Simulating the Effects of the FTAA on Global Carbon Emissions:

A General Equilibrium Analysis

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ABSTRACT

This paper uses a computable general equilibrium (CGE) model of the world economy to simulate trade liberalization under the proposed Free Trade Area of the Americas (FTAA) and analyze the effects on global CO_2 emissions. The case of worldwide trade liberalization is also simulated for comparison. In order to disentangle the forces driving the change in emissions, a decomposition procedure is applied in which changes in each country's emissions are separated into three components: carbon-intensity, energy-intensity, and scale effects. The results of this study indicate that formation of the FTAA is likely to have little effect on CO_2 emissions in the region or in the world as a whole. Worldwide trade liberalization, on the other hand, may bring about a significant rise in global emissions. Under both liberalization scenarios, there are some countries for which the effects on CO_2 emissions are large, sometimes disproportionately so, given that they are accompanied by only modest changes in GDP. In addition, we combine trade liberalization with country-specific carbon taxes, so as to hold each country's carbon emissions at or below pre-liberalization levels. Most countries experience declines in GDP relative to the liberalization-only scenario, although the declines are small. (*JEL* C68, F18, Q25)

I. Introduction

The Free Trade Area of the Americas (FTAA) was proposed in 1994 with the objective of liberalizing trade and investment across the entire Western Hemisphere, from Canada to Chile. Currently, 34 countries are included in the negotiations, which began in 1998 and are scheduled to be finalized by 2005. The intent of the FTAA is to reduce barriers to the flow of goods, services, and investment capital, and in so doing, increase growth throughout the region. However, as has been repeatedly demonstrated in the violent protests surrounding recent FTAA, WTO, World Bank/IMF, and G8 meetings, the environmental effects – real or perceived – of increased global integration are the subject of much contention and debate.

In this paper we set out to examine one aspect of the effects of trade liberalization on the environment. We develop a multi-region computable general equilibrium (CGE) model and use it to simulate the effects of the proposed FTAA on global carbon emissions. In addition, to provide a contrast and context to our analysis of the effects of regional trade liberalization within the FTAA, we also simulate worldwide trade liberalization. In terms of the change in global carbon emissions, we find that the FTAA has only a negligible impact. Small increases in emissions in FTAA countries are almost entirely offset by decreases elsewhere in the world. In contrast, worldwide trade liberalization causes a significant rise in global emissions. Although changes in carbon emissions within a country are usually correlated with changes in that country's total output, this is not always the case. In order to better understand the changes in emissions, we decompose each country's overall emissions change into three separate components, which result from changes in: (i) total output; (ii) the energy intensity of output; and (iii) the carbon intensity of fossil fuel use.

In the next section we review previous work using general equilibrium models to examine the effects of trade liberalization on the environment. In part three we present a profile of the FTAA economies. The model used for the simulations is described in part four. Data sources and preparation are presented in the fifth part of the paper. Part six discusses simulations performed and the results. In the final section, we present some conclusions and ideas for extending the current work. The regions and sectors in the model and the abbreviations used throughout the paper are provided in Tables 1 and 2.

II. Previous Work

In this section we briefly review recent work using CGE models to analyze the effects of trade liberalization on the environment. The models can be categorized across a number of dimensions, including scope (single- vs. multi-country models), the pollutants included in the analysis, and the extent of the trade liberalization pursued.[1] Further distinguishing features include whether changes in trade policy are coordinated with pollution control policies, whether environmental quality is included in the calculation of welfare or has feedback effects on the consumption of market goods, and whether abatement activities are possible. Although it is difficult to generalize the results of these disparate efforts, it is possible to conclude that the impact of trade liberalization on the environment is largely an empirical question and that CGE models are useful tools for investigating these issues.

In this survey, we pay particular attention to efforts using multi-country models. We look first at work that focuses on multilateral trade liberalization and the resulting effects on pollution across a number of countries. One such study is that of Grossman and Krueger (1993), who use simulations from the Brown, Deardorff, and Stern (1991) world model to investigate the effects of trade and investment liberalization within NAFTA on air pollution from the utilities sector and on an aggregate measure of toxic releases from manufactures.[2] In a similar study, Reinert and Roland-Holst (2000) simulate the removal of trade barriers within NAFTA and break down the resulting impacts on toxic releases by 13 IPPS pollutant types.[3] Madrid-Aris (1998) also examines NAFTA trade and investment liberalization and its consequences on hazardous waste generation in the state of California, the rest of the U.S., and Mexico.

