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ON THE DETERMINATION OF THE EXTERNAL DEBT:

THE CASE FOR ISRAEL

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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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ON THE DETERMINATION OF THE EXTERNAL DEBT:

THE CASE OF ISRAEL

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I. INTRODUCTION

Israel's net foreign debt at the end of 1981 was 13.1 billion U.S. dollars, which represents a per-capita burden of about 3,300 dollars. The aim of this paper is to investigate whether the development of this debt can be explained by an equation derived from an intertemporal maximization framework under perfect capital markets. The model used here is a simple version of the type of framework studied recently by Bruno (1982), Dornbusch (1983), Sachs (1981, 1982), and Svensson and Razin (1982, 1983).

In this model the private sector maximizes utility from consumption over an infinite horizon subject to an intertemporal budget constraint which recognizes the intertemporal finance equation of the government -- in other words, the "Ricardian equivalence theorem" is incorporated. Under these conditions, the effect of current disturbances in output, government spending, and so forth, on private consumption decisions is determined by their perceived future persistence. The higher the latter, the stronger the impact of the shock on perceived wealth and hence on current consumption. From the national income accounts, this implies that the effect of the shock on the capital account will be negatively related to its persistence.

The model also predicts that holding all shocks at their zero levels, the foreign debt will follow a path which, in general, depends on the interest rate, the economy's growth rate, and the parameters of the utility function. If these parameters are such that the optimal constant growth of planned consumption equals the economy's growth rate (an assumption that was adopted) the foreign debt will also grow at that rate. Thus, this

set-up does not generate a long-run ratio of foreign debt to GNP. This ratio will remain at the historical initial level unless it is disturbed by exogenous shocks. This outcome is similar to Barro's (1979) result regarding the long-run public debt.

An important additional variable in the case of Israel is the unilateral transfers to the private sector, and, especially, to the government. These transfers have a direct effect on the capital account and also an indirect effect, via the intertemporal budget constraints of the two sectors. The importance of the public transfers is especially evident during the war years of 1967 and 1973, when real government spending went up by about 1/3 of the respective previous years' levels. The increase in the volume of these transfers in 1967 represents about 2/3 of the increment in government expenditures; the comparable figure for 1973 is 1. These large inflows of transfers seem related to the phenomenon that the real foreign debt actually declined in 1973, and increased only slightly in 1967.

The transfers come from world Jewry and friendly governments -- mainly from West Germany until 1965, and from the United States since the early 1970s. The model incorporates a simple equation for the determination of the unilateral transfers to the government. The basic assumption about these transfers is that they are associated with the financial needs of the Israeli public sector. They are positively related to government spending, particularly abnormal expenditures, and to the variations in private income as a measure of taxation capacity. The perceived future path of these transfers

is therefore related to the expected persistence of the shocks affecting their levels. The transfers to the private sector were included in the private income variable since a satisfactory model describing their determination is not available.

The empirical implementation of the model requires the estimation of the exogenous processes driving the economy -- that is, government expenditures and an income variable -- and the transfers equation. The main purpose of this stage of the empirical analysis is to estimate the degree of persistence of the exogenous variables. The model is then formally tested by confronting the coefficients of the foreign debt equation with the values that can be expected given the parameters of the processes estimated previously.

II. THE MODEL

In this section an equation is derived for the external debt growth of a small economy. The external real debt, Z , is composed by the government's debt, Z^G , and the privately held debt, Z^P .

The basic framework for discussing the foreign debt growth comes from the national income accounts. Ignoring investment in this section, the identity between output and its uses in the present period (one) is

$$(1) \quad G_1 + C_1 = GDP_1 + IM_1 - EX_1,$$

where G is government spending, C is private consumption, GDP is gross domestic product, and $IM-EX$ is excess imports of goods and services.

From the balance of payments it follows that

$$IM_1 - EX_1 = T_1^P + T_1^G + Z_1 - (1+r)Z_0,$$

where T^P and T^G are unilateral transfers to the private and public sectors respectively and r is the constant, exogenously given, real interest rate. Substituting this equality into (1) and defining the gross private income variable $Y \equiv GDP + T^P$ yields

$$(2) \quad Z_1 - Z_0 = C_1 + G_1 - Y_1 - T_1^G + rZ_0.$$

This equation expresses the equality between the surplus in the capital account on the one hand, and the difference between total absorption ($C_1 + G_1$) and GNP plus total unilateral transfers ($Y_1 - rZ_0 + T_1^G = GDP + rZ_0 + T_1^P + T_1^G$) on the other.

To analyze the effects of temporary movements of output and government spending, it is assumed that Y and G grow at a common normal rate, μ , with current deviations from trend levels which are known to be serially correlated. Specifically, the current levels of Y and G , and their expected future paths are

$$Y_t = \bar{Y}_1(1+\mu)^{t-1}(1+\eta\lambda^{t-1}), \quad G_t = \bar{G}_1(1+\mu)^{t-1}(1+\epsilon\rho^{t-1}), \quad t = 1, 2, \dots,$$

where $0 \leq \lambda \leq 1$ and $0 \leq \rho \leq 1$. The fractions η and ϵ represent the current deviations from trend of income and government spending respectively. The speed at which each variable is expected to return to its trend level in the future is determined by the parameters λ and ρ . The common normal growth rate implies a long-run constant G/Y ratio.

