Exchange-Rate Adjustment, Trade Policy and
Economic Growth: Experiments with a Dynamic General
Equilibrium Model of Turkey

by

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Part I. Introduction

The aim of this paper is to analyze alternative adjustment mechanisms to foreign-exchange shortages using a fairly elaborate, non-linear general equilibrium model of the Turkish economy. After briefly motivating the type of model used in Part I, its distinctive features and properties are summarized in Part II. Part III presents the results of various policy alternatives. The full formal model in equation form is presented in the Appendix.

Trade policy, broadly defined, essentially affects an economic system through the changes in relative prices that can be achieved by alternative tariff and subsidy structures or alternative exchange-rate policies. It is these changes in relative prices that constitute the link leading from instrument variables such as tariff and exchange-rates to target variables such as rates of reserve accumulation, rates of G.D.P. growth, or desired economic structure. Given the prominent role relative prices play in trade theory and the analysis of trade policy, it is clear that efforts at modelling the effects of trade policy with economy-wide multi-sector models should above all aim at a correct specification of the mechanism of relative price determination and its links to government trade policy. It is the modelling of this link that proved very difficult for the many multi-sector linear programming models built in the 1960's. For a traditional programming model with relative shadow prices determined as a by-product of the optimization procedure, it is very difficult to incorporate exogenous constraints involving endogenous relative-prices or simulate the effects
of policy induced changes in these endogenous prices.¹

One of the major advantages of the class of non-linear computable general equilibrium models developed in the 1970's is the case with which exogenous policy constraints can be imposed on the relative price system. Thus while the proper specification of tariffs, export subsidies or fixed exchange rates is not an easy matter for a large-scale programming model, it presents no difficulties at all within the framework of a general equilibrium simulation model. It is true that for practical purposes the non-linear simulation models have not yet been able to generate "optimal" policies or "optimal" growth paths and that their realism and flexibility has been achieved by giving up, at least temporarily, explicit optimization. But for many purposes the benefits, in terms of policy relevance and realism, far outweigh the loss of explicit optimization.

The present paper presents some preliminary experiments with a general equilibrium trade and growth model of Turkey designed to explore the effects of exchange-rate adjustment on economic growth in the 1976-1980 period. A forthcoming second paper will present the results of longer-run experiments designed to analyse the effects of alternative overall trade-strategies on growth performance in the next decade. The results are preliminary and based on a tentative, rough data set. Although the model has been carefully fitted to its 1973 base-year and adequately simulates Turkish development in the 1973-1976 period, more

¹Much progress has been made recently in extending the programming approach to allow for price and budget constraints and the modelling of decentralized behavior. See for instance Dixon (1975), Duloy and Norton (1975) and Ginsburgh and Waelbroeck (1976).
elaborate and detailed empirical work is required before the many parameters of the equation system can be established with a greater degree of confidence. The results of this paper should therefore be considered as tentative and designed to stimulate discussion.
Part II. Special Features of the Model

The model we use is in the tradition of the non-linear computable general equilibrium models that have been built over the past five years for development planning purposes. The original inspiration for this class of models can be found in Leif Johansen's 1960 model of the Norwegian economy, but computational difficulties at that time prevented the implementation of Johansen's ideas.

In the 1970's, Adelman and Robinson have built what is certainly the largest and most elaborate general equilibrium model to date and computational problems have essentially ceased to be an obstacle.

Our model is very close to the model used in Robinson and De Melo (1976) and De Melo and Dervis (1977) and the specification adopted reflects much intensive joint-thinking done over the last few years.

Import Demands and Relative Prices

Many of the distinctive features of the model relate to the foreign-trade sector that constitutes its focus of interest. As in many other areas of economics, the necessity of aggregation lies at the root of many difficult problems. For purposes of model building

and planning, the most unrealistic assumption of trade theory is the one that treats foreign and domestic goods of the same sectoral classification as identical. The assumption is essentially harmless when it is used to obtain the many important qualitative results and theorems of trade theory. But when it is incorporated into applied planning or model-building exercises, it leads to extremely unrealistic results. Under such a homogeneity assumption, the structure of production and consumption in a given country will be extremely sensitive to slight relative-price variations between foreign and domestic goods, leading to overestimation of the effects of exchange-rate policies as well as a tendency to specialize in the production of a few commodities that in no way reflects the situation in the real world.

An elegant formulation that allows one to keep aggregative commodity categories across countries, but introduces product differentiation by countries of origin into the structure of demand for commodities in any given country, was proposed and implemented in a partial equilibrium framework by Armington in 1969. The crucial assumption is that "marginal rates of substitution between any two products of the same kind (i.e., commodity category) must be independent of the quantities of the products of all other kinds." (Armington 1969)

Robinson and De Melo (1976) have carefully embedded Armington's C.E.S. aggregation into a single-country C.G.E. model, while De Melo, Dervis and Robinson (1977) discuss the use of the same idea within the framework of a proposed multi-region global model of world trade. Deardorff, Stern and Baum (1976) use much the same idea in their study of multilateral trade liberalization, and Petri (1976) uses a somewhat different form of product differentiation with similar practical consequences.
Within the framework of a single country model, the basic idea is to define an "aggregate" commodity that is a C.E.S. function of commodities produced abroad or imports, $M_i$, and commodities produced at home, $D_i$. The aggregation takes the familiar C.E.S. form:

$$Q_i = \gamma_i \left[ \delta_i M_i^{-\rho_i} + (1-\delta_i) D_i^{-\rho_i} \right]^{-1/\rho_i} \quad i=1,\ldots,n_t \quad (1)$$

where $\gamma_i$, $\delta_i$, and $\rho_i$ are the parameters of the C.E.S. function in sector $i$, with $\frac{1}{1+\rho_i} = \sigma_i$ defining the elasticity of substitution. $M_i$ and $D_i$ are like inputs "producing" the aggregate output. Their ratio to each other is determined by relative prices and the sensitivity of this ratio to variations in relative prices varies directly with the elasticity of substitution. The model contains a total of $n$ sectors, of which the first $n_t$ sectors constitutes the subset of sectors producing tradable commodities. The remaining $n-n_t$ sectors produce non-tradables.

The price of the aggregate output, $P_i$, is linked to the price of imports $PM_i$ and the price of domestic goods $PD_i$, by the cost-function derived from the C.E.S. aggregation function:

$$P_i = \frac{1}{\gamma_i} \left[ \delta_i \sigma_i PM_i^{1-\sigma_i} + (1-\delta_i) \sigma_i PD_i^{1-\sigma_i} \right]^{1/(1-\sigma_i)} \quad i=1,\ldots,n_t$$

Consumer demand, intermediate demand and investment demand in the model is for the aggregate commodity $Q_i$ and the price paid for this
aggregate commodity is $P_i$. The demand for imports thus becomes a derived demand, in just the same way as the demand for factor inputs is a derived demand in a traditional production model.

