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INFLATIONARY FINANCE IN AN OPEN ECONOMY

Philip L. BROCK*

Duke University, Durham, NC 27706, USA

Models of inflationary finance that consider trade and capital flows generally conclude that openness curtails the ability of governments to impose the inflation tax due to currency substitution. This paper models two channels that allow central banks to *increase* inflation tax revenue by opening the economy. First, central banks can open the capital account subject to a reserve requirement on capital inflows. Revenue maximization produces a smaller reserve requirement on foreign capital inflows that on domestic deposits. Second, central banks can impose prior import deposits to broaden the monetary base in order to use the inflation tax on imports as an alternative to tariff revenue.

1. Introduction

Articles on inflationary finance generally model the inflation tax as a tax on holders of a homogeneous monetary base in economies that are closed to trade and capital flows.[1] To the extent that links with the rest of the world are analyzed, the conclusion generally reached is that openness curtails the ability of a government to impose the inflation tax on domestic residents. Openness implies some degree of currency substitution away from the domestic currency and toward the foreign one.[2]

This paper shows that once the assumption of a homogeneous monetary base is relaxed, two channels emerge by which central banks can *increase* inflation tax revenue by opening the economy to trade and capital flows. First, central banks can open the capital account subject to a reserve requirement on capital inflows. Revenue maximization produces a smaller reserve requirement on foreign capital inflows than on domestic deposits. Second, central banks can impose non-interest-bearing prior import deposits in place of tariffs to tax

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[1]Among these articles are Cagan (1956), Bailey (1956), Mundell (1965), Friedman (1971), and Phelps (1973).

[2]See Ortiz and Solis (1979) and Fischer (1982) for discussions of currency substitution within the institutional context of developing countries that rely on the inflation tax for a significant portion of government revenue.

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imports. The rate of taxation of imports increases in the presence of a banking system subject to reserve requirements.

Most countries impose the inflation tax on required reserves of the banking system as well as on currency. Developing countries in particular usually augment the currency component of the monetary base by imposing high reserve requirements on bank deposits. Table 1 presents reserve ratios during the 1970's for three large OECD countries and for three large Latin American countries. Two differences between the OECD countries and the Latin American countries stand out: (1) reserve ratios on deposits in Latin American banks are much higher than reserve ratios in OECD countries; and (2) Latin American monetary authorities pursue a more active policy of making large and frequent changes in reserve ratios that their OECD counterparts.

Not too surprisingly, revenue from the inflation tax is larger as a percentage of GNP for the Latin American countries than for the OECD countries, as shown in table 2. More surprising is the reversal of the relative importance of currency and reserve creation for inflation tax revenue. Unlike the OECD countries, Latin American countries collect a larger proportion of the inflation tax from depositors and borrowers of the banking system than from holders of domestic currency.

Section 2.1 of the paper models the imposition of the inflation tax in the context of a developing country, placing the banking system as the primary link between savers and investors. Reserve requirements drive a wedge between the real deposit and borrowing rates of interest. The wedge between interest rates is reflected on the real side of the economy by a divergence of capital's marginal product from the rate of time preference of domestic residents.

Table 1

Effective reserve ratios on bank deposits.[a]

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
U.S.	7.8	6.7	6.6	6.6	6.7	5.3	5.2	5.4	5.2	4.6
Germany	10.3	12.5	12.3	11.8	10.2	10.8	10.2	10.5	10.5	8.7
U.K.	5.3	6.1	9.6	7.2	6.9	8.4	6.6	5.4	5.4	2.8
Mexico	20.7	47.8	50.6	64.8	79.2	31.2	52.5	50.0	50.5	51.4
Colombia	33.1	30.4	32.3	29.7	29.3	31.5	34.3	48.6	52.2	45.2
Brazil	34.4	28.3	30.2	33.2	28.4	32.7	34.7	32.5	36.2	33.4

[a]*Source: International Financial Statistics*, 1971–1973: September 1978, 1974–1980: September 1981.

The effective reserve ratio is calculated by using the formula $(14 - 14a)/(34 + 35 - 14a)$ where 14, 14a, 34, and 35 refer to *IFS* line numbers for total reserve money, currency held outside of banks, money and quasi-money, respectively. The effective reserve ratio expresses legal reserves as a percentage of total bank deposits (both sight and time deposits).

Table 2

Average inflation tax: 1972–80 (as a percentage of GNP).[a]

	Total Revenue	Currency component	Required reserve component
U.S.	0.46	0.39	0.07
Germany	0.74	0.43	0.31
U.K.	0.85	0.62	0.23
Mexico	4.3	1.2	3.1
Colombia	2.7	1.2	1.5
Brazil	2.3	0.9	1.4

[a]*Source: International Financial Statistics*, September 1978 and September 1981.

