Journal of Development Economics 4 (1977) 149–172.

MODELLING THE EFFECTS OF PROTECTION IN A DYNAMIC FRAMEWORK

Jaime A.P. DE MELO*

Georgetown University, Washington, DC 20007, U.S.A.

Kemal DERVIS

Princeton University, Woodrow Wilson School, Princeton, NJ 08540, U.S.A.

Received September 1976, revised version received January 1977

The effects of alternative trade strategies on development performance are analyzed using a small, dynamic, computable general equilibrium model. The static allocation costs of protection are quantitatively weighed against the dynamic benefits resulting from heterogenous capital markets and alternative savings functions.

1. Introduction

The debate over the appropriate trade strategy for developing countries has been and continues to be a lively one. Belief in the need for a development strategy based on protection of the manufacturing sector is powerful in most LDCs. The argument for protection in this context is essentially based on dynamic considerations. It is conceded that trade distortions have static welfare costs but it is then argued that the dynamic benefits associated with a protectionist growth strategy are well worth the static costs. Since the times of Hamilton and List these dynamic considerations essentially relate to some variant of the 'infant industry' argument. The precise form taken by the argument varies, but it is always based on a divergence between static and dynamic considerations and an emphasis on dynamic effects. Trade theorists have on the other hand emphasized the static distortions caused by departures from unified exchange rates and have tended to advocate a movement to freer trade. Although recent investigations of the gains from trade in a growth theoretic context have somewhat qualified the static results, most policy prescriptions derived from trade theory favour free trade.

*We are grateful to the Editor and an anonymous referee for helpful comments. We would also like to thank Sherman Robinson, Peter Kenen, Anne Krueger and Mieko Nishimuzu for fruitful discussions.

But an adequate quantitative analysis of the relationships between trade policy and development performance, weighing the static costs against the potential dynamic gains from alternative trade strategies, remains to be developed. It is with this in mind that we present a dynamic general equilibrium model that can be used for a quantitative investigation of some of these issues.

The model is part of the general family of computable non-linear Walrasian models that incorporate direct substitution in both production and demand.[1] Behavioral equations derived from profit and utility maximization by firms and consumers combine with market clearing equations and technological relations to determine the growth path of the economy. It is the first of these models that addresses itself to the issue of trade policy in a dynamic context. Section 2 presents the equations of the model. Section 3, relating our model to the trade and welfare literature, discusses the major mechanisms that will determine the performance of alternative trade strategies. Sections 4, 5, and 6 present and evaluate the results.

2. A general equilibrium model of trade and growth

We spell out some of the salient features of the model before presenting the set of equations describing it. Behavior is assumed to be competitive and commodity markets must clear in each period. Capital is heterogeneous and once installed cannot be moved across sectors. Since we do not assume perfect foresight or perfect capital markets, profit rates in general will vary between sectors. Several alternative specifications in the labor market are combined with endogenous and exogenous savings behavior.

In the spirit of the barter theory of international trade, the economy faces fixed terms of trade and monetary effects are excluded from the model. However, in line with recent developments in the field, we emphasize the dichotomy between: (1) tradable goods whose prices are fixed with quantities traded clearing their markets, and (2) home goods whose prices adjust to clear their markets.

The structure of the model is general and can accommodate any number of sectors.[2] However, some of its most important properties can be captured with a three sector specification. This also allows better understanding of the rather complex causal chains running through the model and facilitates the interpretations of results. In our experiments based on Turkish data we shall distinguish between agriculture, manufacturing and a nontradable sector, and run the model over forty years. In the presentation of the model $n = q_1 + q_2$ refers to the number of sectors in the economy, q_1 of which are traded, and t is the time subscript.

[1] For models of this type see Johansen's (1960) pioneering study of the Norwegian economy, Taylor and Black (1974), Dervis (1975), de Melo (1975), Adelman and Robinson (1976). For a model specifying noncompetitive pricing behavior, see Staehlin (1976).

[2] The solution algorithm can handle a very large number of sectors and has been tested for a 12-sector version of the model.

Greek letters, lowercase roman letters and roman letters with bars are predetermined variables or parameters. All endogenous variables are denoted by uppercase roman letters.

Below we present the main components of the model along with the complete set of equations describing the foreign trade sector, the producing and consuming sectors, the labor markets and the dynamic linkage equations.

The price equations for tradable sectors are

$$P_{it} = \bar{\pi}_{it}(1+\bar{t}_i)\,E_t, \qquad i = 1, \ldots, q_1, \quad t = 1, \ldots, T. \tag{1}$$

Eq. (1) states that the domestic price of tradable sector i, P_{it}, equals the world price, $\bar{\pi}_{it}$, multiplied by one plus the ad valorem tariff rate, $\bar{t}_i$, times the exchange rate, E_t. If commodity i is exported, $\bar{t}_i$ is the rate of export subsidy. The relative price of tradables are entirely determined by the exogenously specified world prices via the tariff structure, itself determined by government trade policy. In contrast to the nontradable sectors where domestic prices adjust to equate domestic supply and demand, in the tradable sectors quantities traded clear the domestic markets.

This dichotomy between tradables and nontradables is an extreme one. Domestic and foreign tradable goods are perfect substitutes so that the country will either export or import a commodity, but not both.[3] We have chosen to retain this extreme specification and the small country assumption because they are commonly used in trade theory and in the literature on the welfare costs of protection to which this paper is addressed.

The balance-of-payments equations are

$$\sum_{i=1}^{q_1} \pi_{it}\,T_{it} + \bar{\pi}_0\,M_{0t} = \bar{D}_t, \qquad t = 1, \ldots, T, \tag{2}$$

where

$$M_{0t} = \sum_{i=1}^{n} s_{i0}\,Y_{it}.$$

Since we choose to predetermine the trade gap $\bar{D}_t$ (with balance-of-trade when $\bar{D}_t = 0$), the exchange rate adjusts until the balance-of-payments equation is satisfied; T_{it} denotes the quantities traded and we adopt the convention that $T_{it} > 0$ for imports and $T_{it} < 0$ for exports. Noncompetitive imports enter the

[3] In reality, even for a very fine commodity classification, product differentiation is sufficient to allow persistent price differentials as well as two-way trade. For a discussion of these problems, see Armington (1969), Deardorff, Stern and Baum (1976), and Robinson and de Melo (1976).

model and are denoted by M_{0t}. They are assumed to be related to investment by sector of destination, Y_{it}, through noncompetitive import coefficients, s_{i0}.