Government policy directly affects import prices. Adopting the small country assumption, we specify fixed world prices $\Pi_i$. Denoting ad valorem tariffs by $t_i$ and the exchange-rate by $ER$, we get

$$PM = \Pi_i (1+t_i) \cdot ER$$

for any given time period. Government policy determines $t_i$ and, depending on the exchange-rate regime, $ER$. With $\Pi_i$ fixed, this determines $PM_i$. $PD_i$ on the other hand is free to vary so as to equate the supply of domestically produced goods to the demand that is again a derived demand sensitive to the $PM_i/PD_i$ ratio. Note that in the models following the assumptions of pure trade theory, there is no distinction between the foreign and the domestic components with a given sectoral aggregation and $PM_i = PD_i = \Pi_i (1+t_i) \cdot ER$. This leads to the complete determination of all prices of tradable commodities by the world price and tariff equations alone, with demand and supply conditions playing no role whatsoever in the determination of relative in prices of tradable commodities. The model becomes one/which quantities passively adjust to predetermined relative prices. This of course greatly exaggerates the actual control trade policy has over domestic relative prices. In the C.E.S. formulation adopted here, not only the
prices of non-tradable commodities but also the prices of domestically produced tradables are free to vary and cannot be tightly controlled through tariff policy, although they will of course be influenced by changes in the prices of imported commodities due to tariff changes or exchange-rate adjustment.

The Treatment of Exports

The treatment of exports presents even greater difficulties than the treatment of imports. Sticking to the small country assumption, one can argue that export prices are determined in world markets in a manner similar to import prices.

\[ PE_i = \Pi_i^E (1 + s_i) ER \quad i=1, \ldots, nt \]

where \( PE_i \) is the price faced by the domestic exporter, \( \Pi_i^E \) the world price of exports and \( s_i \) the rate of export subsidy. One could thus argue, as done by Robinson and De Melo (1976), that commodity \( i \) will be exported as long as \( PE_i > PD_i \), indeed until domestic production costs are pushed up sufficiently to equate \( PD_i \) to \( PE_i \). This would be in conformity with the basic logic of the model. Furthermore, whenever \( PE_i < PD_i \), there would be no exports.

The problem with such a formulation however, even granted the small country assumption usually considered more debatable for exports
then on the import side, is that it will not yield realistic export behavior. Under conditions of only moderately rising domestic supply curves, it will lead to unrealistically strong export responses to exchange rate adjustment.

It is of course possible to drop the small country assumption but this introduces the necessity of dealing with foreign demand parameters in a single country model.\(^3\)

Instead, we propose the introduction of a kind of further product differentiation, this time on the export side. Let the price of exportables be determined in world markets but let us drop the assumption that there is unrestricted access to foreign markets and that exports will always force \( PD_i \geq PE_i \), and will only take place if \( PD_i = PE_i \). Instead exports are considered a differentiated product within the domestic sector and we allow \( PD_i > PE_i \) as well as \( PE_i < PD_i \). Export performance, or the share of exports in domestic output, will become a function of the relative price differential between exports and domestically sold commodities, with sectoral exports growing at faster rates when export prices lie above domestic prices. We have explored two variants of this idea. In one, year-to-year export growth rates are written as functions of past years' price differentials while in another, the share of exports in domestic output are functions of

\(^3\)It is, in a way, easier to deal elegantly with this problem in a multi-country model where exports and imports can be treated fully symmetrically. For such a specification see De Melo, Dervis and Robinson (1977).
current or past price differentials. Although it is possible to generate much more realistic export behavior when such price differentials are allowed to persist, it must be admitted that the various functional forms linking export shares, or export growth-rates, to the relevant price-differentials are of a rather "ad hoc" nature. There is here great need for careful econometric work, though the price data needed for such work are very hard to get by.

**Labor Markets and Migration**

In each sector we specify a simple single-level Cobb-Douglas or C.E.S. production function. The experiments reported on below deal with the Cobb-Douglas case only. There are no different skill categories but we distinguish between rural-agricultural and urban labor. In the urban sectors, the real-wages are fixed and rise at an exogenously predetermined rate regarded as determined by government policy and the balance of socio-economic power. Labor-markets are essentially of the Lewis-Harris-Todaro type, with migration to the cities regulated by the differential between the expected urban wage and the endogenously determined agricultural wage. The expected urban wage $W^e$ is equal to the weighted average of the fixed sectoral urban wages multiplied by the urban employment rate:


4The specification of migration follows De Melo and Dervis (1977).
\[ W^e = \left( \sum_{i \in U} \frac{L_i}{\bar{W}_i} \right) \left( \sum_{i \in U} \frac{L_i}{URL} \right) \]

where \( L_i \) is sectoral employment, \( URL \) the total urban labor force and \( U \) the set of urban sectors. Migration is then a function of total labor left in agriculture and the difference between \( W^e \) and the wage in agriculture. We assume that the structure of urban wage differentials, reflecting skill composition as well as relative union power, will remain constant over time.

**Capital and Investment**

Capital is heterogeneous and differentiated by sector of destination. Once installed, capital stock cannot be transferred from one sector to another. The production functions take the form

\[ X_{it} = (1+g_i) A_{i0} K_i^{a_i} L_i^{b_i} \]

\[ i=1,...,n \]

where \( X_{it} \) is the level of output in period \( t \), \( A_{i0} \) is the base-year Cobb-Douglas shift parameter, \( g_i \) the sectoral neutral technical progress rate, \( K_i^{1(t-1)} \) the capital stock available and fully installed last year, \( L_i \) the current labor employed, and \( a_i \) and \( b_i \) the Cobb-Douglas exponents.

The capital stock is updated in each sector through dynamic linkage equations of the form:
\[ K_{it} = (1 - \delta) K_{i(t-1)} + Y_{it} \quad i=1, \ldots, n \]

What must be determined each year endogenously is the amount and structure of investment, \( Y_{it} \).

In the experiments reported on below we assume a fixed savings-rate determining the amount of total investment as a fraction of national income. The distribution of this total investment by sectors of destination is governed by the distribution of profits and the structure of profit-rates. Define \( H_{it} \) to be the share of total investment, \( \text{INV}_t \), that goes to sector \( i \), and let \( SP_i \) denote the share of total profits originating in sector \( i \). Investment shares are determined in the following way:

\[ H_{it} = SP_i + \Gamma \frac{R_i - AR}{AR} \quad i=1, \ldots, n \]

where \( AR \) is the average economy-wide profit-rate and \( R_i \) is the profit-rate in sector \( i \). The parameter \( \Gamma \) reflects the extent of intersectoral mobility of investment funds. Note that if \( \Gamma = 0 \), investment shares would equal profit shares. With a positive \( \Gamma \), high profit-rate sectors will be able to attract funds from low profit-sectors and the profit-rate structure will directly affect the allocation of investment. Once the \( H_{it} \) are found, investment is simply determined by the following allocation equations, where \( U_{it} \) denotes capital prices.

\[ Y_{it} = H_{it} \frac{\text{INV}_t}{U_{it}} \quad i=1, \ldots, n \]

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\(^5\)Investment is thus not fixed in real terms or in nominal terms, but as a nominal ratio of total income. This contrasts with the approach taken in the recent very interesting set of papers by Taylor and others (Taylor 1977) that take a much more Keynesian approach. We shall further discuss the issue in the context of the policy experiments presented below.
Inflation and the Price-Level

Most general equilibrium models determine only relative prices and need an extra normalization equation to fix the absolute price-level. In the present case, the normalization equation requires the weighted sum of domestic and import prices to equal a predetermined price level index $XPL$. We have:

$$
\sum_{i=1}^{n} PD_i \left( \frac{D_i}{\sum D_i + \sum M_i} \right) + \sum_{i=1}^{n} PM_i \left( \frac{M_i}{\sum D_i + \sum M_i} \right) = XPL
$$

It is easy to impose an exogenous inflation rate on the model by letting $XPL$ grow over time at some predetermined rate. The model results can thus be made consistent with real-world nominal developments and exchange-rate adjustments. It is important to note however that there is no theory of inflation provided in the model and that nothing that happens elsewhere in the model has an effect on the predetermined price-level variable. In particular a devaluation does not generate cost-push effects and is modelled as a pure relative-price adjustment mechanism with no monetary implications. Whatever monetary changes may occur are assumed to be counteracted by central bank policy.

