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Economic integration results in net welfare gains of 3.5, 6.5, and 6.5 million dollars for 1975, 1980, and 1985 respectively for the six countries. Small plants in Columbia, Peru, and Ecuador would be closed down. Venezuela would increase exports to the other countries. Fertilizer prices in importing countries would decrease significantly, but operators of small plants would lose revenues and might have to be compensated. Government revenues for tariffs would also be diminished. In order to compensate the loses a mixed tariff-subsidy program may be feasible.

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Effects of a Customs Union on the Nitrogenous Fertilizer Industry in the Andean Zone

I. General

The six Andean countries[a] are taking the "sectoral approach" to economic integration. Emphasis is placed on the integration of a single sector or industry, making it possible to concentrate on a limited objective and gradually expand to other economic sectors. This paper considers the case of the nitrogenous fertilizer industry in the Andean countries as an example of the sectoral approach to economic integration. The nitrogenous fertilizer sector is a good candidate for integration because of substantial economies of size of the manufacturing activity. Few small countries can develop the industry for domestic markets alone.

The fertilizer industry in the Andean countries has developed under the protection of high tariffs and trade restrictions. This, in addition to high transport costs and poorly organized marketing systems, has resulted in relatively high fertilizer prices. Regional integration of the fertilizer industry would reduce trade barriers among participating countries, and, it is believed, reduce fertilizer prices by permitting the fulfillment of domestic demands in each country from least cost production sources. The purpose of this paper is to analyze the effects of integration of the nitrogenous fertilizer industry in the Andean countries on (1) trade patterns in and among countries, (2) economic transfers among trading participants in each country, (3) fertilizer prices, and (4) the extent of trade creation within the Andean Zone.

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[a] The six Andean countries are Venezuela, Colombia, Ecuador, Peru, Bolivia and Chile.

II. Analytical Method

(A) Objectives and Procedure

The emphasis of the study is on determining optimal flows and utilization of capacity for existing and proposed plants.

The general procedure is as follows:

(1) Fertilizer use projections are made for 1975, 1980 and 1985 for several regions in each of the six countries, (41 regions in total).

(2) Costs of production at various levels of capacity of existing and proposed ammonia and final products plants are estimated.

(3) Transfer costs from plants to distribution centers are estimated.

(4) Trade flows which minimize transfer and production costs in 1975, 1980 and 1985 are estimated under two alternative structures:

(a) All six countries operate as a customs union, eliminating tariffs between member countries and establishing a common external tariff for non-member countries.

(b) Each country optimizes the production and distribution of its own fertilizer products under the behavior rule that imports from other Andean countries can be made only after all domestic capacity is exhausted. Imports from outside the Andean Zone would be subject to a common external tariff.

(5) Advantages of 4(a) and 4(b) above are compared for each country in terms of fertilizer price, changes in transport costs, value of domestic production, and trade balances.

(6) Finally, several alternative tariff-subsidy policies are discussed for each country in terms of monetary transfers among economic groups within the country.

(B) The Model

The basic analytical tool is the transshipment formulation of the linear programming model with a cost minimization objective function. The following assumptions about industry structure are necessary so that the theoretical model can approximate its real world counterpart:

(1) All participants behave in a perfectly competitive manner, (2) All ammonia and final products are homogenous so that participants are indifferent as to sources of supply, (3) The ratio of variable inputs to outputs for ammonia and final product processing are constant at various output levels, (4) Inputs are in perfectly elastic supply, (5) Relative input prices and dollar exchange rates remain unchanged over the period of analysis, and (6) External (dis) economies are equal at all processing locations.

The model includes the production of ammonia as an intermediate product and urea, ammonium nitrate, ammonium sulfate, compounds, and Chilean nitrates as final products. To simplify computations all products are expressed in "ammonia equivalent" metric tons, i.e. the quantity of ammonia required per metric ton of final product.

The following symbolic representation of the model will explain additional details of the analysis:

C_i^a = Per unit cost of production of intermediate product ammonia in location i, (i=1...n)

C_j^f = Cost of transforming one metric ton of ammonia into final product nitrogen at location j, (j=1...p)

X_{ij}^a = Quantity of ammonia shipped from location i to location j

X_{jt}^f = Quantity of final product nitrogen, expressed in metric tons of ammonia equivalent, shipped from location j to distribution center in location t

T^a_{ij} = Transport costs for shipping one metric ton of ammonia from location i to location j.

T^f_{jt} = Transport costs for shipping one metric ton of ammonia equivalent in the form of final product nitrogen from location j to distribution center in location t.

R^a_i = Processing capacity of ammonia plant in metric tons of ammonia, at the ith location.

R^f_j = Processing capacity of final product plant, in metric tons of ammonia equivalents, at the jth location.

D_t = Quantity of nitrogen demanded at distribution center in location t, expressed in metric tons of ammonia equivalents. t=1...m

Optimization is accomplished by minimizing

$$\min K = \sum_i^n \sum_j^p (C^a_i + T^a_{ij})\, X^a_{ij} + \sum_j^p \sum_t^m (C^f_j + T^f_{jt})\, X^f_{jt}$$

Subject to the following restrictions:

$$0 \leq \sum_{j=1}^{p} X^a_{ij} \leq R^a_i \text{ for all } i$$

$$0 \leq \Sigma\, X^f_{jt} \leq R^f_j \text{ for all } j$$

$$\sum_{i=1}^{n} X^a_{ij} = \sum_{j=1}^{m} X^f_{jt} \text{ for all } i, j$$

$$\sum_{j=1}^{p} X^f_{jt} = D_t \text{ for all } t$$

$$X^a_{ij} \geq 0 \text{ for all } i, j$$

$$X^f_{jt} \geq 0 \text{ for all } j, t$$

$$D_t \geq 0 \text{ for all } t$$

An additional restriction imposed was that urea had to be processed only at ammonia production sites.

