BOLIVIA AND SOUTH AMERICAN FREE TRADE

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The pending merger between the Andean Pact and Mercosur will advance South American free trade. Each member country will have to adjust to free trade and the various sectors of each economy will adjust differently. This article uses a specific factor model of production to predict output changes and income redistribution in Bolivia with South American free trade. Adjustments in outputs and factor prices in the model are substantial.

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An underlying lesson of factor proportions trade theory is that the owners of some factors of production will gain but others will lose due to price changes that occur with free trade. Bolivia provides an example of theoretical interest and practical relevance. The Bolivian government started privatization in 1996, selling half ownership and transferring control of state enterprises. Prices of telecommunication and banking services in Bolivia have fallen and efficiency will continue to improve with increased international competition.

Bolivia is a small economy in the process of opening to free trade, fitting the basic assumptions of models of international competition and trade. Bolivia is a member of the Andean

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Pact, along with Columbia, Ecuador, Peru, and Venezuela. The Andean Pact has the goal of establishing a customs union. Bolivia became a member of the World Trade Organization (WTO) in 1996 and an associate member of Mercosur in 1997. Mercosur is a free trade agreement among Argentina, Brazil, Paraguay, and Uruguay. Bolivia is also involved in negotiations for the Free Trade Area of the Americas (FTAA). As a small open economy, Bolivia will face international price competition with South American free trade. Outputs will adjust along the production frontier and income will be redistributed among the factors of production.

Bolivia had GDP of $7.1 billion in 1997, about $935 per capita. Agriculture accounts for 15 percent of GDP and much of it is traditional. Manufacturing is 17 percent of output. Exports in 1997 were $1.3 billion with 18 percent going to Mercosur and 24 percent to the Andean Pact. Minerals were 40 percent and hydrocarbons were 8 percent of exports. Imports in 1997 of $1.4 billion were 43 percent capital goods and 36 percent intermediate goods.

Free trade will eliminate tariffs on agricultural imports from Brazil and Argentina, the low cost agricultural producers in South America, and these prices will fall in Bolivia. Increased Bolivian exports and higher prices are projected in minerals, natural gas, light manufacturing, and apparel.

This article projects the income redistribution and output adjustment due to free trade using a specific factor model of the Bolivian economy. The competitive model assumes production functions with constant elasticity of substitution. The comparative static model is based on factor shares and industry shares. Thompson (1994) developed a similar specific factor model of commercial policy for the Japanese economy, and Thompson (1996) examined the effects of NAFTA in a specific factor model of Alabama. These applications of a familiar theoretical model

provide insight into their quantitative nature. For instance, elasticities of factor prices with respect to prices turn out to be large compared to elasticities with respect to factor endowments.

There are five sectors in the present model: agriculture, minerals, natural gas, manufacturing, and services. Skilled and unskilled labor are shared inputs in the five sectors and capital is specific to each sector. The model assumes full employment of all factors of production and labor is perfectly mobile across sectors. There is perfect competition in the output markets with costs equal to price. The article derives the effects of projected price changes on factor prices and outputs, and discusses implications for economic policy.

I. FACTOR SHARES AND INDUSTRY SHARES IN BOLIVIA

Table I provides the total payment matrix in domestic currency for each of seven factors of production:

S skilled labor
U unskilled labor
K_j capital in each sector
  A agriculture
  M mining
  G natural gas
  F manufacturing
  V services

Capital payments are derived as residuals of sector value added after labor payments. Data is for 1997.

Table II presents shares of each factor in the revenue of each sector. Summing down a column in Table I gives total sector revenue. For instance, the total revenue of agriculture in

Table I
Factor Payment Matrix, 1997
(millions of bolivianos)

	A	M	G	F	V	Total
S	96	413	160	844	2744	4257
U	1321	622	225	1025	1181	4374
K_j	1635	865	374	1618	3806	8298
total	3052	1900	759	3487	7731	

Source: National Institute of Statistics, 1998

Table II
Factor Shares, θ_{ij}

	A	M	G	F	V
S	.031	.217	.210	.242	.355
U	.433	.327	.296	.294	.153
K_j	.536	.456	.494	.464	.492

Bolivia is 3052 million bolivianos and the share of skilled labor is $96/3052 = 0.031 = 3.1\%$. Agricultural land is implicit in that capital residual. There is an implicit zero share for each type of capital in every sector except its own.