In a fixed exchange rate variant, not considered here, E_t would be fixed and (2) would become a side equation.

The price normalization equations are

$$\sum_{i=1}^{n} P_{it} \bar{X}_{i0} = \sum_{i=1}^{n} \bar{P}_{i0} \bar{X}_{i0}, \qquad t = 1, \ldots, T. \tag{3}$$

Only relative prices are determined by the model and one has to choose a normalization rule. The normalization equations above set a base year weighted price index equal to its initial value for all years throughout the plan period. An appropriate price stabilizing monetary policy is thus implicitly assumed. The base period is denoted by time subscript 0.

It should be noted that eqs. (1) and (3), and the assumption of constant world prices, imply that the exchange-rate adjustment between time periods is given by the change in the relative value of nontraded goods. By manipulating eqs. (1) and (3) it can be shown that

$$\frac{E_t}{E_0} = 1 + \frac{\sum_{i=q_1+1}^{q_2} P_{i0} \bar{X}_{i0} - \sum_{i=q_1+1}^{q_2} P_{it} \bar{X}_{i0}}{\sum_{i=1}^{q_1} P_{i0} \bar{X}_{i0}}.$$

Eqs. (1)–(3) complete the description of the foreign trade sector.

The production functions are

$$X_{it} = \bar{A}_{i0} (1+\bar{g}_i)^t K_{i,t-1}^{\alpha_i} L_{it}^{\beta_i}, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T. \tag{4}$$

Output of sector i, X_{it}, is a Cobb–Douglas function of capital installed at the end of the past period, $K_{i,t-1}$, and currently employed labor, L_{it}. The shift parameters, $\bar{A}_i$, grow at exogenously specific rates, g_i. These technical progress rates play a crucial role in determining dynamic comparative advantage and the price of nontradables.

The material balance equations are

$$C_{it} = X_{it} + T_{it} - \sum_{j=1}^{n} a_{ij} X_{jt} - \sum_{j=1}^{n} s_{ij} Y_{jt}, \qquad i = 1, \ldots, n. \tag{5}$$

Domestic private consumption, C_{it}, is equal to domestic production, X_{it}, plus imports (minus exports), T_{it}, minus intermediate demand, minus invest-

ment demand; Y_{jt} stands for investment by sector of destination; a_{ij} and s_i are the elements of the input–output and capital composition matrices.

The consumer demand functions are

$$C_{it} = \bar{q}_{it}\left(\sum_{i=1}^{n} P_{it}\, C_{it}\right)\Big/ P_{it}, \qquad \begin{matrix} i = 1, \ldots, n, \\ t = 1, \ldots, T, \end{matrix} \tag{6}$$

where

$$\sum_{i=1}^{n} P_{it}\, C_{it} = C_t = \text{income consumed.}$$

These demand functions are derived from a Cobb–Douglas utility function

$$(U = \prod_i C_i^{\bar{q}_i}).^4$$

Multiplying each equation in (5) by P_{it}, summing over i and substituting (2) into this sum, it can be checked that with a zero balance of trade the following identity holds:

$$\sum_{i=1}^{n} P_{it}\, C_{it} = \text{Gross National Income} - \text{Investment},$$

where Gross National Income itself is given by the expression: GNI = total value of output − value of intermediate inputs + or − the trade tax or subsidy.

The net price equations are

$$V_{it} = P_{it} - \sum_{j=1}^{n} a_{ji}\, P_{jt}, \qquad \begin{matrix} i = 1, \ldots, n, \\ t = 1, \ldots, T. \end{matrix} \tag{7}$$

The net price V_{it} equals the domestic price minus the costs of intermediate inputs. Note that the cost of tariffs are included in the P_{jt}, and that changes in the prices of nontradables affect the cost of producing tradables.

The specification of labor markets. We shall experiment with three alternative specifications of the labor market: a full-employment model, a fixed-wage

[4]The parametic restrictions imposed on the utility function rule out inferior and complementary goods and the resulting Engel curves are linear. For this truncated version of the linear expenditure system, the own price elasticity of demand is unity and there are no cross-price effects.

model and a migration model. The full-employment model has the following equations:

$$W_t = \frac{\beta_i V_{it} X_{it}}{L_{it}}, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T, \tag{8a}$$

and

$$\sum_{i=1}^{n} L_{it} = L_0 (1+g_n)^t, \qquad t = 1, \ldots, T. \tag{8b}$$

Here an exogenously growing labor supply, $L_0 (1+g_n)^t$, must be fully employed and the endogenous full employment wage is equalized across all sectors.

The fixed-wage model has the following equations:

$$\gamma_i \overline{W}_t = \frac{\beta_i V_{it} X_{it}}{L_{it}}, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T, \tag{8'b}$$

where

$$\gamma = 1, \quad i = 2, \ldots, n \quad \text{and} \quad \gamma_1 = \bar{\gamma},$$

and

$$\overline{W}_t = \overline{W}_0 (1+g_w)^t \frac{\sum_{i=1}^{n} P_{it} C_{i0}}{\sum_{i=1}^{n} P_{i0} C_{i0}}.$$

Here the real wage, defined in terms of a Laspeyres consumer price index, is specified to grow exogenously at equal rates, g_w, in agriculture and in the urban sectors, preserving a fixed rural urban wage differential, $\bar{\gamma}$. The supply of labor to all sectors is perfectly elastic at the going wage.