Total revenue is $(base_t - base_{t-1})/GNP_t \equiv \Delta\ base/GNP$; the currency component is $\Delta currency/GNP$; and the required reserve component is $\Delta\ required\ reserves/GNP$. Figures for the monetary base, currency, required reserves and GNP are taken from lines 14, 14a, 14–14a and 99a of *IFS*. The figures in the table are simple arithmetic averages.

Mexico, Colombia, and Brazil pay below market interest rates on a proportion of required reserves, thus lowering the inflation tax rate on those reserves. The figures in the table are not corrected for interest payments.

Section 2.2 considers the implications of opening the capital account, subject to a reserve requirement, for the collection of the inflation tax.[3]

Section 3.1 presents some evidence on the use of prior import deposits in a number of developing countries. The most significant recent use of prior import deposits occurred from 1975 to 1979 in Brazil when imports were made subject to a one-year hundred-percent non-interest-bearing prior import deposit. Section 3.2 examines the interaction between prior import deposits and the inflation tax on the banking system.

2. The inflation tax on money and financial intermediation

In most less developed countries, equities markets, where they exist, are insignificant as a channel for intermediation between individual or institutional investors and firms. Virtually all investment activity is financed by firms' retained earnings or by credit extended through the banking system. The modeling strategy in this paper places the banking system as the only link between savers and investors in view of the ability of governments in develop-

[3]Reserve requirements on capital inflows have been used less systematically than quantitative restrictions that generate rents to favored borrowers. However, during the period 1976–1979 Uruguay employed reserve requirements of about 20 percent on foreign capital inflows. From 1979 to 1982 Chile applied a regime of maturity-specific reserve requirements on foreign capital inflows, with reserve ratios declining from 25 percent at short maturities to 0 for maturities greater than 66 months. During most of the 1970's Germany maintained discriminatory reserve requirements on foreign capital inflows, as did France, Austria, and Spain for shorter periods [OECD (1982)].

ing countries to impose very high reserve requirements on the banking system without causing banks to lose their central position as financial intermediaries. The general results of this model continue to hold in more complex financial settings, as long as the structure of financial markets generates finite elasticities of demand for bank deposits and loans.

2.1. The model in a closed economy

A brief characterization will be made here of the structure of the real economy that allows the central bank to impose the inflation tax. All physical capital is financed through loans of the banking system. In equilibrium the marginal product of capital will equal the real borrowing rate of interest (r_b). In the model, the downward sloping schedule of the demand for loans reflects the usual assumption of a declining marginal product of capital with a fixed supply of labor.

Individuals are identical and maximize a utility function that depends on both consumption and holdings of real money balances, $U = U(c, m)$. Utility is an increasing function of both arguments and is strictly concave. The rate of time preference is endogenous and assumed to be an increasing function of both consumption and money holdings: $\delta = \delta[U(c, m)]$.[4] Perfect competition ensures that in the steady state the rate of time preference, δ, will be equal to the real deposit rate, r_d. The deposit rate is the market rate of return to wealth holding. Utility maximization gives rise to a target level of wealth, $W = W(\pi, r_d)$, that is an increasing function of both the deposit rate and the inflation rate.[5] Since money and deposits are the only two assets in the model available to domestic residents, the asset demand functions can be written as

$$M/P = \tilde{m}\Big(\underset{-}{\pi}, \underset{-}{r_d}\Big)W\Big(\underset{+}{\pi}, \underset{+}{r_d}\Big) = m(\pi, r_d),$$

$$D/P = \tilde{d}\Big(\underset{+}{\pi}, \underset{+}{r_d}\Big)W\Big(\underset{+}{\pi}, \underset{+}{r_d}\Big) = d\Big(\underset{+}{\pi}, \underset{+}{r_d}\Big),$$

$$\tilde{m}(\cdot) + \tilde{d}(\cdot) = 1.$$

The results of the model will refer to the gross demands for money and deposits (m and d) rather than to the demands as a proportion of wealth ($\tilde{m}$

[4]The endogeneity of time preference assumed here follows recent work by Svensson and Razin (1983), Obstfeld (1981, 1982) and Findlay (1978).

