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9. ABSTRACT

This paper, which is based on a doctoral thesis in economic modeling, presents estimates of the effects of protection on resource allocation in a general equilibrium resource allocation model. A section of the paper briefly describes a Walrasian general equilibrium trade model applied to Colombia to study the effects of price distortions on sectoral resource allocation. Next discussed are estimates of the effects of protection in Colombia, as obtained from the model. Finally, those results are compared with those that might be obtained by use of a partial equilibrium analysis. The author concludes that even within a simple general equilibrium model, the interaction of many effects ultimately determines the impact of price distortions on resource allocation. Some of the effects are likely to be more important than others. Among those that are likely to escape intuition is the finding that factor price variations and also adjustments in the relative price of non-traded goods in response to tariff changes are likely to affect sectoral output responses to changes in tariff structures. The model developed in this paper may be best viewed as a useful tool for exploring the relative importance of various interdependencies which should be taken into account when formulating a protective policy. The model indicates that Colombia has the greatest comparative advantage in primary products: agricultural products and mining. Next, within the manufacturing sector, it has a comparative advantage in food, beverages, tobacco, and non-metallic products. These sectors are relatively intensive in their use of unskilled labor. Thus a move towards freer trade, by providing greater uniformity of incentives between agricultural and manufacturing sectors, would increase employment of unskilled labor.

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MEASURING THE EFFECTS OF PROTECTION ON RESOURCE ALLOCATION*

by

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Agency for International Development
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August 1976

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MEASURING THE EFFECTS OF PROTECTION ON RESOURCE ALLOCATION

I. Introduction

During the past decade applied trade economists have used extensively the concept of effective protection. Effective rates of protection (ERPs) have usually been estimated in a partial equilibrium framework under the assumptions of pure competition, unchanged factor prices, infinite foreign elasticities of demand (for exports) and supply (of imports) and zero substitution elasticity between inputs. If all goods are traded and the country has no monopoly power in trade, it has been argued that a ranking of industries by ERPs may correctly predict the direction of resource shifts resulting from a change in trade policies. By using output elasticities, ERPs can also be used to measure the resulting sectoral output changes. Under these assumptions, production and consumption effects can be separated; the former are measured by the ERP and the latter by the nominal rate of protection.*

As soon as the presence of non-traded goods is recognized, this simple separation of production and consumption effects breaks down since the production and consumption of non-traded goods have to be

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*See Leith (1971) for an analysis of the effects of tariffs on production, consumption and trade.

brought into equality through a price adjustment for each of these goods. And, if there are any links between non-traded and traded goods through substitution effects in production and/or consumption, it follows that, for the system as a whole, production and consumption effects may no longer be separated. More recently, theoreticians have discussed the consequences of introducing input substitution and have derived the definition of a general equilibrium ERP index in the absence of non-traded goods. Ethier (1971) has shown that introducing substitution gives rise to problems in defining value-added and the effective rate of protection. Bhagwati and Srinivasan (1973) have derived, in a general equilibrium model with more factors than final goods and with separable production functions, a physical measure of value-added for "local" changes in tariffs so that the first term (ERP index) represents the proportionate change in the"price" of a physical unit and the second term represents the proportionate change in the quantity (in physical units) of value-added (1973, p. 263). Finally, it has been pointed out that, regardless of the presence of non-traded goods, a ranking of ERPs will not indicate the relative intensity of resource shifts if factor prices are allowed to vary. Thus, in a three commodity model it is possible for commodity A, having a lower effective rate than commodity B, to enjoy greater protection if it is complementary in factor use with unprotected commodity C so that it benefits from a

protection-induced decline in the prices of primary factors it uses intensively.[1]

These criticisms concerning the neglect of factor price effects, substitution possibilities among inputs, and the treatment of non-traded goods, have been raised by trade theorists whose concern has often been to bring out the possibility of situations giving rise to paradoxes and counter-examples. These criticisms have been useful in helping ERP enthusiasts revise some of the early claims made about effective protection. But, in the meantime, the methodology has gained widespread use and has provided us with valuable information about the structure of protection in developed and developing countries. Because of their widespread use and because tariff structures are among the policy instruments governments may use to influence resource allocation it is of great practical interest not only to understand how well effective protection performs as a qualitative indicator of resource allocation under various commercial policies, but also to what extent it may help us in quantifying these changes in resource allocation.

The purpose of this paper is: (1) to present estimates of the effects of protection on resource allocation obtained from a general equilibrium resource allocation model featuring non-traded goods, direct substitution in supply and demand; and (2) to compare these results with those one would obtain using a partial equilibrium methodology.

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[1] See Balassa (1971a) for a discussion of the possible magnitude of these effects. The list of major contributions to the concept of effective protection may be found in the bibliography of Gruebel and Johnson (1971) and in the symposium published by the Journal of International Economics (1973).

The next section describes briefly a Walrasian general equilibrium trade model applied to Colombia to study the effects of price distortions on sectoral resource allocation. The following section presents estimates of the effects of protection in Colombia obtained from the model. The final section compares these results with those which might be obtained using a partial equilibrium analysis .

II. A General Equilibrium Trade Model

This section describes briefly the model used to study the effects of trade policies on resource allocation. Its primary purpose is to provide insights on the long-run structural consequences of alternative trade policies after all adjustments have taken place and it will be used as a basis for comparison between general and partial equilibrium estimates of resource pulls under trade liberalization. A distinctive feature of the model is that the various agents in the economy-- producers and consumers -- may interact through a variety of specifications of market behavior which lend themselves easily to the incorporation of price distortions.[2]

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[2] See Johansen (1960) for the formulation of the first multi-sector non-linear model. His model, and Taylor-Black (1974) whose specification of the foreign trade sector is similar to this one, were linear in growth rates, and so could be solved as a set of simultaneous linear equations. The Walrasian approach which is used here, involves directly solving for a set of market clearing prices and wages for a specified market behavior. As such it is better suited for a variety of specifications of market behavior than a programming approach where it is difficult to analyze the effects of changing preexisting price wedges such as tariffs and indirect taxes. See Adelman-Robinson (1975) for a discussion and comparison of the Walrasian and programming approaches.