The migration model has an expanded set of equations:

$$\overline{W}_t = \frac{\beta_i V_{it} X_{it}}{L_{it}}, \qquad i = 2, \ldots, n, \quad t = 1, \ldots, T, \tag{8''a}$$

$$W_1 = \frac{\beta_1 V_{it} X_{1t}}{L_t^A}, \qquad t = 1, \ldots, T. \tag{8''b}$$

$$L_t^A = L_0^A (1+g_n)^t - MIG_t, \qquad t = 1, \ldots, T, \tag{8''c}$$

$$L_t^U = L_0^U (1+g_n)^t + MIG_t, \qquad t = 1, \ldots, T, \tag{8''d}$$

$$MIG_t = \mu \left(\frac{W_t^e}{W_1} - 1 \right) L_{t-1}^A, \qquad t = 1, \ldots, T, \tag{8''e}$$

$$W_t^e = \overline{W}_t \left(\sum_{i=2}^{n} L_{it} / L_t^u \right), \qquad t = 1, \ldots, T, \tag{8''f}$$

This is the most popular model in the development literature; L_t^A and L_t^U denote the supply of labor in agriculture and in the urban sectors;[5] in agriculture the wage is allowed to clear the labor market but the urban wage is exogenously fixed as in the fixed-wage model and an endogenous rural urban migration mechanism regulates the supply of urban labor. Migration MIG_t is a function of the expected urban wage W_t^e which is equal to the urban wage multiplied by the urban employment rate. It is clear that this model becomes inconsistent when $\sum_{i=2}^{n} L_{it} > L_t^u$, i.e. when urban unemployment disappears. At that stage we switch to a full employment specification and an endogenous determination of the urban wage. Migration will continue as long as the expected urban wage, now simply equal to the urban wage, exceeds the wage in agriculture.

The capital-price equations are

$$U_{it} = \sum_{j=1}^{n} s_{ji} P_{jt} + s_{0i} \pi_0 (1+t_0) E_t, \qquad j = 1, \ldots, n, \quad t = 1, \ldots, T. \tag{9}$$

The price of capital, U_{it}, in each sector is the weighted sum of the prices of its components including the price of noncompetitive imports, $\pi_0 (1+t_0) E_t$.

The profit-rate equations are

$$R_{it} = \frac{V_{it} X_{it} - W_t L_{it}}{U_{it-1} K_{it-1}} - \frac{U_{it} - (1-\bar{d}_i) U_{i,t-1}}{U_{i,t-1}}, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T. \tag{10}$$

The sectoral profit-rates, R_{it}, equal the rental rates plus the depreciation adjusted rate of capital gains; $\bar{d}_i$ are the exogenously fixed depreciation rates. Profit rates will not in general be equal across sectors.[6]

[5]See Harris and Todaro (1969), Ahmed (1974) and Fields (1975).

[6]See Dervis (1975) for a discussion of profit rates in multi sector growth models in an intertemporal equilibrium model that equalizes profit rates across sectors for all periods.

Eqs. (4) – (10) complete the description of the producing and consuming sectors in the economy. We now turn to the intertemporal linkages which govern the dynamic structure of the model.

The investment allocation equations are:

$$Y_{it} = H_{it} \sum_{i=1}^{n} Y_{it} = H_{it}\, INV_t, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T, \tag{11}$$

$$U_{it}\, Y_{it} = H_{it} \sum_{i=1}^{n} U_{it}\, Y_{it} = H_{it}\, INV_t, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T. \tag{11'}$$

H_{it} is the share of total investment, INV_t, that goes to sector i in period t. The sum of H_{it} must equal one. We have two alternatives: H_{it} may be the share in terms of base year prices (11) or it may be the share in terms of current prices (11').[7] It remains to determine these shares.

The investment shares equations are

$$H_{it} = SK_{i,t-1} + \delta\, SK_{i,t-1} \left(\frac{R_{i,t-1} - AR_{t-1}}{AR_{t-1}} \right), \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T. \tag{12}$$

The investment theory adopted here specifies that the allocation of investment by sector of destination depends on sectoral profit shares and sectoral profit rates; SK_i is the share of total profits originating in sector i; AR_{t-1} is the average profit rate experienced in the previous period; δ is an investment mobility parameter.[8]

The share of investment going to sector i is determined by the share of sector i in total profits of the previous period and the percentage deviation of sector i's profit rate from the average profit rate. When $\delta = 0$ there is no intersectoral mobility of investment funds and the share of each sector in capital formation is identical to its share in profits. This would be the case if all investment were to be financed by retained profit earnings. When δ is positive, investment funds will respond to profit rate differentials: high profit rate sectors will attract profits from other sectors. Thus δ is an index of the intersectoral mobility of investment funds. Note however that it is *not* an index of foresight exhibited in capital markets.

[7] Unless otherwise stated we shall use (11').

[8] It may easily be checked that given $\sum_{i=1}^{n} SK_i \equiv 1$ we have $\sum_{i=1}^{n} H_i \equiv 1$.

The economy-wide capital accumulation equations are:

$$INV_t = \sum_{i=1}^{n} Y_{it} = \overline{GRK} \sum_{i=1}^{n} K_{it-1} + \sum_{i=1}^{n} \bar{d}_i K_{it-1}, \qquad t = 1, \ldots, T, \tag{13}$$

$$INV_t = \sum_{i=1}^{n} U_{it} Y_{it} = \bar{S} \times GNI, \qquad t = 1, \ldots, T, \tag{13'}$$

$$INV_t = \sum_{i=1}^{n} U_{it} Y_{it} = \overline{SP} \times \text{profits}, \qquad t = 1, \ldots, T. \tag{13''}$$

We have three alternative specifications. In (13) we exogenously specify the growth rate of capital, $\overline{GRK}$, in base year prices. We shall refer to (13) as the 'exogenous investment' or 'open-loop savings' specification. It has been used almost exclusively in most previous computable general equilibrium models mainly because of its computational convenience.

The mechanism through which the economy realizes any predetermined $\overline{GRK}$ remains unspecified. An explicit and more elaborate closing of the government and income accounts would be required to specify alternative mechanisms through which any given level of real investment could be achieved. We implicitly rely here on the existence of appropriate Robinsonian 'animal spirits'!

In (13') and (13'') we postulate neoclassical and classical savings functions with a constant fraction of national income saved in the first case and a constant fraction of capitalist income saved in the second. Investment now becomes endogenous.

Finally, the capital updating equations are

$$K_{it} = K_{i,t-1}(1-\bar{d}_i) + Y_{it}, \qquad i = 1, \ldots, n, \quad t = 1, \ldots, T. \tag{14}$$

These are simply accounting relations updating the depreciated sectoral capital stocks in each period.