This model was used to obtain solutions for the Andean countries for the demand and supply situations expected to exist in 1975, 1980 and 1985 under the two alternatives previously mentioned.

The model is unable to account for changes in processing costs due to changing output levels so resort is made to an iterative solution process. Processing costs corresponding to specific assumed output rates for each plant are entered in the transfer cost matrix. If the assumed output rates do not correspond to optimal outputs in the solution, the processing cost data are modified and a new solution is generated. This process is repeated until initial assumed output rates correspond to solution outputs.

III. Data Sources

(A) Processing Costs

Information on existing and planned production facilities was obtained from previous publications.[1] Table 1 shows production facilities of ammonia and final products available in the Andean countries. All these plants are considered to be in operation with the exception of the planned ammonia plant at Puerto La Cruz in Venezuela and the ammonia-urea fertilizer complexes at Punta Arenas, Chile and Yacuiba, Bolivia.

An attempt was made to define technical relationships and cost estimates which were generally representative of the industry as a whole rather than to represent precisely any specific firm or plant. For obvious reasons it is impossible to obtain precise cost information for each plant. Therefore, processing costs were estimated using engineering data and a set of standardized

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[1] Junta del Acuerdo de Cartagena, 1973. "La Situacion de la Industria de Fertilizantes en la Subregion Andina y sus Perspectivas Hacia 1980-85" and in "Informe Final de la Primera Reunion de Expertos Gubernamentales del Sector Fertilizantes."

Table 1. Production Facilities of Ammonia and Final Products of the Nitrogenous Fertilizer Industry in Andean Countries

Plant Location	Product	Size of Plant (metric tons per year)		
		Final Product	Nitrogen nutrient	Amm. equiv.
Maracaibo	Ammonia	297,000		297,000
Maracaibo	Ammonia	297,000		297,000
Maracaibo	Urea	396,000	180,180	227,027
Maracaibo	Urea	396,000	180,180	227,027
Moron	Ammonia	198,000		198,000
Moron	Urea	247,500	112,620	141,891
Moron	Compounds	58,400	26,280	33,113
Pto. La Cruz	Ammonia	495,000		495,000
Cartagena	Ammonia	132,000		132,000
Barrancabermeja	Ammonia	17,800		17,800
Barrancabermeja	Urea	12,800	5,824	7,338
Barrancabermeja	Ammonia/Nitrate	23,290	8,268	10,418
Barranquilla	Urea	89,100	40,540	51,080
Barranquilla	Compounds	43,554	19,600	24,696
Monomeros	Compounds	99,000	45,000	56,700
Guayaquil	Ammonium Sulfate	32,234	6,930	8,732
Guayaquil	Compounds	33,000	15,000	18,900
Talara	Ammonia	99,000		99,000
Talara	Urea	168,300	76,440	96,315
Callao	Ammonia	29,700		29,700
Callao	Ammonium Nitrate	39,600	14,234	17,934
Callao	Ammonium Sulfate	14,500	3,120	3,929
Cachimayo	Ammonia	11,183		11,183
Cachimayo	Ammonium Nitrate	25,000	8,875	11,183
Yacuiba[a]	Ammonia	198,000		198,000
Yacuiba[a]	Urea	297,000	135,135	170,270
Antafogasta	Nitrates		97,500	122,850
Punta Arenas[a]	Ammonia	198,000		198,000
Punta Arenas[a]	Urea	297,000	135,135	170,270

[a]Plants in planning stage, expected to be in operation by 1980.

SOURCES: Junta del Acuerdo Cartagena, Tennessee Valley Authority, and direct interviews with producers.

assumptions which allow the various alternative production processes to be uniformly evaluated. Estimating procedures were based primarily on methods used in TVA feasibility studies in several Andean countries.

Assumptions about fixed factor costs are the following:

(a) Operating Labor: since very small changes in operating labor cost occur by changing levels of output, operating labor is considered fixed. A rate of $3 per man hour is used for all six countries for 1970, 1975 and 1980.
(b) Laboratory costs: 20 percent of Operating Labor cost.
(c) In-plant handling cost: 4 percent of Operating Labor cost.
(d) Overhead: 100 percent of Operating Labor cost. Includes management salaries.
(e) Depreciation: 15 years straight line depreciation.
(f) Interest: assumed to be 8 percent of one half of plant investment.
(g) Maintenance: 5 percent of plant investment.
(h) Supplies: 10 percent of Operating Labor costs.

The important variable costs are for the following inputs: (a) raw materials such as natural gas, heavy oil, etc., (b) electrical power, (c) cooling water, (d) boiler feed water, (e) steam, (f) fuel, (g) catalysts and chemicals and (h) other miscellaneous variable factors inherent in each processing activity. Estimates of per unit costs of variable factors for each country were based on observed 1973 input price data.

Assumptions about estimates of initial plant investment are the following:

(a) The investment cost of constructing various plant processing units in the Andean countries was assumed to be 1.3 times corresponding United States construction costs.
(b) The cost of auxiliary facilities (steam, power, water supply, etc.) was assumed to be 25 percent of the total cost of the plant unit.
(c) The cost of supporting facilities (roads, office and administrative buildings, etc.) are assumed to be 25 percent of the total plant cost plus 25 percent of auxiliary facilities costs.
(d) Estimates of the investment cost of existing plants were based on the year in which the plant was built. Returns on investment were omitted from the analysis because of lack of any basis for differentiating opportunity costs between countries.