Some specific features of the model are outlined here and the reader is referred to the appendix for a list of equations, variables, and parameters. On the supply side, producers maximize profits subject to a Leontief technology for intermediate inputs and non-competitive imports. For value-added, Cobb-Douglas and two-level C.E.S. production functions are specified.[3] Full employment of all factors is maintained, and factor wages are endogenously determined. On the demand side, the representative consumer maximizes a Stone-Geary utility function. When maximized subject to a budget constraint, it yields the linear expenditure system. The parametric restrictions imposed on the utility function rule out inferior and complementary goods.[4] The model, therefore, incorporates direct substitution in both production and demand to reflect changes in consumption patterns and choice of production techniques resulting from changes in the relative price of outputs and inputs.

As specified here, the role of the government is concentrated in the foreign trade sector of the economy. It imposes tariffs, taxes and subsidies on traded commodities. Because there are no equations linking factor payments, savings and total consumption, direct taxes on factor incomes do not appear in the model. However, the difference between government expenditures and revenues from trade policy are covered by direct taxes so that the government budget is implicitly balanced under different trade policies. Since the model is designed for comparative statics, investment remains exogenously fixed in base year prices.

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[3]Cobb-Douglas production functions impose unitary elasticities of substitution across all factors while two level C.E.S. production functions allow for other than unitary elasticities of substitution between aggregated capital and aggregated labor. However, all experiments reported here refer to C-D functions.

[4]As stated, the LES satisfies the conditions of: (1) homogeneity of degree zero in prices and income; (2) the budget constraint; and (3) the Slutsky Symmetry.

There is no explicit introduction of money in the model; therefore, only relative prices can be determined and one has to choose a normalization rule. To compare relative prices, it is convenient to maintain a constant price level, thereby implying that monetary authorities control the money supply during the resource shifts between sectors. This amounts to determining a price level such that base year GNP valued at current prices remains constant. The exchange rate is flexible and adjusts to maintain balance of payments equilibrium. Alternatively one could have assumed a fixed exchange rate and a fluctuating trade gap. This alternative is not considered so as to make results more directly comparable to those obtained in partial equilibrium analysis where some estimates of the likely exchange rate adjustment are provided.

In the context of a small country assumption, Samuelson (1953) has shown that in a perfectly competitive model with n final goods and s primary factors where n>s, the over-determination resulting from more fixed prices through trade than variable factor prices resolves itself through the country specializing in the production of s commodities. Although it is easy to brush aside the specialization problem in theoretical models by specifying more factors than commodities, in practice one is

limited by data availability and one has to recognize that empirically measurable commodities do outnumber primary factors of production. In this model, there are eleven traded sectors and four primary factors of production have been specified: skilled labor, unskilled labor, capital and land, whose use is restricted to the agricultural sectors.[5] The model also assumes mildly decreasing returns to scale, thereby allowing for selective specialization according to comparative advantage since there are no bounds on quantities traded (unless the country faces a quota on world markets as Colombia does for coffee). It is argued that import substituting industries face rising supply costs while on the export side it is argued that increasing exports involve market development (or transport) costs.[6]

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[5] In a multi-sector framework, it is customary to overcome the "specialization problem" by dropping the small country assumption and/or, in an activity-analysis format, by specifying fixed factors and bounds on quantities traded. (See Evans 1972). Taylor-Black (1974) fix capital stocks so that they are restricted to the short-run effects of tariff-cuts while ERPs purport to measure the long-run response after all adjustments have taken place.

[6] The economic justification for rising supply costs in import substituting industries follows Weisskof's (1971) and Ali's (1975), studies of import substitution in India. Owing to the high level of aggregation common in multi-sector models, sectoral production functions are used as proxies for all industries included in a sector, thereby losing information about the relative comparative advantage of industries within the sector. Defining for each of these industries, their average cost as the domestic factor cost needed to save one unit of foreign exchange, one can derive the sector's stepped supply curve by ranking industries according to their costs. Taking a concrete example, the costs of replacing a dollar's worth of, say, metal products varies according to the particular commodity produced. An expansion (contraction) involves moving up (down) the steps on the curve to a successively higher (lower) cost industry. Ali (1975) has derived the relation between cost, efficiency and output using a neoclassical production function. Here, as will be seen later in section IV, it is more convenient to assume decreasing returns to scale since the objective is to compare results with those obtained using ERPs. (See specification in the appendix)

The introduction of increased factor mobility reflecting long-run conditions makes it desirable to consider large changes in relative prices, including a return to free trade. Such parametric variations prohibit linearization techniques used to approximate non-linear models and adopted by Johansen and Taylor-Black; instead the model was solved using a tâtonnement process in factor markets.[7] Having briefly outlined the model, we now turn to an empirical application and examine the effects of a removal of trade distortions in Colombia.

III. An Application of the Model: Protection and Resource Allocation in Colombia

The model outlined above will now be used to estimate the effects of protection in Colombia, taking 1970 as the base year. The sectoral classification reported in Table 1 indicates that eleven out of the fifteen sectors are traded.[8] Though not indicated in that table, two sectors use land: coffee and agriculture. The reason for not lumping these sectors together is that, though there is scant information as to how they should be distinguished on technological grounds, they enter foreign trade in quite a different manner since Colombia has a quota share on the world

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7 Linearization constrained Taylor-Black to examine (10-20%) reductions in tariffs. They report that a typical experiment took 5.4 CPU minutes. The algorithm used here only involves a couple of CPU seconds on a similar computer for a system of equations with nearly as many equations.

8 See de Melo (1975) and the appendix for the data sources particulary those on price distortions which take into account the tariff equivalents of quotas.