We proceed now to the determination of private consumption demand. The model used here assumes certainty about the future path of the exogenous variables. Hence, the optimization problem solved below is deterministic.¹ The representative individual maximizes an intertemporal utility function over an infinite horizon, subject to an intertemporal budget constraint. Assuming a time-separable logarithmic utility function, the individual's optimization problem is

$$\begin{aligned} \text{Max } \sum_{t=1}^{\infty} \frac{U(C_t)}{(1+\delta)^{t-1}} &= \sum_{t=1}^{\infty} \frac{\log C_t}{(1+\delta)^{t-1}}, \text{ subject to} \\ (3) \quad \sum_{t=1}^{\infty} \frac{C_t}{(1+r)^{t-1}} &= \sum_{t=1}^{\infty} \frac{Y_t - \tau_t}{(1+r)^{t-1}} + (1+r)(b_0 - Z_0^P) = W_1, \end{aligned}$$

where τ_t is taxes paid in period t , b is the private holdings of government bonds, and W_1 is current net wealth of the private sector. For W_1 to be finite, it is necessary to assume that $r > \mu$.

The standard solution of this problem is:

$$(4a) \quad C_1 = \frac{\delta}{1+\delta} W_1, \text{ and}$$

$$(4b) \quad C_t = C_1 \left(\frac{1+r}{1+\delta} \right)^t, \quad t=2,3,\dots$$

Current consumption is proportional to wealth, and it is planned to grow at the rate $(1+r)/(1+\delta)$. The solution would not be altered if government spending were included additively in the utility function. Under a more general specification marginal utility from consumption and hence consumption levels would be affected by G .

In general, the rate of consumption growth can be either higher or lower than the rate of income growth, depending on the values of the interest rate and the time preference parameter. In principle, therefore, the consumption-income ratio could approach zero, or alternatively, infinity. These extreme outcomes are ruled out only under the assumption that $(1+r)/(1+\delta) = 1+\mu$. In this case consumption grows at the normal growth rate of output.

The adoption of this simplifying assumption amounts to a restriction on the permissible values of the parameters δ , μ and r . Although this assumption is arbitrary in the present context, it can be justified as an equilibrium condition under a simple structure of the world economy. Assume that the world is composed of a large number of countries, identical to the home country in all respects (in particular, the parameters δ and μ are the same everywhere) but in the current deviations of the exogenous variables from trend and in the outstanding foreign debts. Across countries, those deviations average to zero and the foreign debts cancel out. For the sake of simplicity in this argument, assume no unilateral transfers. Now, given the growth rate, μ , of total output and governments' spending, world-wide dynamic equilibrium requires an equal growth rate of world consumption. This is achieved only when the real interest rate adjusts such as to satisfy $1+r = (1+\delta)(1+\mu)$. This condition also assures worldwide equilibrium in period one.^{2,3} Given this condition, current consumption in (4a) is determined as

$$(5) \quad C_1 = \frac{r-\mu}{1+r} W_1.$$

The next step is the calculation of W_1 . Given the intertemporal budget constraint of the government, the present value of taxes is:

$$(6) \quad \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^{t-1}} = \sum_{t=1}^{\infty} \frac{G_t - T_t^g}{(1+r)^{t-1}} + (1+r)(b_0 + Z^g).$$

The introduction of the outstanding total debt of the government (internal and external) in (6) implicitly rules out the possibility of perpetual debt finance. Substituting (6) into the wealth expression yields:

$$(7) \quad W_1 = \sum_{t=1}^{\infty} \frac{Y_t - G_t + T_t^g}{(1+r)^{t-1}} - (1+r)Z_0.$$

Wealth depends on the $Y_t - G_t + T_t^g$ flows and on the private and public external debts added up. The internal debt cancels out.

Consider now the unilateral transfers to the public sector. These transfers affect the capital account--equation (2)--directly, as well as indirectly, via the intertemporal budget constraint of the government, which is internalized by the private sector. The modeling of these transfers attempts to capture their nature in the case of Israel. The basic presumption, because of their source, is that they are motivated by the financial needs of the government. They are thus assumed to be positively related to government spending, especially extraordinary expenditures, and negatively to income fluctuations, as a measure of the current taxation capacity. It is assumed that this relationship takes the form:

$$T_1^g = a_1 \bar{G}_1 + a_2 \epsilon \bar{G}_1 + a_3 \eta \bar{Y}_1 + \xi, \quad 1 > a_2 > a_1 > 0, \quad a_3 < 0,$$

where ξ is a transitory disturbance with a serial correlation coefficient ω .

Hence, the expected pattern of future transfers to the public sector is:

$$(8) \quad T_t^g = a_1 \bar{G}_1 (1+\mu)^{t-1} + a_2 \bar{G}_1 (1+\mu)^{t-1} \epsilon \rho^{t-1} + a_3 \bar{Y}_1 (1+\mu)^{t-1} \eta \lambda^{t-1} + \xi \omega^{t-1}.$$

Since (8) is believed to hold at all times, transfers in the future are expected to reflect the persistence of the disturbances in government spending and income.

Given the time pattern of Y , G , and T^g , and solving the present value expressions, perceived net wealth can be expressed as:

$$(7') \quad W_1 = \frac{1+r}{r-\mu} [\bar{Y}_1 - (1-a_1)\bar{G}_1] + \frac{(1+r)(1+a_3)}{1+r - (1+\mu)\lambda} y - \frac{(1+r)(1-a_2)}{1+r - (1+\mu)\rho} g + \frac{1+r}{1+r-\omega} \xi - (1+r)Z_0$$

where $y \equiv \eta \bar{Y}_1$ and $g \equiv \epsilon \bar{G}_1$.