Industry shares for labor are presented in Table III. Summing across a row in Table I gives total factor income. Assuming perfect labor mobility across sectors, the wage of each type of labor would be the same across sectors. The resulting industry shares are the portion of each factor employed in each sector. For instance, the total income of skilled labor is 4257 million bolivianos, and $96/4257 = 0.022 = 2.2\%$ of this total income is earned in agriculture. Assuming equal skilled wages across sectors, 2.2% of skilled workers would be in agriculture. The implicit share of each type of capital is 1 in its sector and 0 in all other sectors.

Table III
Industry Shares, λ_{ij}

	A	M	G	F	V
S	.022	.097	.037	.198	.644
U	.302	.142	.051	.234	.270

Table IV
Factor Intensities

	S/K_j	U/K_j	S/U
A	0.06	0.81	0.07
M	0.48	0.72	0.60
G	0.43	0.60	0.71
F	0.52	0.63	0.82
V	0.72	0.31	2.32

Factor intensities are in Table IV. Agriculture uses skilled labor the least intensively by far relative to both unskilled labor and capital. Capital intensity refers to each specific capital. Services use skilled labor the most intensively relative to other inputs. Agriculture uses unskilled labor most intensively. Services use unskilled labor the least intensively.

Mining, natural gas, and manufacturing are similar to each other in factor intensities. Among these three, mining has the lowest intensity of skilled to unskilled labor. Manufacturing uses skilled labor slightly more intensively than mining or natural gas. Natural gas is slightly more capital intensive.

II. A SPECIFIC FACTOR MODEL OF PRODUCTION FOR BOLIVIA

Substitution elasticities describe the adjustment in the cost minimizing input of one factor due to a change in the price of another, as developed by Jones (1965) and Takayama (1982).

Following Allen (1938), the cross price elasticity between the input of factor i and the payment to factor k in sector j is written

$$(1) \qquad E_{ij}^{k} = \hat{a}_{ij}/\hat{w}_k = \theta_{kj} S_{ij}^{k},$$

where $\hat{}$ represents percentage change in a variable, and S_{ji}^{k} is the Allen partial elasticity of substitution. Cobb-Douglas production implies $S_{ij}^{k} = 1$. With constant elasticity of substitution (CES) production, the Allen partial elasticity can have any positive value. Assuming linear homogeneity, $\sum_k E_{ij}^{k} = 0$ and the own price elasticitiy E_{ij}^{i} is derived as the negative of the sum of cross price elasticities.

Substitution elasticities are the weighted average of cross price elasticities for each sector,

$$(2) \qquad \sigma_{ik} \equiv \hat{a}_i/\hat{w}_k = \sum_j \lambda_{ij} \; E_{ij}^{k} = \sum_j \lambda_{ij}\theta_{kj} S_{ij}^{k}.$$

Factor shares and industry shares are used to derive the Cobb-Douglas substitution elastiticies in Table V. Constant elasticity of substitution (CES) production would scale the elasticities in Table V. With CES of 0.5, for instance, elasticities would be half as large as in Table V. With CES of 2, they would be twice as large.

Table V
Cobb-Douglas Substitution Elasticities, σ_{ik}

	$\hat{w}_S$	$\hat{w}_U$	$\hat{w}_A$	$\hat{w}_M$	$\hat{w}_G$	$\hat{w}_F$	$\hat{w}_V$
$\hat{a}_S$	−0.69	0.21	0.01	0.04	0.02	0.09	0.32
$\hat{a}_U$	0.20	−0.70	0.16	0.06	0.03	0.11	0.13
$\hat{a}_A$	0.03	0.43	−0.46	0	0	0	0
$\hat{a}_M$	0.22	0.33	0	−0.54	0	0	0
$\hat{a}_G$	0.21	0.30	0	0	−0.51	0	0
$\hat{a}_F$	0.24	0.29	0	0	0	−0.54	0
$\hat{a}_V$	0.36	0.15	0	0	0	0	−0.51

The largest own substitution elasticity occurs for unskilled labor and the smallest for agricultural capital in Table V. Every 1% increase in the unskilled wage causes a 0.70% decrease in the unit input of unskilled labor. Every 1% increase in the price of agricultural capital decreases its unit input by 0.46%. Own labor substitution elasticities are larger than own capital elasticities. Skilled and unskilled labor are about equal substitutes. Skilled labor is a relatively inelastic input. Higher wages induce more of a shift toward capital than vice versa.