This concludes our discussion of the most important distinctive features of the model. The full equation system and a list of all variables is presented in the appendix. Let us now turn to a discussion of some experiments designed to analyze the effects of exchange-rate adjustment on economic growth and structure in the Turkish economy.

The Foreign-Exchange Gap

The balance-of-payments equation used in the model is of the form:

\[
\text{Total Exports} - \text{Total Imports} + \text{Net Foreign Capital Inflow} + \text{Workers Remittances} + \text{Net Tourism Revenues} = \Delta R
\]

If the exchange-rate is fixed for any one period, \( \Delta R \), the level of foreign reserve accumulation, becomes an endogenous variable. If \( \Delta R \) is negative, the country will lose reserves. We shall call \(-\Delta R\) the foreign-exchange gap. It can also be interpreted as a measure of the need for additional short-term borrowing necessary to finance the balance-of-payments deficit in any one period.

In the case of a flexible exchange-rate regime, \( \Delta R \) will always remain equal to zero and \( ER^* \), the exchange-rate, will move to equate the current demand for foreign-exchange to the current supply of foreign-exchange. In that case, strictly speaking, there is no foreign-exchange gap. This does not however mean that changes in foreign-exchange flows such as for instance a fall in exogenously specified workers remittances, will have no effect on the behavior and growth of the system under flexible exchange-rate conditions. Indeed in many ways the fixed and the flexible exchange rate cases are not as different as it may at first appear.

Consider for instance the case of a fixed exchange-rate simulation over a four year period that leads to a foreign-exchange gap of one billion dollars a year. We thus have \( \Delta R = -1000 \text{ M.} \) for
t=1,…,4. If this deficit could be financed by either running down reserves or by short-term borrowing, it would have no further consequences, within the period considered. If however we have already included in our exogenously specified foreign-capital flows all the funds a country can reasonably expect to borrow and, if there are no more reserves to be run down, we have in fact simulated an unfeasible alternative and ΔR represents a "true" foreign-exchange-gap. Something in the system has to "give": The rate of capital accumulation may have to drop, tariffs and other import restrictions may have to rise, or, giving up the fixed exchange-rate assumption, there may have to be a devaluation.

If the exchange-rate had been specified as flexible, the foreign-exchange gap would never have appeared explicitly. But it would have been "implicit" in the tendency of the dollar exchange-rate to rise. In both cases the economy has to react and adjust to the explicit or implicit foreign-exchange gap. It is true that an explicit gap can be regarded as the manifestation of an overvalued currency and that exchange-rate adjustment can reduce or close the gap. But what is also true is that exchange-rate adjustment, while closing the gap, will affect the overall growth-rate of the economy. It is these growth-costs of a devaluation that may lie at the root of the "structuralist" resistance to accepting it as a policy-cure. The existence of these growth-costs should not be denied. 6 The question

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6See Findlay (1971) for an excellent discussion and a diagrammatic treatment of the foreign-exchange gap problem.
is not whether an underlying foreign payments disequilibrium will or will not be costly to correct. The real question is what the nature of these costs are and how they can be kept to a minimum. It is this issue that we propose to explore below by simulating the effects of alternative policy reactions to the foreign-exchange gap that Turkey faces in 1977.
Prospects for 1977-1980

Turkey, in the second half of the present decade, presents a typical example of a developing economy that must react and adjust to a serious foreign-exchange gap. After a period of extremely rapid growth, with domestic product growing at 8% per annum during the 1973-1976 period, the economy now faces very serious foreign-exchange shortages. The trade deficit has risen from about 800 million dollars in 1973 to about 3300 million dollars in 1975 and 1976. Remittances from Turkish labor working abroad, that in 1973 more than compensated the trade deficit, presently fail to cover more than one quarter of it. Figure 1 provides a summary of the most important aspects of the balance-of-payments over the last few years.

There is little doubt that the very rapid growth rates of the 1973-76 period were at least partly due to the availability of a stock of foreign-exchange reserves that exceeded 2 billion dollars in 1973. At the time this stock was equal to Turkey's yearly import bill. It did not however resist the oil price increases, the rapid investment rates of the 1974 and 1975 years, and domestic inflation averaging about 22% a year. At the end of 1975 the foreign-exchange gap was already apparent only two years after the "plenty" of 1973. The rapid growth realized in 1976 and the relatively low level at which the dollar exchange-rate was maintained, were only made possible through an extraordinary level of short-term borrowing reaching a net figure of 1300 million dollars in 1976, not counting the use of I.M.F. facilities. Thanks to this short-term euro-dollar flow, imports continued at a high level without greatly appreciating
Figure 1. The Balance-of-Payments 1969-1976 (Source: T.S.U.E.)
in price, investment proceeded and there were relatively few shortages of intermediate goods. While it was possible to buy some time, the situation in 1977 is such that a serious adjustment can no longer be delayed. It is the nature of this adjustment that we want to explore below.

If, as a working hypothesis, one were to consider the 1973 real exchange-rate as a long-run equilibrium rate, and if one wanted to maintain this rate in real terms, it would have been necessary to devalue the Turkish Lira by about 75% by 1977 relative to its 1973 dollar value, taking account of the differential inflation rates in Turkey and her trading partners. This would imply a dollar exchange-rate of about 24 T.L. in 1977 instead of the 18.75 T.L. current rate. It is not easy to determine what an optimal rate of devaluation should be. But to show that a mini-devaluation only would not constitute a realistic policy, we undertook the following experiments with our general equilibrium model.

Assume that import taxes and export subsidies remain constant during the 1977-80 period. Further assume that inflation continues at a 22% annual rate in Turkey as opposed to a 7% rate for Turkey's trading partners. Also assume 5% annual real-wage growth in Turkey and the following path for the exchange-rate:
<table>
<thead>
<tr>
<th>Year</th>
<th>ER</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>$\text{ER}_{1977}$</td>
<td>20.2</td>
<td>(20% devaluation over previous year)</td>
</tr>
<tr>
<td>1978</td>
<td>$\text{ER}_{1978}$</td>
<td>24.2</td>
<td>(20% devaluation)</td>
</tr>
<tr>
<td>1979</td>
<td>$\text{ER}_{1979}$</td>
<td>30.3</td>
<td>(25% devaluation)</td>
</tr>
<tr>
<td>1980</td>
<td>$\text{ER}_{1980}$</td>
<td>37.8</td>
<td>(25% devaluation)</td>
</tr>
</tbody>
</table>

The experiments we undertook using these assumptions, indicate that the exchange-rate adjustment described above is insufficient to close the foreign-exchange gap unless extraordinary sources of foreign finance can be found. Tables 1, 2, 3 summarize the results.

As is apparent from Table 1, the foreign-trade deficit rises from 3.4 billion dollars in 1977 to 5.4 billion dollars in 1980. It is not conceivable that workers remittances and foreign-investment could suffice to finance such a series of deficits. It is also clear that tourism, even under extremely optimistic assumptions, cannot constitute a major foreign-exchange source in the immediate future. If our rather optimistic assumptions about workers remittances, foreign-capital and tourism are correct, Turkey would need about 6 billion dollars of additional finance to cover its deficits in the 1977-1980 period.\(^7\)

These 6 billion dollars would be needed over and above the "normal" 4.5 billion foreign inflow projected for the same period. It is extremely doubtful that anything approaching the 6 billion figure could in fact be realized.