Substituting (7') into (5) yields the current consumption level as a function of the exogenous variables and the outstanding foreign debt:

$$(9) \quad C_1 = \bar{Y}_1 - (1-a_1)\bar{G}_1 + \frac{(r-\mu)(1+a_3)}{1+r - (1+\mu)\lambda} y - \frac{(r-\mu)(1-a_2)}{1+r - (1+\mu)\rho} g + \frac{r-\mu}{1+r-\omega} \xi - (r-\mu)Z_0.$$

To obtain the growth of the external debt, equations (8) and (9) and the expressions $Y_1 = \bar{Y}_1 + y$, and $G_1 = \bar{G}_1 + g$ are substituted into (2) to yield:

$$(10) \quad Z_1 - Z_0 = \frac{(1+\mu)(1-\rho)(1-a_2)}{1+r - (1+\mu)\rho} g - \frac{(1+\mu)(1-\lambda)(1+a_3)}{1+r - (1+\mu)\lambda} y - \frac{1+\mu-\omega}{1+r-\omega} \xi + \mu Z_0.$$

Foreign debt growth is affected positively by government spending shocks and negatively by income fluctuations. The systematic components of income and government spending drop out, because their direct effect is fully offset by an opposite effect on private consumption. The independent part of the public transfers, ξ , has a negative effect on foreign borrowing. The transfers that are explained by g and y are taken into account in their coefficients by a_2 and a_3 . Given these parameters, the magnitudes of the coefficients of g and y depend on their corresponding serial correlations. The higher ρ , for example, the larger the increase in the present value of taxes following a positive g . Correspondingly, a large downward adjustment in consumption

follows, resulting in a smaller effect on the capital account. When $\rho=1$, g is permanent and therefore it drops out, similar to the systematic component $\bar{G}_1$. At the other extreme, when $\rho=0$, the shock is purely transitory. In this case the coefficient of g gets its highest possible value: $(1+\mu)(1-a_2)/(1+r)$, which is lower than 1 by assumption. Hence the coefficient of g in (10) is between 0 and 1. The coefficient of the income fluctuations is negative because consumption adjusts by less than the income shift, so that a positive y is followed by positive private savings. The higher the persistence parameter λ , the greater the net wealth and the corresponding consumption adjustments, resulting in a smaller negative effect on the capital account.

The magnitude of the coefficients of g and y decline with the magnitude of the parameters a_2 and a_3 . Namely, the sensitivity of the public transfers to movements in these variables dampens their effects both on private net wealth--and hence on consumption--and on foreign borrowing. The transfers disturbance affects the debt growth according to their perceived persistence.⁴

The last term in equation (10) is μZ_0 , which says that holding spending and output at trend levels, the foreign debt grows at the same rate as the economy. That is, this model does not generate a normal or optimal foreign debt or foreign-debt - income ratio. The outstanding debt is never amortized. It stays at the initial level unless it is altered by exogenous disturbances. This characteristic of the model is the same as that in Barro's (1979) analysis of the behavior of the public debt. In Barro's model it is the smoothing of the tax-income ratios that generates the unamortized government debt. In the present model a similar role is played by the smoothing of consumption levels.

This undetermined movement of the foreign debt has a natural upward limit, which is the future ability of the country to pay the debt. Current foreign debt cannot exceed $\sum_{t=1}^{\infty} (Y_t - G_t + T_t^g)/(1+r)^{t-1}$, which is equivalent to saying that net wealth, and hence consumption, cannot be negative.⁵

III. EMPIRICAL IMPLEMENTATION

To test the hypotheses presented in the previous section, the following procedure has been adopted. First, a way to incorporate investment in the empirical analysis is discussed. Then, the government spending, the income, and the public transfers processes are estimated. This part of the analysis also provides proxies for the different disturbances affecting the foreign debt. Next, the empirical counterpart of the foreign debt growth equation (10) is discussed and estimated. Here the coefficients are expected to conform to the values that can be calculated given the estimates of the normal growth rate, the parameters of serial correlation, and the coefficients of the public transfer process.

a. Treatment of Investment

Although the determination of investment is not discussed in this paper, its correlation with the included variables makes it empirically desirable to incorporate investment in the analysis. The compromise adopted in this respect is as follows.

Total gross capital formation, I , is composed of gross investment of private firms, I^P , and public gross investment, I^G . Correspondingly, private net wealth is now computed as

$$(11) \quad W_1 = \sum_{t=1}^{\infty} \frac{Y_t - I_t^P - \tau_t}{(1+r)^{t-1}} + (1+r)(b_0 - Z_0^P).$$

To see that the relevant before-tax income flow is $Y - I^P$, assume that the firms finance I^P from retained earnings. Then, labor income and dividends (plus private unilateral transfers) equal Y net of private investment. The overall budget constraint of the government is now

$$(12) \quad \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^{t-1}} = \sum_{t=1}^{\infty} \frac{G_t + I_t^G - T_t^G}{(1+r)^{t-1}}.$$

Substituting (12) into the private wealth expression yields

$$(13) \quad W_1 = \sum_{t=1}^{\infty} \frac{Y_t - I_t - G_t + T_t^G}{(1+r)^{t-1}} - (1+r)Z_0,$$

which differs from the original wealth expression in equation (7) by the appearance of $-I_t$ in the capitalized flows. If the government receives income directly from its owned capital, a corresponding term should appear in the numerator of the right-hand side of (12) with negative sign. In this case, the income variable in (11) would be private income only. However, after the substitution of (12), private income and public income from production add up again to Y_t , which was defined as GDP plus private transfers.