Under these assumptions processing costs of ammonia and final products were estimated for each processing facility. Processing unit costs of ammonia (C_i^a 's) and final products per metric ton of ammonia equivalent (C_j^f's) are presented in Table 2.

(B) Transportation Costs

Between country transport of fertilizer materials is normally made by sea. Chile, Peru, Ecuador, and Colombia all have ports on the Pacific, and Colombia and Venezuela have Atlantic ports. Bolivia is the only country completely landlocked but has access to the Pacific through Chilean and Peruvian ports.

Since transportation of anhydrous ammonia among Andean countries has not taken place, quoted anhydrous ammonia transport rates for other routes[2] were used to derive estimates for possible routes in Andean countries.

Direct information on quoted freight charges were used to estimate transport costs of fertilizer materials (final products) from plant sites to distribution centers. Transport costs were divided into:

- Intra-country transport costs or costs of transporting fertilizers from plant site to exporting port and from importing port to distribution center, and

- Inter-country transport costs which in general are composed of port charges and ocean freight costs.

When alternative means of transportation were possible the cheapest cost was selected. Information about intra-country transport costs was obtained

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[2]United Nations, 1967. "Fertilizer Manual," Table 28, p. 66.

Table 2. Estimated Processing Costs at Capacity Output for Nitrogenous Fertilizer at Andean Plants

Location of Plant	Product	Cost (dollars per metric ton of product)			Cost per metric ton of N
		Average Variable Cost	Average Fixed Cost	Average Total Cost	
Maracaibo	Ammonia	8.74	20.59	29.33	-
Moron	Ammonia	8.74	21.99	30.73	-
Puerto La Cruz	Ammonia	8.74	20.41	29.15	-
Cartagena	Ammonia	10.70	20.59	31.29	-
Barrancabermeja	Ammonia	16.64	34.65	51.84	-
Talara	Ammonia	11.32	31.90	43.22	-
Callao	Ammonia	15.84	41.69	57.53	-
Cachimayo	Ammonia	-	-	80.00	-
Yacuiba[1]	Ammonia	10.95	21.97	32.92	-
Yacuiba[2]	Ammonia	10.95	19.39	30.34	-
Maracaibo	Urea	4.87	14.14	19.01	41.78
Moron	Urea	4.87	16.13	21.00	46.17
Barranquilla	Urea	5.13	20.14	25.27	55.53
Barrancabermeja	Urea	30.59	14.32	44.91	98.70
Talara	Urea	5.72	18.41	24.13	53.03
Yacuiba[3]	Urea	5.72	15.30	21.02	46.20
Yacuiba[4]	Urea	5.72	14.63	20.35	44.74
Punta Arenas	Urea	4.49	15.30	19.79	43.49
Barrancabermeja	NH_3NO_4	34.28	17.52	51.80	145.91
Callao	NH_3NO_4	18.14	10.62	28.76	81.03
Cachimayo	NH_3NO_4	-	-	47.59	134.07
Guayaquil	NH_3SO_4	16.29	10.28	26.57	123.50
Callao	NH_3SO_4	20.09	13.42	33.51	155.88
Moron	Compounds	36.39	3.61	40.00	62.50
Guayaquil	Compounds	-	-	68.43	152.08
Barranquilla	Compounds	39.52	3.56	43.08	94.68
Monomeros	Compounds	44.11	3.92	48.03	105.56

[1]Plant size 198,000 metric tons per year

[2]Plant size 330,000 metric tons per year

[3]Plant size 170,270 metric tons per year

[4]Plant size 283,783 metric tons per year

for each country[3] using 1970 nominal official exchange rates for conversion to dollars.

Estimates of ocean freight costs for fertilizer materials in general were based on sodium nitrate freight charges[4] since no significant trade of other fertilizer materials has taken place among Andean countries. Transport costs from each plant site to each distribution center were estimated by adding up corresponding intra-country transport costs, port charges and ocean freight costs. Estimated transport costs are summarized in Table 3.

(C) Consumption Projections

Nitrogenous fertilizer consumption projections were directed toward specific future periods of time: 1975, 1980, and 1985. It was not possible to use a uniform estimating procedure for every country because of dissimilarities in the available data among countries. The estimating procedure

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[3]Sources: (1) FAO, Fertilizer Mission to Venezuela, 1972, "Fertilizer Situation in Venezuela, 1972.
(2) National Department of Planning, "El Transporte en el Grupo Andino," Bogota, Colombia, 1971.
(3) Thyrele Robertson, "The Peruvian Fertilizer Industry, Present Situation and Future Prospects, " Economics Study No. 4, Iowa Universities Mission to Peru.
(4) A. T. Kearney & Co., Inc., Chilean Fertilizer Distribution Vol. 2, Marketing of Fertilizers, Banco del Estado de Chile, Santiago, Chile, 1970.
(5) Urrego, G. T., "Los Insumos Agropecuarios en Colombia," Instituto Colombiano Agropecuario, Bogota, Colombia, 1973.
(6) Russel, D. A., R. J. Ballew, J. I. Bucy and D. A. Waitzman, A Fertilizer Program for Bolivia, Tennessee Valley Authority, Muscle Shoals, Alabama, 1970.

[4]United Nations, Economic Commission for Latin America, 1969. "Los Fletes Maritimos en el Comercio Exterior de America Latina."