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\(^7\)In the case of tourism, the latest figures seem to indicate that our projections are indeed too optimistic.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports</td>
<td>-5797</td>
<td>-6633</td>
<td>-7409</td>
<td>-8264</td>
</tr>
<tr>
<td>Exports</td>
<td>+2349</td>
<td>+2548</td>
<td>+2720</td>
<td>+2900</td>
</tr>
<tr>
<td>Trade Deficit</td>
<td>-3448</td>
<td>-4085</td>
<td>-4689</td>
<td>-5364</td>
</tr>
<tr>
<td>Workers Remittances</td>
<td>+1300</td>
<td>+1500</td>
<td>+1700</td>
<td>+1900</td>
</tr>
<tr>
<td>Net Foreign Capital Inflow</td>
<td>+1000</td>
<td>+1000</td>
<td>+1100</td>
<td>+1300</td>
</tr>
<tr>
<td>Net Tourism</td>
<td>+176</td>
<td>+229</td>
<td>+298</td>
<td>+384</td>
</tr>
<tr>
<td>Remaining Foreign Exchange Gap</td>
<td>+972</td>
<td>+1356</td>
<td>+1591</td>
<td>+1780</td>
</tr>
</tbody>
</table>

Assuming a Low Dollar Exchange-Rate Policy (Million $)

(ER=20.2) (ER=24.2) (ER=30.2) (ER=37.8)
TABLE 2
Projected Economic Growth in the 1977-1980 Period
Assuming a Low Exchange-Rate Policy

<table>
<thead>
<tr>
<th>Average Yearly Growth Rates</th>
<th>Average Yearly Growth Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agriculture</td>
<td>5.3</td>
</tr>
<tr>
<td>2. Consumer Goods Ind.</td>
<td>7.0</td>
</tr>
<tr>
<td>3. Interm. Goods Ind.</td>
<td>10.1</td>
</tr>
<tr>
<td>4. Cap. Goods + Tr. Eq. Ind.</td>
<td>9.8</td>
</tr>
<tr>
<td>5. Services</td>
<td>9.0</td>
</tr>
<tr>
<td>6. Construction + Housing</td>
<td>9.9</td>
</tr>
<tr>
<td>7. Total Capital Stock</td>
<td>10.9</td>
</tr>
<tr>
<td>8. Total Non-Agricultural Employment</td>
<td>2.6</td>
</tr>
<tr>
<td>9. G.D.P.</td>
<td>8.1</td>
</tr>
<tr>
<td>10. Total Consumption</td>
<td>6.8</td>
</tr>
</tbody>
</table>

TABLE 3
Economic Structure in 1980 Assuming a Low Exchange-Rate Policy (%)

<table>
<thead>
<tr>
<th>Shares in G.D.P.</th>
<th>Shares in Employment</th>
<th>Profit Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agriculture</td>
<td>25.3</td>
<td>62.7</td>
</tr>
<tr>
<td>2. Cons. Goods Ind.</td>
<td>8.8</td>
<td>7.7</td>
</tr>
<tr>
<td>3. Interm. Goods Ind.</td>
<td>11.2</td>
<td>3.0</td>
</tr>
<tr>
<td>4. Cap. Goods + Tr. Eq. Ind.</td>
<td>3.4</td>
<td>1.4</td>
</tr>
<tr>
<td>5. Services</td>
<td>38.0</td>
<td>20.2</td>
</tr>
<tr>
<td>6. Construction + Housing</td>
<td>13.3</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Tables 2 and 3 summarize the pace and structure of economic growth that could be achieved with a "low exchange-rate policy." As may be seen from the tables, under these conditions, growth would proceed rapidly, non-agricultural employment could continue to grow at 2.6% per annum and the share of agriculture in G.D.P. would fall to 25% by 1980. Total consumption would increase at 6.8% and total capital stock at almost 11% per annum.

But, as already emphasized, these figures are dependent on a total net foreign capital inflow of over 10 billion dollars, much more than can really be expected. The growth path outlined above does therefore not appear to be a feasible one. A more serious adjustment seems to be required. The obvious and most direct adjustment could be realized by a major devaluation in 1977. A lowering of the savings-rate or an increase in tariffs would constitute alternative adjustment possibilities. The effects of these alternative policies are discussed below.

A Major Devaluation in 1977

Keeping all other parameters and assumptions unchanged, let us impose the following path on the exchange-rate:

\[
\begin{align*}
\text{ER}_{1977} & = 24.00 \\
\text{ER}_{1978} & = 28.80 \\
\text{ER}_{1979} & = 36.00 \\
\text{ER}_{1980} & = 45.00
\end{align*}
\]

8Note that a low exchange-rate policy is one that keeps the price of the dollar low, i.e., that "overvalues" Turkish currency.
The results of such a high exchange rate policy are summarized in Tables 4, 5, 6 and Figure 2.

As may be seen from Table 4 and Figure 2, the sectoral elasticity assumptions implicit in our model do not lead to an immediate and dramatic reduction of the trade deficit. However, by 1980, imports would only reach 7.2 billion dollars instead of 8.2 and exports would run at 3.4 billion dollars instead of 2.9. The trade deficit would thus fall to 3.9 billion dollars, 1.5 billion less than the 5.4 billion dollars projected in the case of a low exchange-rate policy. We did not, for the high exchange-rate experiments, alter our projections concerning long-term foreign capital, workers remittances and tourism. If these flows do not increase, the foreign-exchange gap still averages about 450 million dollars even with the dollar rising to 45 T.L. by 1980. In fact however, workers remittances in particular are likely to respond to higher conversion rates and with a reasonable amount of shorter-term borrowing it should be feasible to close the remaining foreign-exchange gap. The fact that after 1978 the foreign-exchange gap would actually be narrowing indicates that the exchange-rate policy outlined above could lay the foundations for a new self-sustaining equilibrium path. Figure 2 vividly depicts the different behaviour of the foreign-exchange gap in the two simulated cases.

It should of course be clear that the necessity of further devaluations leading to a 45 T.L. = 1 Dollar exchange-rate by 1980 is based on the assumption that average domestic inflation will remain 15 percentage points higher than the inflation affecting the world
TABLE 4

Foreign-Trade and The Balance-of-Payments in The 1977-1980 Period  
Assuming a High Dollar Exchange-Rate Policy (Million $)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports</td>
<td>-5193</td>
<td>-5912</td>
<td>-6556</td>
<td>-7252</td>
</tr>
<tr>
<td>Exports</td>
<td>+2349</td>
<td>+2613</td>
<td>+2937</td>
<td>+3392</td>
</tr>
<tr>
<td>Trade Deficit</td>
<td>-2844</td>
<td>-3299</td>
<td>-3619</td>
<td>-3860</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workers Remittances</td>
<td>+1300</td>
<td>+1500</td>
<td>+1700</td>
<td>+1900</td>
</tr>
<tr>
<td>Net Foreign Capital Inflow</td>
<td>+1000</td>
<td>+1000</td>
<td>+1100</td>
<td>+1300</td>
</tr>
<tr>
<td>Net Tourism</td>
<td>+ 176</td>
<td>+ 229</td>
<td>+ 298</td>
<td>+ 385</td>
</tr>
<tr>
<td>Remaining Foreign Exchange Gap</td>
<td>- 368</td>
<td>- 570</td>
<td>- 521</td>
<td>- 275</td>
</tr>
</tbody>
</table>