To proceed with the analysis, the notion of "net income" is defined as $Y' = Y - I$, which appears both in the private wealth expression and in the national income accounting.⁶ It is assumed that Y' also grows normally at the rate μ , with a current serially-correlated deviation from the trend of y' . Equations (8), (9), and (10) hold again with y' substituted for y . However, to simplify the notation, the "'" is dropped in the following discussions.

b. Public Spending, Net Income and Transfers to the Private Sector

Before proceeding with the empirical analysis, it should be pointed out that the data on the relevant variables is available partly in constant shekels and partly in United States dollars. Hence, prior to the econometric work it is necessary to express all data in the same, constant price units. For this it is necessary to assume purchasing power parity. The assumption used is that $p_t = e_t p_t^*$, where p_t is the Israeli GDP deflator, e_t is the effective exchange rate (on exports) of the U.S. dollar, and p_t^* is "the" U.S. dollar price level. All data are converted into 1975 shekels by multiplying the U.S. dollar figures by e_t and dividing by p_t .⁷

The empirical formulation of the public spending and net income patterns specified in the previous section is

$$(14) \log G_t = \alpha + \mu t + \epsilon_t \quad \epsilon_t = \rho \epsilon_{t-1} + \tilde{\epsilon}_t$$

$$(15) \log Y_t = \beta + \mu t + \eta_t \quad \eta_t = \lambda \eta_{t-1} + \tilde{\eta}_t,$$

where the growth rate μ is constrained to be the same in both equations, and $\tilde{\epsilon}_t$ and $\tilde{\mu}_t$ are normally distributed innovations.

The data used in the estimation of (14) and (15) are annual real consumption of the public sector, gross domestic product, gross domestic capital formation, and unilateral transfers to the private sector. All these variables, except the unilateral transfers, are available in 1975 shekels. The transfers are converted into the same units as previously mentioned.

Public consumption includes all defense expenditures, including those that could be thought of as investment. The unilateral transfers to the private sector include personal transfers, (bequests, gifts, and personal transfers) and restitution payments and pensions from West Germany.⁸ The importance of these transfers relative to the GDP changed during the sample. It ranges from about 1 percent to 10 percent of GDP, with an average of about 6 percent.

Equations (14) and (15) are estimated simultaneously using a nonlinear procedure, and imposing the same normal growth rate across equations. The estimates are:

$$\begin{aligned}
 (14') \quad \log G_t &= 6.33 + 0.056t, \\
 &\quad (0.59) \quad (0.016) \\
 \hat{\rho} &= 0.90 \quad D.W. = 2.15, \\
 &\quad (0.06)
 \end{aligned}$$

$$(15') \quad \log Y_t = 7.20 + 0.056t,$$

(0.51) (0.016)

$$\hat{\lambda} = 0.88 \quad D.W. = 2.41,$$

(0.06)

sample 1953-1981,⁹

where the standard errors appear in parentheses below the corresponding estimates.

The normal growth rate of the economy is estimated at 5.6 percent, and the long run G/Y ratio is 0.42. The estimated equations display a significant degree of positive serial correlation. Using the estimates of ρ and λ it is possible to calculate the "average persistence" of the shocks, i.e., the number of years that a disturbance would have to remain at the same level (and then drop to zero) to make the present value of the deviations from trend equal to that under the asymptotic decline. Assuming that r is 6.5 percent -- which has to be assumed higher than 5.6 percent -- the average persistence of government spending shocks is about 10 years and that of output is about 8 years.¹⁰

Normal levels of government spending and net income are

$$\bar{G}_t = \exp(\alpha + \mu t), \quad \bar{Y}_t = \exp(\beta + \mu t),$$

and correspondingly, the deviations from normal are

$$g_t = G_t - \bar{G}_t, \quad y_t = Y_t - \bar{Y}_t.$$

The empirical equation for the unilateral transfers to the public sector follows directly from the previous section:

$$(16) \quad T_t^g = a_1 \bar{G}_t + a_2 g_t + a_3 y_t + \xi_t, \quad \xi_t = \omega \xi_{t-1} + \epsilon_t.$$

The data on T^g includes the intergovernmental transfers, transfers from world Jewry, and donations to nonprofit organizations. These data are available from 1952 onwards, and consistently constructed only through 1980. In this series, transfers from the United States government were registered at the time of arrival of the imports that the Israeli government purchased with them. This is the same timing as that of the inclusion of these imports in the national accounts, and hence it seems suitable for this study.¹¹

Using as explanatory variables the series of $\bar{G}_t$, g_t , and y_t obtained above, the estimated transfers equation is

$$(16') \quad T_t^g = 0.27 \bar{G}_t + 0.47 g_t - 0.18 y_t$$

$$(0.03) \quad (0.13) \quad (0.15)$$

$$R^2 = 0.80 \quad \hat{\omega} = 0.39 \quad D.W. = 1.86$$

$$(0.17)$$

The signs of the coefficients conform to the expectations, although the coefficient of y is insignificantly different from zero. Fluctuations in government spending affect public transfers with the sizable coefficient of 0.47, which means that almost half of these expenditures are financed by transfers. The coefficient of $\bar{G}_t$ indicates that the long-run ratio of public transfers to government spending is 0.27.

Finally, the estimates of ξ_t are obtained as the residuals of (16').

c. Foreign Inflation and the Empirical Debt-Growth Equation

The model used in the previous section does not include foreign inflation, which is also relevant for the determination of the real value of the external debt. Here, anticipated and unanticipated foreign inflation are incorporated, and an empirical counterpart of equation (10) is specified.

In this discussion, the problem that the data are available in different currencies is assumed away for convenience by pretending that all data are expressed in U.S. dollars. Consider now the nominal counterpart of equation (2)

$$(2') \quad ZN_t = \dots + (1 + i_t)ZN_{t-1},$$

where ZN is the foreign debt in dollars, the dots represent the dollar value of $C_t + G_t - Y_t - T_t^g$, and i_t is the annual nominal interest rate pertinent to the outstanding debt. The value of i_t is viewed as averaging the relevant past interest rates that took into account different inflationary expectations.

