ENVIRONMENTAL AND ECONOMY-WIDE EFFECTS OF POLICY REFORM IN THE DOMINICAN REPUBLIC: A GENERAL EQUILIBRIUM ANALYSIS

Ivonne del C. Díaz Rodríguez *

David Kraybill**

Douglas Southgate ***

Introduction

In the rudimentary policy analyses featured in introductory economics textbooks, problems are portrayed as arising in an isolated fashion and remediable by a single action on the government's part. Under these circumstances, policy reform is a fairly straightforward exercise. Provided that, for the most part, markets function well, there is little doubt that deregulating a price here or taxing pollution there makes good sense.

If the simple problems emphasized in textbooks occur anywhere in the real world, they are the exception to the rule in the Dominican Republic, the second largest country in the Caribbean. In the name of food security, the national government long has pursued a policy of self-sufficiency in the production of rice, which is the staple food crop (Greene and Roe, 1992; Valdés *et al.*, 1995). To keep imports out of the country, a 40 percent import tariff and other trade barriers have been applied, which has driven up internal market values. In 1994, domestic producers received RD$3.26/pound while the border price was RD$1.86/pound (JAD, 1994). Meanwhile, the average retail value was RD$4.24/pound and rice purchases accounted for 17 percent of total consumer food expenditures (JAD, 1994). Since low-income households spend a lot of their income on food and since rice is a very important part of that group's diet, the poor have sacrificed much for the sake of self-sufficiency --and in the name of food security.

There are environmental consequences as well. Rice production requires large amounts of water, which is scarce in the Dominican Republic both because of climatic conditions and because the upper reaches of the country's watersheds are largely deforested and heavily eroded (USAID, 1992; World Bank, 1994). Protected from foreign competition, domestic rice growers use too much water. At the same time, favorable treatment for rice production discourages the switch to other crops (e.g., tobacco, fruits, and vegetables) that are less water-intensive and in which the Dominican Republic holds a comparative advantage.

Another, and more important, cause of inefficient water resource development is irrigation subsidies. The prices paid by farmers amount to approximately 1 percent of the operating, maintenance, and amortized capital costs of delivering water to their fields (IICA, 1999). As a result, incentives to adopt on-farm conservation measures are negligible. At the same time, the Dominican Institute of Water Resources (INDHRI), which builds and operates irrigation projects, lacks money for maintenance. Between farm-level inefficiencies and the losses that occur in primary, secondary, and tertiary canals, only 20 percent of the water diverted to irrigation projects actually ends up contributing to agricultural production (World Bank, 1994).

To be sure, self-sufficiency in rice production and selling irrigation water far below cost have had pervasive economic impacts. By the same token, reforming these two policies is bound to affect virtually every Dominican household. For the poor, who spend a large share of their meager earnings on rice, the benefits of price declines resulting from freer trade are especially important. But lower prices also diminish the incomes of rice producers, who comprise an important segment of the farm population. Farmers also bear much of the burden of decreased irrigation subsidies, although consumers are affected as well inasmuch as food prices are driven up because of higher production costs.

Clearly, a partial equilibrium framework does not suffice for analyzing the economy-wide impacts that result when market forces are given freer rein. In this study, a computable general equilibrium (CGE) model is used to assess the consequences of reducing irrigation subsidies and eliminating the tariff on rice imports. The model's structure allows for examination of the varied effects of price changes on upper-, middle-, and lower-income groups in urban as well as rural areas. Likewise, the CGE model's design allows for analysis of the reallocation of water resources in the agricultural economy resulting from more efficient pricing of water and rice.

A CGE Model

The analytical framework used follows the neoclassical CGE model described by Dervis *et al.* (1982). Through this model, the fundamental links between the production structure and the pattern of demand and income of various economic institutions are analyzed. Consequently, a change or disturbance in one sector of the economy will have repercussions throughout by changing relative prices and the incentives to produce and consume various goods and services.

As a rule, CGE models feature assumptions about consumer's preferences with respect to imported versus domestically produced commodities. In particular, the Armington assumption, after Armington (1969), relaxes the perfect substitutability postulate of the classical theory of international trade, which assumes that domestically produced goods are perfect substitutes for those sold in the world market (Condon *et al.*, 1986; De Melo and Robinson, 1989). Product differentiation on imports is introduced in the model through a constant elasticity of substitution (CES) function of commodities produced abroad and commodities produced domestically. On the export side, a constant elasticity of transformation (CET) function is employed.