(ER=24.0) (ER=28.8) (ER=36.0) (ER=45.0)
FIGURE 2. IMPORTS, EXPORTS AND THE FOREIGN-EXCHANGE GAP UNDER LOW AND HIGH EXCHANGE-RATE POLICIES.
prices of the commodities Turkey trades in. This need not necessarily be the case after 1978 although the spread is likely to be closer to 20 percentage points in 1977. If inflation did in fact turn out to slow down significantly in the 1978-1980 period, the devaluation projected in our "high exchange-rate policy" case would be too great and should be reduced accordingly. The figures should therefore be analysed as contingent on a 22% domestic inflation rate and a 7% "world" inflation rate.\footnote{A discussion of the causes and effects of Turkish inflation is not within the scope of this paper. Any such discussion should consider the government budget constraint which we have not explicitly modelled.}

Tables 5 and 6 turn to the "growth-effects" or "growth-costs" of the high exchange-rate policy. Overall growth is significantly reduced; G.D.P. growth falls from 8.1% to 6.6%, and consumption growth from 6.8% to 4.8%. The sectors most affected are capital goods and construction and housing. Even more dramatically, non-agricultural employment, that had been growing at 2.6% a year with lower exchange-rates, now remains totally stagnant.

To understand the general equilibrium mechanism that generates these results, it is useful to analyse the structure of relative prices and the sectoral distribution of capital endogenously determined by the model. Table 7 presents the sectoral domestic prices, $P_{d1}$, and sectoral capital stocks, $K_1$, that the model determines under the two alternative exchange-rate policies. In the case of higher exchange-rates, 1980 sectoral capital stocks are smaller, in each sector, than in the case of the lower exchange-rate policy. This does not only reflect the negative effect that a lower rate of external-gap financing has on
**TABLE 5**

Projected Economic Growth in the 1977-80 Period Assuming A High Exchange-Rate Policy

| Category                        | Value
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agriculture</td>
<td>5.0</td>
</tr>
<tr>
<td>2. Consumer Goods Ind.</td>
<td>6.5</td>
</tr>
<tr>
<td>3. Interm. Goods Ind.</td>
<td>8.7</td>
</tr>
<tr>
<td>5. Services</td>
<td>7.3</td>
</tr>
<tr>
<td>6. Construction + Housing</td>
<td>6.5</td>
</tr>
<tr>
<td>Total Capital Stocks</td>
<td>9.7</td>
</tr>
<tr>
<td>Total Non-Agricultural Equipment</td>
<td>0.0</td>
</tr>
<tr>
<td>G.D.P.</td>
<td>6.6</td>
</tr>
<tr>
<td>Total Consumption</td>
<td>4.8</td>
</tr>
</tbody>
</table>

**TABLE 6**

Economic Structure in 1980 Assuming a High Exchange-Rate Policy

<table>
<thead>
<tr>
<th>Category</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agriculture</td>
<td>26.1</td>
<td>56.1</td>
<td>26.6</td>
</tr>
<tr>
<td>2. Cons. Goods Ind.</td>
<td>9.6</td>
<td>7.8</td>
<td>30.8</td>
</tr>
<tr>
<td>3. Interm. Goods Ind.</td>
<td>11.7</td>
<td>2.9</td>
<td>29.3</td>
</tr>
<tr>
<td>4. Cap. Goods + Tr. Eq. Ind.</td>
<td>3.2</td>
<td>1.1</td>
<td>27.8</td>
</tr>
<tr>
<td>5. Services</td>
<td>38.3</td>
<td>18.9</td>
<td>29.9</td>
</tr>
<tr>
<td>6. Construction + Housing</td>
<td>11.1</td>
<td>4.0</td>
<td>20.9</td>
</tr>
</tbody>
</table>
TABLE 7

Domestic Prices and Sectoral Capital Stocks arrived at
by 1980 under a Low and High Exchange-Rate Policy

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Low Exchange-Rates</th>
<th>High Exchange-Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_{D1}$ (1973=1)</td>
<td>$K_1$ (M.TL.)</td>
</tr>
<tr>
<td>1. Agriculture</td>
<td>4.1</td>
<td>141137</td>
</tr>
<tr>
<td>2. Cons. Goods. Inc.</td>
<td>4.0</td>
<td>52236</td>
</tr>
<tr>
<td>3. Intern. Goods Ind.</td>
<td>3.9</td>
<td>113392</td>
</tr>
<tr>
<td>4. Cap. Goods + Tr. Eq. Ind.</td>
<td>3.1</td>
<td>29910</td>
</tr>
<tr>
<td>5. Services</td>
<td>3.5</td>
<td>307527</td>
</tr>
<tr>
<td>6. Construction + Housing</td>
<td>4.7</td>
<td>126439</td>
</tr>
</tbody>
</table>
total investment but also lower domestic prices in the case of the high exchange-rate policy. This price effect constitutes an indirect deflationary effect of devaluation. With unchanged monetary supply conditions, an increase in import prices following a devaluation, must lead to a reduction in the average price-level of domestically produced commodities. This does not mean that all domestically produced commodity prices must fall. As can be seen in Table 7, some may even rise. But the weighted-average of domestic prices must relatively fall to accommodate an unchanged rate of money supply growth implicit in the assumed constant inflation rate. In a way this is a naive story but we believe it to be useful in order to separate out the microeconomic effects of devaluation treated here as a pure relative-price adjustment measure, from the macroeconomic and monetary effects which depend on central bank and government behaviour and cannot be discussed without modelling the financial system.

From a microeconomic viewpoint devaluation has, both an income and a substitution effect that affects the pace of real capital accumulation. The relative decline in domestic prices¹⁰ will lower employment and therefore national income. Since a constant nominal ratio of national income is invested, devaluation will have a negative income effect reducing real investment and the growth-rate of the economy. This negative income effect is essentially due to the fixed real-wage nature of our model, as opposed to the fixed real investment nature of, for instance, the Lysy-Taylor model. "Animal spirits" are here affected

¹⁰ Note that domestic prices are not actually falling. They only rise less rapidly if a major devaluation is undertaken than if it is not. Imported goods prices will rise more rapidly so that in both cases the overall inflation rate remains the same.
by devaluation, though the "political spirits" of the working class are not!

On the other hand the substitution effect of devaluation does not depend on the fixed-wage assumption although it would have a different form if the wage were allowed to be flexible. It is clear that imported capital-goods become more expensive. But domestically produced capital goods may become cheaper. We have the following situation affecting relative capital goods prices:

<table>
<thead>
<tr>
<th></th>
<th>Low Exchange-Rate</th>
<th>High Exchange-Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of imported machinery (1977)</td>
<td>1.88</td>
<td>2.24</td>
</tr>
<tr>
<td>Price of domestically produced machinery (1977)</td>
<td>1.78</td>
<td>1.79</td>
</tr>
<tr>
<td>Aggregate machinery price (1977)</td>
<td>1.82</td>
<td>1.94</td>
</tr>
<tr>
<td>Price of (non-tradable) construction output</td>
<td>2.61</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Thus, with a higher exchange-rate, machinery appreciates in price but structures (construction) cheapens. It is therefore natural to expect capital prices to increase in those sectors using machinery-intensive capital and to decrease in those sectors using structures intensively. The figures below verify the situation:
### Table 8