Competitive pricing and full employment are stated

$$(3) \qquad \sum_j a_{kj} x_j = v_k,$$

$$(4) \qquad \sum_i w_i a_{im} = p_m,$$

where a_{ij} is the cost minimizing input of factor i in sector j, x_j is the output of good j, v_k is the endowment of factor k, w_i is the price of factor i, and p_m is the price of good m. Fully differentiate (3) and (4) and use the cost minimizing envelope result in (4) to find

$$(5) \qquad \begin{pmatrix} \sigma & \lambda \\ \theta' & 0 \end{pmatrix} \begin{pmatrix} \hat{w} \\ \hat{x} \end{pmatrix} = \begin{pmatrix} \hat{v} \\ \hat{p} \end{pmatrix}$$

where σ is the 7×7 matrix of substitution elasticities, λ is the 7×5 matrix of industry shares, and θ', is the 5×7 matrix of factor shares. Note that endowments are held constant. The inverse of the 12×12 matrix in Eq. (5) relates exogenous price changes to endogenous factor prices and output. Inverting Eq. (5) leads to comparative static elasticities $\hat{w}/\hat{p}$ and $\hat{x}/\hat{p}$. Outputs and factor prices adjust to maintain full employment and competitive pricing in the comparative statics of the model. The effects of predicted vectors of price changes are examined.

III. COMPARATIVE STATIC ELASTICITIES IN THE BOLIVIAN MODEL

Table VI shows elasticities of factor prices with respect to prices of goods in the general equilibrium comparative statics. The largest elastic effects occur for capital and the smallest for skilled labor. Natural gas prices have very small effects on factor prices other than its own capital. Service prices have the largest impacts on factor prices.

As an example, a 10 percent decrease in agricultural prices would raise skilled wages by 0.7 percent but lower unskilled wages 3.7 percent. Payment to capital in agriculture would fall 15.7 percent, a significant impact for capital (and land) owners. The lower price of agricultural products would decrease agricultural output and release unskilled labor. Movement of labor to the other sectors causes those capital returns to rise. Agriculture uses skilled labor the least intensively and the increase in skilled wages can be understood as a relative increase in the demand for skilled labor with declining agricultural output.

A 10 percent increase in the price of minerals would raise the wage of skilled labor by 0.8 percent and the wage of unskilled labor by 1.7 percent while capital returns in mining rise by 20.2 percent. Both skilled and unskilled labor benefit with a higher

Table VI
Elasticities of Factor Prices with Respect to Prices

	$\hat{p}_A$	$\hat{p}_M$	$\hat{p}_G$	$\hat{p}_F$	$\hat{p}_V$
$\hat{w}_S$	−0.07	0.08	0.03	0.19	0.77
$\hat{w}_U$	0.37	0.17	0.06	0.26	0.14
$\hat{w}_A$	1.57	−0.14	−0.05	−0.22	−0.16
$\hat{w}_M$	−0.23	2.03	−0.05	−0.28	−0.46
$\hat{w}_G$	−0.19	−0.14	1.98	−0.24	−0.41
$\hat{w}_F$	−0.20	−0.15	−0.05	1.88	−0.49
$\hat{w}_V$	−0.06	−0.11	−0.04	−0.22	1.44

price of mining, true for every sector except agriculture. Results are similar for natural gas.

A higher price in a sector increases its capital return but lowers the return in other sectors. While some factors benefit and others lose with any price change, the benefits are uneven. Price changes affect the returns to specific capital more than shared labor.

Thompson and Toledo (2000) proved that the comparative static effects of price changes on factor prices are the same for all CES production functions. Comparative static elasticities in Table VI extend to all CES production functions regardless of the degree of substitution. The degree of substitution, if it is constant along isoquants, does not affect the general equilibrium elasticities of prices on factor prices in competitive models of production.