TABLE I

Tariff - Ridden Solution

1 4	TARIFF	DOMESTIC PRICE	VALUE ADDED	OUTPUT PHYSICAL	OUTPUT VALUE	CONSUMPTION PHYSICAL	CONSUMPTION VALUE	TRADE DOMESTIC	TRADE WORLD	CAPITAL STOCK	UNSKILLED LABOR	SKILLED LABOR
COFFEE	-44.0	1.000	97.2	54.864	54.864	0.0	0.0	42.079	75.141	120.610	470.091	32.145
AGRICULTURE	3.4	1.000	84.2	296.366	296.366	196.276	196.276	12.218	11.822	747.780	1979.165	132.711
FOOD,BEVERAGE,TOBACCO	3.7	1.000	32.1	140.341	140.341	102.657	102.657	15.161	14.622	109.270	42.587	14.536
TEXTILES & APPAREL	15.6	1.000	46.4	81.789	81.789	54.370	54.370	0.964	0.833	107.810	73.925	13.122
PAPER,WOOD,LEATHER	12.2	1.000	41.2	31.025	31.025	8.406	8.406	-1.511	-1.348	38.080	18.618	4.762
RUBBER & CHEMICALS	46.0	1.000	63.1	66.259	66.259	21.042	21.042	-15.812	-10.830	82.320	20.827	12.102
METALS & PRODUCTS	56.2	1.000	37.0	44.344	44.344	0.0	0.0	-18.800	-12.033	55.230	25.176	5.950
NONMETALLIC PRODUCTS	4.7	1.000	50.2	19.687	19.687	7.182	7.182	0.554	0.529	42.220	21.660	4.175
MINING & PETROLEUM	-0.2	1.000	63.2	48.244	48.244	1.999	1.999	5.572	5.585	134.990	76.387	2.419
MACHINERY	144.6	1.000	59.9	21.804	21.804	1.424	1.424	-4.958	-2.027	25.250	14.180	5.024
DIVERSE INDUSTRIES	149.1	1.000	57.4	24.127	24.127	24.097	24.097	-15.071	-6.050	28.270	22.254	5.780
LIGHT DOMESTIC IND.		1.000	54.9	50.767	50.767	12.701	12.701			40.040	13.633	5.982
CONSTRUCTION		1.000	67.5	111.300	111.300	91.207	91.207			201.490	318.523	7.269
TRANSPORT & COMMUN.		1.000	71.4	116.692	116.692	24.625	24.625			326.160	217.623	8.001
SERVICES & ARTISANS		1.000	91.4	374.944	374.944	203.083	203.083			731.310	1884.[illegible]	306.120

coffee market amounting to 14% of world production in that year. Since Colombia filled its quota share, I have determined that export tax which would keep the value of Colombian coffee exports, measured at world prices, equal to their initial value prior to removal of tariffs and subsidies in the other sectors.

Table I provides a description of the Colombian economy in the tariff-ridden base year. In addition to distortions in product markets, factor wage differentials observed in that year are taken as representative of differentials due to differences in the quality of the labor force across sectors or regions and/or policy imposed distortions on labor and capital markets. Since 1970 was a fairly "typical" year in Colombia, at least in the foreign trade sector, Table I is assumed to represent an equilibrium with factor and product market distortions. While such a representation may be questionable, especially for an LDC, it has a great empirical advantage in that the tariff-ridden solution obtained from the model is quite close to the observed allocation in the base year.

Returning to Table I, column 1 indicates the percent ad valorem tariff structure. A negative sign indicates that the sector is a net exporter and has an export tax. Otherwise the price distortion is a subsidy or a tariff according to whether that particular

sector is a net exporter or a net importer. The net trading status may in turn be determined by looking at the signs of quantities traded in either column 8 or 9 (+ for exports - for imports). Column 2 indicates that distorted domestic prices are set equal to unity for the base year. Percentage value-added comes next, followed by gross sectoral outputs in physical and value terms. These two sets of figures are necessarily equal in the base year since prices are set equal to one. The same argument applies to private final demand reported in columns 6 and 7. Exports and imports valued at domestic prices come next, followed by their values at world prices. Finally the last three columns, ten to twelve [9], provide estimates for factor stocks in the base year.

Table II reflects the effects on sectoral resource allocation of removing tariffs and subsidies with capital (and land) fixed; it may be viewed as the short-run response of the economy to the removal of the tariff structure. Here it is assumed that the capital stock in each sector is exogenously given. This implies that the sectoral rates of return to capital are calculated from the equations determing the sectoral demands for capital. As indicated, the table gives the percentage change of the variables entered in Table I.

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[9] All figures are in Colombian pesos x 10^8. Capital stocks are valued in the same units as gross outputs, consumption and trade. Labor stocks are in thousands of man-years. Valued at base-year prices GNP is 107 billion pesos. About one half of GNP is classified as tradable and 12% of GNP is traded. The share of GNP accruing to unskilled labor is 30.3%; to skilled labor 15.4%; to capital 38.7; and 8.2% to land.

TABLE 2

FREE TRADE SOLUTION (CAPITAL·STOCKS FIXED).

PERCENTAGE CHANGE OVER INITIAL SOLUTION

1 2	TARIFF	DOMESTIC PRICE	VALUE ADDED	OUTPUT PHYSICAL	OUTPUT VALUE	CONSUMPTION PHYSICAL	CONSUMPTION VALUE	TRADE DOMESTIC	TRADE WORLD	CAPITAL STOCK	UNSKILLED LABOR	SKILLED LABOR
COFFEE	7.2	5.2	5.4	0.8	6.0	0.0	0.0	5.2	-0.0	0.0	2.2	7.0
AGRICULTURE	-100.0	7.-	10.0	2.8	11.0	-7.3	-0.0	197.8	176.0	0.0	8.8	13.9
FOOD,BEVERAGE,TOBACO	-100.0	7.5	15.7	5.4	13.3	-6.9	0.1	107.7	93.1	0.0	17.2	22.7
TEXTILES & APPAREL	-100.0	-3.6	-3.7	-5.0	-8.4	1.2	-2.4	-377.0	-387.2	0.0	-12.0	-7.9
PAPER,WOOD,LEATHER	-100.0	-0.6	4 9	1.9	1.3	-1.6	-2.2	-127.6	-127.8	0.0	2.8	7.6
RUBBER & CHEMICALS	-100.0	-23.6	-32.0	-16.3	-36.0	26.6	-3.3	42.1	86.0	0.0	-45.2	-42.6
METALS & PRODUCTS	-100.0	-28.6	-42.6	-32.6	-51.9	0.0	0.0	-0.1	40.0	0.0	-62.9	-61.1
NONMETALLIC PRODUCTS	-100.0	6.5	12.2	9.3	16.4	-7.7	-1.7	534.2	495.5	0.0	17.9	23.4
MINING & PETROLEUM	-100.0	11.8	14.6	1.7	13.7	-12.1	-1.8	39.9	25.2	0.0	12.1	17.4
MACHINERY	-100.0	-54.4	-76.0	-71.2	-86.8	107.8	-5.2	85.3	306.5	0.0	-93.3	-93.0
DIVERSE INDUSTRIES	-100.0	-55.2	-82.9	-76.1	-89.3	113.3	-4.5	76.0	293.1	0.0	-96.1	-95.9
LIGHT DOMESTIC IND.		-2.4	-1.3	-1.6	-4.0	0.0	-2.3			0.0	-6.6	-2.2
CONSTRUCTION		-2.3	3.1	-0.1	-2.4	0.0	-2.3			0.0	-1.0	3.7
TRANSPORT & COMMUN.		-1.7	-0.2	-2.6	-4.2	-0.6	-2.3			0.0	-6.6	-2.2
SERVICES & ARTISANS		-0.0	0.0	-2.6	-2.6	-2.1	-2.1			0.0	-6.3	-1.9