**1977 Capital Stock Prices**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Low Exchange-Rate</th>
<th>High Exchange-Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agriculture</td>
<td>2.30</td>
<td>2.25</td>
</tr>
<tr>
<td>2. Cons. Goods Ind.</td>
<td>2.13</td>
<td>2.15</td>
</tr>
<tr>
<td>3. Interm. Goods Ind.</td>
<td>2.11</td>
<td>2.15</td>
</tr>
<tr>
<td>4. Machinery + Tr. Eg. Ind.</td>
<td>2.02</td>
<td>2.07</td>
</tr>
<tr>
<td>5. Services</td>
<td>2.19</td>
<td>2.18</td>
</tr>
<tr>
<td>6. Construction + Housing</td>
<td>2.47</td>
<td>2.36</td>
</tr>
</tbody>
</table>
With higher exchange-rates, capital accumulation cheapens in agriculture, and construction and housing, but becomes more expensive in intermediate goods and machinery producing industries. Capital stock prices remain almost constant in consumer goods industries and services. When these relative changes are aggregated taking into account the relative weights of the sectors, the overall substitution effect turns out to be actually positive, reflecting the important share of construction in total capital accumulation, but remains very close to zero. The income effect dominates and pursuing a higher exchange-rate policy has definite negative short-term effects on employment, capital accumulation and growth. Since some adjustment to the foreign exchange gap is however inescapable, the real question is how these costs compare with costs of alternative adjustment mechanisms.

Lowering the Savings-Rate or Raising Tariffs

There are of course alternatives to a high exchange-rate policy that could reduce or even close the foreign-exchange gap. One possibility would be to reduce investment directly by lowering the savings rate. Another such alternative would be to raise tariffs or otherwise restrict imports.

Tables 9 and 10 summarize the results of lowering the savings-rate to 10% from its original 21.5% value or of doubling all tariffs.

\[11\] It should be noted that devaluation may also have an important "distributive effect" working through different savings propensities of different groups. For a discussion of this effect see DeMelo and Dervis (1977).
TABLE 9

The Results of Lowering the Savings-Rate to 10%: The Investment-Rate Reduction Policy

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports (M.$)</td>
<td>-5304</td>
<td>-5763</td>
<td>-6127</td>
<td>-6568</td>
</tr>
<tr>
<td>Exports (M.$)</td>
<td>+2334</td>
<td>+2504</td>
<td>+2628</td>
<td>+2738</td>
</tr>
<tr>
<td>Trade Deficit (M.$)</td>
<td>-2970</td>
<td>-3259</td>
<td>-3499</td>
<td>-3830</td>
</tr>
<tr>
<td>Workers Remittances + Net Foreign Capital + Net Tourism (M.$)</td>
<td>+2476</td>
<td>+2729</td>
<td>+3098</td>
<td>+3584</td>
</tr>
<tr>
<td>Remaining Foreign Exchange Gap (M.$)</td>
<td>+ 494</td>
<td>+ 530</td>
<td>+ 401</td>
<td>+ 246</td>
</tr>
<tr>
<td>G.D.P. Growth Rate (%)</td>
<td>6.3</td>
<td>3.2</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Growth Rate of Total Consumption (%)</td>
<td>16.8</td>
<td>2.9</td>
<td>2.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Growth Rate of Non-Agricultural Employment (%)</td>
<td>0.0</td>
<td>-0.7</td>
<td>-1.8</td>
<td>-1.5</td>
</tr>
</tbody>
</table>

(ER=20.2) (ER=24.2) (ER=30.2) (ER=37.8)


**TABLE 10**

The Results of Doubling all Tariffs:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports (M.$)</td>
<td>-5072</td>
<td>-5750</td>
<td>-6358</td>
<td>-7031</td>
</tr>
<tr>
<td>Exports (M.$)</td>
<td>+2349</td>
<td>+2554</td>
<td>+2740</td>
<td>+2946</td>
</tr>
<tr>
<td>Trade Deficit (M.$)</td>
<td>-2723</td>
<td>-3196</td>
<td>-3618</td>
<td>-4085</td>
</tr>
<tr>
<td>Workers Remittances + Net Foreign Capital + Net Tourism (M.$)</td>
<td>+2476</td>
<td>+2729</td>
<td>+3098</td>
<td>+3584</td>
</tr>
<tr>
<td>Remaining Foreign Exchange Gap (M.$)</td>
<td>+ 247</td>
<td>+ 467</td>
<td>+ 520</td>
<td>+ 501</td>
</tr>
<tr>
<td>G.D.P. Growth Rate (%)</td>
<td>5.7</td>
<td>7.3</td>
<td>6.4</td>
<td>5.8</td>
</tr>
<tr>
<td>Growth Rate of Total Consumption (%)</td>
<td>2.9</td>
<td>6.6</td>
<td>5.3</td>
<td>4.7</td>
</tr>
<tr>
<td>Growth Rate of Non-Agricultural Employment (%)</td>
<td>5.7</td>
<td>2.3</td>
<td>0.3</td>
<td>-0.7</td>
</tr>
</tbody>
</table>
We hasten to add that both of these policies appear extreme. But they constitute the extent of adjustment required in the saving-rate or the level of tariffs respectively, in order to reduce the foreign-exchange gap to the same extent as it is reduced by the exchange-rate adjustment policy. In both cases the path of the exchange-rate is identical to that traced out by the "low exchange-rate policy" with \( ER^* \) reaching 37.8 by 1980 instead of 45. In both cases the total need for short-term borrowing is close to the 1.8 billion dollars figure over four years, that is also required by the high exchange-rate policy.

By comparing the "growth effects" of an investment reduction policy and of a trade restrictions policy to the effects of an early devaluation policy, we may attempt to establish a ranking of various adjustment strategies. Figure 3 summarizes some of the most important results.

The worst policy is clearly the one that reduces the investment rate. G.D.P. growth falls by almost three percentage points to a 3.9% average. Non-agricultural employment also declines by an average rate of -1.1% a year. It is true that consumption is much higher in the beginning, but by 1980 the consumption level generated by an investment rate reduction policy becomes equal to the level generated by the trade-restrictions and the exchange-rate adjustment policies. On the other hand, total capital stock is, by 1980, almost 20% lower in the case of the investment reduction policy. It should also be noted from Table 9 that the various growth rates show a declining trend, with G.D.P. in 1980 growing at only 2.4% as opposed to a growth rate of 5.1% that would be generated by an exchange-rate
Figure 3: The effects of alternative adjustment policies on the growth of capital stock, G.D.P. and consumption. (Billion T.L. constant prices)
adjustment policy.

The trade restriction policy that consists of a doubling of tariff-rates in 1977 appears at first sight to have very similar effects to the devaluation policy. Indeed consumption is even slightly higher than in the case of an exchange-rate adjustment. One should be careful however before concluding that the two policies are interchangeable. The finite horizon problem is here of crucial importance. Let us reconsider the time pattern of the foreign exchange gap generated in the two cases:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange-Rate Adjustment Policy:</td>
<td>368</td>
<td>570</td>
<td>521</td>
<td>275</td>
</tr>
<tr>
<td>Trade Restrictions Policy:</td>
<td>247</td>
<td>467</td>
<td>520</td>
<td>501</td>
</tr>
</tbody>
</table>

While the total four-year gap is the same, the need for additional borrowing in 1980 is significantly greater in the case of the trade restriction policy. As may be verified from Tables 10 and 1, total exports grow at 15% per year by 1980 under the exchange-rate adjustment policy as opposed to 7.5% under the trade restrictions policy. This suggests that an extension of the time-horizon would lead to less and less favorable results for the trade restrictions policy.