Other work using multi-country models includes Perroni and Wigle (1994) who simulate the effects of worldwide free trade on an analytical index of total environmental quality in three aggregate world regions. Ferrantino and Linkins (1999) look at the global impact on toxic

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[1] We confine our survey to work that examines changes in "conventional" pollutants and do not examine models that focus exclusively on the degradation of natural resources (forests, soil, fisheries, water, etc.).

[2] The authors examine releases of several hundred toxic substances across all media (air, water, subsurface, and land), using data from the U.S. EPA's Toxic Release Inventory (TRI).

[3] The Industrial Pollution Projection System (IPPS) was developed at the World Bank using the U.S. EPA's TRI (see Hettige et al. (1994)). The TRI was used to calculate risk-weighted sectoral pollution coefficients for 13 pollutant categories covering air, water, subsurface, and land releases. The IPPS coefficients are based on data for U.S. manufacturing sectors and do not reflect differences in pollution intensities across countries.

releases following implementation of Uruguay Round provisions and supplemental worldwide liberalization in trade of manufactures and selected primary commodities. Tsigas et al. (2001) examine changes in IPPS pollutants and agricultural pollution brought on by trade liberalization among the Western Hemisphere's five largest economies. Smith and Espinosa (1995) simulate the effect on domestic air pollution of the United Kingdom's unilaterally lowering trade barriers on imports of durable manufactures from other EU countries. Lee and Roland-Holst (1997) explore the removal of import tariffs in Indonesia and the impacts on IPPS pollutants in Indonesia, Japan, and the rest of the world. Strutt and Anderson (2000) focus on changes in air and water pollution in Indonesia, including carbon emissions, following Uruguay Round and APEC trade liberalization.

In addition, a number of studies employ single-country CGE models to examine trade liberalization and its effects on domestic environmental quality. One important effort is a dynamic-recursive model which was developed at the OECD and adapted to a number of different countries. Each country study simulates the progressive removal of tariffs culminating in complete, unilateral liberalization, and examines the effects on IPPS pollutant releases. Using a variant of this model, Dessus and Bussolo (1998) explore the effects of unilateral trade liberalization in Costa Rica while Beghin et al. (1997) do the same for Mexico. For Chile, Beghin et al. (1999) simulate accession to NAFTA and MERCOSUR separately, and then compare these results to the case of unilateral, non-discriminatory trade liberalization. Using an unrelated single country model, Abler et al. (1999) examine the effects on a variety of industrial and agricultural pollutants (including CO_2) of trade liberalization in Costa Rica.

III. Profile of FTAA Economies

As a whole, the 34 countries of the FTAA account for about 14% of world population and 33% of world GDP, while trade within the FTAA amounts to 13% of total world trade. A handful of countries – the United States, Canada, Mexico, Brazil, and Argentina – dominate the economic profile of the region. Table 3 shows that these five countries contain more than 75% of the FTAA's population, produce 95% of its total output, and account for 80% of intra-FTAA trade.[4] The U.S., with an economy over ten times the size of the next largest economy, Brazil,

[4] Much of this trade is among NAFTA countries, amounting to 71% of total intra-FTAA trade.

and over 100 times the size of 28 other individual FTAA economies, is the economic behemoth of the region.

As shown in Table 4, the CO_2 emissions profile of the FTAA is similarly disparate. In total, the countries of the FTAA account for about 31% of world emissions. Of that, three-quarters are from the U.S., the world's largest emitter.[5] In 1995, the U.S. produced well over twice as much CO_2 as the rest of the FTAA combined. Country CO_2 emissions and the share of each of the three fossil fuels – coal, oil, and natural gas – in individual country totals are shown in Figures 1 and 2, respectively. Oil contributes the greatest share of CO_2 emissions within the FTAA as well as in the EU and Japan. Coal's share of emissions is dominant in a handful of regions, most notably China and South Asia.