CGE models also assume that the country is a price taker and cannot affect international terms of trade (the small country assumption). This assumption, together with the perfect substitutability assumption, leads to the law of one price. According to the classical theory of international trade, prices will be the same in all countries after exchange rate adjustments, implying inequality between domestic and world prices of tradable goods (Condon *et al.*, 1986). In addition, the assumption of fixed output is equivalent to assuming full employment of factors, representing a production possibility frontier (CET) that delineates the tradeoffs between exports and domestic supply (Dervis *et al.*, 1982). An external constraint for the balance of trade is also assumed. Without this constraint, import liberalization, which increases imports, would not have to be offset by increased exports or decreased imports in the rest of the economy. That is, "policy changes are not financed by a free lunch from the rest of the world" (De Melo and Tarr, 1992).

In most CGE models, the economy is represented by four sectors: producers, consumers, government, and the rest of the world. The supply side of the economy is represented by production and factor markets. The demand side is represented by income generation and product markets. The rest of the world comes into the model through imports and exports. Supply, which is composed of domestic production and imports, must equal demand (household demand, government demand, intermediate demand, investment demand, and exports). Since the goal of general equilibrium modes is to achieve a vector of prices that will clear all markets for producers and consumers, the interrelationship between the components of supply and demand must be specified. Model equations are based on individual optimizing behavior where producers maximize profits and consumers maximize utility. Equations and variables are described in Appendix 1.

CGE models contain fairly standard neoclassical closing conditions. In this case, investment is not given autonomously. Rather, investment is endogenous and adjusts to the given savings decisions (savings-driven investment). The production side gives output, full employment of factors is assumed, and responses in the production side of the economy are not allowed. The primary effect of fiscal policy is to change the composition of output rather than the magnitude. Output changes very little since full employment is assumed (Rattso, 1982). In addition to the savings-investment closure, two other closure conditions must be met to satisfy the Walras' Law—the government deficit and the balance of trade. That is, private savings plus government savings plus foreign savings must equal aggregate investment (Robinson *et al.*, 1990).

The Dominican CGE Model

The structure of the Dominican model relates to the focus on agricultural water use, and the Dominican economy is divided into five production sectors. One, which uses water intensively, is the rice sector. Other crops, which also require irrigation water but not as intensively as rice production does, comprise a second sector. The remaining sectors are agro-industry, manufacturing, and services (including those provided by the government). Segmentation of agriculture allows for study of the natural resource reallocation and changes in consumption patterns induced by policy change.

Households, which supply factors of production and receive income in return, are disaggregated among six groups: urban high income, urban middle income, urban low income, rural high income, rural middle income, and rural low income. This permits examination of the distributional consequences of policy reform. Of particular concern, of course, are the effects of freer rice trade and diminished irrigation subsidies on the well-being of the poor, who spend a larger share of their income on rice than other people do.

In each of the five productive sectors, technology for converting inputs into outputs is represented by a constant elasticity of substitution (CES) production function. Because they lend themselves to sensitivity analysis using alternative elasticities of factor substitution, CES functions have become routine in CGE modeling. This sort of sensitivity analysis is not possible with Cobb-Douglas functions, in which elasticities of substitution are arbitrarily set at one. In each of this model's five sectors, output is produced using a mix of primary inputs: water, labor, and capital. Water is treated as a separate factor of production since it substitutes for labor, capital, and herbicides in the production of rice and other commodities.

As in other CGE models, the Armington assumption – that imports and domestic goods are imperfect substitutes – is adopted. In other words, foreign and domestic goods in a given category are not identical, and therefore may have different prices. The degree of substitutability varies across sectors (Condon *et al.*, 1986). As with CES modeling of production, using CES functions to represent demand, as we have done, permits sensitivity analysis with different trade substitution elasticities.

The model is calibrated to a 1991 social accounting matrix (SAM) developed by the Dominican Central Bank. In particular, input-output coefficients, sectoral quantities, production taxes and import taxes, sectoral factor demands, allocation of investment, and household and government consumption shares are all derived from the SAM. These are complemented by information on the irrigation sector provided by the INDRHI.

Estimates of elasticities of substitution between domestic and foreign goods and services have been obtained from a study carried out in the Dominican Republic by Aristy-Escuder and Robinson (1995). These are within the range of econometric estimates found in the CGE literature (Agcaoili-Sombilla and Rosegrant, 1994; De Melo and Tarr, 1992; Shiells *et al.*, 1986; Stern *et al.*, 1976). An initial Armington elasticity estimate of 1.1 was used for the rice sector, and sensitivity analysis was conducted using lower (0.80) and higher (2.75) values. Estimates of input substitution elasticities used in the model ranged from 0.40 to 1.0 (De Melo and Tarr, 1992).