Maintaining the assumption of a constant real interest rate, the nominal rate can be expressed as

$$(17) \quad 1 + i_t = (1 + r)(1 + \pi_t^e)$$

where π_t^e is the relevant "average" past expectation regarding the rate of change in the dollar price level from year $t-1$ to year t . Defining

$\tilde{\pi}_t$ as the residual unexpected inflation, p_t^* can be written as:

$$(18) \quad p_t^* = p_{t-1}^* (1 + \pi_t^e) (1 + \tilde{\pi}_t).$$

Substituting (17) into (2'), deflating by p_t^* from (18), and rearranging terms yields:

$$(2'') \quad \frac{ZN_t}{p_t^*} - \frac{ZN_{t-1}}{p_{t-1}^*} = \dots + r \frac{ZN_{t-1}}{p_{t-1}^*} - (1+r) \frac{ZN_{t-1}}{p_{t-1}^*} \left(\frac{\tilde{\pi}_t}{1+\tilde{\pi}_t} \right).$$

This modified version of equation (2) includes an additional random term on the right-hand side, indicating a direct negative effect of unexpected inflation on the real foreign debt.

To obtain the corresponding counterpart of the final equation (10) consider the private wealth which, expressed in constant dollars, now includes the term:

$$- \frac{(1+r)ZN_{t-1}}{p_{t-1}^* (1+\tilde{\pi}_t)} = - \frac{(1+r)ZN_{t-1}}{p_{t-1}^*} + \frac{(1+r)ZN_{t-1}}{p_{t-1}^*} \left(\frac{\tilde{\pi}_t}{1+\tilde{\pi}_t} \right),$$

instead of $-(1+r)Z_0$ in equation (7'). Namely, private wealth now contains an additional random term which represents the positive effect of unanticipated foreign inflation. Correspondingly, the consumption equation here includes the term

$$-(r-\mu) \frac{Z_{t-1}}{p_{t-1}^*} + (r-\mu) \frac{Z_{t-1}}{p_{t-1}^*} \left(\frac{\tilde{\pi}_t}{1+\tilde{\pi}_t} \right),$$

in place of $-(r-\mu)Z_0$ in equation (9). Substituting the modified consumption equation into (2'') yields

$$(10') \quad \frac{Z_t}{p_t^*} - \frac{Z_{t-1}}{p_{t-1}^*} = \dots + \mu \frac{Z_{t-1}}{p_{t-1}^*} - \frac{(1+\mu)Z_{t-1}}{p_{t-1}^*} \left(\frac{\tilde{\pi}_t}{1+\tilde{\pi}_t} \right),$$

where the dots represent the sum of the constant dollars value of g , y , and ξ multiplied by the corresponding coefficients.

In the resulting debt-growth equation expected inflation does not appear because it affects the nominal interest rate and the current price level equally. With respect to the effect of unanticipated inflation -- the last term of the equation -- the econometric procedure adopted in this paper will treat it as a residual. This seems appropriate under the following

considerations. Given that $\tilde{\pi}_t$ is an unanticipated magnitude, it is reasonable to assume that it has zero mean and

that it is uncorrelated with Z_{t-1}/p_{t-1}^* . Also, since the variance of $\tilde{\pi}_t$ can be considered small compared to 1, the variation of $\tilde{\pi}_t/(1+\tilde{\pi}_t)$ can be assumed to closely replicate the movements of $\tilde{\pi}_t$. Under these assumptions, the last term in (10') can be treated as uncorrelated with the explanatory variables, especially with Z_{t-1}/p_{t-1}^* .

Using the equality $p_t^* = p_t/e_t$ and defining

$Z_t \equiv ZN_t \cdot e_t/p_t$ and $v_t \equiv (1+\mu) Z_{t-1} / [\tilde{\pi}_t / (1 + \tilde{\pi}_t)]$, equation (10') is written in

its empirical form:

$$(19) \quad Z_t - Z_{t-1} = b_1 g_t + b_2 y_t + b_3 \epsilon_t + b_4 Z_{t-1} + v_t.$$

Given the estimates of ρ , λ , μ , ω , a_2 , and a_3 , and assuming again that $r = 0.065$ the predictions about the coefficients of (19) are

$$b_1 = (1 - \hat{a}_2) 0.92 = 0.49$$

$$b_2 = -(1 + \hat{a}_3) 0.94 = -0.77$$

$$b_3 = -0.99$$

$$b_4 = \hat{\mu} = 0.056.$$

Public spending and net income have similar degrees of persistence. Hence, the smaller magnitude of the former's coefficient follows primarily from the stronger effect of g on public transfers.

The concept of ZN used in the estimation of (19) is Israel's net liabilities. It includes the short- and the long-term foreign debt of the private and public sectors, net of Israel's foreign assets. The latter includes the reserves at the Bank of Israel and other monetary institutions and private foreign deposits and securities. These data are available from 1955 onwards.

The estimated equation is

$$(20) \quad Z_t - Z_{t-1} = 0.54g_t - 0.39 y_t - 1.34\xi_t + 0.041Z_{t-1}$$

(0.19) (0.20) (0.32) (0.022)

$$R^2 = 0.56 \quad D.W. = 1.46 \quad \hat{\sigma} = 286.2,$$

sample 1956-1980,

where $\hat{\sigma}$ is the standard error of the equation.

The estimates of the coefficients are all significantly different from 0 at the 5 percent level, and those of g and ξ at the 1 percent level. However, the test of the model does not involve the null hypothesis, but whether the estimated coefficients conform to the values predicted. The estimates of b_1 , b_3 , and b_4 are not far from those values, but the magnitude of the coefficient of y is only of about half that expected. Namely, variations in net income are implied to have a stronger effect on consumption than that predicted by the theory, resulting in a low countercyclical foreign borrowing. Also, the only moderate R^2 can be seen, according to the theory, as reflecting an important role of unexpected foreign inflation in the determination of the debt growth.