The dynamic linkage equations close the growth model. Eqs. (11) to (14) are sufficient to determine for any time period t the variables INV_t, H_{it}, Y_{it} and K_{it}, given the exogenous parameters and the values of the remaining variables. Taking for example the full employment specification of the labor market, with sectoral capital stocks given from the previous time period and sectoral investment allocation determined through the linkage equations, eqs. (1)–(10) determine in each period the following endogenous variables:

P_{it}	n		domestic prices
E_t	1		the exchange rate
T_{it}	q_1		imports (exports)
X_{it}	n		output levels
L_{it}	n		sectoral employments
C_{it}	n	$\times T$	sectoral consumption
U_{it}	n		capital stock prices
V_{it}	n		net prices
R_{it}	n		sectoral profit rates
W_t	1		the wage rate

There are $(7n+q_1+2)\times T$ equations to determine these variables. The model can thus be run forward from initial capital stock prices, U_{i0}, and sectoral capital stocks, K_{i0}. It may easily be checked that for the fixed-wage and Harris–Todaro versions the changes in the number of variables equals the change in the number of equations and the model remains determinate.[9]

3. Static costs, dynamic benefits and imperfect markets

Before turning to the quantitative results, it is worth dwelling on the major causal chains implicit in our specification. It is not easy in a general equilibrium model to trace all the determining mechanisms, but we can isolate those that are likely to be most important for a dynamic analysis of trade policy.

We have two tradable sectors, agriculture and manufacturing, and one sector of nontradables.[10] We shall refer to protection as a policy that imposes a 50% tariff on the manufacturing sector and compare the 'protected' growth path to a 'free trade' path of unified exchange rates. Whenever manufacturing becomes the export sector, the 50% differential between the domestic price and the world price must be reinterpreted as an export subsidy. World prices remain constant throughout the analysis. The demand parameters also remain fixed. Changes in tastes thus play no role in determining the dynamics of the growth path.

There is exogenous, neutral, disembodied technical change in all three sectors. But manufacturing, our 'infant' sector is characterized by more rapid technical progress. For our basic runs we used $g_1 = 0.5\%$ in agriculture, $g_2 = 3.0\%$ in manufacturing, and $g_3 = 1.0\%$ in nontradables.

In the exogenous investment specification, capital stock, valued in base-year prices, is assumed to grow at an annual rate of 9%. In the full-employment

[9]It is of course not enough, in principle, to count equations and variables to establish the existence, let alone uniqueness of a solution. However, in rather well behaved general-equilibrium models of this kind the equality of equations and unknowns can be taken as both necessary and sufficient for the existence of a solution.

[10]The parameters for the three sectors given in the appendix were obtained by aggregating the 37-sector data base that underlies the third Turkish Five-Year Plan.

model, the work force grows at 3% per annum while in the fixed-wage model it is the real wage that grows at a 3% rate. In all variants there will be differential factor accumulation characteristic of the development process: the economy-wide capital–labour ratio will increase.

Agriculture is the labor intensive sector, with manufacturing and nontradables relatively more capital intensive. Initially there is a comparative advantage in agriculture but differential rates of factor accumulation and technical progress combine to shift comparative advantage towards manufacturing.

If profit rates were instantaneously equalized across all sectors due to homogeneous and shiftable capital or due to an assumption of perfect futures markets, and if there were no learning externalities that could not be internalized, the fact that comparative advantage was shifting over time would not cause the free trade path to be inefficient. In the absence of distortions, free trade remains optimal even if comparative advantage is shifting.

But in a world of heterogenous nonshiftable capital, changes in the structure of comparative advantage due to the pattern of technical progress and factor accumulation can lead to an infant industry type argument when foresight and capital markets are imperfect or when private discount-rates deviate from social discount-rates. Note that for there to be dynamic benefits associated with protection one does not need to assume the existence of 'learning' externalities that cannot be internalized. Our model does not contain such externalities. But it does specify imperfect foresight and heterogenous imperfectly mobile capital. This is sufficient for an allocation of investment based on the present structure of comparative advantage to be intertemporally inefficient. This does not of course constitute a first-best argument for protection. It does, however, suggest that protection can have a beneficial dynamic effect when compared to a policy of nonintervention. This should be quantitatively weighted against the more familiar static welfare costs of protection, future benefits being discounted at some appropriate social rate.[11]

Quite apart from the infant industry argument, it is well known that protection may be superior to 'laisser faire' in the presence of domestic distortions although, again, tariffs will never, in a small country model, constitute a first-best policy. The specification of labor markets takes on crucial importance in this context.[12]

A full-employment model with no distortions and free labor mobility between rural and urban sectors constitutes our basic specification. It is not a very realistic

[11]If, in addition, the 'infant' sector generates learning externalities that could not be internalized even in a perfect market setting, the argument is further reinforced. For a full discussion of infant industry protection, see Johnson (1971) and Corden (1974, ch. 9).

[12]Excellent surveys of the theory of distortions and first-best remedies in a static context are provided by Bhagwati (1971) and Magee (1973). The welfare effects of imperfect foresight, discussed in multi-sector growth theory, have generally not been discussed in the trade and development literatures. For an exception see however, the interesting analysis in Findlay (1973, ch. 8).

one in the context of developing countries. We therefore have experimented extensively with two alternative specifications: a model postulating perfectly elastic labor supplies at fixed and exogenously growing real wages, and a Harris–Todaro type model with an endogenous migration mechanism as the third case. Depending on the situation in labor markets, tariffs should be expected to have different effects on the level of welfare. In the full employment model without distortions, tariffs will always have negative static allocation effects. But in both the fixed-wage and the Harris–Todaro models, total employment becomes a variable affected by trade policy. It has been shown by Brecher (1974) in the context of the standard 2-by-2 static model of trade theory that in a minimum wage economy tariffs may decrease or increase total employment depending on whether free trade leads to the export or the import of the labor-intensive commodity.[13] The same basic result should be expected from our three-sector model and the direction of the total-employment effect of protection should depend on the direction of trade in the absence of intervention.