Trade and protection data are provided in Tables 5, 6, and 7. Although the U.S. has a more diverse set of trading partners, intra-regional trade dominates for most of the countries that make up the FTAA, as can be seen in Table 5 (columns one and four). The 2% average trade-weighted tariff on trade among FTAA countries is skewed downward by the abundance of reduced-tariff trade among NAFTA members.[6] Taken together, NAFTA countries impose an average trade-weighted tariff of almost 8% on other FTAA countries (not shown). Outside the NAFTA block, the average tariffs that FTAA countries impose on imports from within the FTAA as a whole are also high; sometimes higher than rates they impose on trading partners outside the region (columns two and three). A similar situation exists for FTAA exports and the tariffs they face both within and outside the FTAA (columns five and six).

Average bilateral tariff rates for countries in the model are shown in Table 6.[7] NAFTA members Canada, Mexico, and the U.S. have the lowest average rate – about 2% – followed by the EU and the NICs. At 42% and 24% respectively, South Asia and China impose the highest rates overall. Table 7 shows average regional tariffs by commodity. In terms of intra-FTAA trade, the commodities that face the highest tariffs are wearing apparel (10%); food, beverages,

[5] The U.S. also emits more than twice the CO_2 per capita as the world's other two richest regions, Japan and the EU, reflecting both greater per capita energy use in the U.S. and the greater dependence of the U.S. economy on coal.

[6] As seen in Table 6, Mexico even provides a net subsidy on imports from the U.S. and Canada.

[7] Tariffs in the GTAP version 4 database reflect pre-Uruguay Round levels. Tariffs for Brazil, Argentina, and Chile are at pre-Mercosur levels.

and tobacco (7%); and textiles (5%). For the world as a whole, the highest tariffs are imposed on agricultural products (27%); food, beverages and tobacco (24%); and textiles (19%).

IV. The Model

The model used in this analysis follows in a long line of multi-region CGE models dating back to the work of Whalley (1985) and Deardorff and Stern (1990). Both of these models were used to analyze the impacts of the Tokyo Round of the GATT. The model we use here is closely related to the WALRAS world model constructed at the OECD (Burniaux et al. (1992)) and further developed by Wang (1994) and Lewis, Robinson, and Wang (1995).[8] The economic and trade data used in the model is from the Global Trade Analysis Project (GTAP) and is described in the next section. The model we construct to analyze the impact of the FTAA on carbon emissions includes 19 countries/regions – 10 of which are potential members of the agreement – and 21 commodities.

Like most multi-region CGE models, the model simulates the workings of the real side of the world economy. Following a trade liberalization shock, prices and quantities adjust to clear markets for products and factors within each country or region in the model. In addition, the model solves for a set of world prices which equate supply and demand for sectoral imports and exports across all regions. The current model is static and the simulations generate a snap-shot of the world economy, *ceteris paribus*, after the adjustment period is concluded. This post-shock equilibrium can then be compared with the base year data to calculate percentage changes in endogenous variables.

For each country or aggregate region in the model, producers of goods and services are assumed to maximize profits by choosing their mix of inputs to production and how much of their output to supply to the domestic market and as exports. Primary factors of production included in the model are capital and labor, both of which are mobile between sectors. For the agricultural sector, crop land is also included as a factor. For the natural resource-based sectors, which include the three fossil fuels, a separate factor represents the resource stock. The factors and intermediate goods are combined together through a four-level nested CES production structure.

[8] Appendix A in Noland et al. (1998) contains a detailed description of this model.

In addition to the firms described above, agents in the model include a representative household and a government sector. The representative household receives income in the form of wages and returns on capital. It may also receive government transfer payments. After paying an income tax, the household divides its after-tax income between consumption of goods and services and savings through an extended linear expenditure system (ELES). The government receives its income through tariffs, various taxes on consumption and production, and the household income tax. Government expenditures include payments for goods and services, subsidies, and transfers.

Macroeconomic behavior in the model is specified through a simple set of rules. The model includes the three major macro balances: savings-investment, government surplus/deficit, and the balance of trade. In the current specification, for each country, total investment is fixed as a percentage of GDP. The capital account collects savings from enterprises (as retained earnings and depreciation allowances), households, the government, and foreigners. Savings-investment balance is achieved through changes in household savings. Government expenditures are also fixed as a percentage of GDP. Households are assumed to finance any shortfall in revenues. On the foreign exchange side, in the current specification, each country's balance of trade is fixed and changes in the exchange rate keep the external account in equilibrium. The exchange rate for the U.S. is fixed at unity and serves as the model's numeraire.