The Durbin-Watson statistic indicates the possible presence of positive serial correlation, which is plausible under the interpretation given to the error term. The disturbances in this model follow from unanticipated

inflation as of the "average" date on which the terms of the outstanding liabilities were set. If this date is further in the past than a year -- as it probably is during the sample (see Liviatan (1980)) -- anticipated inflation can display serial correlation. However, reestimating the equation using the Cochrane-Orcutt procedure yields a coefficient of serial correlation that is insignificantly different from zero.

Equation (20) is only partially unrestricted because it involves the restriction of zero coefficients on the systematic components of the exogenous variables. The unrestricted estimation will also include some combination of these components, since they are perfectly colinear among themselves. This combination can be $\bar{Y}_t - (1-a_1)\bar{G}_t$, which is the permanent income type of variable that enters the consumption equation (9). This estimation is unrestricted in the sense that it involves all the exogenous variables with unrestricted coefficients. Including the trend variable the estimated equation is:

$$(21) Z_t - Z_{t-1} = \frac{0.55}{(0.21)} g_t - \frac{0.44}{(0.29)} y_t - \frac{1.40}{(0.41)} \epsilon_t + \frac{0.067}{(0.108)} Z_{t-1} - \frac{0.028}{(0.114)} [\bar{Y}_t - (1-a_1)\bar{G}_t].$$

$$R^2 = 0.56 \quad D.W. = 1.50 \quad \hat{\sigma} = 292.9$$

The coefficient of $\bar{Y}_t - (1-a_1)\bar{G}_t$ is insignificantly different from

zero as predicted, but now the coefficient of Z_{t-1} becomes insignificant. If Z_{t-1} is deleted, the trend variable becomes significant. This seems to reflect a strong correlation between Z_{t-1} , which is heavily trended, and $\nabla_t - (1-a_1)\bar{G}_t$. Also, the inclusion of the trend variable reduces the t-statistic associated with y from 1.97 to 1.51.¹²

The formal test of the model -- given the procedure used to estimate the preliminary equations -- is performed by imposing the predicted values to all the coefficients, amounting to five linear constraints. The corresponding F_{20}^5 statistic is 2.64, which falls uncomfortably close to the corresponding 5 percent critical value of 2.71. Hence, the model is almost rejected at the 5 percent confidence level. The main source of this outcome seems to be the high predicted value for the coefficient of the income variable.

Since the expected estimates were computed under the assumption of a real interest rate of 6.5 percent, a sensitivity analysis in this respect is in order. This was done by using two alternative values for r . Theoretically, admissible values should be higher than 5.6 percent. Hence, a lower r was chosen as 6 percent, and the alternative higher value considered is 8 percent; still higher rates seem unpalatable. When r is 6 percent the resulting F_{20}^5 statistic is 2.77, and for 8 percent it turns out to be 2.35. Therefore, the results do not change much in this exercise. However, higher interest rates make the results slightly improve the goodness-of-fit. It seems that this is because the magnitude of the computed coefficients decline with r . Since the major divergence occurs in the coefficient of y , which is expected to be twice as high, higher interest rates (at least in the 6-8 percent range), tend to improve the overall fit of the equation.

IV. CONCLUDING REMARKS

This paper attempted the empirical implementation of an intertemporal optimization model of the foreign debt with data on Israel. As seen in the previous section, the results are in general inconclusive. The model is not far enough from rejection to conclude that the equation fits well the behavior of Israel's foreign borrowing.

The main problem seems to be that the predicted strong countercyclical behavior of the debt growth appears weaker in the data. This result can be viewed as stemming from a "too" strong procyclical, or Keynesian, behavior of private consumption, which partially offsets the negative effect of income on foreign borrowing. Given the dominant negative values of the income variable during the sample, one could say that if the private sector would have behaved according to this model the foreign debt would today be even larger than it actually is.

With respect to the other estimated coefficients, especially that of public expenditure, they are not very different from the values predicted. The difference between the results for government spending and the income variable could be related to different degrees of accessibility of the government and the private sector to the foreign capital markets — a factor that was not taken into account in the model. Capital controls may interfere with the private smoothening of consumption by foreign borrowing and lending, while the government is free from these constraints. An interesting analysis of the relevance of capital controls is carried out in Greenwood and Kimbrough (1984). The incorporation of this consideration is probably a promising extension of the type of framework studied here.

The present analysis could also be extended in other directions. One is to use a time-series procedure to isolate transitory and permanent shocks instead of the present specification of the exogenous processes -- adopted here because of its simplicity and the relatively smooth transition from the theory to the econometrics it facilitates. Another possible extension involves the incorporation of unexpected foreign inflation in the analysis, rather than leaving it as the residual. Unexpected inflation affects the real value of the foreign debt directly, and also indirectly via the private wealth and consumption demand. The implementation of this extension would require the study of the maturity composition of the outstanding debt during the sample and the estimation of the corresponding unexpected inflation series.