In the Harris–Todaro model, however, the increase in the relative price of agriculture generated by a movement to free trade will no longer have a positive employment effect because labor is no longer fully mobile. A fall in the relative price of manufactures will lead to higher urban unemployment that is not fully compensated by an increase in rural employment.

These are the major mechanisms that theory and an analysis of our specification suggests will determine our results in the case of the exogenous investment specification. Section 4 turns to an evaluation of these quantitative results. Section 5 will deal with the alternative neoclassical and classical endogenous investment or closed-loop saving specifications.

4. The quantitative results

A general-equilibrium model of the type specified leads to a great deal of microeconomic and macroeconomic results but we shall here concentrate on the welfare effects of alternative trade strategies. The welfare indicator used throughout is the Cobb–Douglas utility function, with sectoral consumption as arguments, from which the demand system can be derived.[14] Unless otherwise stated, the investment mobility parameter was set at $\delta = 0.10$ for all experiments we shall report on, implying moderate intersectoral mobility of investment funds.

Table 1 presents the level of utility reached in several years for the basic full employment, exogenous investment version of our model. At a 5% discount rate the protected path is slightly superior to the free trade path in terms of the sum of discounted utility reached at the end of the 40-year plan period. At a

[13]Provided that there is incomplete specialization. See also Lefeber (1971).

[14]Note that percentages are unaffected by multiplicative changes in welfare units. The natural origin of the utility function is given by zero consumption levels.

6% discount rate, free trade would become superior. Fig. 1 summarizes the results graphically.

Table 1

Welfare under free trade and protection: The full-employment model.

	Annual utility levels for years:					Total utility discounted at 5%
	2	10	20	30	40	
Free trade	30.6	52.0	104.0	255.7	662.3	1910
Protection	29.5	48.0	109.5	273.4	674.4	1955
Percentage difference (2−1)/1	−3.6	−7.7	+5.3	+6.9	+1.8	+2.3[a]

[a]Protection slightly superior.

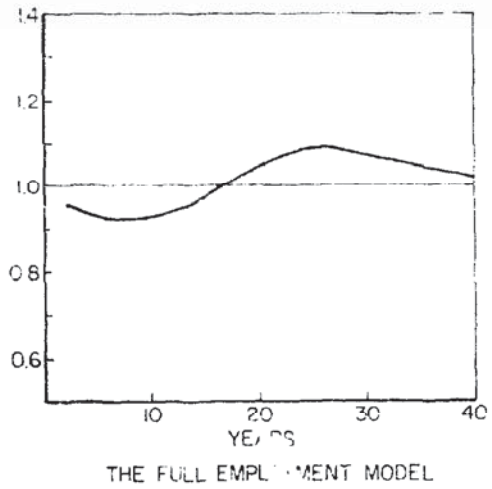

Fig. 1. The ratio of the level of utility under protection to the level of utility under free trade.

As shown in table 1 and fig. 1, at first the static allocation effects predominate, and in year 10 the welfare loss due to protection reaches almost 8%. But the dynamic effects favorable to protection are at work throughout and the protected path 'overtakes' the free trade path in year 17. It is not until year 28, however, that the discounted sum of utility is greater under protection than under free trade. Towards the end of the plan period the relative weight of agriculture in domestic production becomes insignificant for both growth paths. The dynamic investment allocation effect therefore loses its significance which explains the shape of the graph in fig. 1.

Table 2 describes the differences in investment allocation generated by the two alternative trade strategies. The difference in investment allocation reaches its peak in year 10 with manufacturing getting 61.7% under protection as opposed to only 31.5% under free trade. After the first 30 years the allocation of investment begins to look similar in both cases. Since the static effect is still at work in each period and the dynamic effect has lost much of its force, the superiority of the protected path starts to decline again.

Table 2

Profit rates and investment allocation shares: The full-employment model (percentages).[a]

	Years									
	2		10		20		30		40	
	R_i	H_i	R_i	H_i	R_i	H_i	R_i	H_i	R_i	H_i
Free trade										
Agri.	48.1	33.1	39.4	29.7	26.3	16.1	13.1	2.6	7.2	0.2
Mfgr.	16.0	23.7	33.4	31.5	43.4	48.7	45.7	58.7	44.4	56.1
N.T.	36.8	41.2	36.2	38.8	37.6	34.2	46.3	38.7	47.9	43.7
Protection										
Agri.	32.4	15.4	22.1	6.5	9.6	0.5	6.3	0.0	0.0	0.0
Mfgr.	43.2	46.7	52.2	61.7	50.3	64.0	49.7	60.6	50.2	57.4
N.T.	43.4	37.9	44.6	31.8	53.0	35.5	53.2	39.4	52.3	42.6

R_i = profit rates,
H_i = investment shares.
N.T. = non-tradables.

The results presented confirm and quantify the trade-off between static costs and dynamic benefits of protection and show that in our model a protectionist strategy pays-off at discount rates below 5%. There are however many qualifications.

As expected, the result is largely due to the substantial differences in technical progress rates. To verify this we have experimented with different rates. In the case of a 'neutral' run with $g_i = 1.5\%$ in all sectors the discounted sum of the utilities is no longer higher but 3.7% lower under protection and free trade remains superior even with a zero discount rate. Note however that even in this case differential factor accumulation preserves a much weakened but still positive dynamic allocation effect that leads the protected path to 'overtake' the free trade path in year 31.[15]

[15]It is this particular effect, linked to the Rybczynski theorem, that has been qualitatively analyzed by Findlay (1973, ch. 8).

Increasing the investment mobility parameter δ strengthens the dynamic allocation effect favorable to protection by leading to more pronounced investment misallocation under free trade at the beginning of the plan period, but it also weakens its impact on welfare because the eventual correction of the misallocation is also more rapid. Moderate variations in assumed investment mobility do not affect the overall ranking of policies although they do affect the growth path.

What stands out in the results from the full-employment model is the relative smallness of the overall differences in the discounted sum of utilities. This is due to the fact that the static and dynamic effects tend to cancel out. Given that the spread postulated between the technical progress rates can be considered as a rather extreme upper-bound, table 1 should not be interpreted as justifying a policy of continued protection.