The final element of this research addressing proposed policy reform in the Dominican Republic involves evaluation of the impacts of reform on net economic well being and the distribution of those impacts, both positive and negative. For each of the six household groups, a Hicksian measure of net welfare change is calculated. In other words, we estimate either the maximum lump sum payment that a group would make to avoid a policy change that diminishes its net well-being or a minimum payment it would accept to forego a switch, which benefits the group, from the benchmark to the counterfactual general equilibrium. Each of these calculations is based on the assumption of government net revenue neutrality (Shoven and Whalley, 1977). That is, taxes paid by households are increased or decreased in response to any change in spending or tax collections resulting directly from a policy change – in this case, reduced irrigation subsidies or elimination of the tariff on imported rice.

Economy-Wide Impacts of Policy Reform

This study addresses the economy-wide consequences of two policy reforms, each of substantial importance. One reform is repeal of the 40 percent tariff on imported rice. The other is a reduction in irrigation subsidies.

Total elimination of the latter subsidies is politically infeasible. Many farmers have borrowed money to purchase land, at prices inflated because water is artificially cheap. Others have used real estate as collateral for loans. Either way, complete elimination of subsidies would cause land values to plummet, which would in turn create widespread financial distress, even bankruptcy. Recognizing this, we have chosen to investigate the impacts of raising water tariffs by a factor of 25, which would reduce the subsidy rate from 99 percent of the cost of delivering water to farmers (see above) to 75 percent. Although it is large, a 2500 percent increase in water prices is not politically out of the question. As indicated in Yap-Salinas (1995), a pilot project aimed at increasing irrigation efficiency in the Dominican Republic featured a 1500 percent price increase. Since this coincided with major improvements in service quality, the farmers participating in the project found higher prices acceptable.

Simulations carried out with the CGE model indicate the impacts of the two policy changes on production, prices, factor use, and consumption in all sectors of the economy. Special attention is paid to changes in agricultural water use. The sensitivity of CGE results to Armington elasticities – a key feature of this model and others of its type – are also investigated.

Effects of Free Trade in Rice. As cheaper imports come in from abroad, prices are reduced – by a little more than 9 percent if the Armington elasticity of substitution between domestically produced and imported rice is 1.1 (see middle rows of Table 1). In turn, the price decline causes Dominican rice growers to cut back production, by nearly 4 percent (Table 1). However, the increase in imports – 24.75 percent (Table 2) – outweighs the decrease in domestic output. With overall supplies higher by 5.67 percent (Table 2), rice consumption is able to increase.

Changes in the domestic price of rice depend greatly on the Armington elasticity. At the base-case elasticity of 1.1, the price decline is relatively modest, elimination of the 40 percent tariff only causing domestic prices to decline by a little more than 9 percent. With a lower elasticity parameter (0.80 versus 1.10), changes in prices, output, and water use are more modest. By contrast, the price of rice declines by 16.64 percent and domestic output falls by 8.15 percent if a higher parameter (2.75) is used, reflecting that domestically produced and imported rice are highly substitutable (Table 1).

Changes in rice production depend on supply elasticity. As indicated in Table 1, quantity supplied changes by a smaller percentage than does the price, implying that the price elasticity of supply is low (i.e., positive, but less than one). The elasticity of supply depends greatly on how costs vary as output changes. For example, the elasticity of supply will tend to be inelastic if marginal costs are highly sensitive to output levels.

Price impacts also depend on demand elasticities. Rice production is consumed almost entirely in domestic markets, and supply increases associated with a 40 percent tariff reduction have a greater effect on prices, implying that demand is inelastic. By contrast, the elasticity of demand for other agricultural commodities appears to be fairly high. In this case, other agricultural commodities (traditional export crops and non-traditional exports such as fruits and vegetables) are destined for foreign markets, in which changes in the volume of exports from the Dominican Republic, alone, have no significant effect on world prices.

As the market value of rice falls, resources shift from rice production to other agricultural activities (Table 2). There is an increase in supply as exports rise in other agricultural sectors. This increase in supply might be explained within the context of multiple competing demands and changing costs of production. According to general equilibrium theory, an increase in rice imports would be offset by a fall in imports or an increase in exports in other sectors of the economy. Indeed, the results show that exports in other agricultural sectors rise while imports fall. Consequently, markets for water and other primary inputs are affected.