Table 3. Transportation costs of fertilizer materials from plant sites to distribution centers, in dollars per metric ton

	Maracaibo	Moron	Puerto La Cruz	Monomeros	Barrancabermeja	Barranquilla	Guayaquil	Callao	Talara	Cachimayo	Yacuiba	Punta Arenas
Valera	4.61	8.61	20.40	20.61	12.20	25.61	27.61	33.11	27.80	41.61	72.36	43.61
S. Cristobal	10.10	14.00	23.90	19.88	6.80	24.88	33.00	41.60	33.30	47.10	77.85	49.10
Acarigua	10.00	5.40	17.00	19.75	18.81	24.75	26.75	34.45	26.95	40.75	70.50	41.75
Barquisim.	6.80	4.00	15.60	18.35	16.81	23.35	25.35	33.35	25.55	39.35	69.10	40.35
Maracay	13.45	3.35	8.25	17.70	26.85	22.70	24.70	32.70	24.90	38.70	68.45	39.70
Maturin	22.40	12.30	3.00	26.65	35.80	31.65	33.65	41.65	33.85	47.65	77.40	48.65
C. Bolivar	25.45	13.15	4.50	27.50	36.65	32.50	34.50	42.50	34.70	48.50	78.25	49.50
Maracaibo	0.00	10.10	21.70	16.00	16.81	21.00	23.00	31.50	22.00	28.00	63.75	39.00
Bogota	29.25	27.50	27.25	13.25	6.65	18.28	26.75	37.75	28.05	42.75	77.50	43.75
Bucaram.	23.91	22.26	20.91	7.91	2.59	12.91	23.91	32.91	23.31	38.91	73.66	38.91
Cali	22.20	22.55	22.20	16.12	9.47	21.12	16.20	27.20	17.60	32.20	67.35	33.20
Ibague	28.80	29.15	28.80	12.62	7.05	17.62	22.80	33.80	24.20	38.80	73.55	39.80
Manizales	28.00	28.35	28.00	16.20	11.11	21.20	22.00	33.00	23.40	38.00	72.75	39.00
Medellin	27.33	25.68	24.33	11.33	5.64	16.33	27.33	36.33	26.73	42.33	77.48	32.33
Neiva	30.67	29.02	27.67	14.67	8.85	19.67	30.67	39.67	30.07	45.67	80.42	45.67
Pasto	29.00	29.35	29.00	26.25	19.62	31.25	23.00	34.00	24.40	39.00	73.75	40.00
Tunja	28.08	26.43	25.08	12.08	9.53	17.08	28.08	37.08	27.48	43.08	77.82	43.08
Cartagena	16.00	14.35	13.00	6.76	13.08	11.76	16.00	25.00	15.40	31.00	65.75	31.00
Guayaquil	33.00	31.35	31.00	26.00	39.08	31.00	10.00	30.50	16.00	37.00	71.75	37.00
Piura	22.40	20.75	20.40	15.40	29.68	20.40	16.00	10.00	0.80	25.00	60.05	26.30
Trujillo	24.20	22.55	22.20	18.20	28.28	23.20	13.00	5.20	6.00	21.20	58.95	25.10
Chiclayo	24.20	22.55	22.20	18.20	28.28	23.20	13.20	7.00	4.00	23.00	58.95	35.20
Chimbote	24.50	22.85	22.50	18.50	31.58	23.50	14.00	4.00	6.60	18.30	57.75	24.50
Nazca	26.80	25.15	24.80	20 80	33.88	25.80	15.80	4.50	15.70	11.60	42.20	25.80
Callao	31.00	29.35	29.00	25.00	38.03	30.00	20.50	0.00	11.00	16.00	47.06	30.00
Cuzco	35.00	35.35	35.00	31.00	44.08	36.00	27.00	16.40	26.50	0.30	30.66	31.00
Huancayo	36.00	34.35	34.00	30.00	33.08	35.00	25.50	5.00	16.00	21.00	51.66	35.00
Arequipa	27.80	28.15	27.80	23.80	36.88	28.80	19.80	9.00	19.00	12.20	25.60	23.80
Sucre	54.42	52.77	52.42	48.42	61.50	53.42	44.42	34.00	44.00	16.50	15.15	48.42
Cochabamba	52.66	51.00	50.66	46.66	59.74	55.66	42.66	33.00	43.00	18.00	26.00	46.66
La Paz	41.74	40.09	39.74	35.74	38.82	44.74	31.74	28.40	39.40	14.00	26.20	35.74
Oruro	46.14	44.50	44.14	40.14	53.22	49.14	36.14	32.00	42.00	15.50	21.80	40.14
Potosi	52.00	50.35	50.00	46.00	59.08	55.00	42.00	32.50	42.50	16.00	13.80	46.00
Sta. Cruz	63.53	61.88	61.53	57.53	70.61	66.53	53.33	43.00	53.00	28.00	11.45	57.53
Tarija	59.40	57.75	57.40	53.40	66.48	62.40	49.40	43.00	53.00	28.00	6.50	53.40
Antofaga.	33.00	30.35	30.00	23.50	36.58	28.50	21.00	22.00	20.80	23.00	57.75	22.50
Ovalle	43.75	45.10	44.75	37.15	50.23	42.15	35.75	36.75	33.55	34.75	69.50	33.15
Rancagua	34.10	35.45	35.10	27.50	40.58	32.50	26.10	27.10	25.90	28.10	62.85	23.10
Los Angeles	37.90	35.25	34.90	26.90	39.98	31.90	25.90	26.90	25.70	27.90	62.65	20.40
P. Montt	37.40	34.75	34.40	27.00	40.08	32.00	25.40	26.40	25.20	27.40	62.15	16 40
Pta. Arenas	39.00	36.35	35.00	31.00	44.08	36.00	27.00	28.00	25.00	29.00	63.75	5.00

was modified according to the availability of the data and the existence of previous studies. As a general rule the projections were checked against other estimates, particularly against those presented by each country to "La Junta del Acuerdo de Cartagena."[5]