Indeed an intermediate policy of 'gradual' trade liberalization may dominate both paths so far presented. A growth path generated by a policy that lets the tariff decline geometrically starting in year 10 yields a discounted sum of utilities that is slightly greater than in the case of continued protection.

Fig. 2 summarizes the comparisons of growth paths in the fixed-wage and the Harris–Todaro type migration models. Here total employment effects complicate the picture and the percentage differences can no longer be considered as small.

For the fixed-wage case it is now the free trade path that very clearly dominates in terms of discounted utility. It remains true however that the protected path eventually overtakes and in the terminal period it generates a welfare level that is almost 35% greater than under free trade. Fig. 2a depicts the behavior of the two welfare paths.

The major explanation behind these results is the very strong total employment effect. This underlines the importance of trade policy for employment problems. Table 3 summarizes the alternative employment paths. It should be stressed that a rigidly fixed rate of real wage growth that is independent of the other variables in the system is not a realistic specification for a period as long as 40 years. In particular, the extension of the assumption of an infinitely elastic supply of labor at a fixed wage to the agricultural sector is not really justified. The assumption is often made for the urban sector but massive instantaneous reverse migration back to agriculture implied in the free-trade version of the fixed wage model is clearly unrealistic. An increase in the relative price of agriculture generated by a movement to free trade would not be able to generate the dramatic increase in agricultural employment if labor mobility between the urban and rural sectors was imperfect. The total employment effect would therefore lose much of its force. Urban employment would actually fall, leading to a worsened overall employment situation, at least initially. This is reflected in fig. 2, which summarizes the performance of our alternative trade strategies for the third variant of the model specifying an endogenous Harris–Todaro

type migration mechanism. In what is probably the most realistic specification of the labor markets, protection now clearly dominates. Indeed, except between years 7 and 14, the protected path is now consistently above the free trade alternative. The total employment effect is initially detrimental to free trade

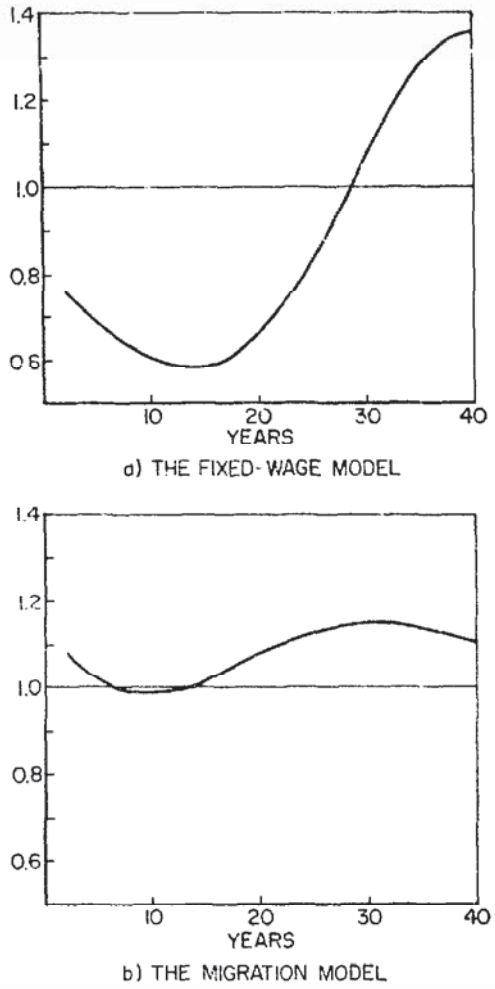

Fig. 2. The ratio of the level of utility under protection to the level of utility under free trade.

actually reducing economy wide employment. Table 4 describes the details of the results.

The conclusions derived from a Harris–Todaro type specification are thus exactly the opposite of those obtained in the fixed-wage case because the employment effect tends to work in opposite directions. This shows that it is extremely important when assessing the impact of alternative trade strategies on employment to analyze the actual degree of intersectoral labor mobility.

Table 3

Economy-wide employment under free trade and protection: The fixed-wage model (thousand workers).

	Years				
	2	10	20	30	40
Free trade	14700	26700	41100	50798	54000
Protection	9071	12131	17930	32024	65796
Difference $(2-1)/1$	−38	−55	−56	−37	+22

Table 4

Economy-wide employment, migration and urban unemployment under free trade and protection: The migration model (thousand workers).

	Years				
	2	10	20	30	40
Free trade					
Economy-wide employment	8300	12100	17500	26300	31700
Rural–urban migration	108	163	219	417	562
Urban unemp. rate	48%	22%	–	–	–
Protection					
Economy-wide employment	9200	12100	17500	23400	31700
Rural–urban migration	108	205	375	289	150
Urban unemp. rate	25%	14%	–	–	–

We have until now assumed that the economy-wide capital stock valued at base year prices grows exogenously. One could alternatively specify savings functions of the classical or neoclassical type. It is to a brief discussion of the issues relating to the interaction between trade policy and saving behavior that we turn in the next section. To conclude the report on the 'exogenous investment' specification of the model, table 5 summarizes the basic characteristics of the growth paths generated by the three variants discussed in this section.

Table 5
Summary characteristics of the growth paths for the exogenous investment case.

	The full employment model		The fixed wage model		The migration model	
	Free trade	Protection	Free trade	Protection	Free trade	Protection
Average annual GNI growth	8.5%	8.7%	8.8%	9.5%	8.3%	8.8%
Average annual growth in base-year valued total consumption	8.4%	8.5%	8.6%	9.5%	8.3%	8.6%
Exports of manufactures starts in year	10	2	31	4	14	4
Average annual growth in the real wage	4.7%	5.4%	3.0%[a]	3.0%[a]	3.9% (2.7%)[b]	4.4% (1.9%)[b]
Total sum of discounted utilities in year 40	1910	1955	2413	2.87	1772	1932
Rankings in terms of utility	protection slightly superior		free trade superior		protection superior	

[a]The wage grows exogenously in all sectors.
[b]The urban wage grows exogenously.