Differences in demand elasticity also help to explain changes in resource allocation between rice and other agricultural activities. In the case of a high Armington elasticity (2.75), water used in rice production decreases by one-fourth while water used to grow other crops, many of which are exported, increases slightly. Furthermore, labor use in rice production falls by more than 22 percent and rises in the non-rice sector by nearly 6 percent (Table 2).

The main beneficiaries of tariff elimination are rice consumers, particularly rural households. The price they pay for rice declines by 9.02 percent as a result of lower import tariffs (Table 1). This allows consumption to increase by one-fifth in the case of an Armington elasticity value of 1.10 (Table 2). Rice is the country's staple food and it is the principal source of calories and protein intake. Accordingly, lower rice prices undoubtedly help to reduce the population at risk nutritionally, which has been increasing in recent years due to reduced consumption of expensive rice.

As indicated in Table 2, consumption of other agricultural goods is not greatly affected by a reduction of the tariff on rice imports. Lower prices for rice should cause demand to decrease for substitute commodities. On the other hand, demand is enhanced because of the increased household purchasing power associated with price declines. Given these two countervailing impacts, the net effects on consumption, be they positive or negative, are small.

Effects of Diminished Irrigation Subsidies. The other policy reform investigated in this paper is a 25-fold increase in the price of irrigation water. As indicated in Table 3, this change causes rice producers to cut back output (by 5.08 percent), if the elasticity of input substitution is 0.60. Production of less water-intensive crops declines as well, but only by 0.73 percent. All told, the 2500 percent price increase causes rice growers and other agricultural producers to decrease water use by more than 85 percent (Table 4).

Changes in input use depend greatly on the elasticity of input substitution. Sensitivity analysis has been carried out using three different elasticities of input substitution (0.40, 0.60, and 0.75) in both the rice and other crops sectors. As indicated in Table 4, the use of a lower elasticity value (0.40) leads to a smaller change in the use of water. By contrast, water use declines by more than 90 percent if a higher parameter (0.75) is used. Furthermore, a lower elasticity parameter leads to a greater reduction in output, particularly in the rice sector (5.64

percent). If a high elasticity value (0.75) is used, output declines by 4.51 percent (Table 3).

As pointed out above, changes in production depend on the elasticity of supply. As we can see from Table 3, the quantity supplied of rice and other crops changes by a smaller percentage than does the price, implying that the price elasticity of supply is low. Price impacts also depend on demand elasticities. Rice production is mainly consumed domestically, implying that demand is inelastic. On the other hand, a large portion of the production of other agricultural crops is destined for foreign markets, in which demand for Dominican output is elastic.

The results show that labor demand in the rice sector rises by 2.64 percent (Table 4) while falling in other agricultural sectors, due to an increase in the price of irrigation water. This result relates to substitution among factors of production. If the use of one factor (in this case water) decreases, the use of other factors would increase. This appears to be the case with rice production in the Dominican Republic, where water is used to substitute for other inputs (such as labor or capital and herbicides) because flooding is an effective method of weed control. This activity can also be accomplished by using more labor.

Certainly, an increase in the price of irrigation water has various consequences, some appealing and others less. On the one hand, water use in the rice sector is greatly reduced. Instead, more labor is used for domestic rice production. On the other hand, a rise in prices associated with an increase in the price of irrigation water, causes overall supplies to fall, decreasing domestic consumption of agricultural commodities (Table 4). Accordingly, a reduction in consumer surplus and economic welfare is experienced. Household savings fall slightly due to a reduction in total household income, associated with higher commodity prices.

Despite the less appealing consequences of increasing the price of water, this policy ameliorates other social costs imposed by the misuse of water resources. For example, the waste and misallocation of irrigation water lead to salinization and soil erosion problems, which further contribute to deterioration of downstream land, water shortages, and decreased electricity generation. For example, the World Bank (1994) has found that siltation of the country's main watersheds (Tavera, Valdesia, Sabaneta, and Sabana Yegua) causes, on average, approximately 18 percent of reservoir capacity lost; and that water delivered to farmers is usually in excess of the crop's technical requirements, causing flooding and soil erosion. Soil erosion problems further reduce soil productivity, agricultural yields and incomes, and hydroelectric production (Hwang *et al.*, 1994; Veloz, 1984; Veloz *et al.*, 1985).