Suppose, we wish to predict output response to changes in tariffs on the basis of price information. Starting with nominal prices, one can check, by comparing columns 2 and 4, whether nominal prices and physical outputs have the same sign. They do in all instances except for paper, wood and leather, where the price declines and output increases. In this case, it is necessary to examine the change in net price to correctly infer that output will expand. Turning to a comparison of the direction of value-added and output changes, construction is the only sector whose output response does not correspond to a priori expectations due to the effect of changes in factor prices. In all other instances, the output of sectors whose value-added was higher under protection declines when tariffs are removed, and vice-versa. On the basis of these results, one can conclude that in practice factor price effects are not likely to outweigh product price effects. Moreover, as expected, both nominal and net prices are good indicators of resource pulls in general equilibrium.

The short-run consumption response to a removal of tariffs is reported in columns 6 and 7.[10] Barring cross-price and income effects, the physical consumption of goods whose relative price increases declines

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[10]The parameters entering the demand system were obtained from Howe (1974). All subsistence minima are positive so that no good has an own price elasticity of demand above unity. Cross-price effects with respect to food are usually quite high. The matrix of expenditure and price elasticities can be found in de Melo (1975, p. 88).

TABLE 3

FREE TRADE SOLUTION (CAPITAL STOCKS MOBILE)

PERCENTAGE CHANGE OVER INITIAL SOLUTION

1 4	TARIFF	DOMESTIC PRICE	VALUE ADDED	OUTPUT PHYSICAL	OUTPUT VALUE	CONSUMPTION PHYSICAL	CONSUMPTION VALUE	TRADE DOMESTIC	TRADE WORLD	CAPITAL STOCK	UNSKILLED LABOR	SKILLED LABOR
COFFEE	0.1	8.8	9.1	12.5	22.4	0.0	0.0	8.9	0.0	20.2	16.0	22.7
AGRICULTURE	-100.0	5.4	7.2	4.0	9.6	-3.2	2.1	34.9	28.0	9.1	5.3	11.4
FOOD,BEVERAGE,TOBACO	-100.0	5.0	9.5	80.5	89.7	-2.8	2.1	741.9	701.4	93.6	86.8	97.6
TEXTILES & APPAREL	-100.0	-5.8	-7.7	-63.0	-65.2	6.7	0.5	-4594.7	-4871.9	-66.6	-67.7	-65.9
PAPER,WOOD,LEATHER	-100.0	-2.9	0.0	-22.0	-24.2	3.8	0.8	278.9	290.2	-23.6	-26.2	-22.0
RUBBER & CHEMICALS	-100.0	-25.4	-34.8	-98.2	-98.7	33.9	-0.1	270.8	397.0	-98.9	-98.9	-98.8
METALS & PRODUCTS	-100.0	-30.3	-46.1	-100.0	-100.0	0.0	0.0	67.2	139.9	-100.0	-100.0	-100.0
NONMETALLIC PRODUCTS	-100.0	4.0	7.6	45.2	51.0	-2.6	1.3	1773.0	1700.7	53.0	47.6	56.2
MINING & PETROLEUM	-100.0	9.2	11.1	38.5	51.2	-7.1	1.4	306.1	272.0	50.8	45.5	53.9
MACHINERY	-100.0	-55.5	-77.7	-100.0	-100.0	119.9	-2.1	125.9	407.3	-100.0	-100.0	-100.0
DIVERSE INDUSTRIES	-100.0	-56.3	-84.7	-100.0	-100.0	125.8	-1.3	93.8	343.4	-100.0	-100.0	-100.0
LIGHT DOMESTIC IND.		-0.1	2.6	-2.6	-2.7	1.1	1.0			-2.3	-5.6	-0.2
CONSTRUCTION		-1.7	4.1	2.1	0.3	2.7	0.9			4.0	0.4	6.2
TRANSPORT & COMMUN.		0.7	3.2	-1.7	-1.1	0.4	1.1			-0.8	-4.2	1.3
SERVICES & ARTISANS		2.6	2.7	-3.4	-0.9	-1.3	1.3			-3.0	-6.3	-0.9

and vice-versa. Comparing columns 2 and 5, this is so except in three instances where price and consumption have the same sign. Since there are only thirteen commodities entering private final demand, it appears that consumption response to tariff changes cannot be forecasted without taking into account expenditure and cross-price effects.

The trade pattern in the absence of tariffs and subsidies is reported in columns 8 and 9. It is noteworthy that textiles and apparel changes status and becomes an import under free trade. However, one cannot infer Colombia's comparative advantage on the basis of this information alone since comparative advantage refers to the long-run when all factors of production are perfectly mobile between sectors.

Table 3 provides the same information as Table 2 but differs in one important respect: capital and land are assumed to be mobile so that it describes the long-run structural changes resulting from a removal of trade distortions. The reader can verify that there are again a few instances where relative price changes do not correctly predict output responses but that relative net price changes are a good indicator of resource pulls for traded goods, and that for all but one non-traded sector, construction, the factor price effect outweighs the product price effect. Tests with a C.E.S. technology yielded similar results with identical output rankings for traded sectors. As suspected, the pattern of output response for non-traded sectors was found sensitive to the specification of technology because of the relative importance of changes in factor prices in determining output response. (See de Melo (1975)).

Table 3 indicates that the following sectors would not operate under free trade: diverse industries (which includes electrical and electronic goods), machinery and metal products. Rubber and chemicals would also disappear. Inspection of trade flows reveals that another sector, paper wood and leather becomes an import sector. On the basis of the pattern of trade, Colombia has a comparative advantage in agricultural products, food industries, mining (mainly petroleum) and non-metallic products. Since these sectors are relatively intensive in their use of unskilled labor, the relative price of that factor increases. Experiments with an infinitely elastic supply of unskilled labor at a fixed real wage indicated that a removal of trade distortions would increase employment of unskilled labor (by 5.4 percent in the short run and 9.0 percent in the long-run).

