes if $x=0$ for all t . This completes the proof. An analogous proof can be used to show that, if $a \geq -\rho k$, then it is optimal to set $z=0$, for all t .

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