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DETERMINANTS OF EXTERNAL IMBALANCES: THE ROLE OF PRODUCTIVITY, EMPLOYMENT, AND TAXES

by

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I. Overview

The purpose of this study is to provide a framework which enables the analysis of the dynamics of external balance in the a small open economy, with special emphasis on deriving a set of policy implications. The framework is implemented on data from the Israel economy for the 1980s. We first uncover a set of stylized facts that characterize the behavior of the external balance. While it is not proper to derive policy implications solely based on these empirical regularities, they set the agenda for a systematic econometric analysis of a macroeconomic model designed so as to account for these regularities. Next, we develop and estimate an intertemporal optimizing model of external-balance behavior. The main feature that distinguishes our approach from previous applied analysis of the Israeli economy is that the external balance is analyzed in terms of the **saving and investment imbalances** arising in the context of a dynamic equilibrium model of intertemporal optimization.[1] Based on the estimates of the fundamental parameters obtained in the econometric analysis, we povide a set of dynamic simulations of the effects of changes in policies and in institutional and technological driving factors on the saving-investment balance. Last, we elaborate on the lessons to be learnt from this study for the issue of whether and how the current account should serve as a policy target.

[1]See, for example Obstfeld (1986) and Persson and Svensson (1988).

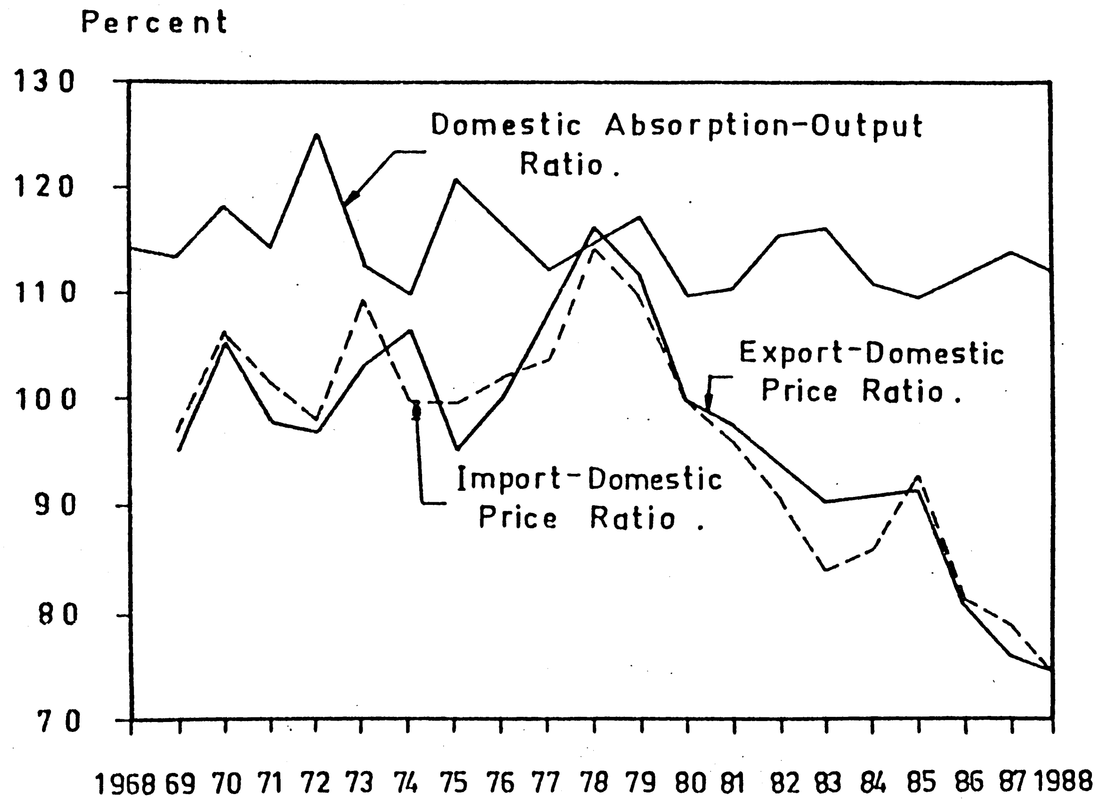
Most policy discussions of structural adjustment focus on the current account, which measures the rate of accumulation of external assets. A broader definition of changes in national wealth incorporates also changes in the value and quantity of the domestic capital stock, due to investment. Accordingly, our study analyzes also the evolution of this broader measure in order to highlight the role of this key determinant of changes in national wealth. Comparing these two measures of asset accumulation is useful for the design of structural adjustment policies in the presence of a tradeoff between investment and the external position.

The time series behavior of Israel's import surplus, our main measure for external balance, exhibits two main features. First, there is no noticeable trend in the long run movements of this surplus, which has remained on average at a level of about 15 percent of domestic output since the late 60's. Second, there are marked short and medium run cyclical movements in the import-export imbalance. That is, periods of balance of payments crises are followed by periods of significant improvements in the external position. On average, it takes approximately three to five years for a whole cycle to be completed (i.e., from one crisis to the next). The amplitude of these cycles has varied over time. The largest difference between peak to trough of about 15 percent of GDP occurred from 1972 to 1974. These features are transparent from the behavior of the ratio of domestic absorption to GDP, which is the mirror image of the ratio of the import surplus to GDP, in Figure 1.

Economic analysis and policymaking discussions in Israel have traditionally attributed imbalances between exports and imports primarily to movements in the real exchange rate. That is, improvements in the external balance were mainly attributed to real devaluations whereas balance of payments crises were thought to be caused by real appreciations. The evidence for two measures of the real exchange rate (i.e., the export-domestic and import-domestic price ratios), is presented in Figure 1. In terms of long run real exchange rate movements, while there was a mild trend of real depreciations from the late 60's to the reform of 1977, the pattern has reversed and a trend of sharp real appreciations has appeared thereafter. Coupling the trendless long run behavior of the import surplus together with the time varying trends of the real exchange rate suggests that in the long run there has been a weak statistical link between these variables. In the short and medium runs, however, one can identify several subperiods in which the comovement of the real exchange rate and the import surplus conforms with the traditional view which asserts that real appreciations are accompanied by external balance crises (and vice versa). The episodes from 1972 to 1976 and from 1980 to 1986 are in line with this view. Despite this, and in conformity with the observed weak long run links, there are episodes such as the late 1960's and 1976-1980 in which real appreciations (depreciations) were associated with improvements (worsenings) in the external balance position.

While both the fact that there are no clearcut long run statistical links between the real exchange rate and the import surplus and the fact that in some subperiods these variables move in the same direction seem

Figure 1 Domestic Absorption and Real Exchange Rates.



Source: <u>Annual Report 1988</u>, Bank of Israel.

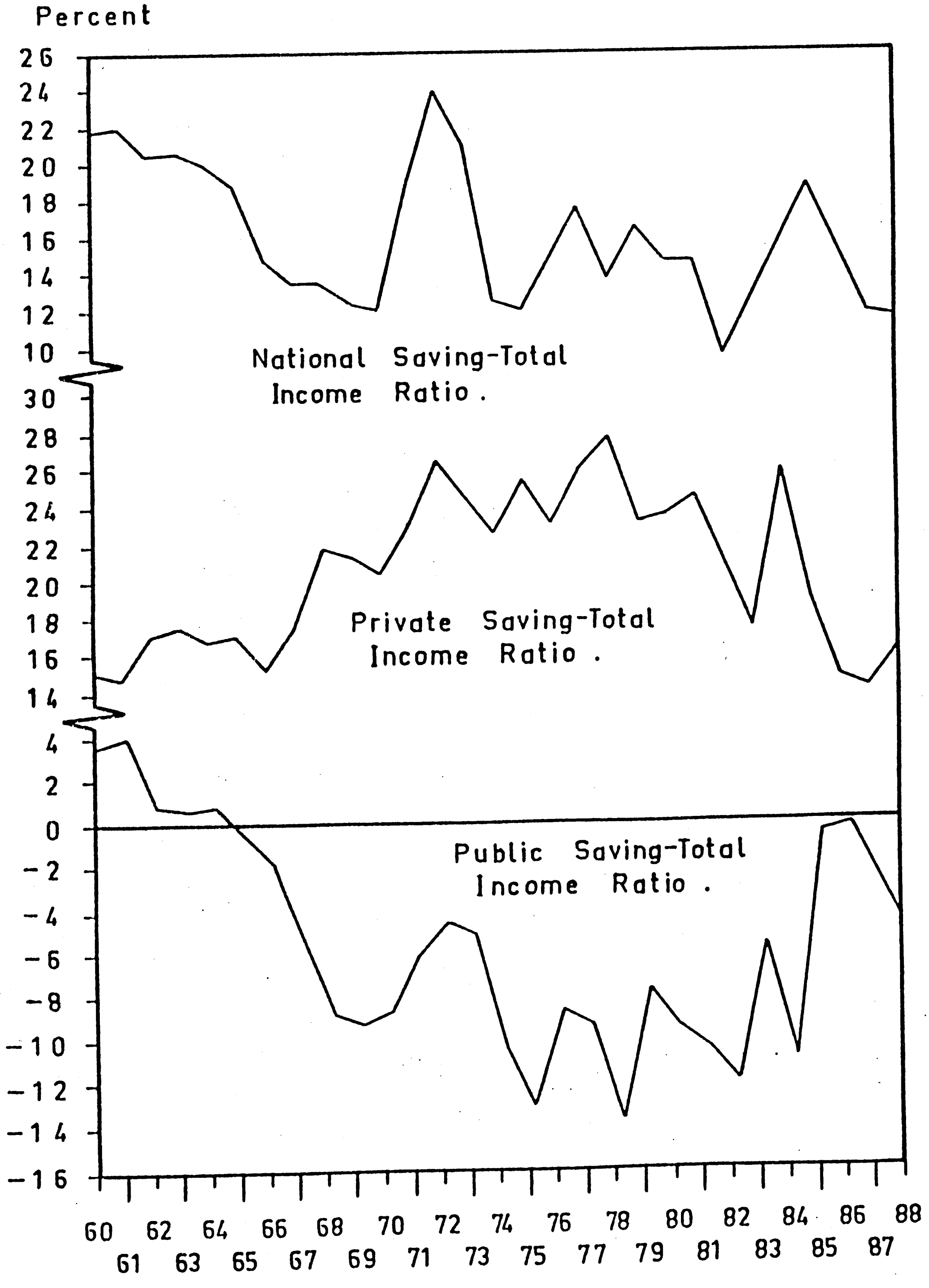
Diagram G-1

to contradict the traditional view, they can be accounted for in a general equilibrium framework. In such framework, both these variables are **jointly** determined and their comovements can be explained by changes in the fundamental factors underlying policy, preferences, and technology. In other words, their time patterns depend on the specific demand and supply shocks that impinge on the system at any particular time period. For example, an exogenous rise in domestic absorption (which was probably the dominant policy change after the Yom Kippur War) is expected to simultaneously result in a real appreciation and a deterioration of the external balance position. On the other hand, supply shocks such as a deterioration in the terms of trade (as in the OPEC II episode) can result in both a real depreciation and worsening of the import surplus. This discussion and interpretation of the evidence highlights the weakness of an approach that is based on postulating ad-hoc import and export functions in which the real exchange rate plays an independent causal role, and at the same time it justifies attempts to relate fluctuations in the import surplus to fluctuations in **fundamentals**, as in modern macroeconomic analysis; see, e.g., Frenkel and Razin (1987).

As is well known, national income accounting implies that the import surplus is equal to the discrepancy between aggregate saving and investment. Aggregate saving, in turn, is typically decomposed into private sector and public sector components. A working hypothesis, commonly used in previous work, is that changes in public sector saving, which are in effect changes in the government budget imbalances, influence directly the import surplus. Specifically, a rise in government's budget deficit is typically predicted to result in a fall in national saving and thus in a worsening of the external deficit. This working hypothesis has been questioned both on theoretical and empirical grounds in recent years; see e.g., Barro (1988).

Turning to the evidence, the behavior of national saving and its private sector and public sector components (expressed as ratios of total income) is presented in Figure 2. The long run behavior of the aggregate saving ratio does not exhibit a clear cut trend from the late 60's and it resulted in a level of about 15 percent of total income (GNP plus unilateral transfers from abroad). Despite this, there have been pronounced cycles in the saving ratio over shorter time periods. In particular, while there was a relatively large decline in saving in the early 80's this was reversed and aggregate saving declined sharply after 1985 (with a large difference between trough to peak of about 10 percent of total income). Paralelling the relatively trendless behavior of the aggregate saving ratio in the long run, private sector and public sector saving have generally behaved as mirror images of each other. The main regularities are that up until the late 70's the private saving ratio exhibited an upward trend, with levels ranging from 17 percent of total income to 27 percent, and the public saving ratio showed a downward trend ranging from -4 percent to -14 percent of total income. In contrast, during the 1980's there was a reversal of this pattern: a downward trend in the private saving ratio accompanied by an upward trend in the public saving ratio. This evidence of private sector saving offsetting, to a large extent, movements in public sector saving does not conform well with the view that changes in the government

Figure 2 - National Saving and its Private and Public Components.



Source: Annual Report 1988, Bank of Israel.

Diagram B-3

budget deficit have a direct impact on the import surplus (i.e., that the "twin deficits" should move in the same direction). Regarding investment, the most salient empirical regularity is the downward trend that prevailed since the early 1970's; see Figure 3 for evidence on private sector's investment.[2] Furthermore, public sector investment has also sharply declined through time: the public investment to GNP ratio in the 1980's is about two-thirds of its level in the 1970s.[3]

Interestingly, saving-investment and current-account patterns of this type are not unique to Israel. It has been observed recently in a number of countries that changes in government saving (the budget surplus) have been offset by opposite changes in private sector saving. This offset is potentially compatible with the notion of Ricardian neutrality, provided that the changes in the government budget were mostly the result of changes in taxes. As a consequence, observed movements in the current account were driven by movements in investment. We briefly describe each one of these episodes (see figure 4).

United Kingdom

From 1981 to 1984, government saving as a fraction of GDP decreased by 1.1 percent (attributed primarily to changes in taxes) and private saving increased by 1.5 percent. Consequently, national saving showed

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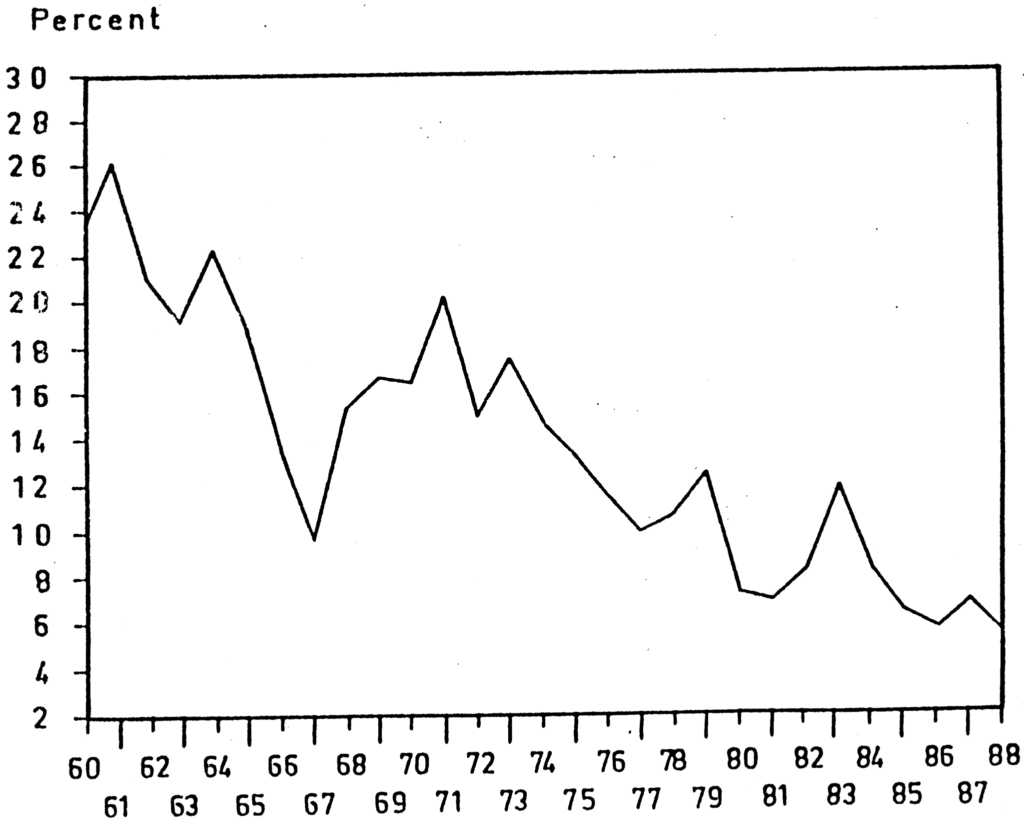
[2]For a related discussion of these empirical regularities, see Ben Porath (1987). Note that it is not straightforward to translate the evidence in Figures 2 and 3 into implications for the import surplus based on Figure 1. The reason is that different variables are used as denominators in expressing the alternative ratios.

[3]See Meridor (1988).

Figure 3 - Net Private Investment

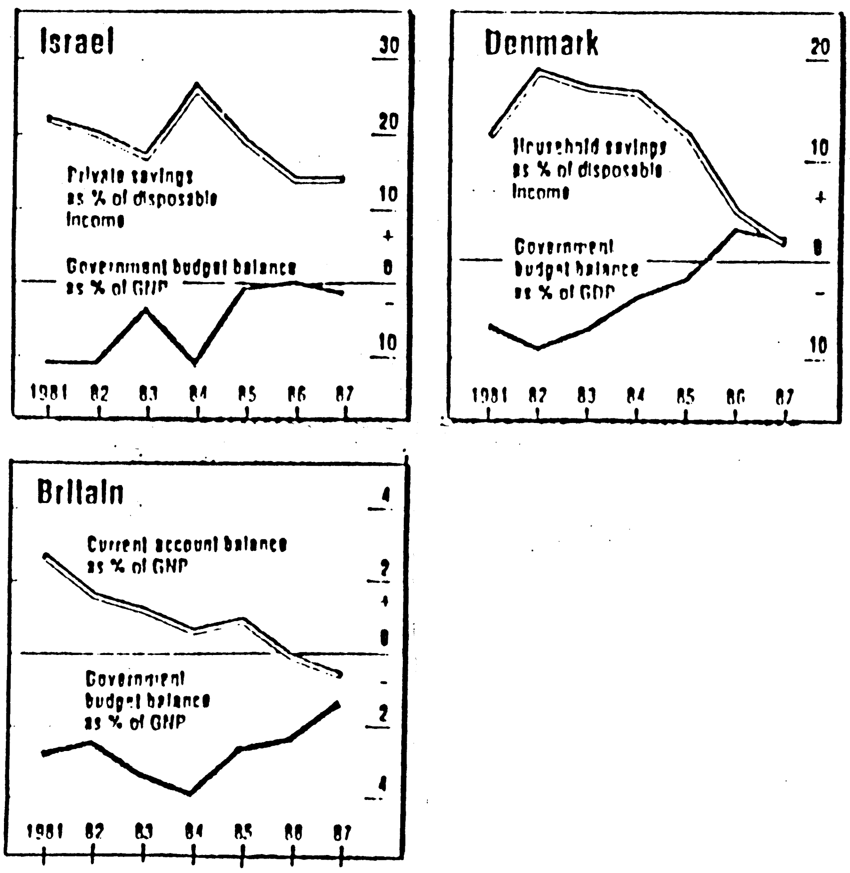
(Percent of Business Sector Output)



Source: Annual Report 1988, Bank of Israel.