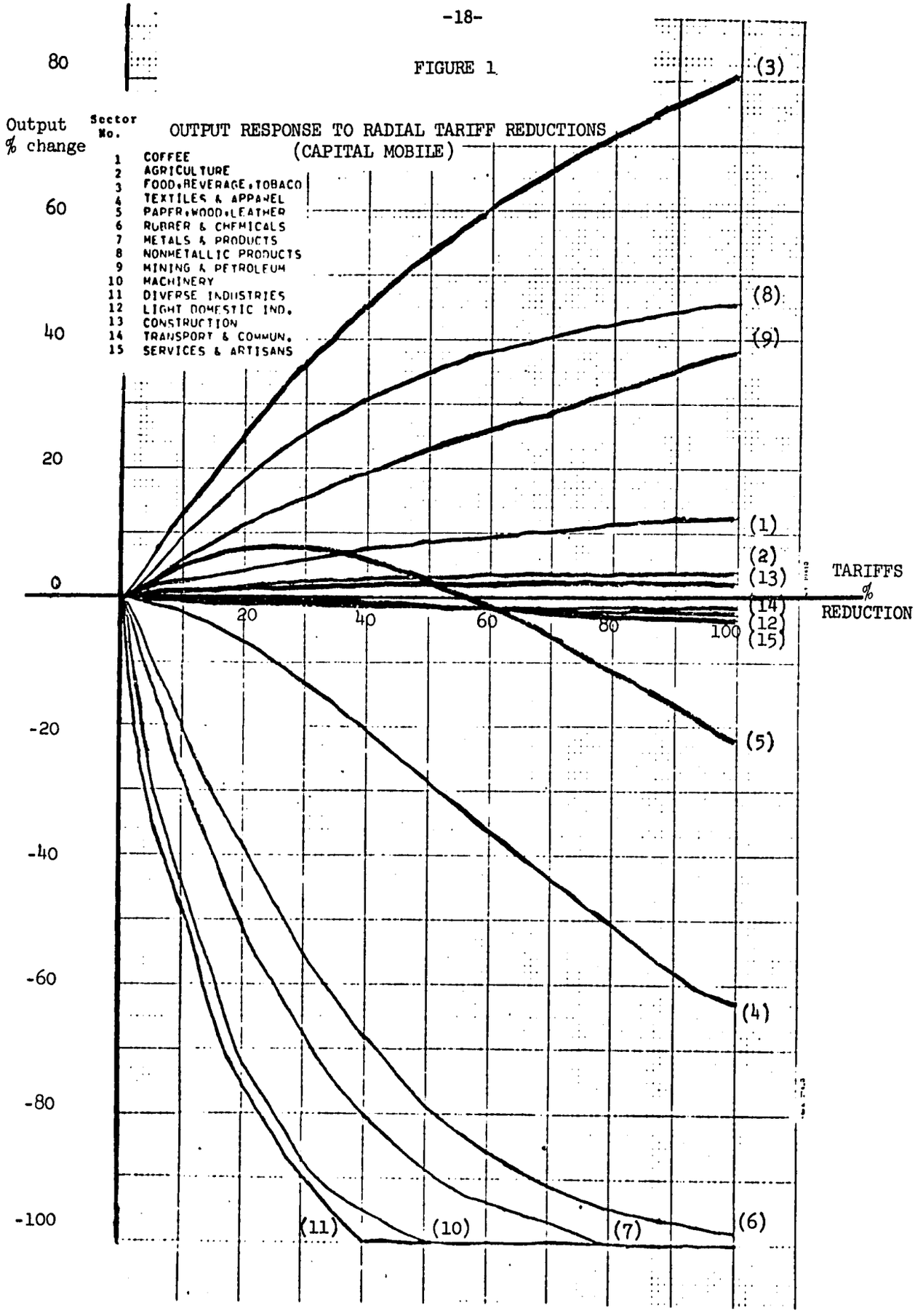
Non-traded sectors are indeed affected by the change in tariff structure. Three sectors contract due to the combined effects of: (a) inter-industry linkages embodied in the input-output table; (b) shifts in consumption away from non-traded goods and; (c) primary resources bid away by the expanding traded sectors. However, one sector construction, expands. This expansion is brought about by the interaction of several factors. On the one hand, that sector delivers a substantial amount of intermediate inputs to several expanding sectors including petroleum. Second, that sector enjoys a decline in the cost of its intermediate inputs and there is some substitution

among its primary inputs following the change in their relative prices. Finally there is an adjustment in the relative price to equate the supply and demand for housing by the private sector.

It is also interesting to note the effect on coffee and agriculture of introducting capital and land mobility. With land and capital fixed, the coffee tax rate has to be increased by 7.2%.so that the coffee quota is met after increased deliveries to the food industries are accounted for. With increased factor mobility, the adjustment in the coffee tax becomes negligible because capital and land are shifted into that sector. Despite a quota, the coffee sector expands to satisfy its deliveries to the food industries. As for agriculture, its expansion is limited as it is constrained by land which it has to share with coffee. It is also noteworthy that the price adjustment of non-traded goods (and therefore the exchange rate adjustment) is also greater when some factors are immobile. This is so because factor rigidity increases the price adjustment necessary to eliminate excess demands in non-traded sectors.

Although the model presented here is designed to study static rather than dynamic comparative advantage, it is interesting to analyze sectoral expansions and contractions resulting from radial reductions in tariffs and subsidies. One would expect sectors to contract and expand monotonically with respect to these successive reductions in tariffs; however, this is not the case. Figure 1 which depicts the output response of each

FIGURE 1


OUTPUT RESPONSE TO RADIAL TARIFF REDUCTIONS
(CAPITAL MOBILE)
Output % change
Sector No.
1 COFFEE
2 AGRICULTURE
3 FOOD, BEVERAGE, TOBACO
4 TEXTILES & APPAREL
5 PAPER, WOOD, LEATHER
6 RUBBER & CHEMICALS
7 METALS & PRODUCTS
8 NONMETALLIC PRODUCTS
9 MINING & PETROLEUM
10 MACHINERY
11 DIVERSE INDUSTRIES
12 LIGHT DOMESTIC IND.
13 CONSTRUCTION
14 TRANSPORT & COMMUN.
15 SERVICES & ARTISANS
80
60
40
20
0
-20
-40
-60
-80
-100
20
40
60
80
100
TARIFFS % REDUCTION
(3)
(8)
(9)
(1)
(2)
(13)
(14)
(12)
(15)
(5)
(4)
(6)
(7)
(10)
(11)

sector to radial tariff reductions reveals that sector 5, paper, wood and leather expands initially until tariffs are reduced by 30%, then contracts until it registers a 21% reduction under free trade. Note also that textiles and apparel (sector 4) contracts at an increasing rate for tariff reductions up to approximately 50%. The behavior of these two sectors exemplifies a possible interaction between traded and non-traded goods which would not be captured by a partial equilibrium analysis.[12]