Estimating equations developed by the Tennessee Valley Authority were used for Colombia, Venezuela and Ecuador. These equations were obtained by applying ordinary least squares regression to equations of the form:

$$Qd_t = \alpha + \beta_1 + \beta_2 t^2 + \varepsilon_t$$

and $$Qd_t = \gamma + \beta_1' t + \varepsilon_t$$

where Qd_t = metric tons of nitrogen nutrient consumed in year t, (t=1 to 11 for the period 1962 to 1972). However, for the case of Peru, Bolivia and Chile estimates from previous studies[6] were adapted (with some adjustments).

Nitrogen fertilizer consumption projections were made for each distribution zone in each Andean country. Selection of distribution zones was based on several factors bearing on homogenity within the zone. Estimated consumption projections for each country were then allocated to each distribution zone proportionally to sales in previous years. Consumption projections for 1975, 1980 and 1985 by countries, expressed in metric tons of nitrogen and ammonia equivalents, are presented in Table 4.

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[5]Technical body of the Cartagena Agreement.

[6]Sources: (1) Diamond, R. B., J. E. Culp, J. L. Nevins and C. H. Davis, "Peru's Distribution and Marketing System." Tennessee Valley Authority, 1968.
(2) Robertson, Thyrele, op. cit.
(3) Russell, D. A., op. cit.
(4) A. T. Kearney, Co., Inc., op. cit.

Table 4. Projected Consumption of Nitrogenous Fertilizer in Andean Zone

	1975	1980	1985
		(metric tons of N)	
Venezuela	40,086	58,565	80,738
Colombia	102,738	159,744	180,747
Ecuador	31,000	56,000	65,065
Peru	133,740	171,238	196,486
Bolivia	7,995	14,148	19,920
Chile	90,000	114,865	133,159

IV. Results

(A) Optimal Shipment Patterns

In the independent-country solution (Table 5) maximum use of existing capacity is made before imports are allowed. The small ammonium nitrate, ammonium sulfate and compounds plants in Colombia, Ecuador and Peru are used despite high costs of processing and distribution. Although existing capacity is utilized, imports of urea from Maracaibo are necessary in 1975, 1980, and 1985 to satisfy domestic requirements in Peru, Ecuador and Bolivia. Colombia seems to have sufficient domestic processing capacity in 1975 but increased needs in 1980 and 1985 require imports from the ammonia-urea complex at Maracaibo. The new plants in Yacuiba and Punta Arenas would partially fulfill Peru's import needs in 1980 and 1985.

In the Customs Union solution (Table 6) the small plants in Colombia, Peru and Ecuador are closed down and imports of urea from Maracaibo, Punta Arenas and Yacuiba fulfill the major part of the requirements in those three countries.

The Customs Union solution shows processing cost savings with the use of the more efficient ammonia-urea complexes at Maracaibo instead of the smaller plants in Peru, Colombia, Ecuador and Chile. On the other hand,

Table 5. Calculated Optimum Shipments, Independent Country Solutions

Year	Final Processing: Location	Final Processing: Product	Final Processing: Quantity (metric tons)	Destination of Final Product	Quantity Shipped (metric tons)
1975	Moron	Urea	33840	Venezuela	33840
	Maracaibo	Urea	77319	Venezuela	16668
				Ecuador	11428
				Peru	39150
				Bolivia	10073
	Guayaquil[a]	NH_3SO_4	8732	Ecuador	8732
	Guayaquil[a]	Compounds	18900	Ecuador	18900
	Barranquilla[b]	Urea	51080	Colombia	51080
	Barranquilla[b]	Compounds	21670	Colombia	21670
	Monomeros[b]	Compounds	56700	Colombia	56700
	Talara	Urea	96315	Peru	96315
	Callao	NH_3NO_4	17934	Peru	17934
	Cachimayo	NH_3NO_4	11183	Peru	11183
	Callao	NH_3SO_4	3929	Peru	3929
1980	Moron	Urea	48703	Venezuela	48703
	Maracaibo	Urea	171384	Venezuela	25089
				Colombia	51046
				Ecuador	42928
				Peru	52321
	Guayaquil[a]	NH_3SO_4	8732	Ecuador	8732
	Monomeros[a]	Compounds	476	Colombia	476
	Guayaquil[a]	Compounds	18900	Ecuador	18900
	Barranquilla[b]	Urea	51080	Colombia	51080
	Barranquilla[b]	Compounds	24696	Colombia	24696
	Monomeros[b]	Compounds	56224	Colombia	56700
	Barrancabermeja	Urea	7338	Colombia	7338
	Barrancabermeja	NH_3NO_4	10418	Colombia	10418
	Talara	Urea	96315	Peru	96315
	Cachimayo[c]	NH_3NO_4	11183	Peru	11183
	Callao	NH_3NO_4	17934	Peru	17934
	Callao	NH_3SO_4	3929	Peru	3929
	Yacuiba	Urea	26364	Peru	8537
				Bolivia	17827
	Punta Arenas	Urea	170270	Peru	25540
				Chile	144730
1985	Moron	Urea	67141	Venezuela	67141
	Maracaibo	Urea	260856	Venezuela	34588
				Colombia	77444
				Ecuador	54268
				Peru	94566
	Guayaquil[a]	NH_3SO_4	8732	Ecuador	8732
	Monomeros[a]	Compounds	476	Colombia	476
	Guayaquil[a]	Compounds	18900	Ecuador	18900
	Barranquilla[b]	Urea	51080	Colombia	51080
	Barranquilla[b]	Compounds	24696	Colombia	24696
	Monomeros[b]	Compounds	56224	Colombia	56224