Diagram B-4

Figure 4: Savings, Investments, and Current Account: Patterns in Israel, Denmark, and Britain



Source: Robert Barro, The Ricardian Approach to Budget Deficits," NBER Working Paper No. 2685, 1988 and The Economist, December 10, 1988.

little change. During this period, there was a sharp worsening of the current account position by about 2.7 percent of GDP, paralleling a sharp increase in investment of about 3.1 percent of GDP. A somewhat different pattern is observed for 1985-1987.

Denmark

The government budget deficit moved from about 9% of GDP in 1982 to a surplus of about 3% of GDP in 1986. Most of these changes resulted from changes in tax revenues. Remarkably, the increase in government saving of about 12% of GDP was almost fully offset by a decrease in private savings. That is, the size of national saving remained stable despite the sharp change in its composition between private and public components. During this period investment showed an increase of four GDP percentage points and it was reflected in a worsening of a similar magnitude in the current account position.

Sweden

From 1983 to 1987 the government budget deficit was sharply reduced by 8.9 GDP percentage points and in fact showed a surplus in 1987. Most of these changes came from changes in the tax revenue. Offsetting these changes, private saving decreased by 9.5 GDP percentage points so that national saving remained almost unchanged. The current account position worsened during this period by 2.3 GDP percentage points, driven to a large extent by the increase in investment (of about 1.7 GDP percentage points).

In our framework, the dynamics of the current account is accounted for in terms of forward looking optimizing behavior of firms and consumers, operating in the presence of changes in three types of **fundamental factors**: productivity, labor input (which can also be interpreted as real wage changes), and tax revenue. A fourth factor, government spending, was included in our previous work using a similar sample (Leiderman and Razin (1988a)). Thus, our model focuses on **real** factors which determine the evolution of the current account[4]. These factors are demonstrated to play an important role in the dynamics of external balance. As such, they supplement previous research that focused on nominal factors, such as nominal exchange rate policy (see e.g. Leiderman and Razin (1988b)).

Before turning to the econometric work and the simulation results, it is useful to briefly discuss the basic empirical regularities that concern the behaviour of these fundamental factors. First, consider the production side of the system pertaining to the private sector; see Table 1. During the 1980's there has been a marked slowdown in the growth rate of output, from level of about 9 percent per year in the 60's and early 70's to about 3 percent per year in the 80's.[5] This slowdown is accounted for by changes in capital, labor, and overall productivity. The rate of growth of the capital stock decreased from

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[4]Our emphasis on real factors, such as productivity and labor supply changes, is along the lines of the modern real business cycle approach; see Kydland and Prescott (1982) and Long and Plosser (1983).

[5]For a discussion of the relation between employment in public and private sectors, see Ben Porath (1987).

about 8.5 percent per year in the 60's to about 3 percent in the 80's. This reflects the downward trend in private investment discussed above. The rate of growth of labor input fell from 3.6 percent per year in the 60's and early 70's to about 1.5 percent in the 80's. In part, this

TABLE 1 - PRODUCTION-SIDE INDICATORS
(Annual Percentage Rates of Change)

Period	Output	Labor Input	Capital Input	Productivity
1960-65	9.1	4.6	10.1	2.8
1966-72	9.2	2.7	7.4	5.1
1973-79	3.9	0.8	6.3	1.4
1980-85	2.4	1.1	3.8	0.4
1986-88	3.7	2.1	2.7	1.4

Note: The figures correspond to the business sector.

Source: **Annual Report 1988**, Bank of Israel, Table F-1.

TABLE 2 - FISCAL INDICATORS
(percents of GNP)

	Domestic Government Spending				Tax Revenue	
Period	Consumption	Investment	Debt Service	Total	Gross	Net
1960-66	16.3	4.5	0.9	21.7	31.2	23.8
1967-72	22.6	4.3	2.2	29.1	37.0	24.7
1973-77	26.2	4.9	4.0	35.1	44.9	22.9
1978-80	25.7	3.9	4.3	33.9	47.0	21.1
1981-86	25.9	3.1	4.1	33.1	47.6	20.8

Note: All variables refer to domestic components of the government budget. Net taxes are gross taxes minus transfers and subsidies to the private sector.

Source: Meridor (1988), Tables 1 and 2.

reflects the declining share of private sector employment in total employment. That is, there has been a growing trend of the relative size of employment in the public sector, from a share of 24 percent in the early 70's to a share of about 30 percent in the 80's. A slowdown is also observed for the rate of growth of productivity (i.e., the Solow residual). While in the 60's and early 70's productivity grew at a rate of about 5 percent per year, the 80's feature productivity growth rates of less than 1 percent per year (even an absolute decline in the level of productivity occurred in 1988). This reflects, in part, the decline in public sector investment in infrastructure, the slowdown in the rate of human capital accumulation, and the effects of the decrease in the relative price of private sector products.

Second, consider underlying fiscal factors such as tax revenue and government spending; see Table 2. Tax revenue (net of transfers to the private sector) decreased from about 24 percent of GNP in the 60's and early 70's to about 21 percent in the 80's. At the same time, government spending (for consumption and investment purposes as well as domestic debt servicing) increased from about 25 percent of GNP in the 60's and early 70's to about 34 percent of GNP in the 80's. Note that the periods before and after the 1985 stabilization exhibit sharply different fiscal stances, in that the latter features a sharp increase in tax revenues, a decrease in government spending, and as a result the government deficit fell to levels similar to those prevailing in the 1960's.

The remainder of the paper is structured as follows. Section II develops a dynamic model of the determination of the import surplus.

Empirical estimates are reported in Section III. We use monthly data on Israel from 1980 to 1988. Dynamic simulations of the effects of changes in fundamentals and in some of the underlying parameters on the import surplus are provided in Section IV. Section V extends the model to allow for substitution between public and private consumption. Section VI applies the model to the analysis of the economic effects of the Aliya. Section VII concludes the paper and outlines the policy implications of this study. Technical material and the complete description of the model appear in the appendices.

II. A Dynamic Model of the Current Account

The observed patterns in Israel in the 1980s seem to conform with the Ricardian neutrality approach, since most of the change in government budget was due to a change in tax policy, and the change in public sector saving was offset almost completely by opposite changes in private saving. This interpretation of the facts can provide only a motivation to pursue a more detailed examination of the hypothesis. Since these saving patterns could have reflected the impact of key variables other than those directly related to the budget, such as monetary changes, business cycle factors, and the like, the observed patterns by themselves cannot provide decisive evidence on the validity of alternative approaches.

To analyze the impact of government budget variables on private saving and the current account, and to discriminate among competing hypotheses, we develop in what follows an analytical framework whose main implications are tested against the data. The empirical implementation of this framework provides estimates of key behavioral parameters that can be used for a quantitative assessment of the effects of alternative fiscal policy changes on private savings and the current account. Such an assessment is, in our view, a prerequisite for the design of rational fiscal management. Chart 1 illustrates the determination of external balance and real wage in the model.

We consider a small open economy, producing and consuming a single aggregate tradable good. Output, Y, is produced by a Cobb-Douglas production function with two inputs, labor, L, the capital, K, i.e., $Y_t = a_0 K_{t-1}^{a} L_t^{(1-a)} \epsilon_t'$, where ϵ_t' measures the level of productivity and a is the capital distributive share. Labor supply to the private sector and productivity changes are specified as exogenous stochastic processes.[6] They are:

$$L_t - \bar{L} = \phi(L_{t-1} - \bar{L}) + \xi_{Lt}, \tag{1}$$

$$\epsilon_t - \epsilon_{t-1} = \zeta(\epsilon_{t-1} - \epsilon_{t-2}) + \xi_{\epsilon t} \tag{2}$$

where ϕ, ζ and $\bar{L}$ are fixed parameters and ξ_{Lt} and $\xi_{\epsilon t}$ are zero mean random variables.

The model of investment is as follows. Firms are assumed to maximize the expected value of the discounted sum of profits subject to

[6]What we have in mind is an inelastic total labor supply out of which government absorbs a certain part, leaving a residual for the private sector that behaves as specified in equation (1). This specification is especially relevant for economies in which the public sector employs a relatively sizable fraction of the labor force.

the production function and to a cost-of-adjustment investment technology. Accordingly, gross investment, Z, is given by:

$$(3) \qquad Z_t = (K_t - K_{t-1})(1 + \frac{g}{2}[\frac{K_t - K_{t-1}}{K_{t-1}}])$$

where g is a cost-of-adjustment coefficient. In this formulation, in order to effectively augment the capital stock by $K_t - K_{t-1}$ firms have to invest an amount Z_t of resources. Evidently, in the absence of costs of adjustment (i.e., $g = 0$), $Z_t = K_t - K_{t-1}$. However, when these costs are present, gross investment exceeds net capital formation.

The optimal investment rule sets, as usual, the cost of investing an additional unit of capital in the current period equal to expected present value of the next period sum of the marginal productivity of capital, the decrease in investment costs of adjustment due to a larger capital stock and the market price of next period's capital, net of depreciation. Linearizing around a steady state point, using the forward solution for investment, incorporating the stochastic processes of the driving variables, and also linearizing the production function yields linear reduced-form equations for capital stock and output:

$$(4) \quad K_t = \bar{K} + \lambda_1(K_{t-1} - \bar{K}) + m_L(L_t - \bar{L}) + m_e(\epsilon_{t-1} - \bar{\epsilon}) + m_e(\epsilon_t - \epsilon_{t-1}),$$

$$(5) \quad Y_t = \bar{Y} + h_k(K_{t-1} - \bar{K}) + h_L(L_t - \bar{L}) + h_\epsilon(\epsilon_t - \bar{\epsilon}),$$

where $\bar{K}$ and $\bar{Y}$ are the steady-state levels of capital and output, respectively, and λ_1, m_L, m_ϵ, m_e, h_L, are reduced-form fixed coefficients. Given labor employment as in equation (1), linearization of the marginal-productivity-of-labor condition yields the real wage equation:

$$(6) \qquad S_t = \bar{S} + s_k(K_{t-1} - \bar{K}) + s_L(L_t - \bar{L}) + s_\epsilon(\epsilon_t - \bar{\epsilon}),$$

where S_t denotes period t real wage, and $\bar{S}$, s_k, s_L, and s_ϵ are reduced-form coefficients. Observe (see Appendix) that the reduced-form coefficients of equations (4)-(6) depend on the parameters of the production and investment technologies as well as on the parameters of the stochastic processes of the driving variables. Also appearing in Equations (4)-(6) are the steady-state values of capital, output and the real wage. These are explicitly given in our model by:

$$(7) \qquad \begin{aligned} \bar{K} &= \bar{L}[(R-1)/a a_0]^{\frac{1}{a-1}}, \\ \bar{Y} &= a_0(\bar{K})^a(\bar{L})^{1-a}, \\ \bar{S} &= (1-a)a_0(\bar{K}/\bar{L})^a. \end{aligned}$$

As is common $\bar{K}$ is derived from the equality between the rate of interest and the marginal product of capital, $\bar{Y}$ is derived from the resulting value of K, and $\bar{S}$ is the resulting value of the marginal productivity of labor. Investment in the steady state amounts to what is required in order to maintain a fixed capital stock.

To illustrate the economic behavior implied by the model, consider the impact of the following two changes. First, a transitory rise in labor employment, described by a positive realization of ξ_{Lt}, generates a transitory increase in dometic investment (see equation (4)), a transitory increase in output (see equation (5)), and a transitory decrease in the real wage (see equation (6)). Since the persistence parameter for labor employment shocks is positive but less than one, these effects have some persistence but they diminish through time. Second, consider an increase in the persistence parameter for productivity shocks (ζ). It can be seen (see Appendices 1 and 2) that this change alters the coefficients of the productivity variables in the reduced form for capital accumulation, i.e., m_ϵ and m_e in equation (4). In particular, both m_ϵ and m_e increase with an increase in ζ. Thus, the sensitivity of the capital formation process to productivity shocks increases in this case. This response of reduced-form coefficients to a change in a structural (or fundamental) parameter captures in our model the Lucas (1976) critique argument.

We turn now to the consumption side of the model. The basic setup, which comes from Leiderman and Razin (1988a), allows for real effects of intertemporal tax shifts and also incorporates durable consumer goods. The stock of consumer goods which generates a flow of consumption services is the argument in the utility function. This stock, C_t, which is subject to depreciation, is augmented every period by purchases of consumer goods, X_t, according to the relation:

(8) $$C_t = (1-\omega)C_{t-1} + X_t,$$

where ω is the depreciation coefficient. The consumer faces a risk-free real interest factor R (one plus the rate of interest). Due to lifetime uncertainty, the effective (risk-adjusted) interest factor is, however, $R/\gamma > R$, where $0 < \gamma < 1$ denotes the probability of survival from one period to the next. Maximization of expected lifetime utility, with a quadratic utility function $u = hc - 0.5c^2$, yields a linear consumption function:

$$C_t = \beta_0 + \beta_1\left[E_tW_t - \frac{R}{\gamma} A_{t-1} + (1-\omega)\gamma C_{t-1}\right], \tag{9}$$

where E_tW_t denote the expected value of the discounted sum of current and future levels of disposable income, A_{t-1} denotes last period debt, and β_0 and β_1 are the consumption function parameters. These parameters depend on the intertemporal elasticity of substitution, the subjective discount factor, the rate of interest, the survival probability, and the consumption stock rate of depreciation (see Appendix). Assuming rational expectations, expected future income streams are calculated by taking into account the output path implied from the capital-formation process and from the processes governing changes in labor supply and productivity, using equations (1)-(5). Likewise, the discounted sum of taxes is assumed to be governed by an exogenous stochastic process, as follows:

$$T_t = T_{t-1} + \kappa(T_{t-1} - T_{t-2}) + \xi_{Tt}, \tag{10}$$

where κ is a fixed coefficient and ξ_T is a zero-mean finite-variance random term. Using (1)-(5) and (9), the expected value of the discounted sum of disposable income is given by:

$$(11) \qquad E_t W_t = n_0 + n_k(K_{t-1} - \bar{K}) + n_L(L_{t-1} - \bar{L}) + n_\epsilon(\epsilon_{t-1} - \bar{\epsilon}) + \\ + n_{T1}T_{t-1} + n_{T2}T_{t-2},$$

where the n coefficients (reported in Appendix 2) depend on the parameters of the underlying production and investment technologies as well as on the parameters of the driving variables: labor, productivity, and taxes. Substituting equation (11) into equation (9) yields a relation for the stock of consumption goods as a function of lagged values of the capital stock, labor employment, productivity, taxes, consumption stock, and debt. Given this relation, the implications of the model for the flow of consumption purchases can be derived using equation (8). Notice that changes in the parameters that characterize the underlying preferences, technology, and tax policy will alter the coefficients in the reduced form for consumption. This holds in particular for changes in the degree of persistence of tax policy shocks, employment and productivity shocks.

To determine the model's implications for the current account of the balance-of-payments, we combine the relationships which describe the consumption side of the model with those pertaining to the production-investment side, and use the national-income accounts relation:

$$(12) \qquad CA_t = (Y_t - rA_{t-1} - T_t) - (X_t + Z_t),$$

where CA denotes the private-sector current-account surplus, and r is the real rate of interest.

While equation (12) is a conventional definition of the private sector current account surplus, it does not take into account changes in the market value of the capital stock due to capital gains or losses. In our model, the market value of one unit of domestic capital is equal to

$$q_t = 1 + g \frac{I_t}{K_t}.$$

Accordingly, a broader definition of changes in private-sector (physical) wealth is given by:

$$(13) \qquad CW_t = q_t K_t - q_{t-1} K_{t-1} + CA_t.$$

Summing up, this section developed a simulation-oriented empirically based model of the dynamics of saving and investment for a small open economy. In the next section, we estimate the model using time series data.

III. Empirical Implementation

We implement the model on monthly time series data for Israel covering the period from 1980:1 to 1988:12. The data consist of quarterly national income accounts figures and monthly figures for government cash flows, imports of investment goods, industrial production, and consumer goods sales of large retailers.[7] Quarterly national income accounts series were converted into monthly series by using the corresponding behavior of their monthly counterparts within each quarter. Obviously, the productivity variable is unobservable. Therefore, we obtained time series for this variable by estimating the Solow residual from a logarithmic version of the production function (under the assumption that the labor elasticity is .75).

Estimation proceeded in two steps. First, we estimated the stochastic processes governing the evolution of productivity and labor input through time (equations (1) and (2)), and the investment behavior equation:

$$(14)\quad \tfrac{1}{2}R\left(\frac{I_{t+1}}{K_t}\right)^2 + \frac{I_t}{K_{t-1}} = \frac{(R-1)}{g} + R\,\frac{I_{t-1}}{K_{t-2}} - \left(\frac{\alpha a_0}{g}\right)\left(\frac{K_{t-1}}{L_t}\right)^{\alpha-1}\epsilon_t' + \theta_t.$$

This equation is derived from the optimal investment rule by replacing the expected by the corresponding realized values in that rule based on the assumption of rational expectations, where the residual θ_t is a rational forecast error and the monthly interest factor R is assumed to be equal to 1.002. The second step consisted of estimating the consumption purchases relation (based on equations (9) to (11)). This second step requires taking into account rational expectations forecasts

[7]Sources for data are the Central Bureau of Statistics and the Bank of Israel.

of the future time path of disposable income, and this was derived using the estimates from the first step.