V. Data

The economic data used to calibrate the CGE model is primarily from the Global Trade Analysis Project (GTAP), which has become the standard database used by economists working with models of the world economy. Version 4 of the database contains comprehensive input-output and national accounting data for 45 world regions and 50 industries linked through detailed trade, transport, and protection data (McDougal (1998)). Although data on factor payments and capital stock is included in the GTAP database, in order to calibrate initial factor prices, data for labor force and agricultural land was compiled from the World Bank (2000).

CO_2 emissions for 1995 were drawn from data published by the Energy Information Administration (EIA) of the U.S. Department of Energy and the Oak Ridge National Laboratory

(ORNL).[9] For each country, the EIA compiles annual data on CO_2 emissions resulting from the burning of fossil fuels – coal, oil, and natural gas. Supplemental country data is available from ORNL on CO_2 emissions associated with the flaring of natural gas during petroleum extraction and with the manufacture of cement. This emissions data, coupled with fuel use and output data from the economic data base, was used to compute the fuel- and output-specific CO_2 emissions coefficients used in the equation for each country's CO_2 emissions:

$$CO_{2r} = \sum_i q_{ir} \cdot TS_{ir} + \sum_j f_{jr} \cdot Q_{jr} \quad ,$$

where q_{ir} represents CO_2 emissions per unit of fuel i in region r; TS_{ir} is the total use of fossil fuel i in region r; f_{jr} represents CO_2 emissions per unit of output of sector j in region r; and Q_{jr} is the total output of sector j in region r. These coefficients are fixed and are used to project CO_2 emissions in simulations using the model.

The developers of the GTAP protection data have attempted to selectively incorporate non-tariff barriers (NTBs) to trade in a number of GTAP sectors, by converting them to equivalent import tariffs, export subsidies, and producer subsidies. These NTBs include import quotas and other forms of protection and support in the agricultural and food sectors, and Multifiber Arrangement (MFA) quotas for textiles and wearing apparel used by industrialized countries to restrict imports from low-cost suppliers. NTBs are widespread and considered to constitute significant barriers to trade, yet the impacts of these instruments are difficult to quantify (Laird (1997) and Deardorff and Stern (1997)). There exists no quantitative data set on NTBs with the country and industry coverage of the current model. It is thus likely that the data presented in Tables 4 and 5 understates the level of protection in key industries around the world.

In order to simulate more realistic trade liberalization scenarios, an attempt was made to incorporate wider use of NTBs into the model. For the four developed country regions – the U.S., Canada, the EU, and Japan – the initial rates of protection were arbitrarily doubled in industries known to be ridden with these barriers. The affected commodities are agriculture; food, beverages, and tobacco; textiles; and wearing apparel. Higher initial rates of protection can

[9] These are Internet-accessible numerical databases; for EIA data see Energy Information Administration (1999) and for ORNL data see Carbon Dioxide Information Analysis Center (2000).

be expected to amplify the effects of trade liberalization, but using the case studies outlined by Deardorff and Stern as a guide, a doubling of these initial rates is probably conservative.

VI. Simulations and Results

We perform two trade liberalization experiments and investigate their effects on global CO_2 emissions. First, we simulate implementation of the FTAA by eliminating tariffs within the region. Next, as a basis for comparison, we simulate global free trade by eliminating tariffs worldwide. As can be seen in Table 8, these two simulations yield quite different results. Although FTAA liberalization leads to a small increase in emissions within the region, it is almost entirely offset by the *decrease* in emissions in the rest of the world.[10] In contrast, worldwide trade liberalization leads to a substantial increase in global emissions, with increases both within the FTAA and more prominently in the rest of the world. Effects on global and regional GDP are similar, but smaller in magnitude.

The impacts on country GDP and CO_2 emissions in the two trade liberalization simulations are presented in Figures 3 and 4. Not surprisingly, there is a strong correlation between the direction of change in GDP and CO_2 emissions, although in both liberalization experiments there are a few cases where an increase in GDP is accompanied by a decrease in emissions. For the majority of countries, the percentage change in emissions is greater than the percentage change in GDP.