Impacts on Economic Well-Being. As indicated already, net welfare changes, both positive and negative, resulting from policy reform have been estimated for each of the six household groups. In order to arrive at valid Hicksian measures of these changes, this analysis is predicated on the assumption that altering public policy will have no effect on net revenues in the public sector (Shoven and Whalley, 1977). To be specific, the direct effects on net revenues of reform – eliminating the tariff on imported rice or reducing irrigation subsidies, depending on which policy is being examined – have been calculated and the corresponding correction in general tax collections have been apportioned among the six household groups in accordance with their respective status quo shares of total payments of income, value-added, and other taxes. It so happens that, although the rich pay more taxes per capita that the poor do, the share of total taxes collected from the poor, who are much more numerous in the Dominican Republic, turns out to be quite high.

Net welfare changes resulting from liberalization of the Dominican rice market and the reduction of water subsidies are reported in Table 5. Elimination of the 40 percent tariff is beneficial for all six household groups. In urban areas, the rich and the middle classes each gain RD$6 million while RD$15 million go to the poor. Interestingly, rural households benefit even more from tariff elimination, even though rice is of course produced in the countryside. The gains are as follows: RD$8 million for the rich, RD$17 million for the middle-income group, and RD$23 million for the poor.

At least as interesting as the absolute magnitude of these gains in net welfare are their relation to benchmark household income (Table 5). For those who are moderately or highly affluent, the relative impacts of lower prices for rice and associated modest adjustments tax collections needed to compensate for the loss of tariff revenues are modest: 0.02 percent of current income for wealthy and middle-class households in urban areas, 0.04 percent for the rural rich, and 0.10 percent for the rural middle class. But the relative impacts are greater for the poor: a 0.11 percent increase in income for city-dwellers and a 0.21 percent gain for those in the countryside. Again, lower prices are worth more to the rural poor than the corresponding tax adjustment and income impacts associated with the diminished relative profitability of rice production are.

A partial analysis would suggest that a 25-fold increase in the price of irrigation water, which leads to higher food prices, reduces income for all six household groups. However, in a general equilibrium context in which tax cuts made possible by a reduction in government spending are considered, some of these groups actually experience a gain in net welfare (Table 5). High- and middle-income households in urban areas lose RD$29 million and RD$13 million, respectively. These amounts are equivalent to 0.10 and 0.05 percent, respectively, of the two groups' base incomes. Likewise, wealthy people in the countryside suffer a loss of RD$5 million, which is equivalent to 0.03 of base household income. But the three other groups experience a gain in net welfare: RD$17 million (0.13 percent of base income) for the urban poor, RD$9 million (0.05 percent) for middle-income households in the countryside, and RD$32 million (0.29 percent) for the rural poor.

Preservation of extremely high irrigation subsidies, then, is no more effective at combating urban and rural poverty than taxing cheap foreign rice is. When implicit tax burdens are considered, poor households end up benefiting if subsidies are reduced.

Conclusions

Where policy changes having economy-wide impacts are contemplated, the impacts on overall economic well-being are a matter of debate and concern. Our analysis of reductions in tariffs on imported rice and irrigation subsidies in the Dominican Republic indicates that reform causes general economic performance to improve.

Furthermore, the distributional impacts are favorable, the poor benefiting relatively more than wealthier people do. This result emerges clearly only in a general-equilibrium analysis, one that takes into account that poor households benefit substantially from the tax cuts made possible by lower irrigation subsidies.

As already acknowledged, our CGE model, like others of its type, furnishes alternative "snap-shots" of the Dominican economy. That is, each model run identifies the general equilibrium emerging in the long run under a specific mix of policies. Certainly, additional research is possible, to identify the path-dependency of adjustment from one equilibrium to another for example. But in spite of the model's limitations, our findings indicate that policy reform programs of the sort that many other countries, not just the Dominican Republic, face can serve equity as well as efficiency goals. For example, another country facing water problems due to government policies is Puerto Rico. According to the USGS (1998), water quantity and quality are greatly affected by the rapid increase in the development of new urban centers, housing, and discharges of liquid wastes from industrial and municipal sources. However, the government does not have an integrated strategy to deal with soil and water resources (Maysonet, 2000). For example, the environmental implications of a construction project are not being considered when a construction permit is given. As a result, there is an increase in water related problems such as soil erosion, sedimentation, water pollution, and lack of potable water (Nazario, 1994; USGS, 2000).