Table 3 presents the parameter estimates from the first step. The estimates of the AR1 parameters of the stochastic processes of labor and productivity change indicate that labor input shocks have a relatively large degree of persistence and that productivity shocks give rise to cycles in first differences of productivity. The estimated value of g implies that at the sample mean 2.8 percent of gross investment is accounted for by the cost of adjustment.[8] To assess the relative importance of the labor input and productivity shocks for capital accumulation, we calculated a variance decomposition based on equation (4) and found that about 55 percent of the variance of capital accumulation is accounted for by the productivity shocks. This indicates an important role of these shocks in the process of investment. Actual and fitted values of the capital stock are plotted in Figure 5. The plots indicate relatively good fits.

Next, we briefly discuss the estimation of the consumption-side parameters jointly with the process for tax revenue (eq.10)). We estimate the system under several auxiliary assumptions: (i) the interest factor, R, is set equal to 1.002 (as in the estimation of the investment equation); (ii) the finite-life coefficient, γ, is set equal to 0.998, the value obtained in our previous work (see Leiderman and Razin (1988a)); and (iii) the number of lags of consumption

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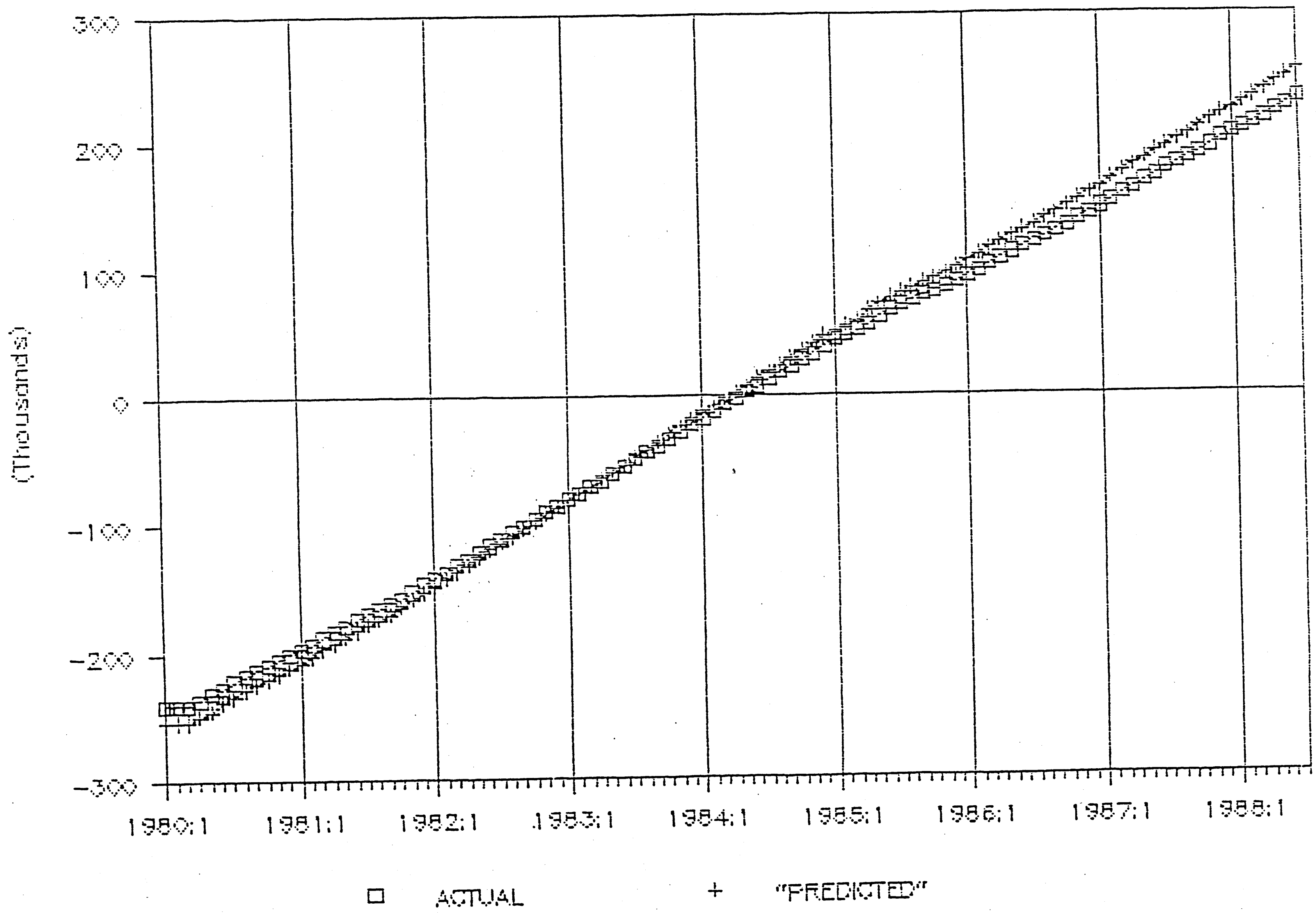
[8]Interestingly, Shapiro (1986) reports a similar magnitude for the cost of adjustment (2.4 percent in his case) for postwar U.S. quarterly data.

FIGURE 5: THE CAPITAL STOCK: PREDICTED AND ACTUAL



purchases is set equal to eight. The system is estimated for the sample period 1980:10 - 1988:12.

Table 4 reports non-linear least squares estimates for the unrestricted and retricted versions of the system. The parameter estimate for κ is negative (and smaller than one in absolute value), indicating that shocks to taxes give rise to a one-month cycle in tax revenue. The utility function parameter h is positive and its per-capita value at population'ssample mean, is 37.86. This value (which is not precisely estimated) is larger than per-capita consumption values over the sample, as required to ensure positive marginal utility. The implied degree of relative risk aversion (C/(h-C)) is 0.1 at consumption's sample mean. The monthly subjective discount factor is close to one, and the consumer durability parameter is 0.569. All in all, the estimates seem to conform to their theoretical counterparts in the model.

TABLE 3 - PRODUCTION-SIDE PARAMETER ESTIMATES

ϕ	= 0.940 (0.031)	(AR1 parameter for labor input process)
ζ	= -0.347 (0.094)	(AR1 parameter for first difference in productivity process)
g	= 3.00 (0.20)	(Coefficient of Investment Cost of Adjustment)
λ_1	= 0.926	(Roots of the Investment Behavior Equation)
λ_2	= 1.082	

Note: Figures in parentheses are estimated standard errors. The λ_1 and λ_2 coefficients were computed according to the formula appearing in Appendix 1.

TABLE 4: CONSUMPTION-SIDE PARAMETER ESTIMATES

I. Unrestricted System

$$T_t - T_{t-1} = \underset{(0.085)}{-\,0.573}\,(T_{t-1} - T_{t-2})$$

$$X_t = \underset{(1880.6)}{6262.6} + \underset{(0.002)}{0.005}\,k_{t-1} + \underset{(3.765)}{13.032}\,\ell_{t-1} + \underset{(1101.7)}{3182.4}\,\epsilon_{t-1}$$

$$\underset{(1209.0)}{-2452.2}\,e_{t-1} + \underset{(0.091)}{0.103}\,T_{t-1} + \underset{(0.091)}{0.241}\,T_{t-2} +$$

$$\underset{(0.096)}{0.275}\,X_{t-1} + \underset{(0.102)}{0.052}\,X_{t-2} + \underset{(0.093)}{0.114}\,X_{t-3} - \underset{(0.089)}{0.045}\,X_{t-4} + \underset{(0.096)}{0.156}\,X_{t-5}$$

$$\underset{(0.102)}{-0.102}\,X_{t-6}\quad \underset{(0.100)}{-0.140}\,X_{t-7} + \underset{(0.090)}{0.010}\,X_{t-8}$$

II. Restricted System

$\kappa = \underset{(0.079)}{-0.545}$ (AR1 coefficient in tax equation (20))

$h = \underset{(189000.0)}{159000.0}$ (constant in the utility function $hc - 1/2c^2$)

$\delta = \underset{(0.016)}{1.003}$ (subjective discount factor)

$\omega = \underset{(0.082)}{0.431}$ (consumer goods depreciation coefficient)

Figures in parentheses are estimated standard errors.

IV. Dynamic Simulations

The simulations reported in this section are based on the parameter estimates obtained in the previous section. The simulations are reported in Table 5. Each entry in the table consists of two figures. The first figure is the approximate percentage deviation from the baseline case on impact; the second gives this deviation after 72 periods. Figures 6-13 plot the simulated deviations of the current account surplus and of wealth accumulation, as a ratio of GDP, from the baseline case. We consider the following set of changes:

1. Productivity

The first simulation consists of a permanent 10 percent rise in overall productivity. In discussing this change, it is useful to trace its effects on the various components of the current account equation (11) and on its permanent counterparts. To do so it is useful to express the current account as

$$(15) \qquad CA_t = (Y_t - Y_t^p) - (X_t - X_t^p) - (Z_t - Z_t^p),$$

where the superscript p denotes the permanent value[9] of the relevant variable. In (15) we use the fact that $CA_t = 0$ and assume that government spending does not deviate from its permanent value. The permanent rise in productivity leads to an increase in both current and permanent levels of output, but since the former effect is weaker than

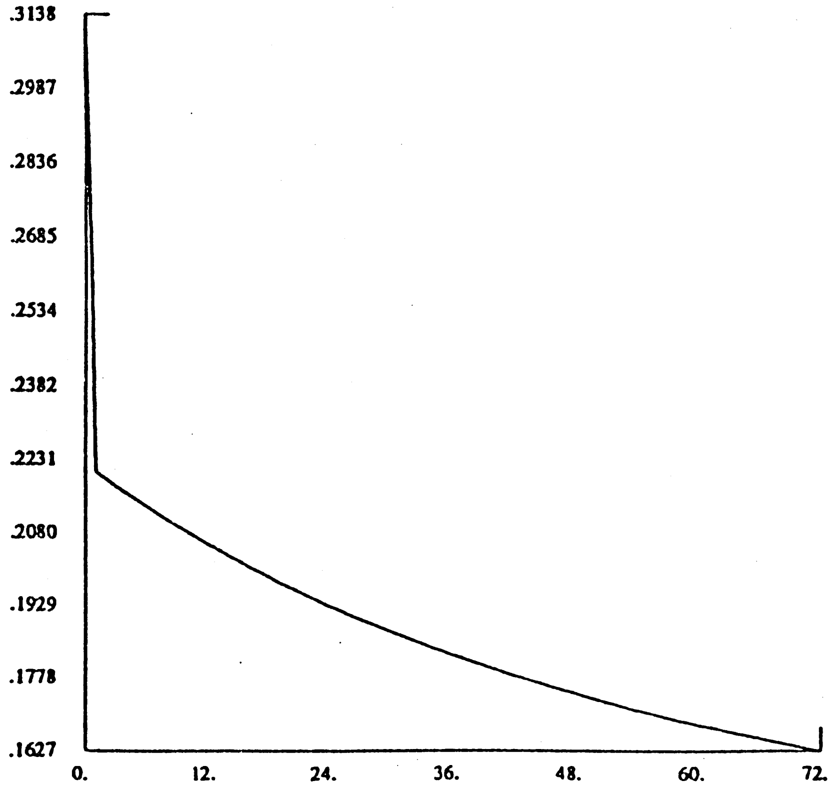
[9]For any variable, y_t, we define its permanent value as that which satisfies $\Sigma_{\tau=0}^{\infty} d_\tau y_{t+\tau} = y_t^p \, \Sigma_{\tau=0}^{\infty} d_\tau$, where d is the present value factor. We thank Torsten Persson for suggesting to us this useful approach.

the latter, i.e., $Y_t < Y_t^p$ this factor contributes toward a worsening of the current account position. An additional effect in the same direction arises from investment behavior. That is, since current investment after the productivity shock must exceed the permanent level of investment (i.e., $Z_t > Z_t^p$) the latter being the amount of resources required to maintain the permanent stock of capital, this component of the economy's response to the shock worsens the current account position. The consumption component, however, tends to improve the current account since current consumption increases by less than permanent consumption (i.e., $X_t < X_t^p$) due to the overlapping generations structure of the model. The latter implies that in a growing economy future generations have larger permanent income than the current generation. The changes in the components of the current account are summarized in the first line of Table 5.

Despite the worsening of the current account position, there is an improvement in the current account surplus and wealth accumulation when expressed as ratios to output, as seen in Figures 6a and 6b. The rise in the level of output following the productivity shock combined with a deficit position in the baseline current account leads to a decrease in the deficit relative to GDP. Since the productivity shock causes increases in investment and in the market value of the capital stock it results in a rise in the ratio of wealth accumulation to output, see Figure 6b, a rise that indicates that these factors dominate the negative effect arising from the increase in external debt.

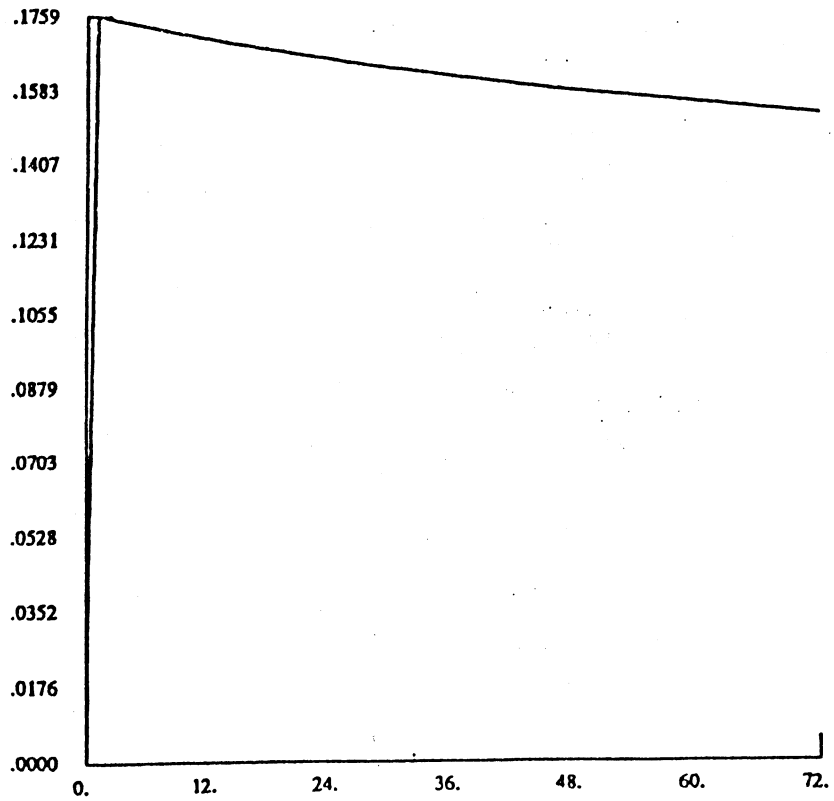
Figures 7a and 7b display the effects of a different productivity change, namely a change in the persistence parameter ζ, see equation

FIGURE 6A
EFFECTS OF A PERMANENT PRODUCTIVITY-CHANGE
ON THE CURRENCY ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of a ten percent rise in α_{η}.

FIGURE 6B
EFFECTS OF A PERMANENT PRODUCTIVITY-CHANGE ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of a ten percent rise in α_n.

Figure 6C: Change in Real Wage in Response to an Increase in Productivity.

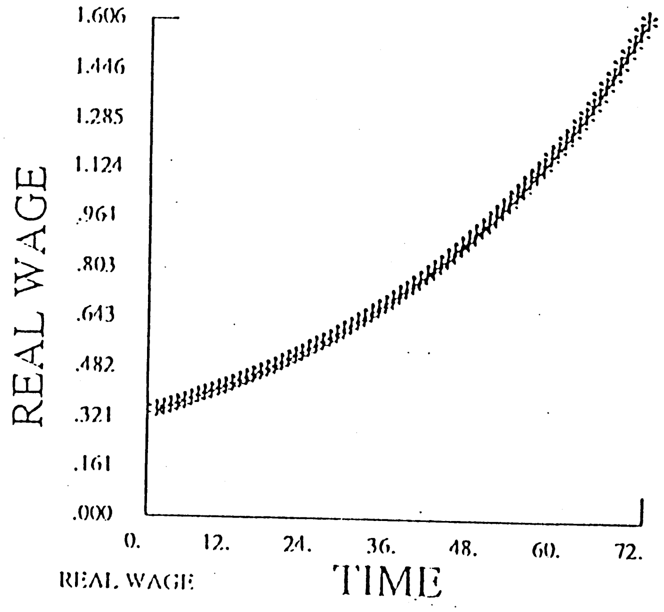
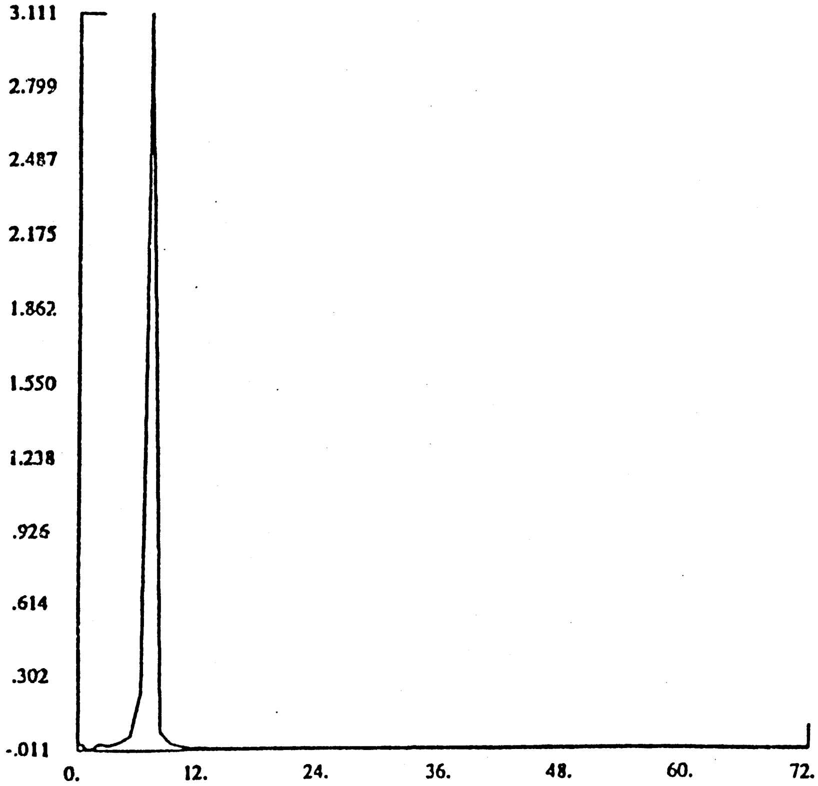


FIGURE 7A:

EFFECTS OF ALTERING THE PRODUCTIVITY-CHANGE PROCESS

ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)

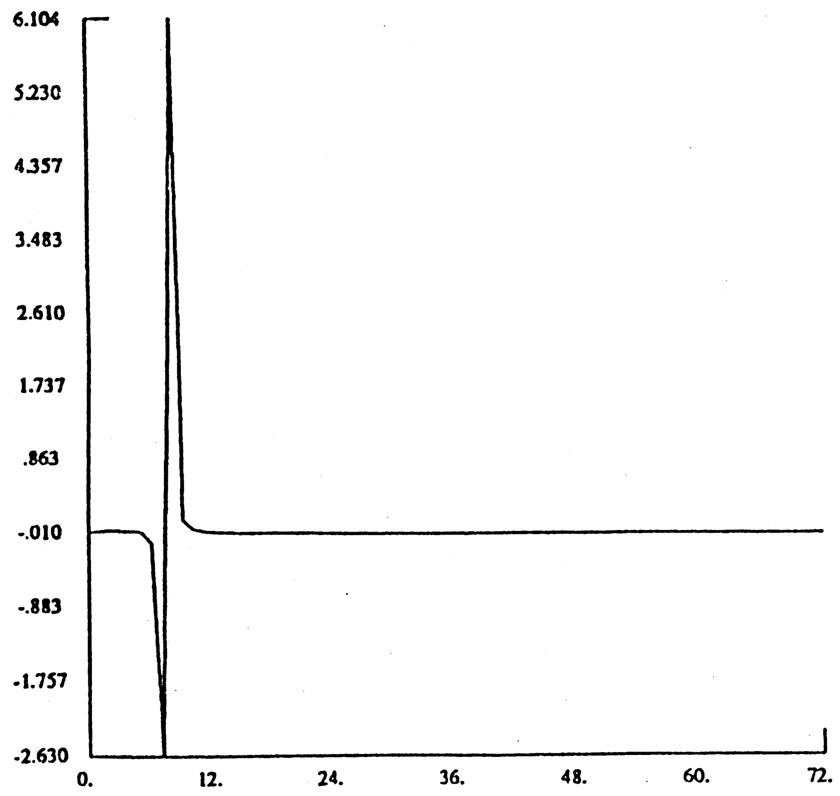


Note: Effects of lowering the persistence parameter (see Equations (2)) by 10 percent, starting from $\epsilon_{-2} = 0.5$ and $\epsilon_{-1} = 0.75$.