Table VII shows the price elasticities of outputs along the production frontier. A higher price raises output in a sector, drawing labor away from other sectors and lowering other outputs. The largest own output effect occurs for mining, where a 10 percent price increase would raise output 10.3 percent. All other effects are inelastic and the smallest effect occurs for services. The price of services has the largest effects on other outputs and natural gas prices have the smallest cross effects.

Table VII
Elasticities of Outputs with Respect to Prices

	$\hat{p}_A$	$\hat{p}_M$	$\hat{p}_G$	$\hat{p}_F$	$\hat{p}_V$
$\hat{x}_A$	0.57	−0.14	−0.06	−0.22	−0.16
$\hat{x}_M$	−0.23	1.03	−0.05	−0.28	−0.46
$\hat{x}_G$	−0.19	−0.14	0.98	−0.24	−0.41
$\hat{x}_F$	−0.20	−0.15	−0.05	0.89	−0.49
$\hat{x}_V$	−0.06	−0.11	−0.04	−0.22	0.44

IV. PROJECTED PRICE CHANGES AND ADJUSTMENT FOR BOLIVIA

Projected price changes from Bolivia's Department of Analysis of Economic Policy (1998) are used in the present study. Predictions include higher prices for mining, natural gas, and manufacturing due to increased export demand. Prices of mining are projected to increase 4 percent, natural gas 8 percent, and manufactures, 30 percent. Import competition will lower prices in agriculture and services. Agricultural prices are projected to fall as much as 12 percent and service prices as much as 20 percent. These price projections are based on comparisons of similar products in surrounding countries. This article uses various price changes as a gauge of model sensitivity.

The vector of projected price changes is multiplied by the matrix of factor price elasticities in Table VI to find the vector of factor price adjustments in Table VIII. Skilled wages are projected to fall by 12.9 percent and unskilled wages by 4.7 percent due mainly to the falling prices in services and agriculture. Other losers from free trade would be capital in services and agriculture with return declines of 29.8 percent and 17.7 percent. Free

Table VIII
Trade Liberalization with
Cobb-Douglas Production

Projected Prices Changes		Factor Prices Adjustments		Output Adjustments	
$\hat{p}_A$	−12%	$\hat{w}_S$	−12.0%	$\hat{x}_A$	−5.7%
$\hat{p}_M$	4%	$\hat{w}_U$	−4.7%	$\hat{x}_M$	3.6%
$\hat{p}_G$	8%	$\hat{w}_A$	−17.7%	$\hat{x}_G$	5.3%
$\hat{p}_F$	30%	$\hat{w}_M$	18.3%	$\hat{x}_F$	18.8%
$\hat{p}_V$	−20%	$\hat{w}_G$	24.5%	$\hat{x}_V$	−7.6%
		$\hat{w}_F$	20.5%		
		$\hat{w}_V$	−29.8%		

trade benefits capital in mining, natural gas, and manufacturing by 18.3 percent, 24.5 percent, and 20.5 percent, respectively.

The effects of free trade on outputs are also in Table VIII, found by multiplying the output elasticities in Table VII by the projected vector of price changes. Agricultural output is projected to fall by 5.7 percent and service sector output by 7.6 percent. Mining output is predicted to rise 3.6 percent and natural gas output by 5.3 percent. Output in manufacturing is projected to increase considerably.

The lower return to capital in agriculture suggests there will be secondary problems for the banking industry in Bolivia. Agriculture represents about one tenth of the banking loan portfolio. Low agricultural prices have already forced some banks to reschedule loans and the government has been negotiating with the International Monetary Fund (IMF) to complete rescheduling.

Projected output adjustments are large. The model projects revenue in agriculture will fall 17.7 percent due to lower prices and falling output. Agriculture has been about 40 percent of Bolivian exports. The projected changes would lower the trade balance but exports of natural gas and minerals should increase. The share of manufactured goods in exports has been small and the effects of manufacturing on the trade balance should be small. Domestic firms in the service sector will find it difficult to survive.

To gain some insight into sensitivity, more conservative price changes are used in Table IX. The resulting decline in skilled wages is about one third as large as in Table VIII. Unskilled wages rise slightly. Effects on capital returns are smaller. Capital returns are generally smaller except for manufacturing. Output declines in agriculture and services are larger and the increase in manufacturing output is larger. Mining and natural gas have much smaller output increases.