[5]A higher deposit rate of interest will cause individuals to accumulate wealth until the higher levels of consumption and money holdings raise the rate of time preference to the new level of the deposit rate. A higher inflation rate causes individuals to economize on money holdings, thereby reducing utility. With a constant real deposit rate, individuals will accumulate wealth in order to raise consumption and restore utility to its initial level.

and $\tilde{d}$), and will always assume that the substitution effects on the demand for money with respect to π and r_d are greater than the wealth effects.[6]

2.1.1. Equilibrium conditions in financial markets

Bank deposits are subject to a reserve requirement (k) so that bank lending to the private sector consists of $(1-k)d$. The central bank acquires a portfolio of loans to the private sector in exchange for its liabilities of money and required reserves so that the monetary base is backed by a stock of interest-earning assets.[7] The following balance sheets illustrate the equilibrium asset positions of the central bank, commercial banks and non-bank private sector:

A — Central bank	L
Loans to private sector ($m+kd$)	Money (m) Reserves (kd)

A — Commercial banks	L
Reserves (kd) Loans [$(1-k)d$]	Deposits (d)

A — Non-bank private sector	L
Money (m) Deposits (d)	Loans ($l=m+d$)
Capital stock (K)	Net worth Capital stock (K)

In equilibrium the stock of loans equals the sum of the stocks of money and deposits,

$$l\left(\underset{-}{r_b}\right)=m\left(\underset{-}{\pi},\ \underset{-}{r_d}\right)+d\left(\underset{+}{\pi},\ \underset{+}{r_d}\right). \tag{1}$$

Since the monetary authority controls the nominal supply of the monetary

[6]This assumption guarantees, among other things, that $-m/(\mathrm{d}m/\mathrm{d}\pi)$ is positive so that revenue maximization will yield a finite rate of inflation.

[7]Base money is often treated as an outside asset so that the central bank extends credit to the treasury and never accumulates a stock of earning assets. This sort of behavior leads to the creation of a stock of future tax liabilities of the private sector equal in size to the monetary base. In a model where the inflation tax is the only source of revenue, such a specification of central bank behavior leads to problems of time inconsistency [see Calvo (1978)].

base, the price level is left free to equilibrate the real demand for the monetary base with the nominal supply of base money,

$$H/P = m(\pi, r_d) + kd(\pi, r_d). \tag{2}$$

From (2) it follows that the steady-state rate of inflation in the economy will be determined by the rate of growth of the monetary base,

$$\hat{H} = \pi, \tag{3}$$

where $\hat{H} = (1/H)(\mathrm{d}H/\mathrm{d}t)$ and π is the expected (and actual) rate of inflation.

The banking system costlessly intermediates between depositors and borrowers so that the nominal deposit rate differs from the nominal borrowing rate only by the amount of the distortion induced by the required reserve ratio: $i_d = (1-k)i_b$, where $i_d = r_d + \pi$ and $i_b = r_b + \pi$.[8] In real terms the wedge between deposit and borrowing rates is

$$r_d = (1-k)r_b - k\pi. \tag{4}$$

Eqs. (1) through (4) determine π, r_d, r_b and P and hence determine financial market equilibrium. H, $\hat{H}$, and k are the exogenous variables determined by the monetary authorities.

2.1.2. Inflation tax revenue

Steady-state revenue from the inflation tax on the monetary base is the real quantity of base money times the nominal lending rate received by the monetary authorities on their portfolio of loans: $R = (m + kd)(\pi + r_b)$, where R is the revenue from the inflation tax. By using the zero-profit constraint (4), revenue from the inflation tax can be expressed equivalently as

$$R = (r_b - r_d)d + (\pi + r_b)m. \tag{5}$$

This model makes the usual assumption that revenue from the inflation tax is redistributed back to households in lump-sum form.[9]

The financial market equilibrium that comes out of eqs. (1)–(5) is illustrated in fig. 1. The distribution of revenues from loans can be divided into four

[8]Reserves pay no interest in this model. If they did, the distortion would result in the zero-profit condition $i_d = (1-k)i_b + ki_r$, where i_r is the nominal rate paid on reserves.

[9]In practice, of course, revenue from the inflation tax will go to a few favored sectors of the economy, usually in the form of subsized credit from the central bank to 'vital' industries. When central banks are directed to hold a portfolio of low-yielding loans, the amount of revenue directly transferred to the treasury from the inflation tax may be small relative to the total tax.