FIGURE 7B:

EFFECTS OF ALTERING THE PRODUCTIVITY-CHANGE PROCESS

ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of lowering the persistence parameter (see Equations (2)) by 10 percent, starting from $\epsilon_{-2} = 0.5$ and $\epsilon_{-1} = 0.75$.

(2). Taking as an initial position a rising trend in productivity, this change has noticeable dynamic impacts on the current account and on wealth accumulation, that occur with a lag. The real wage (which is an indicator of the inverse of the real exchange rate) increases in response to the former (10 percent) increase in productivity. The increase in the real wage, however, is proportionally smaller than the increase in labor productivity (see Figure 6c). Accordingly, real wages exhibit an upward trend over time due to capital accumulation which is induced by the productivity change.

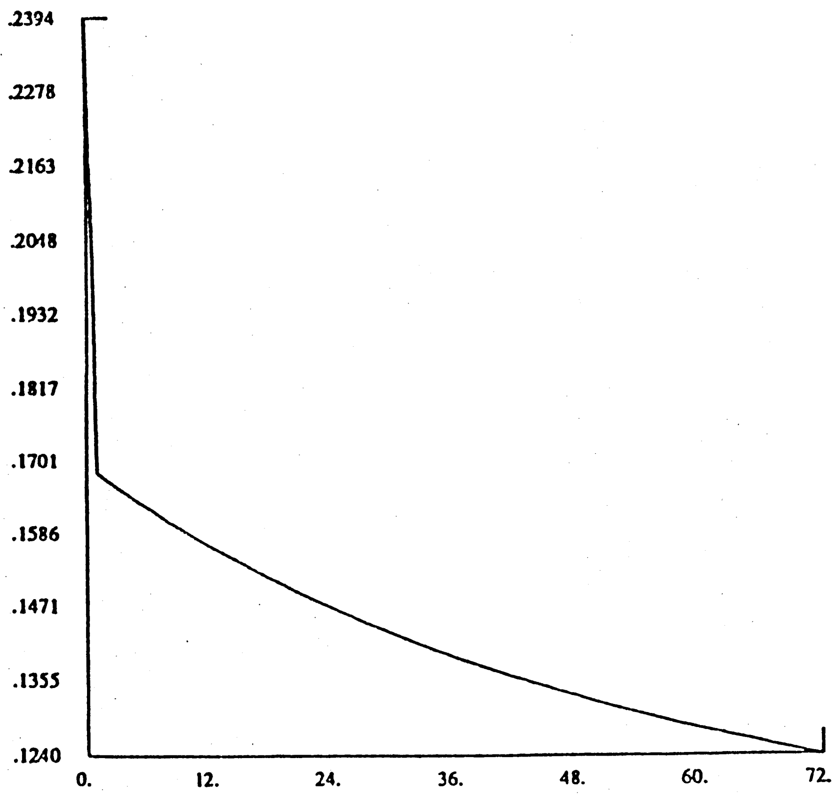
2. Labor Employment

We consider first a permanent (10 percent) rise in labor supply. This change has similar effects to those of the permanent increase in productivity discussed above. As in that case, the simulations show an improvement in the current account and in wealth accumulation when measured as ratios of output; see Figures 8a-8b.[10]

We simulated also the effects of lowering the persistence parameter ϕ governing the evolution of changes in labor employment. The results depend on the initial position of the economy relative to its steady state. In a growing economy (i.e., initially below the steady state), the decrease in ϕ noticeably stimulates investment; see Table 5. This parameter change leads to a deterioration in the external balance position in the first few periods, but to an increase in wealth

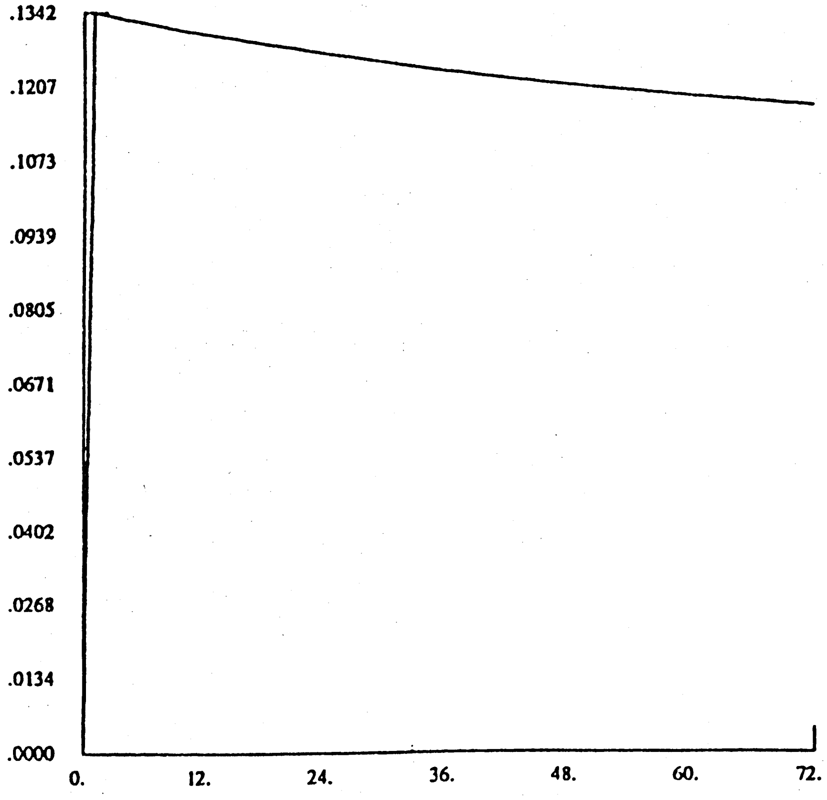
[10]Evidently, this shock leads to a decrease in the real wage while the productivity shock leads to an increase in the real wage.

FIGURE 8A:
EFFECTS OF PERMANENT CHANGE IN THE PRIVATE-SECTOR LABOR EMPLOYMENT ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



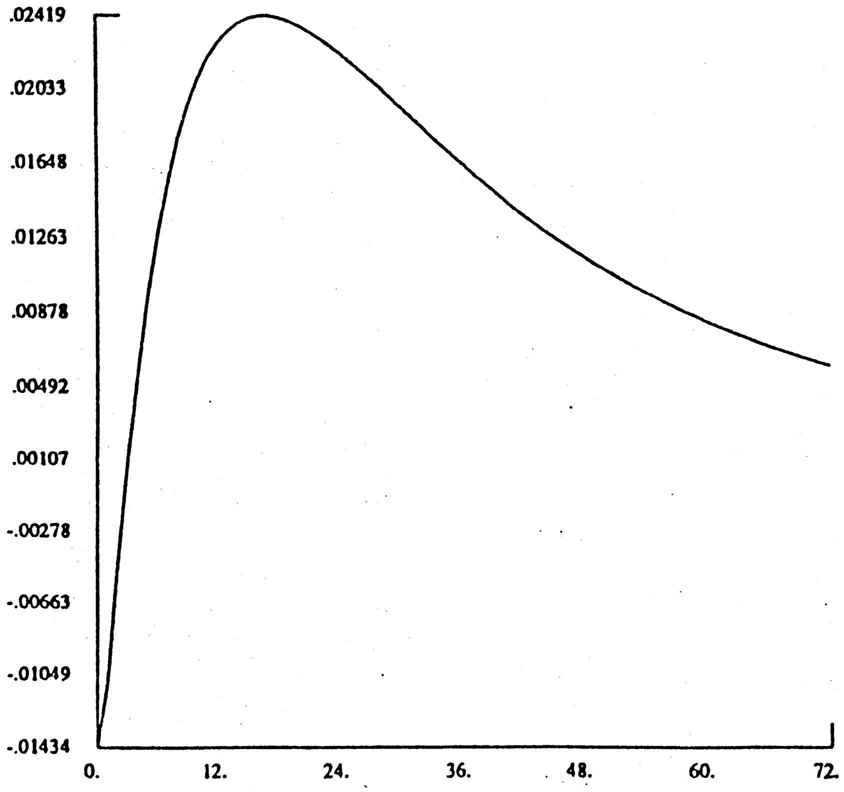
Note: Effects of a 10 percent rise in ζ.

FIGURE 8B:
EFFECTS OF A PERMANENT CHANGE IN THE PRIVATE-SECTOR LABOR EMPLOYMENT ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



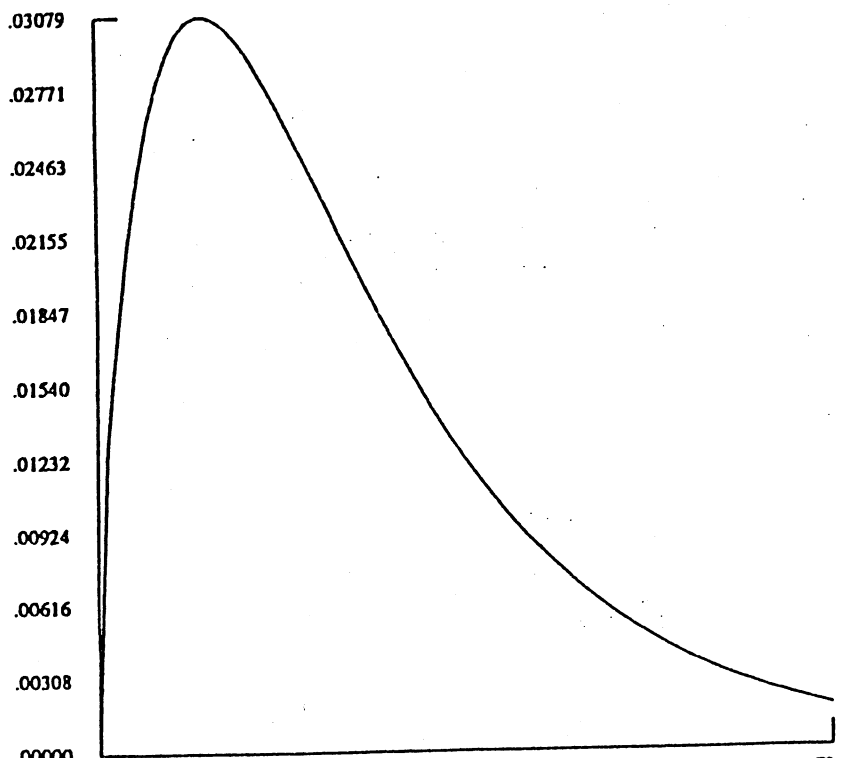
Note: Effects of a 10 percent rise in ζ.

FIGURE 9A:
EFFECTS OF ALTERING THE PROCESS OF PRIVATE-SECTOR LABOR EMPLOYMENT ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of lowering ϕ from 0.94 to 0.90, with L_{-1} = −122 as an intial value.

FIGURE 9B:
EFFECTS OF ALTERING THE PROCESS OF PRIVATE-SECTOR LABOR EMPLOYMENT ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of lowering ϕ from 0.94 to 0.90, with L_{-1} = −122 as an initial value.

accumulation. In both cases the dynamic responses reach peaks in the medium run (periods 12 to 24) and subside later on; see figures 9a and 9b. This pattern is reversed if initial labor exceeds its steady state level.

3. Cost of Adjustment

Line 4 of Table 5 reports the results of increasing the cost of adjustment parameter by 10 percent. As expected, this increase has a negative impact on investment. It turns out that this impact lasts for about 50 periods after the shock, and thereafter investment rises. This rise compensates the previous negative effects and it is required in order to maintain the steady state level of capital intact. Consumption purchases respond on impact positively to the increase in g, reflecting the increase in output net of investment in the current period. Obviously, this response weakens through time to yield no change in steady state consumption.[11] The value of wealth accumulation falls reflecting the depreciation of the capital stock. This depreciation more than offsets the positive effect on wealth accumulation arising from the improvement in the current account position. As time progresses and investment picks up, and these effects are reversed; see Figures 10a-10b. The increase in the cost of adjustment has a long run negative effect on the real wage; see Figure 10c.

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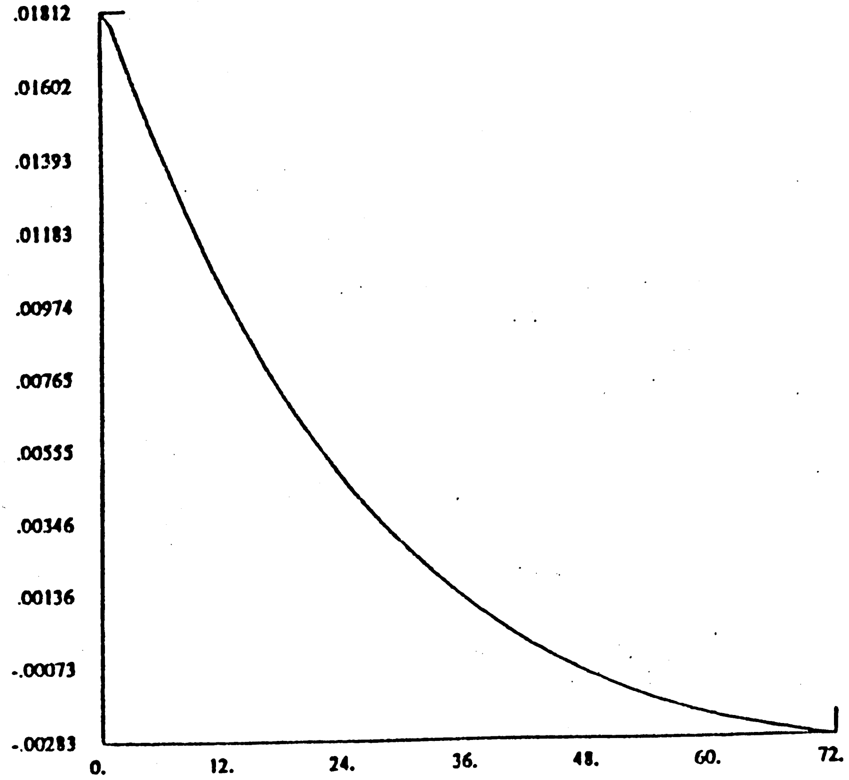
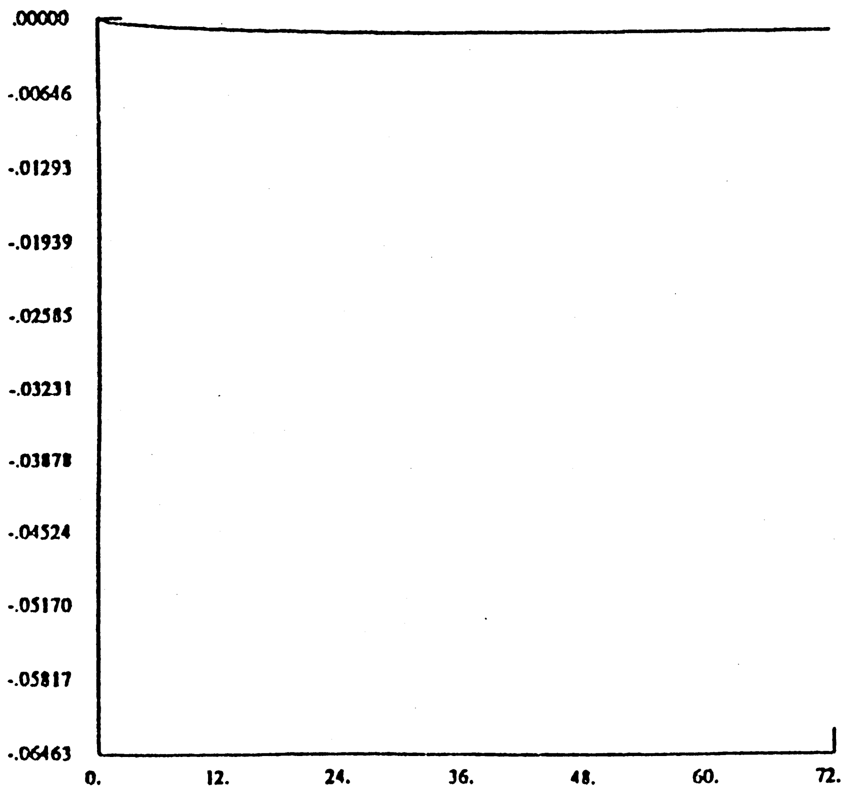
[11] A positive capital depreciation coefficient (i.e., $d > 0$) would, however, imply a fall in steady-state consumption.