Obviously, the water crisis in Puerto Rico has implications that affect the entire economy. What would be the economy-wide and environmental effects of policy reforms programs in Puerto Rico? A general equilibrium analysis, of the kind developed for the Dominican Republic, would help explain those multisectoral linkages. However, to support policy analysis and the development of economy-wide models, there is a need to use consistent multisectoral economic data, such as the data included in the social accounting matrix (SAM). Although almost every country around the world has developed a SAM, the economy of Puerto Rico lacks this fundamental policy tool.

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APPENDIX 1

TABLE 1: OUTPUT AND PRICE CHANGES DUE TO ELIMINATION OF RICE IMPORT TARIFF.

Scenarios	*Output Change (%)*	*Price Change (%)*

Armington Elasticity Estimate of 0.80		
Rice	-2.62	-6.40
Other Crops	0.21	0.32
Agro-Industry	0.55	-0.28
Manufacturing	-0.04	0.39
Services	-0.07	0.33
Armington Elasticity Estimate of 1.10		
Rice	-3.88	-9.02
Other Crops	0.30	0.22
Agro-Industry	0.63	-0.32
Manufacturing	-0.04	0.46
Services	-0.08	0.39
Armington Elasticity Estimate of 2.75		
Rice		

Other Crops		
Agro-Industry	-8.15	-16.64
Manufacturing	0.59	-0.11
Services	0.89	-0.44
	-0.05	0.65
	-0.11	0.55

TABLE 2: ECONOMY-WIDE IMPACTS OF RICE TARIFF ELIMINATION (PERCENTAGE CHANGES).

Scenarios	*Rice*	*Other Crops*	*Agro-Industry*
Armington Elasiticity Estimate of 0.80			
Water use	-8.53	0.42	--
Labor use	-7.91	1.10	1.56
Total supply	5.02	0.22	0.24
Domestic supply	-2.64	0.23	0.35
Imports	20.48	0.12	-0.60
Exports	--	0.33	1.58
Consumption	17.55	-0.25	0.22
Exchange rate: 1.004			
Armington Elasticity Estimate of 1.10			

	-12.48	0.43	--
Water use	-11.46	1.60	1.81
Labor use	5.67	0.30	0.27
Total supply	-3.91	0.32	0.41
Domestic supply	24.75	0.03	-0.69
Imports	--	0.68	1.83
Exports	19.96	-0.18	0.25
Consumption			
Exchange rate: 1.005			
Armington Elasticity Estimate of 2.75	-24.41	0.46	--
Water use	-22.41	3.12	2.54
Labor use	7.64	0.52	0.38
Total supply	-8.22	0.57	0.57
Domestic supply	37.83	-0.28	-0.98
Imports	--	1.76	2.57
Exports	27.29	0.06	0.34
Consumption			

Exchange rate: 1.007			

TABLE 3: OUTPUT AND PRICE EFFECTS OF A 25-FOLD INCREASE IN THE PRICE OF IRRIGATION WATER.

Scenarios	*Output Change (%)*	*Price Change (%)*
Input Substitution Elasticity Estimate of 0.40		
Rice	-5.636	9.702
Other Crops	-0.677	1.124
Agro-Industry	-0.430	0.267
Manufacturing	0.178	-0.125
Services	0.020	-0.280
Input Substitution Elasticity Estimate of 0.60		
Rice	-5.08	8.62
Other Crops	-0.73	1.27
Agro-Industry	-0.43	0.27
Manufacturing	0.18	-0.13
Services	0.02	-0.28
Input Substitution Elasticity Estimate of 0.75		
Rice	-4.51	7.54
Other Crops	-0.73	1.29
Agro-Industry	-0.41	0.25
Manufacturing	0.17	-0.12
Services	0.02	-0.27

TABLE 4: ECONOMY-WIDE IMPACTS OF A 25-FOLD INCREASE IN THE PRICE OF IRRIGATION WATER (PERCENTAGE CHANGES).