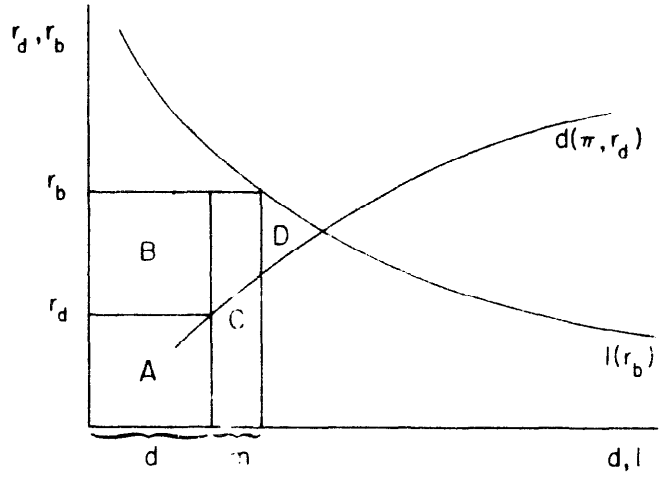

Fig. 1. The inflation tax in a closed economy.

parts. Area A is the payment to depositors. Area B is the revenue accruing to the monetary authorities from the imposition of reserve requirements. Area C is the real return on the stock of loans financed by money issue. In addition the monetary authority collects the amount $m\pi$ in capital gains as a part of the inflation tax.[10] Area D is the deadweight loss on financial intermediation that results from the use of reserve requirements and non-interest-bearing money.

Revenue maximization yields two first-order conditions derived by setting $\mathrm{d}R/\mathrm{d}\pi = 0$ and $\mathrm{d}R/\mathrm{d}k = 0$,

$$\eta_{b\pi} = \eta_{i_b\pi}, \tag{6}$$

$$\eta_{bk} = \eta_{i_b k}. \tag{7}$$

Expressions (6) and (7) state that the two tax instruments, π and k, should be used up to the point that the elasticity of the tax rate (i_b) with respect to each tax instrument is the same as the elasticity of the tax base (b) with respect to each tax instrument.[11]

Expression (7) gives rise to expressions for revenue maximization in the two limiting cases where the marginal product of capital is constant so that r_b is a constant and where the rate of time preference is constant so that r_d is a constant. The two extreme elasticity conditions have counterparts in the next

[10]Eq. (5) can also be expressed as $R = (i_b - i_d)d + i_b m$ where i_b and i_d are nominal interest rates. Fig. 1 could then be drawn using nominal interest rates on the vertical axis in order to capture the division of the nominal interest payments on loans into nominal payments to depositors plus the inflation tax.

[11]When $r_b = 0$, expression (6) is the familiar condition that $\eta_{b\pi} = 1$. When r_b is a positive constant, eq. (6) is $\eta_{b\pi} = \pi/(\pi + r_b)$.

section on inflation tax revenue in an open economy:

$$\eta_{dr_d|r_b} = \frac{r_d}{r_b - r_d}\left(1 + \frac{R_m}{r_d d}\eta_{mr_d}\right), \qquad R_m = (\pi + r_b)m, \tag{8}$$

$$\eta_{lr_b|r_d} = \frac{r_b}{r_b - r_d}. \tag{9}$$

Expression (9) indicates that when the deposit rate is constant, revenue-maximizing use of the reserve requirement proceeds independently of the demand for money. However, when the borrowing rate is constant as in expression (8), the revenue-maximizing reserve requirement depends on the demands for both money and deposits. Revenue maximization will entail a lower reserve requirement and, hence, a higher real deposit rate than would be the case if the demand for money were insensitive to changes in r_d. At the point of revenue maximization, the marginal revenue from the taxation of additional holdings of money and deposits (since desired wealth depends positively on r_d) will equal the marginal loss of revenue caused by higher interest payments on deposits and by the change in portfolio composition out of money and into deposits.

2.2. The model in an open economy

Two additional equilibrium conditions are sufficient to open the previous model of inflationary finance to international trade and capital flows. The first, a purchasing power parity condition with one tradeable good, links the domestic price level (P) to the foreign price level (P^*) by the domestic exchange rate: $P = EP^*$.[12] The second, an interest rate parity condition with perfect capital mobility, links domestic and international interest rates. In the absence of capital controls the nominal domestic borrowing rate (i_b) equals the nominal world rate of interest (i^*) plus the expected rate of change of the exchange rate ($\hat{E}$). The monetary authority can impose a reserve ratio (k^*) on foreign capital inflows so that the interest rate parity condition becomes $(1 - k^*)i_b = i^* + \hat{E}$. By using the purchasing power parity condition in terms of rates of change, the interest rate parity condition can be expressed in real terms as

$$r^* = (1 - k^*)r_b - k^*\pi \quad \text{where} \quad r^* = i^* - \pi^*. \tag{10}$$

[12]The exchange rate in the model will always be perfectly flexible. A non-tradeable good can easily be added to the model with an appropriate price index and 'real' exchange rate that is stationary in the steady-state.