FIGURE 10A:
EFFECTS OF A CHANGE IN INVESTMENT COST OF ADJUSTMENT ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



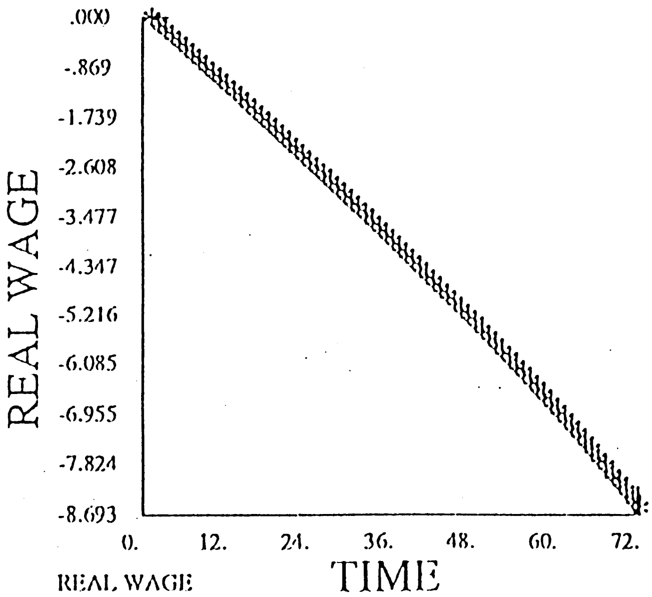
Note: Effects of a 10 percent rise in g (see equation (3)).

FIGURE 10B:
EFFECTS OF A CHANGE IN INVESTMENT COST OF ADJUSTMENT ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of a 10 percent rise in g (see equation (3)).

FIGURE 10C: Change in Real Wage in Response to an Increase in the Cost of Adjustment.



4. World Rate of Interest

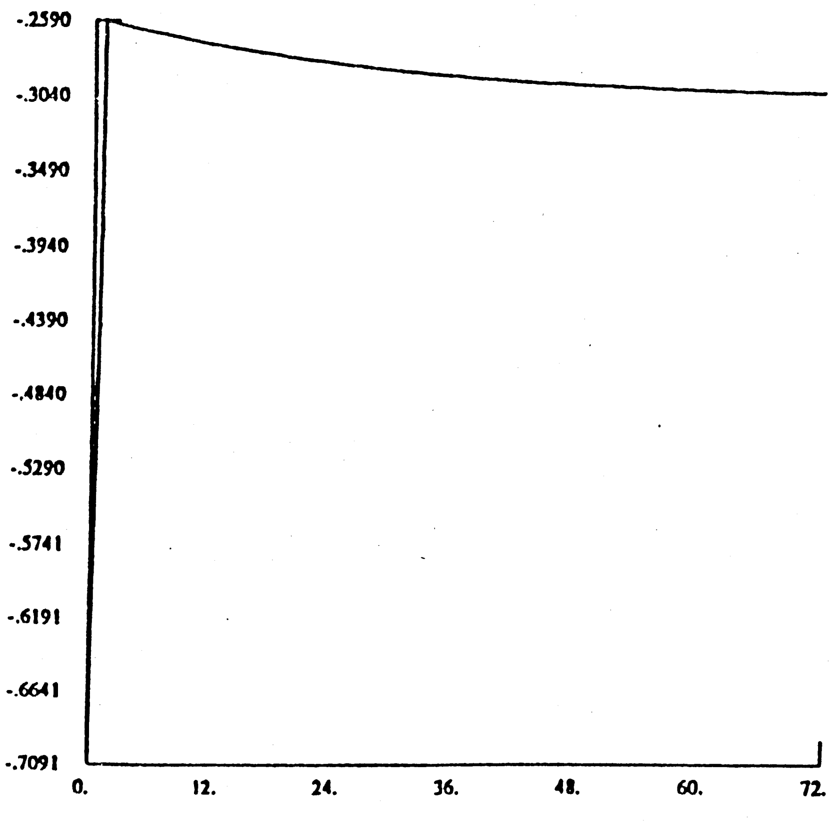
When the real interest rate is permanently decreased by 0.025 basis points per month, there is on impact an increase in investment, and consumption. As a result, the current account as a ratio of output worsens. In principole, a decrease in the rate of interest has ambiguous impact effect on wealth accumulation. On the one hand, the worsening in the current account due to the rise in consumption tends to lower wealth accumulation. On the other hand, there is a positive capital valuation effect. For the present set of parameters the first effect dominates. In the long run, the lower interest rate leads to a higher capital stock and output and therefore higher consumption. Overall, our simulations indicate a relatively high degree of sensitivity of external balance arising mainly from strong effects of interest rate changes on consumption (see Figures 11a-11b). The decrease in the real interest rate is followed by real appreciations indicated by the rise in the real wage; see Figure 11c.

5. Taxes

A rise in the initial value of taxes by 10 percentage points of output (with a continuing increase through the tax-evolution equation) decreases consumption by about 3-4 percent relative to the baseline case and slightly improves the current account. This improvement results in an increase in wealth accumulation (see Figures 12a-12b).

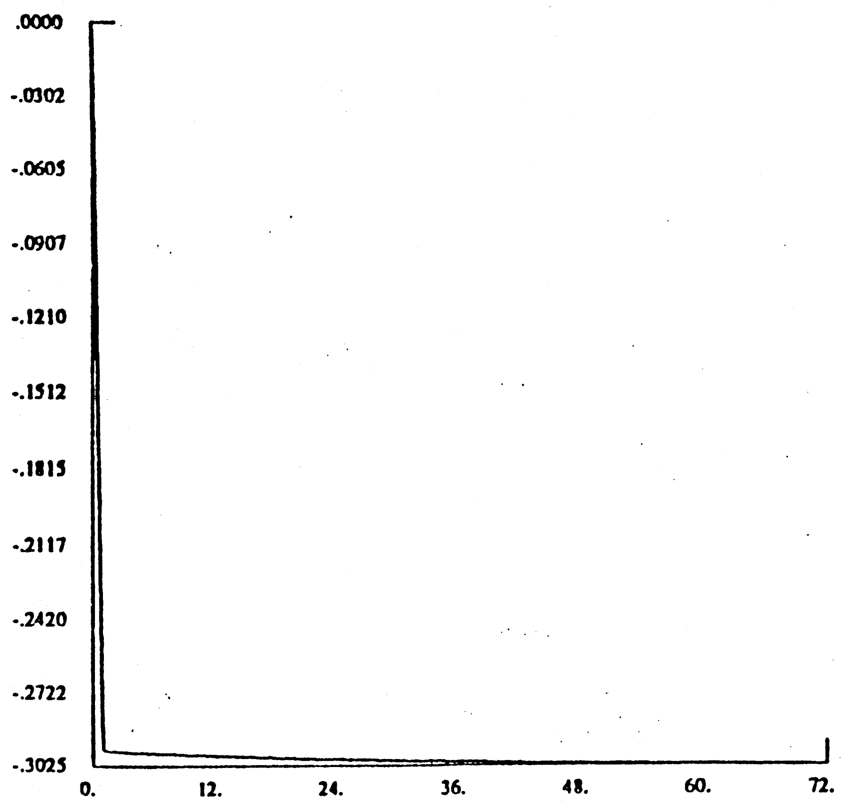
Another simulation consists of changing the κ-parameter in the stochastic process for taxes. In Table 5 and Figures 13a-13b, we change κ from -0.57 to -0.50. Using our parameter values and initial

FIGURE 11A:
EFFECTS OF A PERMANENT DECLINE IN THE REAL RATE OF INTEREST ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of lowering the real interest rate from 0.2 percent per month to 0.175 percent per month.

FIGURE 11B:
EFFECTS OF A PERMANENT DECLINE IN THE REAL RATE OF INTEREST ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of lowering the real interest rate from 0.2 percent per month to 0.175 percent per month.

FIGURE 11C: Change in Real Wage in Response to a Decrease in the Rate of Interest.

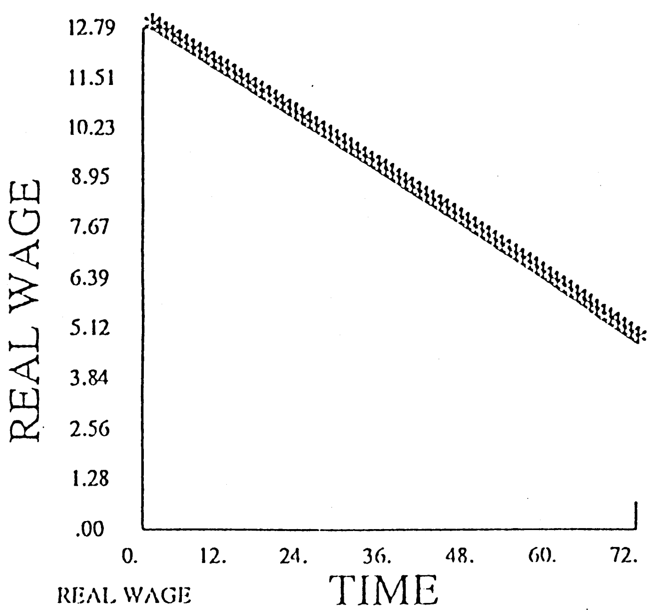
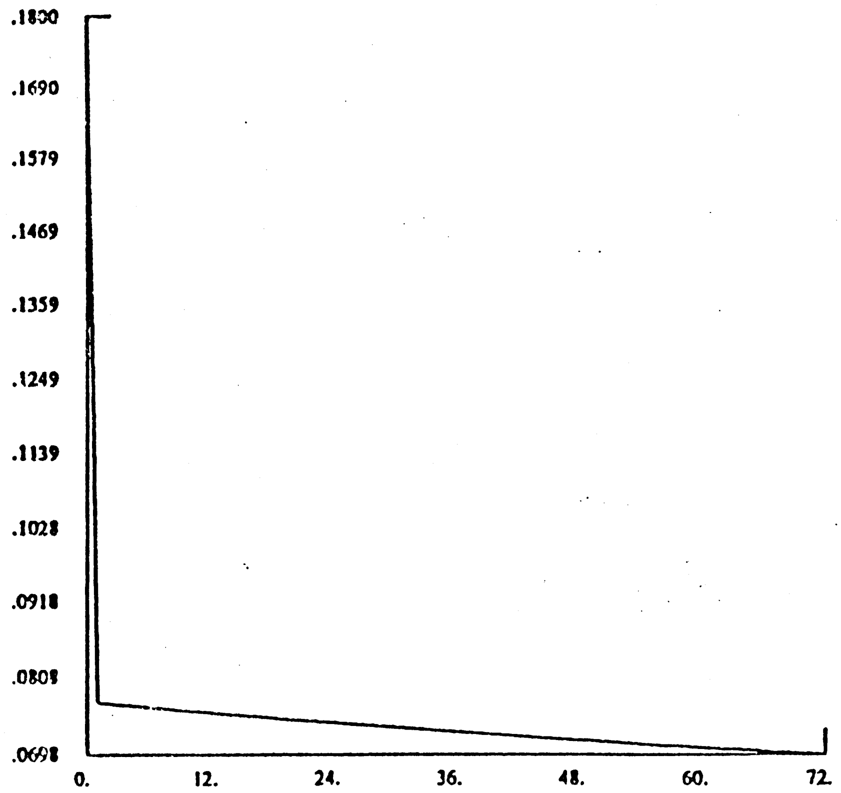
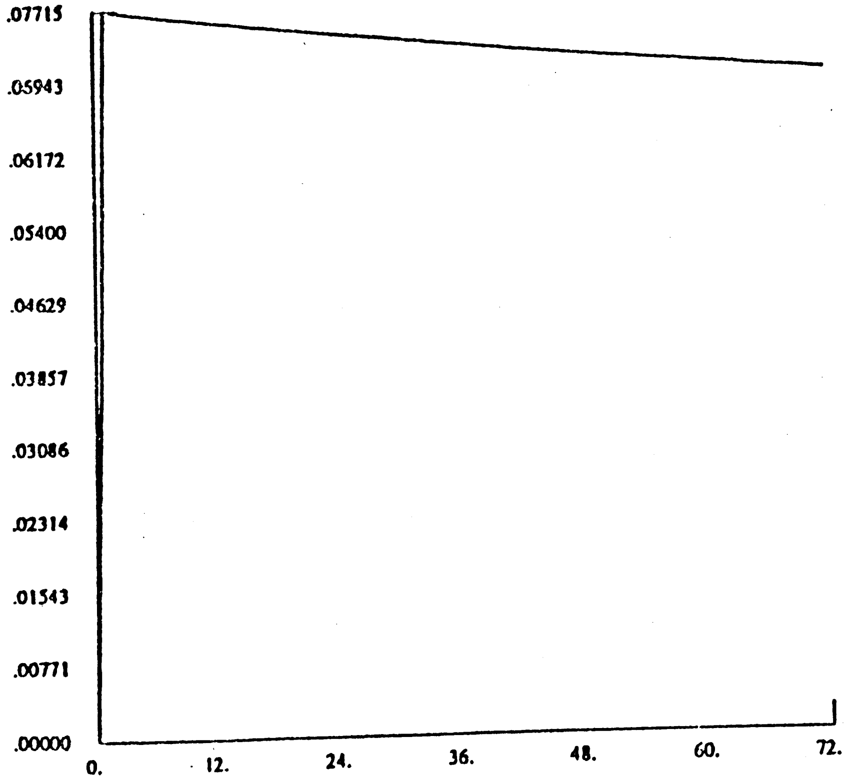


FIGURE 12A:
EFFECTS OF A PERMANENT RISE IN THE LEVEL OF TAXES
ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of increasing T_{-1} and T_{-2} by 1247.

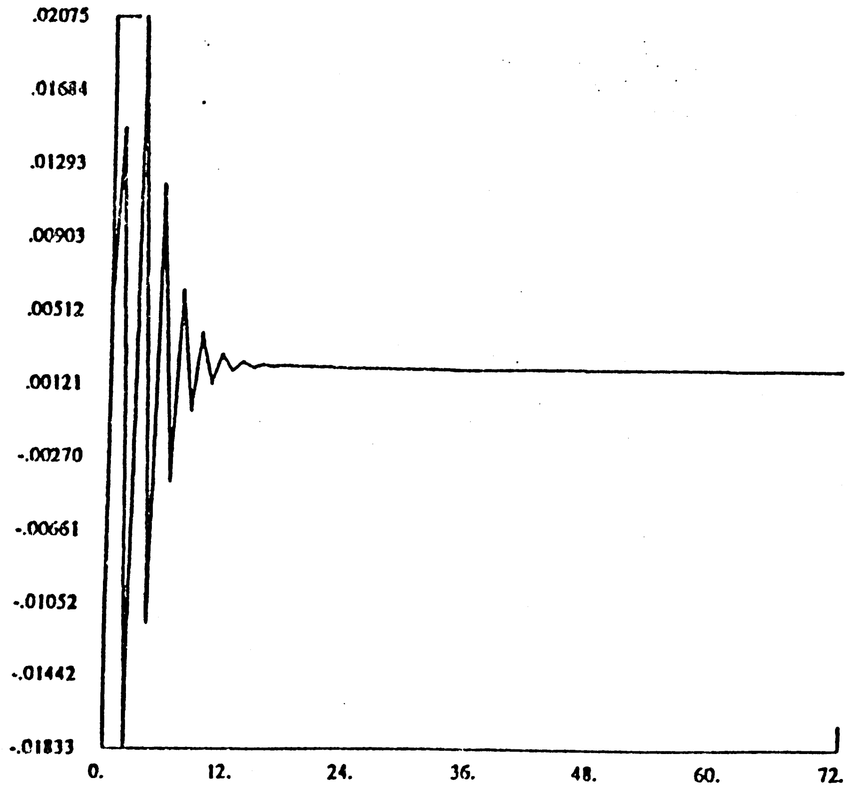
FIGURE 12B:
EFFECTS OF A PERMANENT RISE IN THE LEVEL OF TAXES ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of increasing T_{-1} and T_{-2} by 1247.

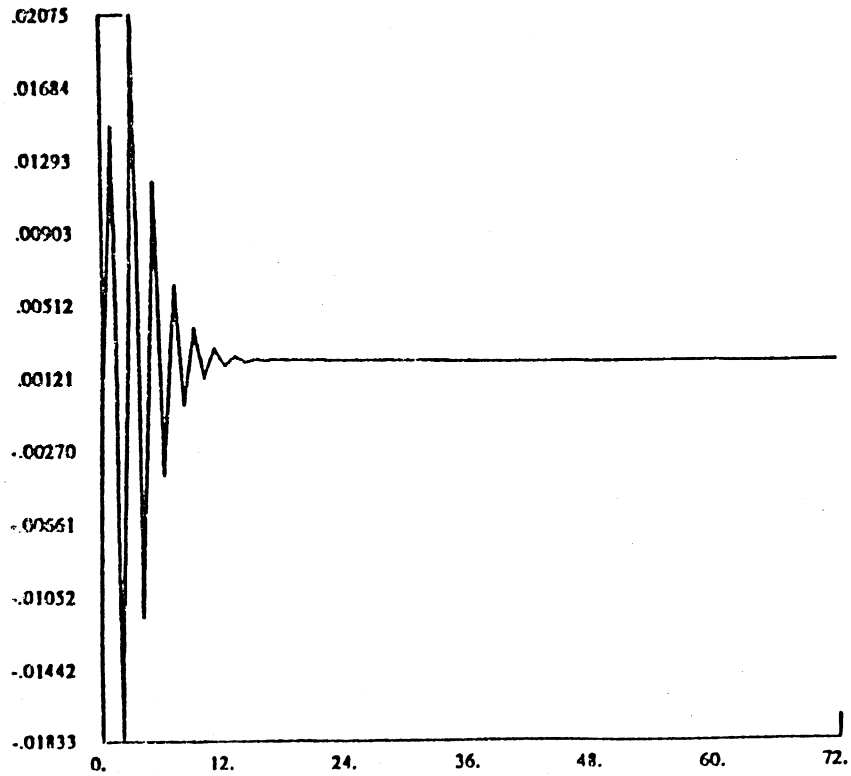
conditions, this change amounts to an increase in taxes on the current generation. Notice from Figures 13a and 13b that the current account and wealth accumulation ratios to output exhibit cyclical responses to this change, arising from cyclical changes in consumption. The latter can be interpreted in light of the overlapping generations structure of the model. Given the stochastic process of taxes employed here, consecutive generations face alternating high and low tax burdens which are reflected in the cyclical responses of the above.