FOOTNOTES

1. This, of course, presents the problem of using a deterministic model as the basis for empirical work. The reason for following this procedure is that it yields a simple closed form solution--suitable for econometric estimation in the sense that the endogenous variable depends on exogenous variables only. An alternative way to generate a similar certainty-equivalent solution is to specify stochastic exogenous variables under a quadratic utility function. For the present purposes, however, one does learn any additional insight by this route and hence I believe that the additional complications involved are unwarranted.
2. To verify this, substitute the expression for W_1 as developed in (7') into (5) and average across countries. Then all disturbances and the foreign debt terms drop out. Note that the parameter a_1 is assumed to be zero.
3. With a general isoelastic utility function $U(C) = C^{1-\gamma}/(1-\gamma)$, the worldwide equilibrium condition would be $1+r = (1+\delta)(1+\mu)^\gamma$.
4. However, even when $\omega=1$, ξ still has an effect on debt growth. This is so because the persistence of this disturbance was defined on its magnitude and not percentage from normal levels. Thus, a perfectly persistent transfer shift declines over time relative to income and government spending.
5. The interest rate that the country is subject to in the international capital markets would probably adjust upwards well before the foreign debt approaches the $\Sigma(Y_t - G_t - T_t^G)/(1+r)^{t-1}$ level. This possibility can be generalized by specifying that the relevant interest rate is a positive continuous function of Z_t , relative to the future ability to pay. I tentatively explored the introduction of this specification

into the present model in which the interest rate becomes endogenous. The main modification that follows is that shocks have a smaller effect on foreign borrowing, because a domestic savings reaction partially offsets the demand for funds generated by those shocks. Also, this setup seems to yield a long-run optimal foreign-debt-income ratio.

6. The corrected equation (2) is $Z_1 - Z_0 = C_1 + G_1 - (Y_1 - I_1) - T_1^g + rZ_0$.
7. The effective exchange rate on exports was used because of its availability on the entire sample. It seems unlikely that the alternative use of the exchange rate on imports or some average of the two would affect the results.
8. Donations to nonprofit organizations that could be considered part of these transfers are included in the public transfers series. The reason for this is that the data prior to 1962 is available in this form, with no separate figures on nonprofit organizations.
9. The sample starts in 1953 because private transfers data is available only from 1952 onwards.
10. The calculation is made as follows. Taking public spending for example, the present value of the deviations from trend is

$$\sum_{t=0}^{\infty} \frac{\bar{G}(1+\mu)^t(1+\epsilon\rho)^t}{(1+r)^t} = \epsilon\bar{G}\left[\frac{1+r}{1+r-(1+\mu)\rho}\right] .$$

If ϵ fully persists k years, the corresponding present value is

$$\epsilon\bar{G} \sum_{t=0}^{k-1} \left(\frac{1+\mu}{1+r}\right)^t = \epsilon\bar{G}\left[\frac{1+r}{r-\mu} - \frac{(1+\mu)}{r-\mu} \left(\frac{1+\mu}{1+r}\right)^{k-1}\right] .$$

The average persistence is now calculated by equating

$$\frac{1+r}{1+\mu} - \left(\frac{1+\mu}{1+r}\right)^{k-1} = \frac{1+r}{1+r-(1+\mu)\rho} \quad .$$

From this it follows that

$$k = \log\left[\frac{(1+\mu)(1-\rho)}{1+r-(1+\mu)\rho}\right] / \log\left(\frac{1+\mu}{1+r}\right) \quad .$$

11. In 1981 the timing of the registration of the transfers from the U.S. government was changed to a cash-flow basis. For example, if the Israeli government uses these funds to make a down payment on its imports, this payment is registered as a unilateral transfer at that time.
12. Including a constant in the equation the corresponding t-statistic is only 0.67.

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TABLE 1

	GDP	I	P	E
50	844.793	455.611	5399.000	3642.31E-01
51	1093.455	554.333	6338.92E-01	3642.31E-01
52	1153.32	472.200	9193.63E-01	7142.96E-01
53	1133.97	395.793	1177.19	1224.51
54	1054.72	441.211	1297.19	1733.472
55	1033.71	543.100	1380.11	1857.17
56	1073.34	513.800	1513.53	1877.58
57	1023.45	601.100	1604.37	1953.21
58	1053.76	645.600	1738.52	2020.44
59	2193.23	713.911	1777.41	2081.66
60	2342.57	739.011	1862.35	2145.95
61	2533.37	892.000	2027.81	2209.22
62	2853.45	972.011	2192.03	3015.37
63	3156.60	1007.00	2371.61	3117.39
64	3403.00	1217.00	2504.27	3121.47
65	3783.76	1223.11	2745.11	3125.53
66	3821.50	1125.00	2984.17	3183.65
67	3909.70	795.700	3042.18	3331.68
68	4518.30	1183.51	3096.52	3774.54
69	5089.10	1494.00	3172.47	3783.77
70	5430.90	1594.00	3430.69	3872.50
71	6100.70	2163.11	3863.13	4283.74
72	6843.00	2328.00	4426.96	4675.60
73	7183.60	2443.00	5363.78	4683.74
74	7500.40	2347.11	7256.15	5124.56
75	7754.00	2444.00	1000.00	7095.11
76	7302.00	2138.00	1263.84	8953.00
77	7942.00	1979.10	1800.72	1203.41
78	8293.00	2000.00	1823.37	1802.40
79	8590.00	2257.00	1655.55	2740.80
80	8820.00	1864.00	1821.4	5551.11
81	9143.00	1846.00	26.7175	12.4101
	1	2	3	4

	ZN	TSN	TPN
52	175.400	15.800	15.800
53	163.200	9.600	9.600
54	239.000	33.500	33.500
55	156.611	53.800	53.800
56	179.100	61.400	61.400
57	152.800	85.700	85.700
58	150.800	102.800	102.800
59	149.700	101.300	101.300
60	173.700	137.300	137.300
61	189.800	152.500	152.500
62	124.800	200.500	200.500
63	114.700	224.100	224.100
64	104.800	220.800	220.800
65	117.600	202.100	202.100
66	97.000	193.800	193.800
67	312.500	209.800	209.800
68	157.400	281.800	281.800
69	159.600	292.500	292.500
70	255.211	383.400	383.400
71	244.300	544.500	544.500
72	352.200	695.300	695.300
73	1528.90	661.900	661.900
74	1085.20	632.800	632.800
75	1151.90	622.000	622.000
76	1649.40	564.000	564.000
77	1403.90	685.000	685.000
78	1576.40	809.000	809.000
79	1536.30	953.000	953.000
80	1929.50	1024.00	1024.00
	1	2	3