Scenarios	*Rice*	*Other Crops*	*Agro-Industry*
Input Substitution Elasticity of 0.40			
Water use	-72.28	-72.44	--
Labor use	0.50	-0.07	-1.21
Total supply	-2.10	-0.55	-0.28
Domestic supply	-5.69	-0.63	-0.33
Imports	4.54	0.59	0.08
Exports	--	-2.47	-0.97
Consumption	-5.82	-0.91	-0.28
Exchange Rate 0.999			
Input Substitution Elasticity of 0.60			
Water use	-85.04	-85.48	--
Labor use	2.64	-037	-1.21
Total supply	-1.91	-059	-0.28
Domestic supply	-5.13	-0.67	-0.33
Imports	4.01	0.70	0.08
Exports	--	-2.74	-0.97
Consumption	-5.23	-1.02	-0.28
Exchange Rate 0.999			
Input Substitution Elasticity of 0.75			
Water use	-90.63	-91.63	--
Labor use	3.74	-0.52	-1.15
Total supply	-1.71	-0.57	-0.27

Domestic supply	-4.55	-0.66	-0.32
Imports	3.50	0.72	0.07
Exports	--	-2.74	-0.91
Consumption	-4.62	-1.02	-0.26
Exchange Rate 0.999			

TABLE 5: ESTIMATED WELFARE CHANGES USING THE EQUIVALENT VARIATION (EV) MEASURE.

Income Household Categories	*Welfare Change from Elimination of 40%Tariff on Rice Imports (million pesos)*	*Percent of Base Income*	*Welfare Change from a 25-fold Increase in the Price of Irrigation Water (million pesos)*	*Percent of Base Income*
Urban High I.	6.0	0.02	-29.0	0.10
Urban Middle I.	6.0	0.02	-13.0	0.05
Urban Low I.	15.0	0.11	17.0	0.13
Rural High I.	8.0	0.04	-5.0	0.03
	17.0	0.10	9.0	0.05

Rural Middle I.	23.0	0.21	32.0	0.29
Rural Low I.				

APPENDIX 2

INDICES, PARAMETERS, AND VARIABLES

Indices

i,j	Sectors
im	Sectors with imports
imn	Sectors without imports
ie	Sectors with exports
ien	Sectors without exports
f,k	Factors of production: *water, labor, and capital*
ins	Institutions: *enterprises, labor, water*
hh	Households: *rural and urban (high, middle, and low income)*

Parameters

ai,j	Input-output coefficients
ACi	Armington function shift parameter
ADi	Production function shift parameter
ai,f	Factor share parameter
ATi	CET function shift parameter
bi,j	Capital composition matrix
CLESi,hh	Household consumption share
di	Armington function share parameter
DEPRi	Depreciation rate
DSTRi	Ratio of inventory investment to gross output
ECONi	Export demand constant
ei	Export demand price elasticity
gi	CET function share parameter
GLESi	Government consumption shares
HTAXhh	Household tax rate
KSHRi	Shares of investment by sector of destination
MPShh	Marginal propensity to save by type of household
pvbi	Base value added price
pwei	World price of exports

pwmi	World price of imports
pwmbi	Base import price
pxbi	Base output price
ri	Armington function exponent
fi	CET function exponent
si	Elasticity of factor substitution
SINTYHhh,ins	Household distribution of institutional income
SREMIThh	Household remittance share
TCi	Consumption tax
TEi	Export subsidy rate
TMi	Tariff rate on imports
tmbi	Base tariff rate
TXi	Indirect tax rate
txbi	Base indirect tax
WFDISTi,f	Factor price sectoral proportionality ratios

Variables

CAPTG	Capital transfers to government

CDHi,hh	Final demand for private consumption by household
CDHThh	Total final demand by type of household
CDi	Final demand for private consumption
CLIVhh	Cost of living index by household
DAi	Domestic sales
DCi	Domestic commodity sales
DEPREC	Total depreciation expenditure
DKi	Volume of investment by sector of destination
DSTi	Inventory investment by sector
Ei	Exports
ENTSAV	Enterprise savings
ENTTF	Enterprise transfers abroad
ENTTAX	Enterprise tax revenue
ESR	Enterprise savings rate
ETR	Enterprise tax rate
EXR	Exchange rate
FDSCi,f	Factor demand by sector
FSf	Factor supply
FSAV	*Net foreign savings*
FTG	*Foreign transfers to government*
FTL	Foreign transfers to labor

FXDINV	Fixed capital investment
GDi	Final demand for government consumption
GDPVA	Value added in market prices GDP
GDTOT	Total volume of government consumption
GOVSAV	Government savings
GR	Government revenue
HHSAV	Total household savings
HHTAX	Household tax revenue
IDi	Final demand for productive investment
INDTAX	Indirect tax revenue
INTi	Intermediate uses
INVEST	Total investment
Mi	Imports
MAKEj,i	Make matrix
PCi	Consumption price of composite goods
PDAi	Domestic activity goods rice
PDCi	Domestic commodity goods price
PEi	Domestic price of exports
PINDEX	GDP deflator
PKi	Price of capital goods by sector of destination
PMi	Domestic price of imports