To explain the behavior of textiles and paper, (sectors 4 and 5), it is necessary to consider their input requirements from non-traded sectors. Both of these sectors require substantial deliveries from transport and services (sectors 14 and 15). In fact, their intermediate input requirements from these sectors are well above those of other traded sectors. While both sectors have nominal and effective rates of protection which do not differ greatly, sector 4 uses unskilled labor more intensively than sector 5 which is therefore relatively more intensive in its use of skilled labor and capital. When tariffs are reduced by 10% across the board, the relative price of sectors 14 and 15 declines while the unskilled wage rate increases relative to the skilled wage and rate of return to capital. The combined effects of declining intermediate and primary input prices brings about an increase in output of sector 5. However, because the unskilled wage rate increases,

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[12]Note that the ranking of output changes is not invariant as one moves towards free trade and that such a change would not be captured by a ranking of ERPs which would be invariant under uniform tariff reduction across the board.

sector 4 cannot follow the same path as sector 5 and contracts. But increased intermediate input requirements from sector 5 soon brings about an increase in the relative prices of sectors 14 and 15 as smaller amounts of these goods remain to satisfy private final demand. Increased intermediate input costs induced by the rising supply prices of non-traded goods reduces the rise in value-added initially registered in sector 5 for small reductions in tariffs. Eventually, as tariffs are further reduced, and the relative prices of sectors 14 and 15 continue to rise in response to increased final demand, the initial output expansion of sector 5 turns into a decline as can be seen from figure 1. The bunching of non-traded goods around the horizontal axis indicates a small output response to tariff reductions conforming to a priori expectations.[13]

The results in this section indicate that relative net price and relative gross price adjustments are not an infallible indicator of resource shifts and consumption responses to large revisions in the tariff structure, even when they are estimated from the model. Moreover,we have seen that there are quantitatively significant links

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13 A similar graph for the case of fixed capital stocks indicated a fairly linear output response to tariff reductions. In contrast with figure 1, the expansion and contraction of all sectors, including those of sectors 4 and 5, showed a very slight convexity to the origin. It is on the basis of such an experiment that Taylor and Black concluded that ERPs provided a good measure of output response to small tariff reductions.

between traded and non-traded sectors. The next section compares the results obtained by solving the model with those one would obtain in a partial equilibrium framework.

IV. A Partial Equilibrium Analysis of Price Distortions and Resource Allocation

We have just examined the effects of protection in a general equilibrium trade model. Because implementation of such a model requires a good deal of work, including substantial data collection and a fair amount of experimentation with solution techniques, it is desirable to find out how much information is lost by using a partial equilibrium analysis to measure the effects of price distortions on resource allocation.

Suppose we have some information about the tariff structure and the elasticity of supply, e_i, of commodity i. Then the percentage change in sectoral output for commodity i, X_i', following a change in tariffs, is given by:[14]

$$X_i' = e_i \, EP_i \qquad (1)$$

Where EP_i is the ERP for commodity i. However, use of (1) will not yield acceptable estimates of sectoral output changes since, unless some sectors have a negative ERP, a reduction in tariffs would, according to the above

[14] See Leith (1971, p. 75), who also derives an expression for the change in consumption. Note that EP_i need not refer to a comparison between a tariff ridden situation and free trade but may refer to comparisons between two tariff-ridden situations.

formula, lead to reduction in sectoral output.[15] This may be remedied by using net ERPs to adjust for the extent of over-valuation as compared to the free trade situation. The exchange rate adjustment provided by the free trade solution of the model is used on the grounds that it is the "correct" adjustment under the given assumptions.

Taking sectoral technological structure to be defined by Cobb-Douglas production functions for primary factors, the short and long-run sectoral elasticities of supplies, e_i, may be derived by differentiating the sectoral production functions and the demand equations for primary factors and the resulting expression is:

$$x_i' = \frac{\sum_\lambda \alpha_{\lambda i}}{V_i - \sum_\lambda \alpha_{\lambda i}} \overline{EP_i} \qquad \begin{matrix} i = 1 \ldots q_1 \\ \lambda = 1 \ldots s \end{matrix} \qquad (2)$$

Where $\overline{EP_i}$ is the net ERP.[16] To conform with the partial equilibrium

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15 Taylor-Black, who used formula (1) to compare partial and general equilibrium predictions of resource shifts for local tariff revisions finessed this issue by assuming that all exports violated the small country assumption so that use of (1) resulted in a contraction for import competing sectors and an expansion for export sectors.

16 The necessity of assuming "decreasing returns to scale to resources in general'" (Johnson 1971, p. 369) can be easily seen from (2) since, with constant returns to scale ($V_i = 1$), the denominator of the first term on the RHS of (2) would be equal to zero. This point explains why the linearization problem discussed on page 6 was resolved here by assuming decreasing returns to scale. In the case where capital and land are fixed, their exponents drop out of expression (2). EP_i is defined here as the ratio of the difference between domestic value-added under protection and under free trade to domestic value-added under free traded and it is assured that the price of non-traded goods remains unchanged between the two situations. The expression for the net effective rate of protection is given in Balassa (1971, p. 324). As an alternative, (2) was also estimated using domestic rather than world value-added as denominator for the expression determing EP_i. The predictive power of this version of the partial equilibrium model was no higher than the one reported in figure 2; for estimates in the first quadrant it yielded lower predicted values and vice-versa for estimates in the third quadrant.