In order to disentangle the forces driving the change in CO_2 emissions in each liberalization experiment, an emissions decomposition procedure is applied. For each country, emissions are decomposed into three separate effects using a simplified version of the Kaya (1990) equation:

$$C = \frac{C}{E} \times \frac{E}{GDP} \times GDP \quad ,$$

where C is CO_2 emissions, E is energy from fossil fuel use, and GDP is gross domestic product. Converting to instantaneous rates of change gives us:

[10] The contribution of CO_2 emissions to climate change is independent of the source of emissions, so the change in *global* emissions is ultimately the important figure.

$$\frac{\dot{C}}{C} = \frac{\dot{\left(\frac{C}{E}\right)}}{\left(\frac{C}{E}\right)} + \frac{\dot{\left(\frac{E}{GDP}\right)}}{\left(\frac{E}{GDP}\right)} + \frac{\dot{GDP}}{GDP} \quad .$$

The first effect in the decomposition measures the change in CO_2 emissions due to a change in the carbon intensity of energy use. An increase in a country's carbon intensity occurs if there is a shift towards greater use of carbon-intensive fuels, relative to the total amount of fossil fuel energy consumed.[11,12] An overall shift to greater use of coal from oil or natural gas would be an example.[13] The second effect measures the change in carbon emissions due to a change in the energy intensity of GDP. An increase in energy intensity occurs if there is a shift in the composition of total output toward more energy-intensive goods or if, on average, industries intensify the use of energy in their overall input mix. The third effect in the decomposition measures the change in carbon emissions due to the growth or contraction of the overall economy. This is often referred to as the scale effect.

Results of the decompositions are presented in Figures 5 through 8. Figures 5 and 7 decompose the changes in emissions in percentage terms for the FTAA and worldwide liberalization simulations, respectively. In Figures 6 and 8 the decompositions for the two experiments are presented in absolute tons of CO_2. In general, in both the FTAA and worldwide liberalization simulations, the energy intensity effect is the most significant component of the change in carbon emissions, followed by the scale effect. Reflecting the difficulty in rapidly changing the mix of energy inputs, the carbon intensity effect is never very significant in these simulations.[14]

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[11] In the model, this can occur in two ways: (i) through a shift in the composition of total output toward sectors which use relatively carbon-intensive fossil fuels and/or (ii) through input shifts by sectors using relatively carbon-intensive fossil fuels to greater use of the composite intermediate input, and thereby fossil fuels, relative to value added.

[12] Shifts in final demand for fossil fuels (e.g., an increase in consumption of natural gas for household heating and cooking) can also contribute to the change in a country's total carbon emissions, as will a shift in output of the two sectors – oil and cement – which emit carbon as a by-product of their manufacture. In the base year, however, more than 90% of world carbon emissions were generated through the use of fossil fuels as intermediate inputs.

[13] Relative to natural gas, oil and coal are, respectively, 38% and 77% more carbon intensive.

[14] Changes in the CO_2 to energy ratio have been shown in general to contribute far less to the change in CO_2 emissions over time than the other two effects (Energy Information Administration (2001)). An exception is the EU,

As mentioned previously, the effect of the FTAA on global carbon emissions is negligible. As shown in Figure 5, the effects on emissions in percentage terms appears to be significant for a handful of countries, however, in Figure 6, none of the changes is significant in terms of absolute tons of CO_2. Reflecting the minimal impact on total output brought on by trade liberalization within the FTAA, most of the changes in country emissions occur through changes in energy intensity, rather than through scale effects.

As can be seen in Figures 7 and 8, worldwide liberalization has significant effects on the CO_2 emissions of a number of countries in both percentage *and* absolute terms, particularly outside the FTAA. Inside the FTAA, the effects on emissions for most countries under worldwide liberalization are roughly similar to the effects under regional liberalization. Outside the FTAA, however, the effects on emissions are now significant for a number of countries. Particularly notable is the case of China, where CO_2 emissions increase by almost 20 million tons, mostly by way of the scale effect. An interesting counterpoint is the case of South Asia, where despite an increase in GDP comparable to that of China, a decline in energy intensity almost offsets the increase in emissions. In the case of ASEAN, the decline in energy intensity is so great that it overwhelms the positive scale and carbon intensity effects, resulting in an overall *decrease* in emissions.[15]