TABLE 1 (Cont'd)

	Z	T ₂	TP
52	0.0000	136.276	12.2759
53	0.0000	169.775	9.98676
54	0.0000	319.613	31.4264
55	0.0000	210.732	72.3370
56	0.0000	223.657	76.6751
57	0.0000	198.807	104.634
58	0.0000	186.876	119.472
59	0.0000	175.018	119.109
60	0.0000	200.130	156.208
61	0.0000	206.779	166.251
62	0.0000	171.733	76.233
63	0.0000	150.759	294.570
64	0.0000	130.629	75.218
65	0.0000	133.947	30.193
66	0.0000	133.387	206.561
67	0.0000	342.239	229.763
68	0.0000	191.865	343.534
69	0.0000	202.337	349.046
70	0.0000	300.482	432.776
71	0.0000	270.898	643.894
72	0.0000	382.624	735.141
73	0.0000	1335.06	577.982
74	0.0000	755.419	446.907
75	0.0000	817.273	441.303
76	0.0000	1156.85	398.995
77	0.0000	935.032	456.256
78	0.0000	1004.22	515.553
79	0.0000	858.040	505.556
80	0.0000	935.995	486.795

NOTES TO TABLE 1

- GDP: Gross domestic product in 1975 shekels.
- I: Gross domestic capital formation in 1975 shekels.
- P: GDP deflator, base 1975.
- E: Effective exchange rate on exports of goods and services.
Calculated by adding to the formal exchange rate the subsidies per dollar of exports.
- ZN: Israel's end-of-year net foreign liabilities in millions of dollars. Calculated as follows: Government and Bank of Israel debt plus foreign deposits in domestic banks and other private debt minus (foreign reserves at the Bank of Israel and other monetary institutions plus deposits with banks abroad and other assets and foreign liabilities).
- TGN, TPN: Unilateral transfers to the public and private sectors respectively, in millions of dollars.
- $Z = ZN \cdot E/P$, $TG = TGN \cdot E/P$, $TP = TPN \cdot E/P$.

SOURCES: The series GDP, I, G (below) P, and ZN from the Statistical Abstract of Israel 1982, Central Bureau of Statistics. The TGN, TPN, and E from the Bank of Israel's Research Department data and the Annual Reports 1980 and 1981.

TABLE 2

	Y	y	G	g	ε
52	693.333	-837.412	261.174	-399.985	-9.864
53	743.253	-934.178	274.272	-424.959	8.31757
54	944.344	-834.391	321.189	-418.326	162.613
55	1003.000	-613.316	372.311	-409.300	41.0970
56	1241.222	-748.992	534.664	-292.494	-47.4926
57	1323.700	-776.139	456.701	-424.099	18.7757
58	1423.03	-736.442	464.679	-460.393	6.63274
59	1613.44	-740.849	483.250	-495.225	6.02332
60	1701.73	-728.115	515.304	-519.229	30.5513
61	1802.02	-750.684	603.709	-490.353	3.51891
62	2153.49	-625.487	667.216	-490.258	-25.5838
63	2444.20	-501.150	741.980	-482.151	-45.3645
64	2523.69	-531.137	762.300	-531.349	-77.7857
65	2795.89	-498.557	842.110	-527.113	-79.7023
66	3003.06	-431.142	934.711	-513.382	-34.814
67	3343.77	-341.119	1292.70	-238.788	-21.9012
68	3678.30	-218.821	1411.31	-209.393	-187.309
69	3944.15	-177.444	1644.40	-68.5839	-360.642
70	4237.00	-121.303	2075.30	265.247	-336.037
71	4647.59	37.5421	2103.91	187.911	-327.977
72	5253.14	377.562	2063.91	37.5430	-12.326
73	5317.50	158.130	3021.50	878.430	371.954
74	5600.31	145.909	3085.01	818.494	-203.880
75	5751.31	-15.1921	3394.00	996.948	-302.439
76	6122.33	23.2934	3039.00	503.884	249.343
77	6413.26	-31.7674	2628.11	-53.1329	230.335
78	6903.36	-14.2230	2794.51	109.441	184.436
79	6840.50	-358.935	2705.00	-292.881	128.025
80	7442.80	-188.356	2913.00	-258.511	36.623
	1	2	3	4	5

NOTES TO TABLE 2

$Y \equiv GDP + TP - I$. y is the residual calculated from equation (15').

(See below).

G: General government consumption expenditure in 1975 shekels. It includes all defense expenditures.

g: the residual calculated from equation (14').

ξ : the residual calculated from equation (16').

A distinct characteristic of the y series (and also of the g series to a lesser extent) is that it is mostly negative, with strongly negative values in the first part of the sample. Just by looking at the series one can conclude that if OLS would have been used to estimate the trend values of Y , the resulting growth rate estimate $\hat{\mu}$ would have been higher (and correspondingly $\hat{\alpha}$ lower) than that reported in the text. This difference can be interpreted as follows. In the first period of the sample

$\eta_1 = \rho\eta_0 + \tilde{\eta}_1$. Assume that the sample starts off with $\eta_0 < 0$, i.e., with a negative deviation from the normal Y values -- as seems natural in the early years of the state. Then, aside from new zero-mean disturbances, the value of η_t will become less negative over time. This means that η_t is positively correlated with time, which is the only OLS explanatory variable. Consequently the OLS estimate of μ is biased upwards. This bias disappears when the equation is transformed to deal with the serial correlation. Then the error term of the equation is $\tilde{\eta}_t$, which is white noise.

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1984

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