Table X shows factor price and output adjustments with CES production. Intermediate projected price changes are used

Table IX
Trade Liberalization with Smaller Projected Price Changes

Projected Price Changes		Factor Price Adjustments		Output Adjustments	
$\hat{p}_A$	−6%	$\hat{w}_S$	−3.9%	$\hat{x}_A$	−5.9%
$\hat{p}_M$	4%	$\hat{w}_U$	1.1%	$\hat{x}_M$	5.8%
$\hat{p}_G$	2%	$\hat{w}_A$	−11.8%	$\hat{x}_G$	3.0%
$\hat{p}_F$	15%	$\hat{w}_M$	9.8%	$\hat{x}_F$	18.7%
$\hat{p}_V$	−10%	$\hat{w}_G$	5.0%	$\hat{x}_V$	−7.8%
		$\hat{w}_F$	33.6%		
		$\hat{w}_V$	−17.8%		

for services and manufacturing, and others are rounded off to increments of 5 percent. Factor price adjustments remain large. Output adjustments are very large with the lower degree of substitution.

Brown, Deardorff, and Stern (1998) predicted smaller adjustments in Chile with a move to hemispheric free trade. Their model is different in various respects. It is a multicountry model with monopolistic competition and an input-output scheme. They consider the removal of tariffs averaging about 11 percent in

Table X
Trade Liberalization with CES Production

Projected Price Changes		Factor Price Adjustments		Output Adjustments			
				CES = .05		CES = 2	
$\hat{p}_A$	−15%	$\hat{w}_S$	−5.8%	$\hat{x}_A$	−11.8%	$\hat{x}_A$	−5.7%
$\hat{p}_M$	5%	$\hat{w}_U$	−0.9%	$\hat{x}_M$	9.4%	$\hat{x}_M$	3.6%
$\hat{p}_G$	10%	$\hat{w}_A$	−26.8%	$\hat{x}_G$	13.8%	$\hat{x}_G$	5.3%
$\hat{p}_F$	20%	$\hat{w}_M$	14.4%	$\hat{x}_F$	26.7%	$\hat{x}_F$	18.8%
$\hat{p}_V$	−15%	$\hat{w}_G$	23.2%	$\hat{x}_V$	−11.0%	$\hat{x}_V$	−7.6%
		$\hat{w}_F$	46.7%				
		$\hat{w}_V$	−25.9%				

Chile. The present model assumes competition with final products and considers rising export prices as well as falling import prices.

V. CONCLUSION

Neoclassical international trade theory emphasizes welfare gains due to free trade. Factor proportions trade theory examines the underlying income redistribution across factors of production. This article uses the specific factor model to project the magnitude of income redistribution for skilled labor, unskilled labor, and capital in various sectors of the Bolivian economy due to emerging South American free trade.

Bolivian agriculture and services are projected to suffer falling prices with free trade, while minerals, natural gas, and manufacturing are projected to enjoy higher prices. Resulting output adjustments in the specific factor model are quite large, ranging from an average decrease of almost 10 percent in services to an average increase of about 20 percent in manufacturing.

Projected factor price adjustments are also large. Wages would fall with the move to free trade and skilled wages are the most exposed. The share of skilled labor in the economy is small except in the service sector, which is projected to lose in the face of increased import competition. The return to capital in manufacturing is projected to increase by more than 20 percent. Returns to capital in mining and natural gas are projected to increase considerably, from 10 percent to 20 percent. The return to capital in services is projected to fall over 20 percent. In agriculture, the return to capital (including land) will fall. The redistribution of capital income will affect the financial sector in Bolivia, itself facing increased international competition.

Increased investment in a competitive and more efficient Bolivian economy could result in higher income for every factor of production. The benefits of free trade due to competition and

increased efficiency have been documented in numerous instances around the world. Results in the present model are not a call to avoid free trade and investment. Nevertheless, it should be recognized that various sectors and factors of production in Bolivia stand to lose with free trade and the losses may be quite large. Anticipating pending income redistribution may ease the political struggle to establish free trade in Bolivia and South America.

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