FIGURE 13A:
EFFECTS OF ALTERING THE TAX POLICY PROCESS
ON THE CURRENT ACCOUNT — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of raising κ from -0.57 to -0.50 (see Equation (10)), with $T_{-2}=0$ and $T_{-1}=1247$.

FIGURE 13B:
EFFECTS OF ALTERING THE TAX POLICY PROCESS
ON THE WEALTH ACCUMULATION — GDP RATIO
(Percentage deviations from baseline)



Note: Effects of raising κ from -0.57 to -0.50 (see Equation (10)), with $T_{-2} = 0$ and $T_{-1} = 1247$.

TABLE 5: SIMULATIONS[2]
(Percentage deviations from baseline)

Change in Parameter	Response of: Output	Investment	Consumption	External[2] Balance	Wealth[3] Accumulation
(1) a_0[4]	[14.1,13.7]	[*,*]	[6.3,5.9]	[.31,.16]	[.18,.15]
(2) $\bar{L}$	[10.4,10.1]	[*,*]	[4.6,4.3]	[.24,.12]	[.13,.12]
(3) ϕ[5]	[0.3,.12]	[7.8,-4.8]	[.07,.07]	[-.01,*]	[.13,*]
(4) g	[*,-0.1]	[-4.9,-2.4]	[.02,.01]	[.018,-.003]	[*,*]
(5) R[6]	[5.3,4.6]	[-5.9,3.5]	[25.5,20.9]	[-.7,-.30]	[-.29,-.30]
(6) $T_{-1}=T_{-2}$[7]	[0,0]	[0.0]	[-4.6,-3.2]	[.18,.070]	[.08,.07]
(7) κ[8]	[0,0]	[0,0]	[0,0]	[.05,.05]	[.01,*]

[1] The simulations are based on the model described in the text and Appendix. Each entry consists of two figures. The first is the approximate percentage deviation from the baseline case on impact; the second gives this deviation after 72 periods. A "*" indicates figures smaller than .01 in absolute value.

[2] Private-sector current account to output ratio.

[3] Wealth accumulation (that is, the current account surplus plus the change in the value of domestic capital) expressed as ratio to output.

[4] The parameter is increased by 10 percent.

[5] The parameter is decreased from 0.94 to 0.90 and L_{-1} is set to -122.

[6] The rate of interest is reduced from .20 to .175 basis points.

[7] Taxes are raised from 0 to 10 percent of GDP.

[8] The parameter is changed from -.57 to -.50. The initial value of $T_{-1} - T_{-2}$ is set equal to 1247.

V. An Extension: Substitution between Public and Private Consumption

In the model of the preceding sections, government consumption affects private consumption and investment depending on the channels of financing of such consumption: tax or debt finance. The model incorporates government consumption as a separate element in the utility function of the representative individual. In addition, government consumption has a direct effect on the current account by being one of the components of the country's spending.

The purpose of this section is to extend the model to allow for direct substitution (or complementarity) effects of public consumption and private consumption. What we have in mind are cases such as education and defense. It is plausible that government spending on education is a substitute for private spending on education. Thus, a 1 shekel increase in government spending on education is likely to be accompanied by some decrease in private sector spending on education. At the same time, government spending on defense may be complementary to private consumption spending because the increased security may enhance consumption. To the extent that the substitution effects of government spending offset the complementarity effects, we are back to the model of the preceding sections.

The extension is based on Leiderman and Razin (1988). Note that in this extension output follows an exogenous stochastic process. Let the utility function be specified by:

$$U(c_t, G_t) = \alpha(c_t + \theta G_t) - \frac{1}{2}(c_t + \theta G_t)^2 + V(G_t), \tag{16}$$

where

$$(17) \qquad G_t = (1-\omega)G_{t-1} + g_t,$$

and where G denotes the stock of public consumption, g denotes the flow of government purchases, and θ is a parameter that measures the impact of public consumption in total private **effective** consumption, $c_t + \theta G_t$ (see Aschauer 1985). $V(G_t)$ denotes the separate role of government consumption in private utility as is implicitly assumed in the model of the preceding sections.

Positive values of θ indicate substitution between government and private consumption, since when G increases by one unit it is required to reduce private consumption, c, in order to maintain constant **effective** consumption. On the other hand, a negative value of θ indicates complementarity betwen private consumption and public consumption.

For tractability, the rates of depreciation of the stocks of private and public consumption goods are assumed to be identical and are denoted by ω. As shown in Leiderman and Razin (1988), in this case, the analogue of equation (9), expressing aggregate per capita consumption, C_t, is

$$(18) \qquad C_t = \beta_0\Big[E_t \sum_{t=0}^{\infty} \left(\frac{\gamma}{R}\right)^{\tau}(y_{t+\tau}+\theta g_{t+\tau}) - RB_{t-1}$$

$$+ \gamma(1-\omega)(C_{t-1} + \theta g_{t-1})\Big] - \theta G_t \, .$$

We assume that the expected flow of future public consumption evolves according to a simple process, given by:

$$(19) \qquad g_t - g_{t-1} = \rho_g(g_{t-1} - g_{t-2}) + \eta_{gt}$$

and that the output and tax processes are:

$$(20) \qquad Y_1 - Y_{t-1} = \rho_y(Y_{t-1} - Y_{t-2}) + \eta_{yt}$$

$$(21) \qquad T_1 - T_{t-1} = \rho_T(T_{t-1} - T_{t-2}) + \eta_{Tt}.$$

Equation (14) can now be written as

$$(22) \qquad \begin{aligned} X_t &= d_0 + \sum_{i=1}^{n} d_{1i}(X_{t-i} + \theta G_{t-i}) + d_2 Y_{t-1} + d_3 Y_{t-2} \\ &\quad + d_4 T_{t-1} + d_5 T_{t-2} + d_6 g_{t-1} + d_7 g_{t-2} + \epsilon_t', \end{aligned}$$

where the d-coefficients are given by

$$d_0 = \frac{\gamma a(R-1)(\delta R-1)}{\delta R(R-\gamma)};$$

$$d_{1i} = \left[\Gamma - \gamma(1-\omega)\right]\gamma^{i-1}(1-\omega)^{i-1} \quad , \quad \text{for} \quad i = 1,\ldots,n;$$

$$d_{1,n+1} = \Gamma\gamma^{n}(1-\omega)^{n};$$

$$d_2 = (1-\gamma) \; 1 - \left(\frac{\gamma}{\delta R^2}\right)\left[1 - \frac{\gamma}{R}(1-\omega)\right]^{-1}\left[\left(\frac{R}{R-\gamma}\right)(1+\rho_y)\right.$$

$$\left. + \frac{\rho_y^2\gamma}{R} + \frac{\gamma^2\rho_y^2}{R(1-\rho_y)(R-\gamma)} - \frac{\rho_y^4\gamma^2}{(1-\rho_y)R(R-\rho_y\gamma)}\right];$$

$$d_3 = (1-\gamma)\left(1 - \frac{\gamma}{\delta R^2}\right)\left[1 - \frac{\gamma}{R}(1-\omega)\right]^{-1}\left(\frac{R}{R-\gamma}\right) - d_2;$$

$$d_4 = -\;(1-\gamma)\left(1 - \frac{\gamma}{\delta R^2}\right)\left[1 - \frac{\gamma}{R}(1-\omega)\right]^{-1}\left[\left(\frac{R}{R-\gamma}\right)(1+\rho_T)\right.$$

$$\left. + \frac{\rho_y^4\gamma}{R} + \frac{\gamma^2\rho_T^2}{R(1-\rho_T)(R-\gamma)} - \frac{\rho_T^4\gamma^2}{(1-\rho_T)R(R-\rho_T\gamma)}\right];$$

$$d_5 = (1-\gamma)\left(1 - \frac{\gamma}{\delta R^2}\right)\left[1 - \frac{\gamma}{R}(1-\omega)\right]^{-1}\left(\frac{R}{R-\gamma}\right) - d_4.$$

$$d_6 = \theta(1-\gamma)\left(1 - \frac{\gamma}{\delta R^2}\right)\left[1 - \frac{\gamma}{R}(1-\omega)\right]^{-1}\left[\frac{R}{R-\gamma}(1+\rho_g)\right.$$

$$\left. + \frac{\rho_g^2\gamma}{R} + \frac{\rho_g^4\gamma^2}{R(1-p_g)(R-\gamma)} - \frac{\rho_g^4\gamma^2}{(1-\rho_g)R(R-\rho_g\gamma)}\right] - \theta(1+\rho_g),$$

$$d_7 = \theta(1-\gamma)\left(1 - \frac{\gamma}{\delta R^2}\right)\left[1 - \frac{\gamma}{R}(1-\omega)\right]^{-1}\left(\frac{R}{R-\gamma}\right) + \theta\rho_g - d_6.$$

Table 6 reports the results of estimating constrained and unconstrained versions of the system. The latter also allows for the existence of liquidity-constrained consumers whose proportion in the population is $(1-\Pi)$. Liquidity-constrained consumption is equal to last period's disposable income. To save degrees of freedom the number of lags used in estimating the durability parameter is set equal to 3. Column (1) gives the parameter estimates under the model's restrictions. These restrictions are not rejected against the unrestricted version of the model; the corresponding likelihood ratio is 14.52 (with seven degrees of freedom), which is below the critical one percent value of 18.5. Column (2) can be used to test the Ricardian neutrality hypothesis which implies that $\gamma = \Pi = 1.0$. The hypothesis is not rejected by the data.

TABLE 6: THE MODEL WITH PUBLIC GOODS (ISRAEL: 1980:9 - 1985:12)

	The Model Restrictions	$\gamma = \Pi = 1.0$
Parameters	(1)	(2)
ρ_y	-0.23	-0.22
	(0.08)	(0.10)
ρ_T	-0.59	-0.59
	(0.07)	(0.07)
ρ_g	-0.56	-0.55
	(0.08)	(0.07)
δ	1.17	1.04
	(0.12)	(0.04)
h	152.66	128.78
	(218.47)	(36.64)
ω	0.41	0.39
	(0.08)	(0.09)
γ	0.989	1.00[a]
	(0.02)	
Π	1.38	1.00[a]
	(0.29)	
θ	-0.52	-0.47
	(0.20)	(0.26)
L	-781.87	-782.52

Notes: L denotes the value of the log-likelihood function. Figures in parentheses are the estimated standard errors. The value of L for the unrestricted system is - 774.61 (16 free parameters).

[a] Imposed value

The estimated value of θ is negative, indicating that there is some degree of complementarity between public and private consumption. However, the complementarity coefficient is not estimated with great precision. Thus, the formulation adopted in previous sections is not markedly at variance with the data. Observe also that the intertemporal substitution parameter h (although measured in different units) is more precisely estimated in the present shorter sample.

VI. An Application: The Economic Effects of the Aliya

In this section we illustrate the usefulness of the model for analyzing the economic effects of the aliya from Eastern Europe, expected in the 1990s. The analysis and discussion draw on Neubach, Razin, and Sadka (1990) who used our model for this purpose.

Reliable forecasts indicate that the aliya, expected for 1990, is of approximately 100,000 olim. In order to quantitatively assess the effects of such a significant wave of immigration on key macroeconomic variables (output, private consumption, and the current account deficit), it is first required to evaluate the implied changes in the **labor force, productivity,** and **government spending.**

The 100,000 olim represent a once-and-for-all increase of about 2.8 percent in the labor force. We assume that the average oleh is endowed with roughly 25 percent more years of schooling than the average participant in the existing labor force. We further assume that this difference can be captured by a 1.25 productivity factor of olim compared with the existing average labor productivity in Israel. Thus, the **effective** growth in the labor force is 3.5 percent (= 1.25 x 2.8), which exceeds by 0.7 percent the increase in manpower. Assuming that the output elasticity with respect to the labor input is 0.8, this amounts to 0.56 percent increase (=0.7 x 0.8) in productivity.

Turning to government spending, we estimate the government funded absorption costs $50,000 per family. Thus, government spending is estimated to rise by about $1.25 million in 1990 as a result of the aliya. We consider two polar modes of financing the additional expenses an increase in taxes, and an increase in transfers from abroad.

Table 7 provides a capsule summary of the model's multipliers of output, private consumption, and current account deficit in the medium run (4-5 years ahead) with respect to a 1 percent change in the fundamental factors: labor force, productivity, and government spending (financed by taxes or through transfers from abroad). Note that the government spending entry in the table reports the impact of one shekel changes in government spending on the shekel magnitude of output, private consumption, and the current account deficit. To illustrate the meaning of the figures in the table, notice that a 1 percent increase in productivity raises output by 1.4 percent while raising private consumption by 0.6 percent. In the medium run, after the short-run effect of the induced rise in investment on the current account is attenuated, these changes bring about a 12 percent reduction in the current account deficit. As far as the effects of alternative methods of financing government expenditures are concerned, notice that in either case there is no change in output or in the current account deficit. When taxes are used, private consumption decreases, one to one, relative to government spending. This result reflects the permanent-income feature of our model; namely a one shekel permanent fall in disposable income leads to a one shekel permanent decrease in consumption. In contrast, when transfers from abroad are used to finance the increase in government spending, private consumption remains unchanged.

TABLE 7: THE MEDIUM RUN EFFECTS OF A ONCE-AND-FOR-ALL INCREASE IN THE LABOR FORCE, PRODUCTIVITY AND GOVERNMENT SPENDING ON THE MACROECONOMY

	Output	Private Consumption	Current Account Deficit
Labor Force[1]	1.00	0.45	- 6.70
Productivity[2]	1.40	0.60	-12.00
Government Consumption[3]			
a) Tax Financed	0	-1	0
b) Financed Through transfers from abroad	0	0	0

Notes:

1 Percentage changes in the column variable resulting from a one percentage change in the labor force.

2 Percentage changes in the column variable resulting from a one percent increase in productivity.

3 The effect of 1 shekel rise in government spending, under alternative means of its finance, on the shekel value of the column variable.

TABLE 8: THE MEDIUM-TERM EFFECTS OF THE 1990-ALIYA ON THE MACROECONOMY (IN MILLIONS OF DOLLARS PER ANNUM)

	Output	Private Consumption	Current Account Deficit
Labor Force	1,100	450	-550
Productivity	300	100	-200
Government Consumption			
a. Tax Financed	0	-125	0
b. Financed through transfers from abroad	0	0	0
Total Effect			
a. Tax Financed	1,400	425	-750
b. Financed through transfers from abroad	1,400	550	-750

VII. Conclusions and Policy Implications

In this paper we develop estimated, and simulated an intertemporal model of external balance dynamics in a small open economy. Despite the complexity of the full-blown optimizing model, it is transformed into a relatively small scale set of reduced form relations, capable of delivering a potentially rich set of macroeconomic simulations. By virtue of the optimizing nature of the analysis, these relations embody the structural, or policy invariant, parameters of preferences, policy, and technology. In what follows, we elaborate on some of the policy implications of the analysis and on extensions.

It is commonplace in policy discussions to assume that the policy maker targets the current account. This assumption can however be questioned. In effect, the current account measures the rate of accumulation or depletion of external assets. This is only a subset of the assets owned by the country, as there is also domestic physical and human capital. Thus, a broader measure of changes in national wealth ought to include the latter, and our analysis indeed proceeded in this direction. While there are episodes, especially balance of payments crises, in which the current account can serve as a meaningful target, there are certainly other times at which concentrating on the current account alone may miss important determinants of national wealth and growth.

Our analysis and results can be used to assess the effects of alternative structural adjustment policy scenarios on the economy's external position. One such scenario entails the following ingredients: (i) an increase in public investment in infrastructure, incentives to research and development, and budget allocations to enhance investment in human capital. These measures are likely to result in an increase in productivity. (ii) a decrease in public sector employment as part of an attempt to reduce the size of the government sector. This, coupled with at least unchanged private sector demand for labor, implies an increase in the size of the labor input in the production of the private sector. Our analysis and simulations indicate that both these changes have similar effects on the import surplus and the broader measure of change in national wealth. That is, on the one hand they tend to stimulate investment and to accelerate output growth and thereby to temporarily worsen the current account position despite their positive effect on saving. On the other hand, however, they result in an increase in national wealth (i.e., the increase in the value of the domestic capital stock exceeds the deterioration in the current account position). Thus, this secenario confronts the policy maker with a **tradeoff** between the prospects of enhanced economic growth and capital accumulation at the expense of an increase in external debt.

This discussion illustrates that there is no simple relation between output growth, the current account, and changes in national wealth. A consumption-driven increase in growth, probably not sustainable in the long run, is likely to generate a worsening of the current account. However, an investment or export driven increase in output growth is likely to last. Thus it worsens the current account in the short run, but adds to the accumulation of wealth in both the short and the medium runs.

Another interesting set of scenarios includes policy measures that exert a direct impact on saving. Our analysis shows an important degree of sensitivity of saving to changes in the rate of return. Thus, incentives that effectively raise this return can be predicted to result in an increase in saving. This would contribute toward improvement in both external balance and national wealth. If this scenario includes an increase in tax revenues from other sources in order to compensate for the loss of revenue from enhanced saving incentives, then our analysis indicates that by themselves these additional taxes have only a negligible impact on the saving-investment balance.

Our research constitutes obviously a "first attack" on applying dynamic models to the empirical analysis of the current account in small open economies. As such, it incorporated a number of simplifying working assumptions and it used the most readily available set of data. It would be desirable to extend and refine this work in several important directions. First, the analysis can be refined to allow for the distinction between tradables and nontradables. This would entail analyzing how the economy's industrial structure varies along with the current account. In addition, the real exchange rate would be brought directly into the analysis and the real interest rate would be affected by the path of the real exchange rate. Second, a major extension consists of incorporating the nominal (monetary) side of the economy into the analysis. This would enable one to investigate the roles of nominal exchange rate and monetary policies for current account dynamics. Third, the data on Israel used here and the specifications could be refined so as to: (i) take into account unilateral transfers from abroad to the private sector in the disposable income measure of the latter; (ii) decompose consumption purchases into durables and nondurables; (iii) investigate the stability of the estimated saving, investment, and policy parameters within the present sample (e.g., before and after the disinflation plan of 1985), as well as by considering earlier periods such as the 60s and 70s. Fourth, it would be interesting to analyze the impact of changes in our fundamental factors on long-term growth in the context of the new endogenous growth literature; see Romer (1986). Although these extensions and refinements are beyond the scope of the present study, the model and approach developed in this paper can be usefully applied in pursuing them.