In an open economy the real stock of money and deposits does not have to equal the stock of loans. Eq. (11) states that the real stock of foreign deposits (f) in the economy (expressed in domestic prices) plus domestic deposits and money will equal the stock of loans that have financed the capital stock.

$$l(r_b) = m(\pi, r_d) + d(\pi, r_d) + f. \tag{11}$$

The monetary base now consists of money (m), required reserves on domestic deposits (kd), and required reserves on foreign deposits (k^*f). Using eq. (11), the market clearing condition for the monetary base can be expressed as

$$H/P = (1 - k^*)m + (k - k^*)d + k^*l. \tag{12}$$

Eqs. (3), (4), (10), and (12) determine the four endogenous variables π, r_d, r_b, and P when financial markets are in long-run equilibrium. The monetary authorities now have the use of the reserve requirement on foreign deposits as an instrument of revenue collection in addition to control of the domestic reserve requirement and the rate of growth of the monetary base.

Revenue from the inflation tax in an open economy is just the nominal lending rate times the monetary base. Inflation tax revenue can be expressed equivalently as

$$R = (r_b - r_d)d + (\pi + r_b)m + (r_b - r^*)f. \tag{13}$$

Eq. (13) differs from eq. (5) for the closed economy by the amount of revenue generated by the tax on foreign capital inflows. By imposing a reserve requirement on foreign capital inflows, the monetary authority collects the difference between the domestic borrowing rate and the world rate of interest on all foreign deposits.

Fig. 2 illustrates equilibrium in the financial market in an open economy subject to two sets of reserve requirements. As in fig. 1, areas A, B and C correspond to payments to domestic depositors, revenue from required reserves on domestic deposits, and the real return on the stock of loans financed by money creation. Area E is the revenue from required reserves on foreign deposits, while area F is interest payments to foreigners. As in fig. 1, area D is the deadweight loss in the financial system due to the use of reserve requirements and non-interest-bearing money.

It is straightforward to show that revenue maximization will result in a larger reserve requirement on domestic deposits than on foreign ones. Setting $\mathrm{d}R/\mathrm{d}k = 0$ in eq. (13) gives the revenue-maximizing domestic reserve require-

ment

$$k = k^* + \frac{\overset{<0}{d - (\pi + r^*)(\mathrm{d}m/\mathrm{d}r_d)}}{\underset{>0}{(\pi + r_b)(\mathrm{d}d/\mathrm{d}r_b)}}.$$

The result that domestic deposits should be taxed at a higher rate than foreign ones ($k > k^*$) follows from the twin assumptions of a perfectly elastic supply of foreign deposits and a less-than-perfectly elastic supply of domestic deposits. The case for a tax on foreign deposits rests entirely on the finite elasticity of demand for loans by domestic firms (which in turn rests on diminishing returns to capital with a fixed supply of labor). On the other hand, the finite elasticity of supply of deposits by domestic residents works together with the finite elasticity of demand for loans to produce a larger revenue-maximizing reserve ratio on domestic deposits than on foreign ones. When reserve ratios are not discriminatory ($k = k^*$), then $r_d = r^*$ and the monetary authority loses the revenue $(r^* - r_d)d$ in fig. 2.

Revenue maximization yields three first-order conditions derived by setting $\mathrm{d}R/\mathrm{d}\pi = \mathrm{d}R/\mathrm{d}k = \mathrm{d}R/\mathrm{d}k^* = 0$ in eq. (13). The three corresponding revenue-maximizing elasticity conditions are the following:

$$\eta_{h\pi} = \frac{\pi}{\pi + r^*},$$

$$\eta_{dr_d} = \frac{r_d}{r^* - r_d}\left(1 + \frac{R_m}{r_d d}\eta_{mr_d}\right), \qquad R_m = (\pi + r^*)m,$$

$$\eta_{lr_b} = \frac{r_b}{r_b - r^*}.$$

The addition of the reserve requirement on foreign deposits relaxes a constraint on the monetary authority's ability to tax and will allow the monetary authority to collect at least as much revenue as in a closed economy. In particular, revenue generation from the inflation tax on foreign deposits will outweigh the lost tax revenue on domestically-financed loans (resulting from a lower r_b) if the elasticity of demand for loans is greater than $r_b/(r_b - r^*)$ at the point of revenue maximization in a closed economy. In that case the monetary authority will use k^* to lower r_b in order to reach a more inelastic position on the demand for loans schedule (although the revenue-maximizing elasticity will still be greater than one as long as r^* is positive). Similarly, the monetary authorities will raise the domestic reserve requirement when opening