PQi	Price of composite goods
PVi	Value added price
PWEi	World price of imports
PXi	Average output price
Qi	Composite goods supply
REMIT	Remittances from abroad
RGDP	Real gross domestic product (GDP)
SAVING	Total savings
TARIFF	Tariff revenue
WFf	Average factor price
Xi	Domestic output
YFCTRf	Factor income
YHhh	Household income
YINSTins	Institutional income

APPENDIX 3

EQUATIONS IN THE MODEL

Price Equations

1. PMim = PWMim (1+TMim)EXR

2. PEie = PWEie(1+TEie)EXR

3. PDCj = åj(MAKEij*PDAi)

4. PQi = (PDCi*DCi + PMi*Mi) / Qi

5. PXi = (PDAi*DAi + PEi*Ei) / Xi

6. PCi = PQi(1+TCi)

7. PVi = PXi(1-TXi) - åj(PCi*aji)

8. PKi = åj(PCi*bji)

9. PINDEX = GDPVA/RGDP

10. CLIVhh = Õi PCi clesi,hh

Production Equations

11. Xi = ADi(å if (aif (FDSCif)-si))-1/si

12. 12. WFf * WFDISTif = PVi*ADi ((åk (aik (FDSCik)-si)))(-1/si) –1) (aif ((FDSCif)-si-1

13. INTi = åj(aij*Xj)

14. DAi = åj(MAKEij*DCj)

15. Xie = ATie[gieEiefie + (1-gie)DAiefie]1/fie

16. Xien = Daien

17. Eie = DAie[(PEie / PDAie) * ((1-gie)/ gie)](1/fie-1)

18. Eied = ECONied (PWEied/PWSEied)-eied

19. Qim = ACim[dimMimrim + (1-dim)DCimrie]1/rim

20. Qimn = DCimn

21. Mim /DCim = [(PDCim / PMim)*(dim /(1-dim)] 1/1+rim

Income Equations

22. YFCTRf = åi WFf * WFDISTif * FDSCif

23. YINSTK = YFCTRK – [ENTSAV + ENTTAX + DEPREC + EXR*

24. YINSTL = åL (YFCTRL) + EXR*FTL

25. YINSTW = YFCTRW

26. YHhh = åins SINTYHhh,ins * YINSTins + REMIT * SREMIThh * EXR

27. TARIFF = åim TMim * Mim * PWMim * EXR

28. INDTAX = åi TXi * PXi * Xi

29. HHTAX = åhh HTAXhh * YHhh

31. DEPREC = = åi DEPRi * PKi * FDSCi,K

32. ENTTAX = (ETR*YFCTRK) – DEPREC

33. ENTSAV = (ESR * YFCTRK) – ENTTAX – DEPREC

34. HHSAV = åhh MPShh * YHhh * (1 – HTAXhh)

34. GR = TARIFF + INDTAX + HHTAX + ENTTAX + CAPTG + FTG*EXR + YFCTRW

35. SAVING = HHSAV + GOVSAV + DEPREC + FSAV*EXR + ENTSAV

Expenditure Equations

36. CDi = [åhh clesi,hh * (1- mpshh)* YHhh* (1-HTAXhh)] / PCi

37. CDHi,hh = clesi,hh * (1- mpshh)* YHhh* (1-HTAXhh) / PCi

38. CDHThh = [åi (PCi * CDHi,hh)] / CLIVhh

39. GDi = glesi*GDTOT

40. GOVSAV = GR - åi (PCi * GDi)

41. DSTi = DSTRi * Xi

42. FXDINV = INVEST - åi DSTi * PQi

43. å i PCi * IDi = FXDINV

Market Clearing

44. Qi = INTi + CD i + GD i + ID i + DST i

45. FSf = å i,f FDSC i,f

46. å im PWMim*Mim = (å ie PWEie*Eie) + FSAV + REMIT + ENTTF + FTG + FTL

47. SAVING = INVESTMENT

Gross National Product

48. GDPVA = å i (PVi * Xi) + INDTAX + TARIFF

49. RGDP = å i pvbi + txbi * pxbi * Xi + tmbi * exrb * pwmbi * Mi

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* Catedrática Auxiliar del Departamento de Economía en la Universidad de Puerto Rico: Recinto Universitario de Mayagüez

** Associate Professor of the Department of Economics in Ohio State University

*** Professor of the Department of Economics in Ohio State University

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