APPENDIX 1: THE COMPLETE MODEL

In this appendix we present the details of the complete general-equilibrium model.

(1.1.) Production and Investment

Assume the existence of an aggregate production function

$$(1.1) \qquad Y_t = a_0 K_{t-1}^{a} L_t^{(1-a)} \epsilon_t',$$

where Y_t denotes output, K_{t-1} denotes the capital stock, L_t denotes labor employment, and ϵ_t' denotes a productivity variable, in period t. L and ϵ' are treated below as exogenous stochastic variables. Capital formation entails costs of adjustment such that the amount of resources foregone in the process of investment, Z_t, exceeds net additions to the capital stock, I_t:

$$(1.2) \qquad Z_t = I_t\left(1 + \frac{g}{2}\frac{I_t}{K_{t-1}}\right),$$

where g is the adjustment-cost coefficient. Net capital formation is given by

$$(1.3) \qquad I_t = K_t - (1-d)K_{t-1},$$

where d is the rate of depreciation.

The representative firm maximizes the expected discounted sum of profits as given by

$$(1.4) \qquad E_t\sum_{\tau=0}^{\infty} R^{-\tau}(Y_{t+\tau} - S_{t+\tau}L_{t+\tau} - Z_{t+\tau}),$$

where E_t denotes expectations taken conditionally on the information known at time t and S denotes the real wage.

The first-order (Euler) condition for maximization of (1.4) with respect to investment is

$$(1.5a) \qquad E_tR^{-1}[\alpha a_0K_t^{\alpha-1}L_{t+1}^{1-\alpha}\epsilon'_{t+1} + \frac{1}{2}g(\frac{I_{t+1}}{K_t})^2 (1-d)q_{t+1}] = q_t,$$

where

$$(1.5b) \qquad q_t = 1 + g\frac{I_t}{K_{t-1}}$$

is equal to the market value of the firm per unit of capital (the Tobin-q measure). Accordingly, the marginal cost of investing an additional unit at time t (q_t) is equated to the expected present value of the sum of next period's marginal productivity of capital, the fall in next period costs of adjustment due to the augmented capital stock, and the market resale value of the depreciated capital.

As usual, the firm's demand for labor is derived from the maximization of eq.1.4 with respect to L. This yields:

$$(1.6) \qquad (1-\alpha)a_0K_{t-1}^{\alpha}L_t^{-\alpha}\epsilon'_t - S_t = 0.$$

That is, the marginal product of labor is set equal to the real wage. We assume that labor is inelastically supplied and follows a stochastic process (specified below). Thus, at the economy-wide level eq.1.6 determines the wage rate. It can be seen that the evolution of the capital stock along with the stochastic processes for labor and productivity shocks determine the time path of the real wage.

To obtain explicit solutions for the path of the (economy-wide) capital stock we linearize the Euler condition, eq.1.5, around steady state as follows

$$(1.7) \qquad k_{t-1} + a_0 k_t + a_1 E_t k_{t+1} = b_L E_t \ell_{t+1} + b_\epsilon E_t \epsilon_{t+1},$$

where $\bar{K}$, $\bar{L}$, and $\bar{\epsilon}'$ denote the steady state values of capital, labor and productivity, and $k_t \equiv (K_t - \bar{K})$, $\ell_t \equiv (L_t - \bar{L})$, and $\epsilon_t \equiv \epsilon'_t - \bar{\epsilon}'_t$ denote deviations from steady-state levels of capital, labor and productivity, respectively. The a and b coefficients given in Appendix 2, depend on steady-state values of the marginal productivities of capital and labor, on the steady-state productivity level, and on the cost-of-adjustment coefficient, the rate of interest, and the depreciation factor.

The solution for k_t is given by[12]

$$(1.8) \qquad k_t = \lambda_1 k_{t-1} - \lambda_1 \sum_{i=0}^{\infty} \left(\frac{1}{\lambda_2}\right)^i E_t (b_L \ell_{t+1+i} + b_\epsilon \epsilon_{t+1+i}),$$

---

[12]For a similar derivation see Sargent (1987), 197-204.

where $\lambda_1 < 1$ and $\lambda_2 > 1$ are the roots of the quadratic equation $1 + a_0\lambda + a_1\lambda^2 = 0$. Equation (1.8) expresses capital stock in period t as a function of the capital stock in period $t-1$ and the expected future path of employment and productivity. Since b_L and b_ϵ are negative coefficients, increases in expected future levels of labor and factor productivity raise firms' current demand for capital.

To close the model we use the following simple stochastic processes for labor employment and productivity:[13]

$$1.9 \qquad \ell_t = \ell_0 + \phi\ell_{t-1} + \xi_{\ell t},$$

$$1.10 \qquad \epsilon_t - \epsilon_{t-1} = e_0 + \rho(\epsilon_{t-1} - \epsilon_{t-2}) + \xi_{\epsilon t},$$

where $\xi_{\ell t}$ and $\xi_{\epsilon t}$ denote the zero-mean and finite-variance components of ℓ_t and $(\epsilon_t - \epsilon_{t-1})$ which cannot be predicted using variables dated up to $t-1$.

Using eqs.(1.9) and (1.10) to calculate the expected future values appearing in eq.(1.8), and substituting these calculations into eq.(1.8) yields

$$(1.11) \qquad k_t = \lambda_1 k_{t-1} - m_L\ell_t - m_\epsilon\epsilon_t - m_e e_t - m_1\ell_0 - m_2 e_0,$$

where $e_t \equiv \epsilon_t - \epsilon_{t-1}$, and the m-coefficients are specified in Appendix 2. They consist of parameters governing the production and the cost of

[13]These expectations are chosen after fitting alternative forms to the data.

adjustment technology, the stochastic processes of labor and productivity, and the rate of interest.

1.2. Consumption

The consumer is assumed to face a given risk-free interest factor R (where $R = (1+r)$ and r denotes the rate of interest). Yet, due to lifetime uncertainty the effective (risk-adjusted) interest factor is R/γ, where γ is the probability of survival from one period to the next.[14] Disposable income is stochastic and is denoted by y^d. Consumer's utility from his stock of consumption goods during period $t + \tau$, $c_{t+\tau}$, viewed from the standpoint of period t, is given by $\delta^\tau U(c_{t+\tau})$, where δ is the subjective discount factor. The probability of survival from period t through period $t + \tau$ is γ^τ, and therefore expected lifetime utility as of period t is

$$(1.12) \qquad E_t \sum_{\tau=0}^{\infty} (\gamma\delta)^\tau U(c_{t+\tau}),$$

where E_t is the conditional expectations operator. Individuals are assumed to maximize 1.12 subject to

$$(1.13) \qquad c_t = (1-\omega)c_{t-1} + x_t,$$

[14]See Blanchard (1985) and Frenkel and Razin (1986). The parameter γ can also be viewed as the rate of population growth in an overlapping-generation economy with an operative bequest motive but with no altruistic relations across dynasties (see Weil (1987)).

$$(1.14) \qquad x_t = a_t + y_t^d - \left(\frac{R}{\gamma}\right) a_{t-1},$$

and the solvency condition $\lim_{t\to\infty} (\gamma/R)a_t = 0$. The variable x_t denotes the flow of consumption purchases, c_t denotes the stock of consumer goods, and ω denotes the rate of depreciation of this stock. The variable a_t is the one-period debt issued in period t. Consolidating eqs.(1.13) and (1.14), the expected value of the lifetime budget constraint is given by

$$(1.15) \qquad \left[1 - \left(\frac{R}{\gamma}\right)(1-\omega)\right] E_t \sum_{\tau=0}^{\infty} \left(\frac{\gamma}{R}\right)^{\tau} c_{t+\tau} = E_t \sum_{\tau=0}^{\infty} \left(\frac{\gamma}{R}\right)^{\tau} y_{t+\tau}^d -$$

$$- \left(\frac{R}{\gamma}\right) a_{t-1} + (1-\omega)c_{t-1} \equiv E_t w_t,$$

where $E_t w_t$ is expected wealth, adjusted for consumer goods' durability. If the depreciation rate is equal to zero and $\omega = 1$, expected wealth is equal to the expected (discounted) current and future disposable income stream minus initial debt commitment. If, on the other hand, the durability coefficient falls short of unity the undepreciated stock of consumption from the last period is added to wealth. This consolidated budget constraint is implied from the equality of the expected value of the discounted sum of the flow of consumption purchases and the corresponding discounted sum of the flow of disposable income (minus initial debt commitment).

With a view towards empirical implementation, we specify utility as a quadratic function, that is,

$$(1.16) \qquad U(c_t) = hc_t - \frac{1}{2} c_t^2,$$

where $h > 0$ and $c_t < h$, where $c_t/(h-c_t)$ is the measure of relative risk aversion.

The solution to the consumer optimization problem is:[15]

$$(1.17) \qquad c_t = \beta_0 + \beta_1 E_t w_t,$$

where

$$\beta_0 = \gamma h \frac{1-\delta R}{\delta R(R-\gamma)},$$

and

$$\beta_1 = \left[1 - \frac{\gamma}{\delta R^2}\right] \left[1 - \left(\frac{\gamma}{R}\right)(1-\omega)\right]^{-1}.$$

Equation (1.17) is a linear consumption function, relating the stock of consumer goods, c_t, to the expected value of wealth, where β_1 is the marginal propensity to consume out of wealth.

The economy consists of overlapping generations. The size of each cohort is normalized to 1, there are γ^a individuals of age a, and the size of population is constant at the level $1/(1-\gamma)$. Aggregating consumption across cohorts yields the following expression for the total stock of consumption:

[15]See Leiderman and Razin (1988).

$$(1.18) \qquad C_t = \gamma h(R-1)\,\frac{\delta R-1}{\delta R(R-\gamma)}$$

$$+ (1-\gamma)\left(1-\frac{\gamma}{\delta R^2}\right)\left[1-\left(\frac{\gamma}{R}\right)(1-\omega)\right]^{-1}$$

$$E_{t-1}\sum_{\tau=0}^{\infty}\left(\frac{\gamma}{R}\right)^{\tau}(Y_{t+\tau}-Z_{t+\tau}-T_{t+\tau}) + \Gamma C_{t-1} + v_t$$

where $\Gamma = \left[\frac{\gamma}{\delta R}+\gamma(1-\omega)\right]\left[1-\gamma\left(1+\frac{1}{\delta R^2}\right)\right]\left[1-\left(\frac{\gamma}{R}\right)(1-\omega)\right]^{-1}$,

and where Y is gross domestic output, T is the level of taxes, and v is a zero-mean, finite-variance, error term. Expressed in terms of observed consumer purchases the consumption equation is given by

$$(1.19) \qquad X_t = \gamma h(R-1)\,\frac{\delta R-1}{\delta R(R-\gamma)} + (1-\gamma)\left(1-\frac{\gamma}{\delta R^2}\right)\left[1-\left(\frac{\gamma}{R}\right)\cdot\right.$$

$$\left.\cdot\,(1-\omega)\right]^{-1} E_{t-1}\sum_{\tau=0}^{\infty}\left(\frac{\gamma}{R}\right)^{\tau}(Y_{t+\tau}-Z_{t+\tau}-T_{t+\tau})$$

$$+ (\Gamma-\gamma(1-\omega))\cdot\sum_{\tau=0}^{\infty}\gamma^{\tau}(1-\omega)^{\tau}X_{t-\tau-1} + v_t,$$

where X is the per capita value of consumer purchases.

Equation (1.19) expresses consumption purchases as a function of a constant term, the expected discounted sum of current and future disposable income net of investment, lagged purchases, and an error term. When $\gamma = 1$, Ricardian neutrality holds and in that case equation

(1.19) relates consumption purchases at any time t only to a constant and lagged consumption purchases plus an error term. When $\gamma < 1$ there is an additional explanatory variable -- the expected discounted sum of present and future net income.

To implement eq.(1.19), it is required to express explicitly the expected future variables appearing on the right-hand-side of the equation in terms of the current and lagged variables (which comprise the consumers' information set). To form expected future values of output net of investment (Y - Z), we use the stochastic processes describing labor and capital accumulation as well as the production and investment functions from the previous subsection. Accordingly, we use eqs. (1.9)-(1.11), and the linearized version of the production and investment functions (evaluated around the steady state). In this way, we incorporate into the analysis of consumption determination proper elements from the analysis of output and investment determination, as suggested by general-equilibrium considerations. To specify expected future taxes, we assume the following first-order autoregressive process:

$$T_t - T_{t-1} = \kappa(T_{t-1} - T_{t-2}) + \theta_{Tt}. \tag{1.20}$$

Using the derivations from Appendix B, consumption purchases can be expressed as follows:

$$(1.21) \qquad X_t = \gamma h(R-1)\left(\frac{\delta R-1}{\delta R(R-\gamma)}\right) + 1-\gamma)\left(1 - \frac{\gamma}{\delta R^2}\right) \left[1 - \left(\frac{\gamma}{R}\right)(1-\omega)\right]^{-1}$$

$$\left\{n_0 + n_k k_{t-1} + n_\ell \ell_{t-1} + n_\epsilon \epsilon_{t-1} + n_{T1} T_{t-1} + n_{T2} T_{t-2}\right\}$$

$$+ \qquad (\Gamma - \gamma(1-\omega))\sum_{\tau=0}^{\infty} \gamma^\tau (1-\omega)^\tau X_{t-\tau-1} + v_t,$$

where the n-coefficients are defined in Appendix B, and v_t is a random error term.

1.3. The Current Account

The non-interest current account of the balance-of-payments is given by the standard output minus absorption (i.e., national income accounting) equation:

$$(1.22) \qquad CA_t = Y_t - rA_{t-1} - (X_t + Z_t + G_t),$$

where G denotes government spending. Note that by adding and subtracting taxes from the right-hand-side of eq. (1.22), the current account can also be specified as the difference between saving (private and public) and investment. Using linearized versions of eqs. (1.1) and (1.2), eq. (1.11), and eq. (1.21), the current account can be expressed as a linear function of current and lagged values of the capital stock, employment, productivity, taxes, lagged consumption purchases, and government spending.

A distinguishing feature of the present rational-expectations optimizing analysis is that it allows for productivity and labor supply shocks to affect **jointly** saving and investment. Therefore, the model is capable of generating different sets of correlations between saving and investment, depending on the source and degree of permanence of these shocks as well as on their interaction with tax policy shocks (as in Obstfeld (1986)). The analysis, therefore, can provide interpretation for some of the controversies surrounding the puzzling correlations between saving and investment found by Feldstein and Horioka (1980) and elaborated upon by Dooley, Frankel, and Mathieson (1987), Ghosh (1988), Obstfeld (1986), and Roubini (1988). How these shocks affect the savings-investment balance is analyzed in section 4 below.

2. Empirical Implementation

The small-country model that we implement in this section consists of the production function (eq.(1.1)), the investment behavior (eqs.(1.5a) and (1.5b)), the consumption purchases behavior (eq.(1.21)), and the stochastic processes for labor, productivity, and taxes (eqs.(1.9), (1.10), and (1.20)). We use monthly time series data for Israel covering the period from 1980:1 to 1988:12.

To obtain time series of the productivity variable, we first estimate a logarithmic transformation of eq.(1.1). We set the capital elasticity, a, equal to the standard figure of 0.25, obtain an estimate for a_0, and compute the monthly productivity level ϵ_t'. Table 1.1 reports the behavior of productivity, ϵ_t', across subperiods classified according to macroeconomic regimes and Figure 3 portrays its behavior over the sample period. It can be seen that productivity shows a pattern of decline throughout the 1980s. There has also been a decline in the variability of productivity from the early 1980s to the latter part of the sample.

The derived productivity series (regardless of whether they reflect changes in technological progress, increased efficiency or better utilization of capital) are used in the next stage to estimate the investment behavior equation. This is done by using eqs.(1.3), (1.5a) and (1.5b) and by replacing the expected by the corresponding realized values (minus a forecast error) in eq.1.5a, based on the assumption of rational expectations. This yields:[16]

$$(1.23)\quad \frac{1}{2}R\left(\frac{I_{t+1}}{K_t}\right)^2 + \frac{I_t}{K_{t-1}} = \frac{(R-1)}{g} + R\,\frac{I_{t-1}}{K_{t-2}} - \left(\frac{\alpha a_0}{g}\right)\left(\frac{K_{t-1}}{L_t}\right)^{\alpha-1}\epsilon_t' + \theta_t,$$

where θ_t is a rational forecast error. We estimate this equation by least squares and obtain $g = 3.0$, standard error = 0.20, and $R^2 = 0.95$. The value of g implies that at the sample mean 2.8 percent of gross investment is accounted for by the cost of adjustment. Correspondingly, marginal q (see eq.(1.5b)) is 1.15 at the sample mean where standard errors are given in parentheses. These estimates indicate that shocks to labor employment are highly persistent. A different dynamic pattern holds for changes in productivity which show one-period cycles.

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[16]For simplicity we assume that $d = 0$, and $R = 1.002$.

TABLE 1.1: BEHAVIOR OF THE PRODUCTIVITY COEFFICIENT ACROSS SUBPERIODS

Period	Mean	Coefficient of Variation
1980:2 - 1981:2	1.54	0.18
1981:3 - 1983:9	1.10	0.11
1983:10 - 1985:6	0.94	0.04
1985:7 - 1987:12	0.84	0.06

Note: The productivity coefficient, ϵ', is calculated from the regression equation $\log Y_t = \log a_0 + 0.25 \log K_{t-1} + 0.75 \log L_t$. The estimate for log a_0 is 1.708 (standard error = .02), and R^2 = 0.47. Subperiods are chosen according to changes in the macroeconomic regimes. The period 1980:2-1981:2 featured temporarily tight fiscal and monetary policies. The following period, up to 1983:9, is characterized by relatively easy monetary and fiscal policies as well as by an overvalued currency. Rapid escalation of inflation, attempts to impose fiscal restraint, and real depreciations correspond to the period from 1983:10 to 1985:6. The last period follows the July 1985 inflation stabilization program.