FIGURE 2

ACTUAL AND PREDICTED CHANGES OF SECTORAL OUTPUTS: COBB-DOUGLAS VALUE-ADDED PRODUCTION FUNCTIONS. 100% REDUCTION IN TARIFFS (EXCEPT COFFEE)

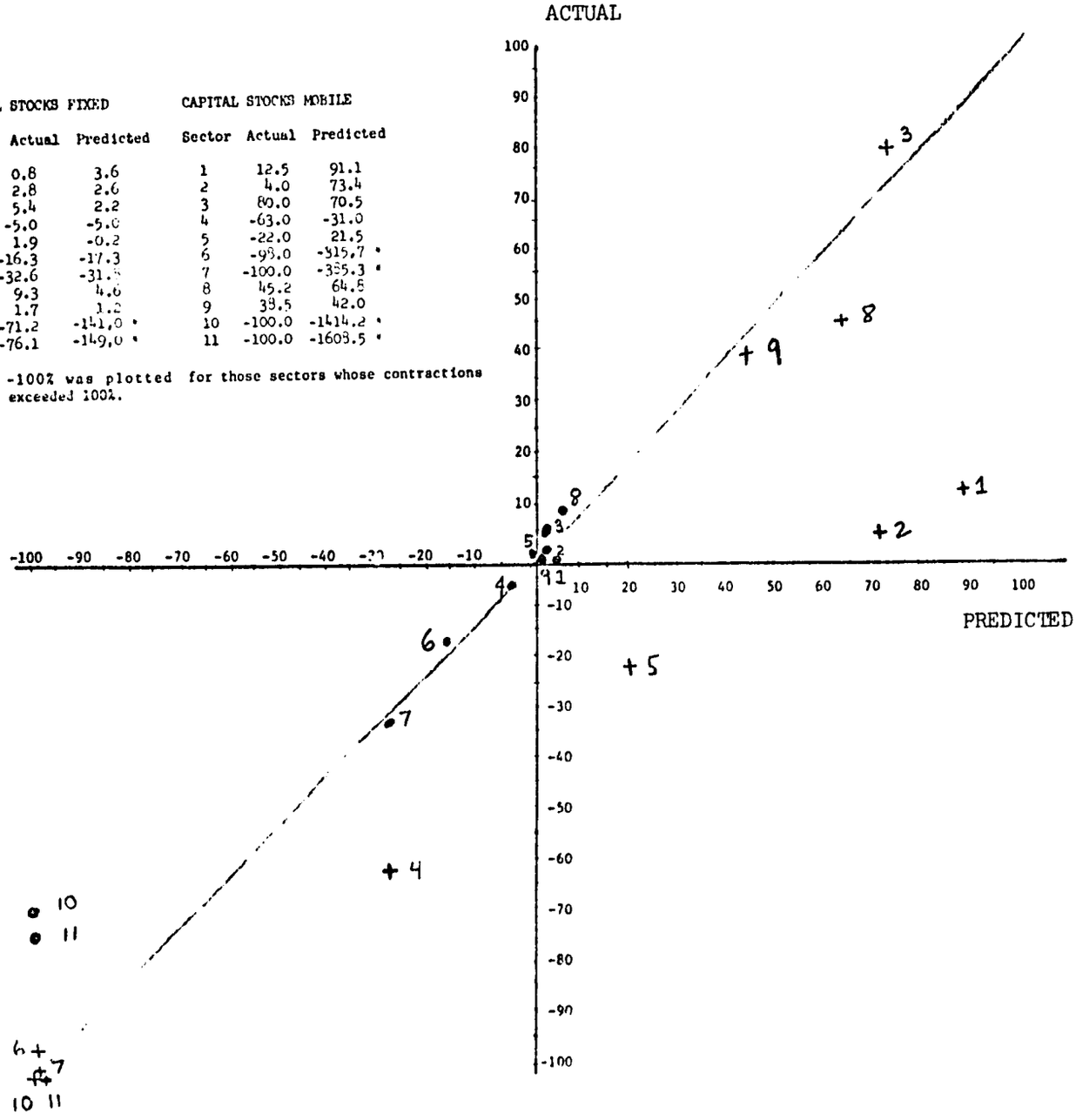
CAPITAL STOCKS FIXED

Sector	Actual	Predicted
1	0.8	3.6
2	2.8	2.6
3	5.4	2.2
4	-5.0	-5.0
5	1.9	-0.2
6	-16.3	-17.3
7	-32.6	-31.5
8	9.3	4.6
9	1.7	1.2
10	-71.2	-141.0 *
11	-76.1	-149.0 *

CAPITAL STOCKS MOBILE

Sector	Actual	Predicted
1	12.5	91.1
2	4.0	73.4
3	80.0	70.5
4	-63.0	-31.0
5	-22.0	21.5
6	-98.0	-315.7 *
7	-100.0	-385.3 *
8	45.2	64.5
9	38.5	42.0
10	-100.0	-1414.2 *
11	-100.0	-1608.5 *

* -100% was plotted for those sectors whose contractions exceeded 100%.



CAPITAL STOCKS MOBILE (+); CAPITAL STOCKS FIXED (•)

analysis, factor price adjustments are omitted from (2).

Figure 2 plots the output response predicted by equation (2) against the "actual" physical output response predicted by the model under the two assumptions about factor mobility. By plotting both sets of points one can see whether: (a) ERPs are a good indicator of resource shifts in the short-run when tariff revisions are substantial and: (b) there is any pattern in the divergences between "actual" and predicted reponses in the short-run and in the long-run.

Before examining successively these questions one point should be made: if ERPs are properly adjusted for overvaluation by choosing the exchange rate adjustment from the model (11.5% and 8.8% devaluations for fixed and mobile capital stocks), they correctly identify expanding and contracting sectors, since all but one set of observations (sector 5) in figure 2 lie in the first and third quadrants. Although this statement would have to be altered for tariff reductions other than a return to free trade because of the behavior of sector 5 discussed earlier, this result is nonetheless reassuring and extends the results obtained by Taylor-Black for small tariff revisions in the short-run. Moreover, as indicated in the appendix,there is a high rank correlation between ERPs and physical output changes.

Concerning the first of the issues raised here, figure 2 indicates that the partial equilibrium estimate is not a good predictor of output response in the short-run when tariff reductions are substantial. The "local" results obtained by Taylor-Black using linear approximations do

not extend to the case of large revisions in the tariff structure. Moreover, the margin of error does not show any systematic variation with the size of the output change, although the short-run predictions are usually closer to the 45° line than the long-run estimates. Unfortunately the sample size of 11 is too small to allow for any generalization concerning a comparison of the two sets of estimates.

Returning to figure 2, one can examine the relation between the short-run and long-run output elasticities. With the exception of sector 5, all sectors which contract in the short-run, also contract in the long-run, although there are some changes in the ranking among sectors. The most notable of these concerns sector 3, whose short-run expansion is constrained by the high input costs from sector 1 due to the fixity of land in producing coffee. Naturally, this is an effect which is not captured by the partial equilibrium model where the coffee tax rate is exogenously determined.