Table 5 (continued)

Year	Final Processing			Destination of Final Product	Quantity Shipped (metric tons)
	Location	Product	Quantity (metric tons)		
1985	Barrancabermeja	Urea	7338	Colombia	7338
	Barrancabermeja	NH_3NO_4	10418	Colombia	10418
	Talara	Urea	96315	Peru	96315
	Cachimayo[c]	NH_3NO_4	11183	Peru	11183
	Callao	NH_3NO_4	17934	Peru	17934
	Callao	NH_3SO_4	3929	Peru	3929
	Yacuiba	Urea	46261	Bolivia	25099
				Peru	21162
	Punta Arenas	Urea	170270	Peru	2491
				Chile	167779

[a]Source of ammonia is Maracaibo

[b]Source of ammonia is Cartagena

[c]Source of ammonia is Talara

Table 6. Calculated Optimum Shipments, Customs Union Solution

Year	Final Processing			Destination of Final Product	Quantity Shipped (metric tons)
	Location	Product	Quantity (metric tons)		
1975	Moron	Urea	33840	Venezuela	33840
	Maracaibo	Urea	310384	Venezuela	16668
				Colombia	78370
				Ecuador	39060
				Peru	54262
				Bolivia	10073
				Chile	111951
	Callao[a]	NH_3NO_4	17934	Peru	17934
	Barranquilla[b]	Urea	51080	Colombia	51080
	Talara	Urea	96315	Peru	96315
1980	Moron	Urea	48703	Venezuela	48703
	Maracaibo	Urea	302096	Venezuela	25089
				Colombia	150198
				Ecuador	70560
				Peru	56249
	Callao[a]	NH_3NO_4	17934	Peru	17934
	Barranquilla[b]	Urea	51080	Colombia	51080
	Talara	Urea	96315	Peru	96315
	Yacuiba	Urea	37548	Peru	19721
				Bolivia	17827
	Punta Arenas	Urea	170270	Peru	25540
				Chile	144730
1985	Moron	Urea	67141	Venezuela	67141
	Maracaibo	Urea	391569	Venezuela	34588
				Colombia	176596
				Ecuador	81900
				Peru	98485
	Callao[a]	NH_3NO_4	17934	Peru	17934
	Barranquilla[b]	Urea	51080	Colombia	51080
	Talara	Urea	96315	Peru	96315
	Yacuiba	Urea	57444	Peru	32345
				Bolivia	25099
	Punta Arenas	Urea	170270	Peru	2491
				Chile	167779

[a]Source of ammonia is Maracaibo

[b]Source of ammonia is Cartagena

transport costs increase with heavier reliance on imports. Net cost savings per year for the six countries combined are $8.7 million in 1975 and $6.5 million in 1980 and 1985, all in terms of constant dollars at 1973 exchange rates. Estimates of individual country savings, which are given in Table 7, indicate that Colombia, Peru and Ecuador benefit most in cost savings arising from the use of a Customs Union. Estimates of cost savings include fixed costs (which implicitly assumes that existing small plants are already completely depreciated out).

Price reductions of $81.66, $73.51 and $63.63 per ton of ammonia equivalent are indicated in 1980 and 1985 for Peru, Colombia and Ecuador, respectively, with the adoption of a Customs Union as defined in this study.

Price differences of this magnitude could affect the agricultural development goals of the three countries.

Table 7. Cost and Price Changes Associated with Integration of Nitrogenous Fertilizer Industry in the Andean Zone.

		Venezuela	Colombia	Ecuador	Peru	Bolivia	Chile
				(thousand dollars)			
1975	Added Transport Costs	0	1,641	483	1,195	0	2,647
	Decrease in Processing Costs	0	3,934	2,222	2,358	0	6,171
	Net Cost Savings	0	2,293	1,738	1,163	0	3,524
1980	Added Transport Costs	0	2,169	483	1,031	0	0
	Decrease in Processing Costs	0	5,659	2,222	2,279	0	0
	Net Cost Savings	0	3,490	1,739	1,248	0	0
1985	Added Transport Costs	0	2,176	483	1,033	0	0
	Decrease in Processing Costs	0	5,659	2,222	2,279	0	0
	Net Cost Savings	0	3,483	1,739	1,246	0	0

The increase in value of fertilizer trade in 1980 and 1985 in the Andean Zone (net of transport costs) available through the Customs Union is 8.6 million dollars. This is the commonly called "trade creation effect" of a Customs Union.

(B) Transfers Among Groups

Despite demonstrable cost savings it is often difficult politically to reduce trade barriers because of resultant income transfers among groups. Using the analytical model developed in this study the Customs Union solution is compared with the independent-country solution to quantify economic transfers among groups in individual countries under alternative protection policies. Figure 1 illustrates how these transfers can be quantified for any individual country. The following notation is helpful:

S_a = the rest of the Andean Group supply, assumed to be perfectly elastic at the import price (P_m) implied for this country by the A.G.C.U. solution.

T = tariff or "tariff equivalent" resulting from protection policy, equal to FD.

$S_a + T$ = the rest of the Andean Group supply under domestic industry protection policy.

D_d = perfectly inelastic country demand, Qt being the fixed quantity demanded.

P_m = import price as implied by the A.G.C.U. solution.