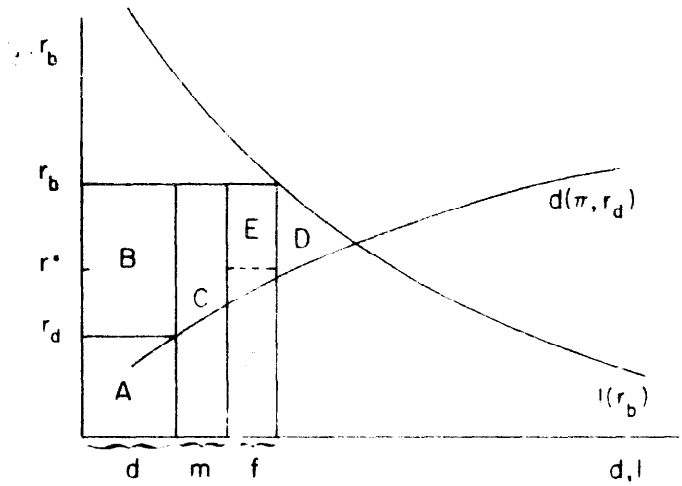

Fig. 2. The inflation tax in an open economy.

the economy whenever the marginal loss in revenue caused by lower wealth holding is exceeded by the marginal gain in revenue from foreign deposits ($r_b - r^*$) and from the shift in portfolio holdings out of deposits and into money.

3. The inflation tax on trade

3.1. Prior import deposits

Central banks in developing countries can, and often do, extend the monetary base to include prior import deposits placed with the central bank by importers.[13] These prior import deposits are specified as a fraction of the c.i.f. value of the imports and are placed with the central bank for a specified period of time at interest rates that are below market rates (usually zero). The frequent recourse to import deposits to tax imports has been explained as an administrative response to the difficulty of obtaining quick legislative approval for changes in tariffs.[14]

Prior import deposits are similar to tariffs: the opportunity cost of holding prior import deposits can always be expressed as an equivalent ad valorem tariff. Unlike tariffs, however, import deposits enter into the determination of the general price level when they are deposited with the central bank. The prior import deposit requirement creates a stock of reserves that form a part of the

[13]For a general discussion of the use of prior import deposits, see Marshall (1958), Birnbaum and Qureshi (1960), and Makdisi (1963). Accounts of the use of prior import deposits are given by Behrman (1976, pp. 92–95) for Chile, Diaz-Alejandro (1976, pp. 111–115) for Colombia, and Leith (1974, p. 17) for Ghana.

[14]See Birnbaum and Qureshi (1960, p. 123) and Krueger (1978, p. 47) for this explanation.

Table 3

Prior import deposits (as a percentage of monetary base).[a]

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Brazil	3.7	4.9	5.5	5.0	8.0	25.5	19.9	20.3	15.3	4.3
Colombia	12.2	11.7	12.9	11.3	5.0	1.7	6.4	4.9	6.4	6.2
Ecuador	11.9	15.1	0.2	0.1	6.3	13.1	12.5	9.6	8.9	9.9
Paraguay	3.1	2.3	2.9	2.9	2.1	2.4	3.0	3.6	3.8	2.9
Uruguay	16.5	22.9	21.4	24.0	7.6	0.6	0.1	—	—	—
Burundi	5.7	10.3	10.8	10.1	8.1	9.0	7.9	9.8	6.9	7.8
Ghana	27.2	35.5	25.2	17.6	14.6	10.8	11.5	11.7	12.9	7.4
Iran	8.1	12.4	15.8	30.8	14.2	17.7	17.0	n.a.	10.1	9.9
Korea	0.5	1.9	2.8	7.6	16.7	15.3	8.4	3.7	4.8	10.5
Zaire	3.5	3.2	3.3	13.8	6.3	6.8	23.9	27.8	38.2	17.7

[a]*Source*: *International Financial Statistics*, various issues.

The monetary base equals reserve money plus prior import deposits (lines 14 plus 16b).

monetary base. Just as the demand for bank reserves is induced by a reserve requirement on deposits, so too is the demand for prior import deposits induced by reserve requirement on imports. Because prior import deposits form a part of the monetary base, the choice of revenue-maximizing inflation rate, domestic reserve requirement and foreign reserve requirement will depend on the size of prior import deposits.