5. Specifying explicit savings behavior

On the growth paths we have discussed so far, a certain fraction of national income was implicitly saved each year and spent on the acquisition of new capital goods. By using the 'exogenous investment' version [eq. (13)] of our model, we implied that the 'real' rate of capital accumulation is somehow determined independently of trade policy.

In this section we shall instead attempt to capture the interaction between trade policy and aggregate capital formation by specifying neoclassical and classical savings functions [eqs. (13′) and (13″)] familiar from descriptive growth theory. As has recently been emphasized in the theoretical literature,[16] the relative price and income changes generated by changes in trade policy may have important effects on savings behavior, real growth, and therefore development performance. Note that our model with its nontraded sector that includes construction and its treatment of capital as a composite commodity will always retain some domestic production of capital goods in contrast to the 2-by-2 models where generally investment goods are either only exported or only imported.

[16]See, for example, Corden (1971), Johnson (1971) and Deardorff (1973).

The impact of trade policy on savings behavior can essentially be decomposed into income, substitution and distribution effects.

If real income increases, due to changes in trade policy, there will be greater saving and therefore greater real capital accumulation. This is the essence of the income effect and it strengthens the argument for free trade. As noted above, in the early phase of our plan period the static allocation effects favorable to free trade are dominant. If this leads to greater capital accumulation free trade will now itself have a positive dynamic effect that must be set against the dynamic investment allocation effect favorable to protection. The situation may however, reverse itself if, because of strong dynamic allocation effects, income under protection were ever to overtake income under free trade. At that point the income effect would start reinforcing the positive effect of protection.

Turning to the substitution effect, its direction depends on which kind of trade policy leads to a fall in the relative price of investment goods. Tariffs on imported capital goods will clearly increase their relative prices. On the other hand, the higher exchange rate implied in a free trade strategy will increase the cost of capital goods that can be imported without a tariff. In our model the noncompetitive import component of capital goods is more expensive under free trade, while the machinery component domestically produced or competitively imported is cheapened by freer trade. Moreover, the price of nontradable capital (construction) is substantially lower under free trade so that, netting out, free trade leads to a significant reduction in the relative price of capital goods. Table 6 describes the behavior of capital prices.

Table 6

The impact of trade policy on the relative prices of capital goods (U_I) with full employment and neoclassical savings.

	Years				
	2	10	20	30	40
Free trade					
Agri.	0.780	0.719	0.718	0.792	0.860
Mfgr.	0.848	0.840	0.839	0.850	0.859
N.T.	0.787	0.724	0.723	0.799	0.870
Protection					
Agri.	0.806	0.801	0.895	0.969	1.016
Mfgr.	0.921	0.921	0.929	0.935	0.939
N.T.	0.805	0.800	0.898	0.970	1.024

With the income and substitution effects working together in the same direction whenever initially free trade increases national income, the results obtained when specifying a neoclassical saving function should be expected to be more favorable to free trade than those reported on in section 4.

If however, we specify a classical savings function so that savings depends only on total profits, a distribution effect will work in conjunction with the income and substitution effects discussed above. A trade policy that increases the relative prices of the goods that use capital more intensively will tend to increase real accumulation. In our model, manufacturing and nontradables being capital intensive, the distribution effect will be favorable to protection.

Fig. 3 summarizes the results obtained for the full employment version of our model when a neoclassical or a classical savings function is specified. These results should be compared to those given in table 1 and fig. 1. While protection was slightly better than free trade for the exogenous investment specification, free trade is now clearly preferable for the neoclassical and even the classical savings function. Note that the dynamic allocation effect is still at work but in the case of the neoclassical savings function it is never powerful enough to wholly offset the combined static allocation, income and substitution effects. When a classical savings function is specified, the protected path overtakes the free trade path for a few years. But as the relative weight of agriculture becomes insignificant towards the end of the plan-period, the dynamic allocation and distribution effects lose their strengths and the free trade path again overtakes the protected path (see fig. 3). In terms of total discounted utility, free trade remains superior.

The nature of the results remains basically unchanged for the fixed wage and migration variants of our model. Specifying a neoclassical savings function substantially strengthens the case for free trade particularly in the fixed-wage model. In the migration model, where free trade lowers urban employment without being able to rapidly increase agricultural employment, the income effect is favorable to protection but it is only with a classical savings function when it is combined with a distribution effect, that it is able to offset the substitution effect and actually strengthen the case for protection. Protection remains superior in the migration model: by 4% with the neoclassical savings function (less than the 8.9% obtained with the exogenous investment specification) but by 10% with the classical savings function.

6. Conclusion

The small 'stylized' general-equilibrium model presented was able to capture and quantify many of the relationships that should be considered and quantified when designing trade policy in a developing country. In principle it could easily be extended into a fully disaggregated multisector model and it is such disaggregation based on extensive and reliable data that would transform it into an actual planning model. The kind of data needed to properly estimate the structure of the model are difficult to obtain but not beyond reach. It should also be noted that in a disaggregated model a much more careful analysis of techno-

logical change incorporating the concept of international product cycles could yield qualitatively new results.

If an overall conclusion can be drawn from our model, it is that when labor is mobile only very strong dynamic effects can make protection a superior

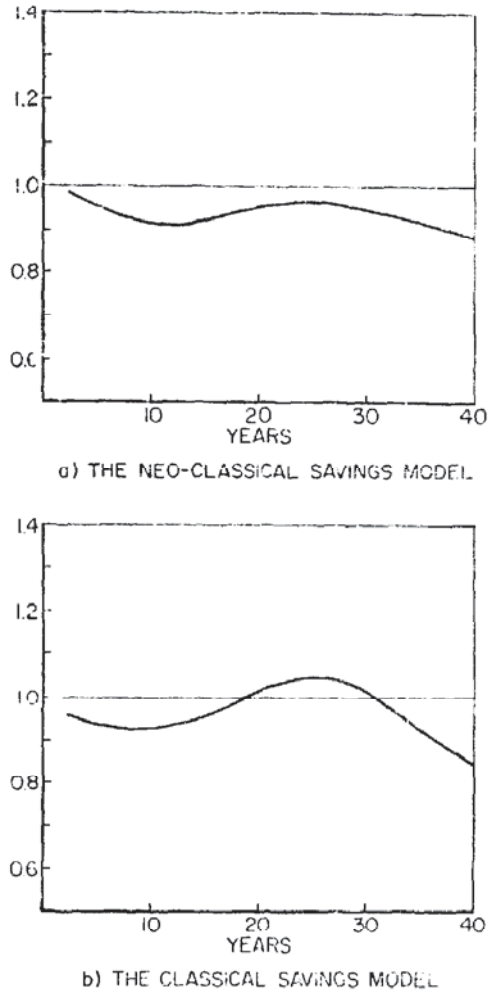

Fig. 3. The ratio of the level of utility under protection to the level of utility under free trade under the full employment specification.