The estimates for the parameters of the stochastic processes of labor and productivity change (eqs.(1.9) and (1.10) respectively) are as follows:

$$\ell_0 = \underset{(0.94)}{1.543} \qquad \phi = \underset{(0.031)}{0.940}$$

$$e_0 = \underset{(0.009)}{-0.017} \qquad \rho = \underset{(0.094)}{-0.347}$$

These parameter estimates together with those associated with from eqs.(1.1) and (1.23) and the calculated values of λ_1 (= 0.926) and λ_2 (=1.082) can be used to assess the fit of the capital-accumulation equation (eq. (1.11)). Figure 5 plots the actual and the fitted values (of the capital stock), and Figure 4.1. plots the actual and predicted values of "gross" investment, Z_t (see Eq.(1.2)). On the whole, the model fits the data reasonably well. Note that there is a slight tendency of over acceleration in capital accumulation in the later periods of the sample. A variance decomposition based on the parameter estimates and on eq.(1.11) indicates that 55 percent of the variance of $k_t - \lambda_1 k_{t-1}$ is accounted for by the ϵ and e shocks. Thus, productivity shocks appear to play an important role in the process of capital accumulation.

Next, we turn to the estimation of the consumption-purchases relation (eq.(1.21)) jointly with the process for tax revenue (eq.(1.20)). We estimate this system under several auxiliary assumptions: (i) the interest factor, R, is set equal to 1.002 (as in the estimation of the investment equation); (ii) the finite-life coefficient, γ, is set equal to 0.998, the value obtained in our previous work (see Leiderman and Razin (1988)); and (iii) the number of lags of consumption purchases is set equal to eight. The system is estimated for the sample period 1980:10 - 1988:12.

Estimation is performed by nonlinear least squares jointly applied to the system. The estimator is based on computing maximum likelihood, and the estimates are obtained by concentrating variance parameters out of the multivariate likelihood, and then maximizing the negative of the log-determinant of the residual-covariance matrix. As is well known, the estimates are efficient if the disturbances are multivariate normal and identically distributed.

Table 1.2 reports estimates for the unrestricted and retricted versions of the system. The parameter estimate for κ is negative (and smaller than one in absolute value), indicating that shocks to taxes give rise to a one-month cycle in tax revenue. The utility function parameter h is positive and its per-capita value at population'ssample mean, is 37.86. This value (which is not precisely estimated) is larger than per-capita consumption values over the sample, as required to ensure positive marginal utility. The implied degree of relative risk aversion (C/(h-C)) is 0.1 at consumption's sample mean. The monthly subjective discount factor is close to one, and the consumer durability parameter is 0.569. All in all, the estimates seem to conform to their theoretical counterparts in the model. The likelihood ratio based on comparing the restricted and unrestricted systems in Table 1.2 is 22 (with 12 degrees of freedom). Thus, the overidentifying restrictions imposed by the model are not rejected by the data at usual significance levels.

Using the parameter estimates of the investment and saving blocks of the model, we calculate the "predicted" values for the current account of the private sector and compare those with the actual values. The comparison is graphically given in figure 4.2. It can be seen that the model tracks reasonably well movements in the external balance position of the private sector.

TABLE 1.2: THE CONSUMPTION AND TAX EQUATIONS

I. Unrestricted System

$$T_t - T_{t-1} = \underset{(0.085)}{-\,0.573}\,(T_{t-1} - T_{t-2})$$

$$
\begin{aligned}
X_t = {} & \underset{(1880.6)}{6262.6} + \underset{(0.002)}{0.005}\, k_{t-1} + \underset{(3.765)}{13.032}\, \ell_{t-1} + \underset{(1101.7)}{3182.4}\, \epsilon_{t-1} \\
& \underset{(1209.0)}{-2452.2}\, e_{t-1} + \underset{(0.091)}{0.103}\, T_{t-1} + \underset{(0.091)}{0.241}\, T_{t-2} + \\
& \underset{(0.096)}{0.275}\, X_{t-1} + \underset{(0.102)}{0.052}\, X_{t-2} + \underset{(0.093)}{0.114}\, X_{t-3} \underset{(0.089)}{-0.045}\, X_{t-4} + \underset{(0.096)}{0.156}\, X_{t-5} \\
& \underset{(0.102)}{-0.102}\, X_{t-6} \underset{(0.100)}{-0.140}\, X_{t-7} + \underset{(0.090)}{0.010}\, X_{t-8}
\end{aligned}
$$

Log of Likelihood Function = -1556.74

II. Restricted System

$\kappa = \underset{(0.079)}{-0.545}$ (AR1 coefficient in tax equation (20))

$h = \underset{(189000.0)}{159000.0}$ (constant in the utility function $hc - 1/2c^2$)

$\delta = \underset{(0.016)}{1.003}$ (subjective discount factor)

$\omega = \underset{(0.082)}{0.431}$ (consumer goods depreciation coefficient)

Log of Likelihood function = -1575.86.

χ^2 critical 0.01 value (12 d.f.) = 26.22.
Figures in parentheses are estimated standard errors.

APPENDIX 2 - THE REDUCED-FORMS' COEFFICIENTS IN TERMS OF FUNDAMENTAL PARAMETERS

I. Coefficients for Equations (4)-(6) in Text

Define the quadratic equation $1 + a_0\lambda + a_1\lambda^2 = 0$ where

$$a_0 = -\left(1 + \frac{(1-d)}{R} + \frac{\bar{K}}{gR}\left[\alpha(1-\alpha)a_0\bar{K}^{\alpha-2}\bar{L}^{1-\alpha}\epsilon'\right]\right),$$

$$a_1 = (1-d)R^{-1}$$

Then, λ_1 and λ_2 are the roots of this equation. Define

$$b_L = -\frac{1}{gR}\alpha a_0(1-\alpha)(\bar{K})^{\alpha}(\bar{L})^{-\alpha}\bar{\epsilon}',$$

$$b_\epsilon = -\frac{1}{gR}\alpha a_0(\bar{K})^{\alpha}(\bar{L})^{(1-\alpha)}.$$

Accordingly, the m coefficients in eq.(4) are:

$$m_L = \frac{-\lambda_1 b_L\phi\lambda_2}{\lambda_2-\phi},$$

$$m_\epsilon = \frac{\lambda_1 b_\epsilon\lambda_2}{\lambda_2-1},$$

$$m_e = -\lambda_1 b_\epsilon\frac{\rho}{(1-\rho)}\left[\frac{\lambda_2}{\lambda_2-1} - \frac{\lambda_2\rho}{\lambda_2-\rho}\right].$$

The h and s coefficients in (5) and (6) are:

$$h_k = \alpha a_0 (\bar{K})^{\alpha-1} (\bar{L})^{1-\alpha} \bar{\epsilon}', \qquad s_k = (1-\alpha) a_0 \alpha (\bar{K})^{\alpha-1} (\bar{L})^{1-\alpha},$$

$$h_\ell = (1-\alpha)\ a_0 (\bar{K})^{\alpha} (\bar{L})^{-\alpha} \bar{\epsilon}', \qquad s_\ell = -(1-\alpha) a_0 \alpha (\bar{K})^{\alpha} (\bar{L})^{-\alpha-1},$$

$$h_\epsilon = a_0 (\bar{K})^{\alpha} (\bar{L})^{1-\alpha} \qquad s_\epsilon = (1-\alpha) a_0 (\bar{K})^{\alpha} (\bar{L})^{-\alpha}.$$

II. Coefficients for Equation (9)

The β-coefficients in (9) are:

$$\beta_0 = \gamma h \frac{1-\delta R}{\delta R(R-\gamma)}, \quad \text{and}$$

$$\beta_1 = \left[1 - \frac{\gamma}{\delta R^2}\right]\left[1 - \left(\frac{\gamma}{R}\right)(1-\omega)\right]^{-1},$$

where the intertemporal elasticity of substitution is $(h-C)/C$, δ is the subjective discount factor, R is one plus the rate of interest, γ is the survival probability, and ω is the rate of depreciation of the stock of consumption.

III. Coefficients for Equation (11)

The n coefficients are given by

$$n_0 = \left(\frac{R}{R-\gamma}\right)\bar{Y} - \Bigg[\left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right)\left(m_\ell\left(\frac{R}{R-\gamma\lambda_1}\right)\left(\frac{\gamma}{R-\gamma\phi}\right)\right.$$

$$- m_\ell\left(\frac{\gamma^2}{1-\phi}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)$$

$$\cdot\left(\frac{1}{R-\gamma} - \frac{1}{R-\gamma\phi}\right) - \lambda_1 b_L\left(\frac{1}{1-\phi}\right)\left(\frac{\lambda_2}{\lambda_2-1} - \frac{\phi\lambda_2}{\lambda_2-\phi}\right)\left(\frac{\gamma R}{\rho-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)\Big) +$$

$$+ h_\ell\left(\frac{R}{R-\gamma\phi}\right) + h_\ell\left(\frac{R}{1-\phi}\right)\left(\frac{1}{R-\gamma} - \frac{1}{R-\gamma\phi}\right)\Bigg]\ell_0 +$$

$$+ \Bigg\{-\left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right)\Bigg(m_\epsilon\Bigg[\left(\frac{1}{\lambda_1}\right)\left(\frac{R}{R-\gamma\lambda_1}\right) + \left(\frac{\gamma}{\lambda_1}\right)^2\left(\frac{1}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right) +$$

$$+ \left(\frac{R}{1-\rho}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)\left(\frac{\gamma^2}{R\lambda_1-\gamma}\right) - \frac{\rho}{(1-\rho)^2}\left(\frac{\gamma}{\lambda_1}\right)^2\left(\frac{1}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)$$

$$+ \left(\frac{\gamma\rho}{1-\rho}\right)^2\left(\frac{1}{R-\gamma\rho}\right)\left(\frac{1}{R-\gamma\lambda_1}\right) + \left(\frac{\rho}{1-\rho}\right)\left(\frac{\gamma}{\lambda_1}\right)^2\left(\frac{1}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right) -$$

$$\left(\frac{\gamma^2\rho^2}{1-\rho}\right)\left(\frac{1}{R-\gamma\rho}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)\Bigg] - \left(\frac{\lambda_1 b_\epsilon}{1-\rho}\right)\Bigg[\left(\frac{1}{\lambda_2}\right)\left(\frac{\lambda_2}{\tau_2-1}\right)^2\left(\frac{1-2\rho}{1-\rho}\right)\left(\frac{\lambda_2}{\lambda_2-1}\right)$$

$$+ \left(\frac{\rho^2}{1-\rho}\right)\left(\frac{\lambda_2}{\lambda_2-\rho}\right)\Bigg]\left(\frac{\gamma R}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)\Bigg) + h_\epsilon\Bigg[\left(\frac{R}{R-\gamma}\right) + \left(\frac{\gamma R}{1-\rho}\right)\left(\frac{1}{R-\gamma}\right)^2$$

$$- \frac{\rho}{(1-\rho)^2}\left(\frac{\gamma}{R-\gamma}\right) + \left(\frac{\rho}{1-\rho}\right)^2\left(\frac{\gamma}{R-\gamma\rho}\right) + \left(\frac{\rho}{1-\rho}\right)\left(\frac{\gamma}{R-\gamma}\right) - \left(\frac{\rho}{1-\rho}\right)\left(\frac{\gamma\rho}{R-\gamma\rho}\right)\Bigg]$$

$$- \left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right) m_e\Bigg[\left(\frac{\gamma R}{R-\gamma\rho}\right)\left(\frac{1}{R-\gamma\lambda_1}\right) + \left(\frac{\gamma^2}{1-\rho}\right)\left(\frac{R}{R-\gamma\lambda_1}\right)\left(\frac{1}{R-\gamma}\right)$$

$$- \left(\frac{1}{1-\rho}\right)\left(\frac{\gamma}{R}\right)^2\left(\frac{\rho R}{R-\gamma\rho}\right)\Bigg]\Bigg\}e_0$$

$$n_k = \left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right)\left(\frac{R}{R-\gamma\lambda_1}\right) + \frac{R}{\gamma}$$

$$n_\ell = - \left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right)\phi m_L\left(\frac{R}{R-\gamma\lambda_1}\right)\left(\frac{\gamma}{R-\gamma\phi}\right) + h_L\left(\frac{\phi R}{R-\gamma\phi}\right)$$

$$n_\epsilon = - \left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right) m_\epsilon\left[\left(\frac{1}{\lambda_1}\right)\left(\frac{R}{R-\gamma\lambda_1}\right) + \left(\frac{\gamma}{\lambda_1}\right)^2\left(\frac{1}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)\right] + h_\epsilon\left(\frac{R}{R-\gamma}\right)$$

$$n_e = - \left(h_k\left(1 - \frac{R}{\gamma h_k}\right) + 1\right)\rho\Bigg\{m_\epsilon\Bigg[\left(\frac{1}{\lambda_1}\right)\left(\frac{R}{R-\gamma\lambda_1}\right) + \left(\frac{\gamma}{\lambda_1}\right)\left(\frac{1}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)$$

$$+ \left(\frac{\rho}{1-\rho}\right)\left(\frac{\gamma}{\lambda_1}\right)^2\left(\frac{1}{R-\gamma}\right)\left(\frac{1}{R-\gamma\lambda_1}\right) - \left(\frac{\gamma^2\rho^2}{1-\rho}\right)\left(\frac{1}{R-\gamma\rho}\right)\left(\frac{R}{R-\gamma\lambda_1}\right)\Bigg]$$

$$+ m_e\left(\frac{\gamma R}{R-\gamma\rho}\right)\left(\frac{1}{R-\gamma\lambda_1}\right)\Bigg\} + h_\epsilon\rho\left[\left(\frac{R}{R-\gamma}\right) + \left(\frac{\rho}{1-\rho}\right)\left(\frac{\gamma}{R-\gamma}\right) - \left(\frac{\rho}{1-\rho}\right)\left(\frac{\gamma\rho}{R-\gamma\rho}\right)\right].$$

APPENDIX 3: THE SIMULATION MODEL

The linearized model used in the simulations consists of the following equations:

(3.1) $K_t = \bar{K} + \lambda_1 k_{t-1} - m_\ell \ell_t - m_\epsilon \epsilon_t - m_e e_t,$ (Capital)

(3.2) $Y_t = \bar{Y} + h_k k_{t-1} + h_\ell \ell_t + h_\epsilon \epsilon_t,$ (Output)

(3.3) $S_t = \bar{S} + s_k k_{t-1} + s_\ell \ell_t + s_\epsilon \epsilon_t,$ (Real Wage)

(3.4) $Z_t = (k_t - k_{t-1})(1 + \frac{g}{2} \frac{(k_t - k_{t-1})}{k_{t-1} + k})$ (Investment)

(3.5) $$C_t = \beta_0 + \beta_1 \Big[n_0 + n_k k_{t-1} + n_\ell \ell_{t-1} + n_\epsilon \epsilon_{t-1} + n_e e_{t-1} + n_{T1} T_{t-1} + n_{T2} T_{t-2} - (R/\gamma) a_{t-1} + (1-\omega)\gamma C_{t-1} \Big]$$ (Consumption Stock)

(3.6) $X_t = C_t - (1-\omega) C_{t-1}$ (Consumption Purchases)

(3.7) $X_t + Z_t = Y_t - r a_{t-1} - T_t + (a_t - a_{t-1})$ (Resource Constraint)

(3.8) $CA_t = a_{t-1} - a_t$ (Private Sector Current Account Surplus)

(3.9) $\ell_t = \phi \ell_{t-1}$ (Employment Process)

(3.10) $\epsilon_t = e_t + \epsilon_{t-1}$ (Productivity)

(3.11) $e_t = \rho e_{t-1}$ (Change in Productivity Process)

(3.12) $T_t = T_{t-1} + \kappa(T_{t-1} - T_{t-2})$ (Taxes' Process)

Equation (3.1) corresponds to Eq.(11) in the text, eq.(3.3) is a linearized version of Eq.(6), eq.(3.4) corresponds to eq.(2) in the text, eq.(3.5) is derived from eqs.(18), (20) and (B3), eq.(3.6) corresponds to Eq.(13), eq.(3.7) is the resource constraint of the private sector and eq.(3.8) is the current account surplus of the private sector (external balance). Equations (3.9), (3.11) and (3.12) are the dynamic processes for the driving forces: employment (see eq.(9)), change in productivity (see Eq.(10)), and taxes (see eq.(20)). We have set $e_0 = \ell_0 = 0$ to assure the existence of a steady state. The model's coefficients are given as functions of the underlying parameters in Appendix 2 as well as in eq.(17) in the text. The coefficients of eq.(3.3) are:

$$s_k = (1-\alpha)a_0\alpha(\bar{K})^{\alpha-1}(\bar{L})^{1-\alpha},$$

$$s_\ell = -(1-\alpha)a_0\alpha(\bar{K})^{\alpha}(\bar{L})^{-\alpha-1},$$

$$s_\epsilon = (1-\alpha)a_0(\bar{K})^{\alpha}(\bar{L})^{-\alpha}.$$

The baseline scenario for the simulations is based on the following parameter values and initial conditions:

Parameters	**Initial Condition**
$\phi = 0.94$	$k_{-1} = -223552$
$\rho = -0.35$	$X_{-1} = 15000$
$\kappa = -0.57$	$a_{-1} = 0$
$R = 1.002$	$\ell_{-1} = 0$
$\gamma = 0.998$	$\epsilon_{-1} = 0$
$\omega = 0.43$	$e_{-1} = 0$
$\delta = 0.997$	$T_{-1} = 0$
$h = 159000$	$T_{-2} = 0$
$\alpha = 0.25$	$\bar{L} = 1220.$
$\alpha_0 = 1.71$	
$g = 3.0$	

Also λ_1 and λ_2 are solved from

$$1 + q_0\lambda + q_1\lambda^2 = 0,$$

where

$$q_0 = \left\{-(g/\bar{k}) + (1/R)[\alpha(\alpha-1)\alpha_0(\bar{K})^{\alpha-2}(\bar{L})^{1-\alpha} - (g/\bar{K})]\right\}(\bar{K}/g),$$

and $q_1 = 1/R$.

The steady state values in the baseline scenario are as follows:

$$\bar{K} = \bar{L}\left[(R-1)/\alpha\alpha_0\right]^{\frac{1}{\alpha-1}}$$

$$\bar{Y} = \alpha_0(\bar{K})^{\alpha}(\bar{L})^{(1-\alpha)}$$

$$\bar{S} = (1-\alpha)\alpha_0(\bar{K})^{\alpha}(\bar{L})^{-\alpha}$$

$$\bar{Z} = \bar{I} = d\bar{K}.$$

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