P_t = domestic price of fertilizer per metric ton of ammonia - equivalent, given domestic industry protection policy.

Q_d = domestic output produced as implied by A.G.C.U. solution in metric tons of ammonia equivalent.

Q_d' = domestic output produced under protection policy in metric tons of ammonia equivalents.

The following magnitudes can be identified:

LDJO = total cost of fertilizer to farmers under protection (net of intra-country transport costs)

KFJO = total cost of fertilizer to farmers without protection.

LDFK = additional cost to farmers due to protection.

LVRBK = additional producer surplus due to protection (transfer from consumers to producers.

BECVR = added domestic processing cost due to protection

CDFE = transfer from farmers to the government

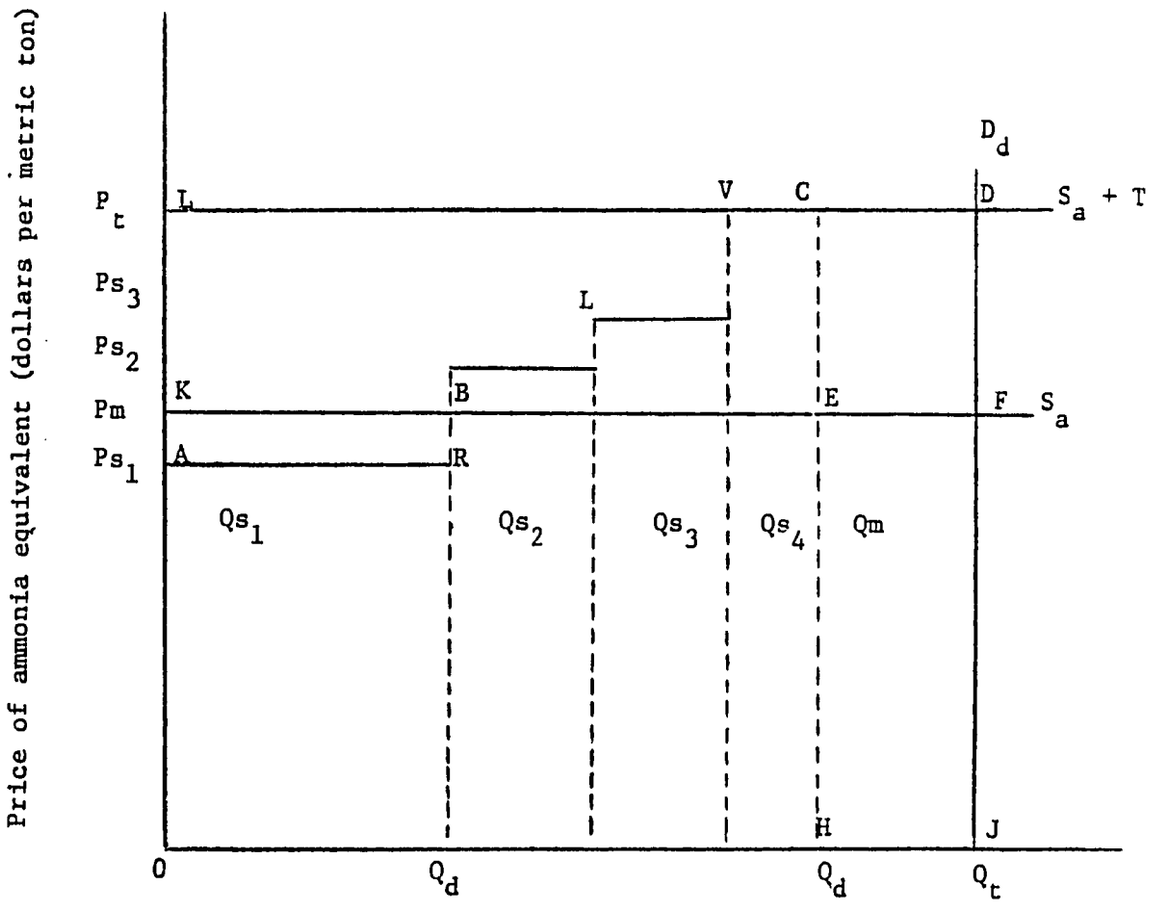

Figure 1. Linearized form of effects of domestic industry protection policy

Estimates of the indicated areas in Figure 1 were thus obtained for each Andean Group country for the years 1975, 1980 and 1985 on the basis of the two alternative solutions. These results can be analyzed in the light of three

alternative protection policies: (1) Tariffs and/or quotas on imports (2) subsidies to domestic processing facilities, and (3) a mixed policy of tariff and subsidy. These results are summarized in Table 8.

V. Alternative Tariff-Subsidy Policies

(A) Tariffs and Quotas on Imports of Final Products

Tariffs yield the same results as import quotas in terms of costs of fertilizers to farmers, additional processing costs of fertilizers (social cost), and transfers, if, under the quota system, the government is the only importer. Otherwise, transfers from farmers to the government will actually go instead to importers receiving quotas (unless importers purchase the quotas). Keeping in mind this important difference, the results of a tariff policy on imports are analyzed first.

The main problems associated with a tariff on imports compared with alternative protection policies can be summarized as follows:

- Higher prices of fertilizers to farmers, which will reduce fertilizer use and increase prices of farm products.
- Economic transfers from farmers to fertilizer processors which will generate "rents" to less inefficient domestic processors, making it more difficult for the government to change this policy.
- Economic transfers from farmers to the government. This also increases the difficulties for policy changes, since the government would have to find substituting sources of revenue.

Under an "equivalent quota system" the transfers from farmers to government would actually go instead to importers receiving quota assignments. Thus opposition to policy changes would arise not only from domestic producers but also from importers.