strategy. Whenever labor supply is very elastic to labor intensive export sectors free trade will be preferred. If, moreover, economy wide employment is a variable, a very strong total employment effect reinforces the case for free trade, provided again that labor is intersectorally mobile. On the other hand, when labor is relatively immobile most of the static and dynamic mechanisms that lead to improved welfare under free trade can no longer fully work and protection may dominate free trade.

Our experiments also indicate that the kind of savings behavior specified is important and that the substitution, income and distribution effects that trade policy generates in this context are as important as the more traditional allocation effects.

Finally, it should be stressed that comparing two extreme trade strategies does not lead to knowledge of an optimal strategy. Future research may have to concentrate on finding optimal paths for tariff rates. If the model could be extended into an optimizing direction that would allow the computation of optimal tariffs and subsidies, the solution may well prove to be an in between strategy of gradual and carefully phased trade liberalization.

Appendix

This appendix presents the parameters that have remained constant during the computations and that have not been explicitly given in the text. They have been derived by aggregation and rounding from the 37-sector data base of the Third Turkish Five-Year Plan. Sectors 1, 2 and 3 are agriculture, manufacturing and nontradables.

The input–output matrix: a_{ij}.

	1	2	3
1	0.220	0.180	0.030
2	0.040	0.260	0.170
3	0.100	0.200	0.150

The capital composition matrix: s_{ij}.

	1	2	3
1	0.000	0.000	0.000
2	0.200	0.500	0.150
3	0.700	0.300	0.700

The noncompetitive import coefficients: s_{0j}.

1	2	3
0.100	0.200	0.150

The base-year shift parameters in the production functions: $\bar{A}_{i0}$.

1	2	3
0.920	1.500	1.350

The Cobb–Douglas elasticities.

1	2	3	
0.300	0.650	0.700	Capital α_i
0.700	0.350	0.300	Labor β_i

The base-year capital stocks (billion 1967 TL.).

1	2	3
36.0	70.0	62.0

The consumption shares: q_i.

1	2	3
0.28	0.40	0.32

The base-year urban labor supply (million workers) = 4.0.
The base-year total labor force (million workers) = 10.0.
The base-year urban wage (1967 TL. per year per worker) = 6600.
The savings parameters $\overline{S} = 0.25$, $\overline{SP} = 0.45$.

References

Adelman, I. and S. Robinson, 1976, Income distribution policy in developing countries: A case study of Korea (Stanford University Press, Stanford, CA).
Ahmed, F., 1974, Migration and employment in a multi-sector model – An application to Bangladesh, unpublished Ph.D. Dissertation (Princeton University, Princeton, NJ).
Armington, P., 1969, A theory of demand for products distinguished by place of production, Staff Papers 16, 159–178.
Bhagwati, J., 1971, The generalized theory of distortions and welfare, in: J. Bhagwati et al., eds., Trade, balance-of-payments and growth: Papers in international economics in Honor of C.P. Kindleberger (North-Holland, Amsterdam).
Brecher, R., 1974, Minimum wage rates and the pure theory of international trade, Quarterly Journal of Economics 88, 98–116.
Corden, W.M., 1971, The effects of trade on the rate of growth, in: J. Bhagwati et al., eds., Trade, balance-of-payments and growth (North-Holland, Amsterdam).
Corden, W.M., 1974, Trade policy and economic welfare (Oxford University Press, Oxford).

Deardorff, A.V., 1973, The gains from trade in and out of steady state growth, Oxford Economic Papers 25 July, 173–191.

Deardorff, A.V., R. Stern and C. Baum, 1976, A stimulation model of world trade and production, paper presented to the International Finance Seminar, Princeton University, November.

De Melo, J.A.P., 1975, A multi-sector, price endogenous trade model applied to Colombia, unpublished Ph.D. Dissertation (Johns Hopkins University, Baltimore).

Dervis, K., 1975, Substitution, employment and intertemporal equilibrium in a non-linear multi-sector planning model for Turkey, European Economic Review 6, January, 77–96.

Fields, G., 1975, Rural–urban migration, urban unemployment and underemployment, and job search activities in LDCs, Journal of Development Economics 2, no. 2, 165–187.

Findlay, R.E., 1973, International trade and development theory, (Columbia University Press, New York).

Harris, J. and M. Todaro, 1970, Migration, unemployment and development: A two-sector analysis, American Economic Review 60, 126–142.

Johansen, L., 1960, A multi-sector study of economic growth (North-Holland, Amsterdam).

Johnson, H.G., 1971, Aspects of the theory of tariffs (Allen and Unwin, London).

Johnson, H.G., 1971, The theory of trade and growth: A diagrammatic analysis, in: J. Bhagwati et al., eds., Trade, balance-of-payments and growth (North-Holland, Amsterdam).

Lefeber, L., 1971, Trade and minimum wage rates, in: J. Bhagwati et al., eds., Trade, balance-of-payments and growth (North-Holland, Amsterdam).

Magee, S., 1973, Factor market distortions, production and trade: A survey, Oxford Economic Papers 25, 1–43.

Robinson, S. and J.A.P. de Melo, 1976, A planning model featuring trade, intra-sector product differentiation and income distribution, Research Program in Development Studies, Princeton University, November.

Staelin, C.P., 1976, A general equilibrium model of tariffs in a non-competitive economy, Journal of International Economics 6, no. 1, 39–63.

Taylor, L. and S. Black, 1974, Practical general equilibrium estimation of resource pulls under trade liberalization, Journal of International Economics 4, no. 1, 37–58.