As far as employment is concerned, the two policies give rise to the following paths:
Non-Agricultural Employment (1000 people)

<table>
<thead>
<tr>
<th>Year</th>
<th>Exchange-Rate Adjustment Policy</th>
<th>Trade Restriction Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>5045</td>
<td>4888</td>
</tr>
<tr>
<td>1978</td>
<td>5166</td>
<td>5003</td>
</tr>
<tr>
<td>1979</td>
<td>5187</td>
<td>5018</td>
</tr>
<tr>
<td>1980</td>
<td>5172</td>
<td>4983</td>
</tr>
</tbody>
</table>

Taking the 1976 employment figure of 5166 as the starting point for both alternatives, this represents 0.0% average growth for the exchange rate adjustment policy and a -0.9% negative growth rate for the trade restrictions policy. From the point of view of employment, the former policy is thus preferable. An investment-reduction policy would lead to a figure as low as 4837 by 1980, yielding even lower non-agricultural employment.

We may now conclude this section. A policy that attempts to close a foreign-exchange gap by reducing the investment-rate is clearly dominated by both the exchange-rate adjustment policy described at length above and a trade-restrictions policy. While providing some short-lived consumption gains, it very seriously slows down G.D.P. growth, employment growth and in only four years, leads to a capital stock that is almost 20% lower than in the case of the alternative policies. The longer-run effects of such a policy would clearly be disastrous.

The comparison between a trade restrictions policy and an exchange-rate adjustment policy is not as clear cut. In terms of the initial year impact, the trade restrictions policy may even dominate. But going beyond the first impact, an exchange-rate
adjustment policy begins to look superior in the medium and longer-run. The importance of the time-span considered in determining an effectiveness-ranking for alternative adjustment policies deserves further exploration. The preliminary results reported in this paper may help to explain why a trade restrictions policy may often be favored by political authorities with very short-term horizons. A more complete analysis of the various trade-offs involved and of the role played by the time horizon, requires running the model over longer time periods. We hope to report on these longer-run experiments in a forthcoming discussion paper.
APPENDIX: FORMAL SUMMARY OF THE MODEL'S EQUATIONS AND VARIABLES

The Within-Period Equations

All endogenous variables are denoted by upper-case Roman letters. Variables directly controlled by the government carry an asterisk.

(1) Import Prices

\[ PM_i = \Pi_i^N (1 + t_i^*) E_i^* \quad i=1,\ldots,nt \]

(2) Export Prices

\[ PE_i = \Pi_i^E (1 + s_i^*) E_i^* \quad i=1,\ldots,nt \]

(3) Aggregate Prices

\[ P_i = 1/\gamma_i \left[ \delta_i^{1-\sigma_i} PM_i^{1-\sigma_i} + (1 - \delta_i)^{\sigma_i} PD_i^{1-\sigma_i} \right]^{1/(1-\sigma_i)} \quad i=1,\ldots,nt \]

\[ P_i = PD_i \quad i=nt+1,\ldots,n \]

(4) Value-Added

\[ V_i = PD_i (1 - e_i) + PE_i e_i - \sum_{j=1}^n P_j a_{ji} - e_i^* FD_i \quad i=1,\ldots,n \]

(5) Capital Stock Prices

\[ U_i = \sum_{j=1}^n P_j s_{ji} \quad i=1,\ldots,n \]
(6) Employment Functions

\[ W_i = \frac{\beta_i V_i A_i K_i(t-1) L_i^\beta_i}{L_i} \quad i=1 \]

\[ L_i = (\frac{\beta_i V_i A_i K_i(t-1)}{W_i})^{1/1-\beta_i} \quad i=2, \ldots, n \]

(7) Production Functions

\[ X_i = A_i K_i(t-1) L_i^\beta_i \quad i=1, \ldots, n \]

(8) Sectoral Experts

\[ E_i = e_i X_i \quad (a) \quad i=1, \ldots, nt \]

or

\[ E_i = (1 + g_i^E) E_i(t-1) \quad (b) \]

(9) Sectoral Supplies of Domestic Origin

\[ DS_i = X_i - F_i \quad i=1, \ldots, nt \]

\[ DS_i = X_i \quad i=nt+1, \ldots, n \]
(10) Sectoral Imports

\[ M_i = \left( \frac{\sigma_{i}}{1 - \delta_{i}} \right) \frac{P_{D_i}}{P_{M_i}} \sigma_{i} DS_i \]

\[ i = 1, \ldots, nt \]

(11) The Balance-of-Payments

\[ \sum_{i=1}^{nt} \Pi_{E_i} - \sum_{i=1}^{nt} \Pi_{M_i} + \Pi_{E} \overline{E}_h - \Pi_{D} \overline{T}_h + \overline{F}_b - \overline{X}_h = \Delta R \]

(12) The Total Income Equation

\[ \text{GNI} = \sum_{i=1}^{n} V_i X_i + \sum_{i=1}^{n} e_{i}^* P_{D_i} X_i + \sum_{i=1}^{nt} t_{i}^* \Pi_{M_i} E_{R_i} - \sum_{i=1}^{nt} s_{i}^* \Pi_{E_i} E_{R_i}^* \]

\[ + (\overline{F}_b - \overline{X}_h) E_{R_i}^* \]

(13) Total Consumption and Investment

\[ \text{CON} = (1 - s) \text{GNI} \]

\[ \text{TINV} = s (\text{GNI}) - \Delta R.E_{R_i}^* \]

(14) Sectoral Consumption Levels

\[ C_i = \delta_i \text{GNI} / P_i \]

\[ i = 1, \ldots, n \]
(15) Profit-Rates

\[ R_i = \frac{V_i X_i - W_i L_i}{U_i(t-1) K_i(t-1)} + \frac{U_i(1-\delta_i) - \bar{U}_i(t-1)}{U_i(t-1)} \]

\[ i=1,\ldots,n \]

(16) Investment by Sector of Destination

\[ Y_i = \frac{H_i}{U_i} \text{ TINV} / U_i \]

\[ i=1,\ldots,n \]

(17) Investment by Sector of Origin

\[ Z_i = \sum_{j=1}^{n} S_{ij} Y_j \]

\[ i=1,\ldots,n \]

(18) Intermediate Input Use

\[ I_i = \sum_{j=1}^{n} a_{ij} X_j \]

\[ i=1,\ldots,n \]

(19) Demands for Goods of Domestic Origin

\[ \text{DD}_i = \left(1-\delta_i\right) \frac{P_i}{P_{D_i}} \sigma_1 \gamma_i \frac{1}{\bar{P}_i} \sigma_1 \left( C_i + I_i + Z_i \right) \]

\[ i=1,\ldots,nt \]

\[ \text{DD}_i = C_i + I_i + Z_i \]

\[ i=nt+1,\ldots,n \]
(20) The Price Level Equation

\[
\sum_{i=1}^{n} PD_i \left( \frac{DD_i}{\Sigma DD_i + \Sigma EM_i} \right) + \sum_{i=1}^{nt} PM_i \left( \frac{M_i}{\Sigma DD_i + \Sigma EM_i} \right) = \bar{XPL}
\]

(21) The Equilibrium Conditions

\[ DS_i = DD_i \quad i=1, \ldots, n \]
The Endogenous Variables of the Within-Period Model