For Peru and Colombia the magnitudes of these transfers are significant and can be taken as an indication of the degree of difficulty these governments would have to face in carrying out economic integration.

It can be seen in Table 8 that farmer-to-government transfers (farmer-to-importers with quotas) for Peru would be $3.170 million in 1975, $6.6 million in 1980 and $9.0 million in 1985. Such transfers in Colombia would be 0 in 1975, $3.7 million in 1980 and $5.7 million in 1985. Transfers from farmers to fertilizer processors would be of similar magnitude (also indicated in Table 8).

Transfers from one economic group to another within a country are not normally considered a social loss. Additional processing costs due to protection of inefficient processors, on the other hand, is considered a social cost engendered by mis-allocation of productive resources (employment and income distribution aspects aside). These social costs are indicated in Table 8 under the category "social costs to economy."

(B) Subsidy of Domestic Processors

The main results of a subsidy policy to domestic processors can be summarized as follows:

- Fertilizer prices to farmers will be basically equal to the price of imports.
- Since there are no transfers from farmers to processors or from farmers to the government, it will be easier for governments to change this policy and to adjust to regional economic integration.
- In the absence of tariff revenues governments must find other sources of fiscal revenues, which in most cases are difficult to obtain, and may have economic effects on other sectors.

Table 8. Economic Transfers due to Protection[1/]

YEAR	Venezuela	Colombia	Ecuador	Peru	Bolivia	Chile
			(thousand dollars)			
1975						
Cost of fertilizer (under protection)	3,321	14,896	693	31,140	1,262	13,336
Additional cost due to protection	0	1,403	1,561	1,625	0	-592
Added transport cost (in-country)	0	890	178	-462	0	4,116
Transfer from farmers to government	0	0	727	3,170	0	0
Processors Surplus						
Under protection	0	2,216	197	10,914	0	0
Without protection	0	992	0	2,557	0	0
Transfer, farmers to processor	0	1,223	197	8,357	0	0
Social Cost to Economy (BECVR in Fig. 1)	0	2,293	1,738	1,163	0	3,524
1980						
Cost of fertilizer (under protection)	4,849	33,742	11,729	40,218	1,241	9,130
Added cost due to protection	0	2,373	1,561	1,969	0	0
Added transport cost (in-country)	0	1,117	178	-721	0	0
Transfer from farmers to government	0	3,740	2,732	6,608	0	0
Processors Surplus						
Under protection	0	11,110	197	10,914	0	0
Without protection	0	959	0	2,370	0	0
Transfer farmers to processor	0	10,151	197	8,544	0	0
Social Cost to Economy (BECVR in Fig. 1)	0	3,490	1,738	1,248	0	0
1985						
Cost of fertilizer (under protection)	6,684	38,168	13,614	46,147	1,747	10,584
Additional cost under protection	0	2,434	1,561	1,986	0	0
Additional transport cost (in-country)	0	1,049	178	-740	0	0
Transfer farmers to government	0	5,693	3,457	9,060	0	0
Processors Surplus						
Under protection	0	11,110	197	10,914	0	0
Without protection	0	959	0	2,370	0	0
Transfer farmers to processor	0	10,151	197	8,544	0	0
Social Cost to Economy (BECVR in Fig. 1)	0	3,483	1,739	1,246	0	0

[1/] Measured in 1973 dollars.

(C) "Mixed" Policy of a Tariff on Imports and a Subsidy to Domestic Processing Facilities

The problem of lack of government revenues necessary to carry out a subsidy protection policy can be solved by establishing a "mixed" policy of tariffs on imports to provide for revenues and a reduced subsidy to less efficient processing facilities not able to produce under the protection of this reduced tariff. Essentially the tariff revenues collected by the government are paid as subsidies to fertilizer manufacturers.

The effects of this policy as compared with the previous two alternative policies can be summarized as follows:

- "Prices" of fertilizers to farmers will be greater than those resulting under the Customs Union solution or under the subsidy policy but lower than those under the tariff policy.

- Transfers from farmers to processors will be smaller than those resulting from the tariff-only policy.

- The government will receive less revenue under the mixed policy than in the case of the tariff-only policy, but the drain in revenues from the government would be less than in the case of a subsidy-only policy.

This policy may well be considered as a compromise between the other two extremes. It is easy to fix the tariff at a level which would generate just enough revenues to cover the subsidy.

VI. Conclusions

The fertilizer industries in Colombia, Peru and Ecuador have developed under substantial protection, so that an Andean Customs Union for fertilizer will present certain adjustment problems. Estimated annual savings in fertilizer costs under a Customs Union are $3.5 million, $1.7 million and $1.2 million in Colombia, Peru and Ecuador, respectively, in the year 1980. The possible price reductions in these countries of about 40 percent point out important implications for increased agricultural production. These are the direct benefits of the Customs Union.

However, past protection policies have engendered a set of economic transfers from agriculture to domestic fertilizer manufacturers and to the government treasuries in these three countries. In 1980, for example, estimated annual transfers from farmers in Colombia to domestic processors and to the treasury would amount to about $10 million and $3.7 million respectively. The reduction of tariffs under an Andean Zone Customs Union would cause importation of urea from the relatively more efficient plants in Venezuela and planned plants in Yacuiba, Bolivia, and Punta Arenas, Chile and would disturb the pattern of economic transfers which have been generated under protection.

The possible integration of the fertilizer industry in the Andean Zone will be guided by political factors and by economic factors in addition to those discussed in this study. However, this study does point out important economic issues bearing on the question of integration.