As mentioned earlier, ERPs and equation (2) do not take into account factor price adjustments. While in most instances such a simplification appears to be satisfactory, this is certainly not the case for coffee and agriculture where the predicted output elasticities are well overestimated. This result is to be explained by the fact that

agriculture, the largest traded sector, has a low rate of protection and would expand substantially if land were not a constraint. The resource pull on that factor raises its rate of return by 14% when it is mobile. If this effect were captured in equation 2, the resulting overestimation for sectors 1 and 2 would be substantially reduced. These results indicate the importance of correctly estimating factor price changes and tariff or tax changes when there are quotas in specified sectors.

V. Conclusion

Even within a simple general equilibrium model, it is the interaction of many effects which ultimately determines the impact of price distortions on resource allocation. Implementation of the model outlined here suggests that some effects are likely to be empirically more important than others. Among the more important effects likely to escape intuition, it was found that factor price variations and perhaps more importantly, adjustments in the relative price of non-traded goods in response to tariff changes, are likely to have a bearing on sectoral output responses to changes in tariff structures. The results indicate that ERPs provide a good qualitative index of resource pulls. However, the importance of adjustments in factor prices and non-traded goods is revealed when one attempts to predict output response to tariff changes on the basis of ERPs and output elasticities; partial equilibrium estimates are no longer close to those provided by the general equilibrium model.

Above all multi-sector models are an effort at consistently organizing one's information. The model developed in this paper may be best viewed as a useful tool in exploring the relative importance of various interdependencies which should be taken into account when formulating a protective policy. The model indicates that Colombia has the greatest comparative advantage in primary products: agricultural products and mining. Next within the manufacturing sector, it has a comparative advantage in food, beverages and tobacco and in non-metallic products. On average, these sectors are relatively intensive in their use of unskilled labor. One can therefore conclude that a move towards freer trade by providing greater uniformity of incentives between agricultural and manufacturing sectors would increase employment of unskilled labor.

APPENDIX

To facilitate exposition, the following notation is adopted throughout: Greek letters and lower case Roman letters refer to exogenous parameters whose values are given to the model; upper case Roman letters refer to endogenous variables, but upper case Roman letters with a bar are used for exogenous variables. There are $n=q_1 + q_2$ goods produced in the economy; q_1 of these goods are traded; the remainder q_2 are classified as non-traded; Non-competitive imports are lumped into a sector, o. Superscripts are used to distinguish between the initial distorted situation (zero) and any other situation (one). In the case of a single representative consumer considered here, and under the proper assumptions of separability in the production and utility functions maintained in any empirical estimates, Arrow and Hahn (1971) have proved the existence and uniqueness of the solution to the system of equations described in the summary table. Indeed experiments taking widely different starting guesses always converged to the same solution.

The following table gives the rank correlation between different measures of protection and actual output responses under alternative assumptions concerning factor mobility.

TABLE A1

RANK CORRELATION OF MEASURES OF PROTECTION

	Nominal Tariffs	Effective Tariff	General Equilibrium Value-added
Capital Stocks Fixed	.764	.800	.950
Capital Stocks mobile	.845	.864	.955

MODEL SUMMARY

		Number of Equations
	Production Functions	
(1)	$X_i = A_i \prod_\lambda R_{\lambda i}^{\alpha_{\lambda i}}$; $i = 1 \ldots n$, $\lambda = 1 \ldots s$	n
	where: $V_i = \sum_\lambda \alpha_{\lambda i}$	
	Factor Demand Equations	
(2)	$P_i^* \dfrac{\partial X}{\partial R_{\lambda i}} = W_\lambda$	n·s
	Factor Differential Equations	
(3)	$W_{\lambda i} = d_{\lambda i} \hat{W}_\lambda$	s
	Trading Price Equations	
(4)	$P_o = \pi_o (1 + t_o)$	1
	$P_k = \pi_k (1 + t_k)$	q_1
	Net Price Equations:	
(5)	$P_i^* = P_i - \sum_j a_{ji} P_j - a_{oi} P_o$	n
	Price Normalization Equation:	
(6)	$\sum_i P_i^{*1} X_i^o = \sum_i P_i^{*o} X_i^o$	1
	Consumption Equations:	
(7)	$C_i P_i = P_i \delta_i + \gamma_i (Y - \sum_j P_j \delta_j)$	n-1
	where $Y = \sum_i C_i P_i$	
	Resource Constraints:	
(8)	$\sum_i R_{\lambda i} = \bar{R}_\lambda$	s
	Flow Balance Equations	
(9)	$X_i - T_i - \sum_j a_{ji} X_i - a_{oi} X_i = C_i + Z_i$; $T_i = o$ for $i > q_1$	n
(10)	$\sum_k \pi_k T_k - \pi_o \sum_i a_{oi} X_i = \Delta$; $k = 1 \ldots q_1$	1

LIST OF VARIABLES AND PARAMETERS

X_i, C_i, $\bar{Z}_i$	Gross output, private consumption and exogenous demand (Government demand + investment demand + depreciation) in sector i.
$R_{\lambda i}$	Use of primary factor λ. Estimates of sectoral capital stocks are from Berry (1974)
$\hat{W}_\lambda$	Average wage of primary factor λ .
P_i, P_i^*	Domestic and net price (inclusive of tariffs and subsidies) of sector i.
T_k	Quantity traded (competitively) of sector k (> o for exports) $\bar{T}_1$ fixed by quota export coffee tax.
$\alpha_{\lambda i}$	The exponent for factor λ in sector i . The exponent for capital, α_{ki}, is derived residually, i.e., $\alpha_{ki} = V_i - \sum_{\lambda \neq k} \alpha_{\lambda i}$
V_i	Returns to scale in sector i : $V_{1\ldots k} = .9$ $V_{k+1\ldots n} = 1$
a_{ij}, a_{oi}	Physical input-output coefficient and non-competitive import coefficient of sector i.
$\bar{A}_i$	Normalizing constant (shift parameter) defining units of measurement for sector i; calculated from eq. 1 using base year values.
Δ	Trade gap measured at world prices.
γ_i, δ_i	Marginal expenditure share and subsistence minimum for sector i. These were obtained from Howe (1974).
$d_{\lambda i}$	Differential wage scale parameter for primary factor R_λ. These parameters are the weights defining the average wage $\hat{W}$ in the base period so that $\sum_i d_{\lambda i}(R_{\lambda i}/\bar{R}_\lambda) = 1$
Y	Total private expenditures.
Π_k	World price of commodities produced by sector k; $k=1\ldots q_1$
t_k	Ad valorem tariff (subsidy) for sector K. These were obtained from Hutcheson (1973).

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