Table 3 presents figures on the use of prior import deposits during the 1970's for ten developing countries. In Brazil, Uruguary, Ghana, Iran, and Zaire, prior import deposits rose to one quarter of each country's total monetary base during the 1970's. Brazil, for example, took a series of measures to reduce imports in 1975, including the imposition of one-year hundred-percent non-interest-bearing prior import deposits. Despite many exceptions (such as petroleum) to the prior import requirement, the deposits rose to a stock level that represented one quarter of the value of annual imports. According to Sjaastad (1981), the tarriff equivalent of prior import deposits in 1977 was about 16 percent of the value of non-oil imports.

3.2. Revenue maximization with prior import deposits

This section modifies the model of section 2.2 to include two tradeable goods. The economy produces an exportable good (x) and imports all of the importable good (z) needed for consumption.[15] The domestic price of the exportable good is equal to the world price times the domestic exchange rate,

[15] The exportable good can be used either for consumption or investment purposes. The demand for imports will depend positively on π and r_d due to wealth effects and negatively on ρ, the internal terms of trade (P_z/P_x).

$P_x = EP_x^*$. The domestic price of the importable good will diverge from the world price by the amount of the distortion induced by the imposition of prior import deposits: $P_z = [1 + \phi_z(\pi + r_b)]EP_z^*$, where ϕ_z is the implicit reserve requirement placed on imports.[16]

Domestic relative prices are then related to world relative prices in the following way:

$$\rho = [1 + \phi_z(\pi + r_b)]\rho^*, \tag{14}$$

where ρ is the internal terms of trade (P_z/P_x) and ρ^* is the external terms of trade (P_z^*/P_x^*). The nominal stock of import deposits held by the central bank in the steady-state will equal $\phi_z EP_z^* z$. By writing the economy's price level as $P = P_x^\alpha P_z^{1-\alpha}$, the real stock of import deposits may be expressed as $\phi_z \rho^* z/\rho^{1-\alpha}$.

With two traded goods, the rate of time preference will be an increasing function of consumption of both goods and holdings of real money balances. As in section 2, the level of desired wealth will depend positively on both the real deposit rate and the inflation rate. In this section the target level of wealth will also depend positively on ρ, the internal terms of trade. The imposition of the inflation tax on prior import deposits will cause ρ to diverge from ρ^* and thus will reduce the welfare of domestic residents due to deadweight consumption losses. Therefore, given a deposit rate that is tied to the world interest rate, domestic residents will respond to an increase in ρ by accumulating wealth. As wealth is accumulated, the rate of time preference will rise until it equals the real deposit rate of interest.[17]

The total stock of loans will equal loans made by the banks plus loans made by the central bank:

$$L/P = \underbrace{(1-k)d + (1-k^*)f}_{\text{banks}} + \underbrace{m + kd + k^*f + \phi_z \rho^* z/\rho^{1-\alpha}}_{\text{central bank}}. \tag{15}$$

The monetary base will equal the stock of money plus required reserves on domestic and foreign deposits plus the stock of prior import deposits. Using eq. (15), the monetary base can be written as

$$H/P = (1-k^*)m + (k-k^*)d + (1-k^*)(\phi_z \rho^* z/\rho^{1-\alpha}) + k^* l. \tag{16}$$

[16]The implicit reserve requirement ϕ_z is the effective proportion of a year (if imports are measured as a flow per year) that the full value of an import must be held with the central bank as a prior import deposit. Thus, if the prior import deposit is 0.30 and the holding period at the central bank is 0.5 years, then $\phi_z = 0.15$ years. Assuming that the central bank pays no interest on prior import deposits, the opportunity cost to firms of financing prior import deposits will be the nominal borrowing rate, $\pi + r_b$.

[17]This sort of argument underlies the recent controversey over the existence of the Harberger–Laursen–Metzler effect. The argument presented here is similar to that of Obstfeld (1982) and Svennson and Razin (1983).

Eqs. (3), (4), (10), (14) and (16) form a complete system of equations that determines the steady-state values of π, r_d, r_b, ρ, and P. The monetary authority controls the rate of growth of the monetary base plus reserve requirements on domestic deposits, foreign deposits, and imports.

Revenue from the inflation tax (equal to the nominal borrowing rate times the monetary base) can be expressed after some manipulation as

$$R = (r_b - r^*)l + (r^* - r_d)d + (\pi + r^*)m + (\pi + r^*)(\phi_z \rho^* z/\rho^{1-\alpha}). \tag{17}$$

Eq. (17) states that on the margin, each new loan is financed by foreigners so that the monetary authority can only capture $r_b - r^*$ of the revenue from the loan, with r^* paid to foreign depositors. Similarly, each new domestic deposit crowds out a foreign deposit so that the marginal revenue to the central bank from a domestic deposit is only $r^* - r_d$. Finally, central bank loans made possible by greater holdings of real money balances or by higher levels of prior import deposits will generate marginal revenue to the central bank of $\pi + r^*$ rather than $\pi + r_b$ since the central bank loses $r_b - r^*$ on each foreign deposit crowded out.