The following variables are determined by the equations of the within-period model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n</td>
<td>Domestic Prices</td>
</tr>
<tr>
<td>PM&lt;sub&gt;i&lt;/sub&gt;</td>
<td>nt</td>
<td>Import Prices (Determined by tariffs and the exchange-rate)</td>
</tr>
<tr>
<td>PE&lt;sub&gt;i&lt;/sub&gt;</td>
<td>nt</td>
<td>Export Prices (Determined by export subsidies and the exchange-rate)</td>
</tr>
<tr>
<td>P&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n</td>
<td>Aggregate Prices</td>
</tr>
<tr>
<td>V&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n</td>
<td>Value-Added or Net Prices</td>
</tr>
<tr>
<td>U&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n</td>
<td>Capital Goods Prices</td>
</tr>
<tr>
<td>L&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n-l</td>
<td>Sectoral Non-Agricultural Employment</td>
</tr>
<tr>
<td>W&lt;sub&gt;i&lt;/sub&gt;</td>
<td>l</td>
<td>The Average Wage in Agriculture</td>
</tr>
<tr>
<td>X&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n</td>
<td>Sectoral Production Levels</td>
</tr>
<tr>
<td>E&lt;sub&gt;i&lt;/sub&gt;</td>
<td>nt</td>
<td>Sectoral Exports</td>
</tr>
<tr>
<td>D&lt;sub&gt;i&lt;/sub&gt;</td>
<td>n</td>
<td>Supplies of Domestically Produced Commodities</td>
</tr>
<tr>
<td>M&lt;sub&gt;i&lt;/sub&gt;</td>
<td>nt</td>
<td>Sectoral Imports</td>
</tr>
<tr>
<td>ΔR</td>
<td>l</td>
<td>Reserve Accumulation</td>
</tr>
<tr>
<td>GNI</td>
<td>l</td>
<td>Total Income</td>
</tr>
<tr>
<td>CON</td>
<td>l</td>
<td>Total Consumption</td>
</tr>
</tbody>
</table>
Total Investment

Sectoral Consumption

Profit-Rates

Sectoral Capital Accumulation

Investment by Sector of Origin

Intermediate Demands

Total Demand for Domestically Produced Commodities

Total \ = \ 13n + 4n + 4

The number of endogenous variables is thus equal to the number of equations. In practice this is at least a necessary condition for a unique solution. The following variables are directly controlled by the government:

The Policy Control Variables

\( ER^*_t \) The exchange-rate (for the fixed exchange-rate case)

\( t^*_i \) Tariff rates

\( s^*_i \) Export subsidy rates

\( e^*_i \) Sales tax rates
The Dynamic Linkage Equations

(22) Technical Progress

\[ A_{it} = (1 + g_i) A_i(t-1) \]

(23) Capital Accumulation

\[ K_{it} = (1 - \delta_i) K_i(t-1) + Y_{it} \]

(24) Investment Allocation*

\[ H_{it} = \bar{SP}_i(t-1) + \Gamma \bar{SP}_i(t-1) \left( \frac{R_i(t-1) - AR(t-1)}{AR(t-1)} \right) \]

(25) World Inflation

\[ \Pi^M_{it} = (1 + \bar{w}^M_{int}) \Pi^M_i(t-1) \]

\[ \Pi^E_{it} = (1 + \bar{w}^E_{int}) \Pi^E_i(t-1) \]

\[ \Pi^E_{ot} + (1 + \bar{w}^E_{int}) \Pi^E_o(t-1) \]

\[ \Pi^T_{ot} = (1 + \bar{w}^T_{int}) \Pi^T_o(t-1) \]

*The profit-shares \( \bar{SP} \), and the average profit-rate \( \bar{AR} \) are determined by simple accounting side-equations.
(26) Domestic Inflation

\[ X_{PL_t} = (1 + \bar{\Pi}_{inf}) X_{PL(t-1)} \]

(27) Export Growth

\[ \varepsilon_{it} = \varepsilon_{i(t-1)} + \xi_{i} \left( \frac{PE_{i(t-1)} - PD_{i(t-1)}}{PD_{i(t-1)}} \right) \]

or

\[ E_{it} = E_{i(t-1)} + \lambda_{i} \left( \frac{PE_{i(t-1)} - PD_{i(t-1)}}{PD_{i(t-1)}} \right) \]

(28) Urbanization and Labor Markets

\[ \hat{W}_{t-1}^{exp} = \sum_{i=2}^{n} \frac{W_{i}}{L_{i(t-1)}} / \sum_{i=2}^{n} L_{i(t-1)} \]  

\[ \hat{L}_{t-1}^{mig} = \mu \left( \frac{\hat{W}_{t-1}^{exp}}{\hat{W}_{1}} - 1 \right) L_{1(t-1)} \]

\[ L_{lt} = (1 + \bar{g}_{l}) L_{1(t-1)} - \hat{L}_{t-1}^{mig} \]

\[ URL_{lt} = (1 + \bar{g}_{u}) URL_{l(t-1)} + \hat{L}_{t-1}^{mig} \]
Some of the dynamic linkage equations presented above are pure updating equations and the updated variables do not depend on current or lagged endogenous variables. This is the case for the technical progress, the domestic and world inflation, and the wage growth equations. The equations governing capital accumulation, investment allocation, export growth and urbanization are of a different kind, incorporating feedback mechanisms that endogenize the pattern of investment, exports and rural-urban migration.
The Variables Updated by the Dynamic Linkage Equations

\begin{align*}
A_{it} & \quad \text{The Cobb-Douglas shift parameters} \\
K_{it} & \quad \text{Sectoral capital stocks} \\
\{M_{it}, E_{it}\} & \quad \text{World prices of imports, exports and service sector outputs} \\
\{E_{ot}, I_{ot}\} & \\
XPL_t & \quad \text{The domestic price level} \\
W_{x(t-1)} & \quad \text{The expected urban wage} \\
L_{mig(t-1)} & \quad \text{Rural-urban migration} \\
L_{it} & \quad \text{Agricultural labor force} \\
ULR_t & \quad \text{Urban labor force} \\
W_{it} & \quad \text{Urban wages} \\
E_{it} & \quad \text{Export shares} \\
\xi_{it} & \quad \text{Export growth-rates}
\end{align*}
Other Exogenous Variables and Parameters Appearing in the Model

$\gamma_i$, $\delta_i$, $\sigma_i$, $\rho_i$  The parameters of the C.E.S. aggregation function

$a_{ij}$  Input-output coefficients

$s_{ij}$  Capital composition coefficients

$\alpha_i$, $\beta_i$  The exponents of the Cobb-Douglas production functions

$EBAR$  Foreign-exchange earnings of the services sector (excluding tourism)

$XMAR$  Foreign-exchange expenditures of the services sector

$TOUR$  Tourism revenues

$FB$  Net foreign capital inflow including workers remittances

$S$  The savings rate

$\theta_i$  Consumption-share parameters

$\bar{d}_i$  Sectoral depreciation rates

$A_{\bar{g}_i}$  Technical progress rates

$\bar{E}, \bar{M}, \bar{T}$  World inflation affecting imports, exports and tourism sector

$\bar{X}_{inf}$  Domestic inflation
\( \xi_i \)  
Export share price sensitivity parameters

\( \lambda_i \)  
Export growth price sensitivity parameters

\( \mu \)  
The rural-urban speed of migration parameter

\( P \)  
The natural rate of rural population growth

\( g_A \)  
The intersectoral investment mobility parameter

\( P \)  
The natural rate of urban population growth

\( g_U \)  
The growth of real urban wages

The data-set used for the experiments presented in this paper is available upon request. It is organized around the 1973 S.I.S. Input-Output Table and has also benefited from the data gathering effort undertaken by the Princeton-Boğaziçi Income Distribution Project.
References