Revenue maximization by the central bank is found by setting $\mathrm{d}R/\mathrm{d}\pi = \mathrm{d}R/\mathrm{d}k = \mathrm{d}R/\mathrm{d}k^* = \mathrm{d}R/\mathrm{d}\phi_z = 0$. The four corresponding revenue-maximizing elasticity conditions are presented below:

$$\eta_{h\pi} = \frac{\pi}{\pi + r^*},$$

$$\eta_{dr_d} = \frac{r_d}{r^* - r_d}\left[1 + \frac{R_m}{r_d d}\eta_{mr_d} - \frac{R_z}{r_d d}\eta_{zr_d}\right],$$

$$\eta_{lr_b} = \frac{r_b}{r_b - r^*}\left[1 - \frac{R_z}{(\pi + r_b)l}\right],$$

$$\eta_{z\phi_z} = \frac{1 + \alpha\phi_z(\pi + r_b)}{1 + \phi_z(\pi + r_b)} + \frac{R_m}{R_z}\eta_{m\phi_z} + \frac{R_d}{R_z}\eta_{d\phi_z},$$

where

$$R_m = (\pi + r^*)m, \quad R_z = (\pi + r^*)(\phi_z \rho^* z/\rho^{1-\alpha}), \quad R_d = (r^* - r_d)d.$$

A comparison of the above results with those of section 2.2 indicates that the use of prior import deposits will cause a revenue-maximizing central bank to raise domestic reserve requirements in order to lower r_d and move to a more

inelastic position on the deposit schedule. The central bank will gain revenue by replacing bank deposits with prior import deposits and by causing individuals to switch out of deposits and into money. Since a lower deposit rate of interest lowers the desired stock of wealth, the central bank will raise the domestic reserve requirement to the point where the gain in revenue from altering the composition of wealth equals the loss in revenue caused by the decline in wealth.

The central bank will also lower k^* and r_b so as to move to a less elastic portion of the loan schedule. The volume of loans will expand to absorb some of the loans financed by prior import deposits. At the revenue-maximizing point the yield from an additional prior import deposit will just equal the revenue loss from a lower borrowing rate.

Finally, the central bank will raise ϕ_z beyond the usual revenue-maximizing point for tariffs. When the central bank raises ϕ_z, domestic residents increase their stocks of money and deposits in order to offset the welfare loss associated with the distortion of relative prices induced by ϕ_z. At the revenue-maximizing point the additional increment to the monetary base from larger holdings of money and deposits will be just offset by the loss of prior import deposits on a lower volume of imports.

4. Conclusion

Although almost all models of the inflation tax consider currency as the entire monetary base,[18] the inflation tax in most countries is also levied on borrowers and lenders via reserve requirements on the banking system. In a smaller number of countries the inflation tax is also levied on consumers by the use of prior import deposits on imported goods. In addition to revenue generation, the use of the inflation tax on required reserves draws both the banking system and international trade into the determination of the domestic price level.[19]

This paper presented a framework for modeling the inflation tax as it is currently applied in many developing countries. The paper indicated how governments can use the rate of growth of base money creation, two types of reserve requirements, and prior import deposits to generate inflation tax revenue. Because the paper emphasized the interactions among the policy

[18]The few exceptions are Fry (1981), McKinnon and Mathieson (1981), and Siegel (1981). All three papers look at different aspects of the use of reserve requirements in a closed economy.

[19]Fama (1980) has expressed the view that the banking system gets involved in the determination of the price level only through the reserve requirement on deposits. He writes that future generations might impose a reserve requirement on a commodity, such as spaceships, to create a demand for the monetary base and hence determine the price level. Countries that impose prior import deposits bring their countries' foreign trade into the determination of the price level in a way that is similar to Fama's spaceship proposal.

instruments for revenue maximization, the problem of minimizing welfare costs for any level of tax revenue was not considered. Also ignored was the explicit treatment of transition paths between different steady-state equilibria.

The analysis in this paper contains an important implication for developing countries that are trying to liberalize by dismantling controls on trade and the banking system. Since a move to broader-based taxes to replace the inflation tax generally takes some time, authorities should remove controls in a manner consistent with revenue requirements. In particular, for as long as the monetary authority has to impose the inflation tax on domestic depositors and borrowers, it should allow foreign capital inflows only when subject to a reserve requirement.

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