Although not the primary focus of this paper, the results of our simulations provide some useful insights into the likely welfare effects of the FTAA and more broadly into the debate on the merits of regional versus multilateral trade liberalization. Some authors have questioned whether regional trade agreements in general (Bhagwati (1992, 1998), Panagariya and Dutta-Gupta (2001)) and the FTAA in particular (Panagariya (1996)) are welfare-improving propositions for member countries and the world at large. Our analysis lends some justification to these doubts. With the exception of the Caribbean and Central America region, we find that establishment of the FTAA does not improve welfare in a meaningful way in any FTAA country (Figure 3). Moreover, the trivial gains accruing to FTAA members are counterbalanced by welfare *losses* in the rest of the world. Overall, the net change in global welfare from the creation of the FTAA is barely positive. This contrasts with the results of our simulation of

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where a notable decrease in carbon intensity occurred due to greater use of natural gas and nuclear power in the early 1990s.

[15] A similar scenario exists for Colombia in both simulations and for Argentina in the FTAA simulation.

worldwide trade liberalization, in which welfare increases in all world regions. Although the overall gain for members of the FTAA under global free trade is still small, all members are individually *at least as well off* as they would be under the regional agreement.[16]

The lackluster welfare result following creation of the FTAA seems to be driven in large part by the high degree of trade diversion that occurs. In general, when barriers to trade within the FTAA are removed, the total exports and imports of FTAA members – to and from all world regions – increase. However, as shown in Table 9, the increase in trade that occurs within the FTAA is to a large extent offset by reduced trade with the rest of the world. While increases in GDP in countries in the region do imply that the benefits of trade creation exceed the inefficiencies of trade diversion, as discussed previously, these benefits are small.

Following FTAA-wide liberalization, the overall shifts in trade are more profound for FTAA regions outside of NAFTA. As shown in Table 9, the U.S., Canada, and Mexico do not on average increase their intra-FTAA trade as much as the other members. Rather, NAFTA countries reduce their trade with one another slightly while increasing trade with their non-NAFTA FTAA partners to a much greater extent – i.e., the FTAA also diverts trade out of NAFTA (not shown). Because the volume of trade among NAFTA partners was quite large prior to liberalization, the net effect of these two changes is to temper the increase in NAFTA countries' trade with the FTAA as a whole.

This difference in the impact of liberalization on trade patterns for NAFTA versus other FTAA countries helps to explain why the effects on GDP are even smaller for NAFTA members. Even though FTAA liberalization causes NAFTA countries to markedly increase their trade with other FTAA members, their trade with these countries was so small to begin with that it has little effect on their overall economies. However, the effects on FTAA members outside of NAFTA are quite different. Many of these countries were already trading heavily with the U.S. prior to

[16] The static, neoclassical model used here is not equipped to capture the gains from trade liberalization that the "new trade theory" suggests are possible in an environment of increasing returns, imperfect competition, dynamic influences, etc. (Robinson and Thierfelder (1999)). While inclusion of these features might amplify welfare gains under the FTAA, the gains under global free trade would also likely be amplified. We thus suspect that most of the qualitative results in this section would not change. Indeed, using a global CGE model with increasing returns to scale, monopolistic competition, and product variety, Brown et al. (2001b) get qualitatively similar welfare results in simulations of a Western Hemisphere free trade agreement, where the regions include the U.S., Canada, Mexico, Chile, and a residual aggregate representing the rest of the hemisphere.

the creation of the FTAA. From their perspective, this marked increase in trade with a major trading partner, the U.S., gives their economies more of a boost.

VII. Conclusions

The results of this study suggest that formation of the FTAA is likely to have little effect on CO_2 emissions in the region or in the world as a whole. Worldwide trade liberalization, on the other hand, may bring about a significant rise in global emissions. Under both liberalization scenarios, there are some countries for which the effects on CO_2 emissions are large, sometimes disproportionately so, given that they accompany only modest changes in GDP. One practical implication of these results is that for countries contemplating taking on an emissions target under the Kyoto Protocol or some alternative climate change treaty, it would be important to factor into their calculations the likely effects of trade liberalization on future emissions.

Regarding its effects on welfare, our simulations indicate that the FTAA would have a significant positive impact on only a handful of countries and that its economic impact on the region as whole, beyond some shift in trade patterns, would be negligible. In particular, the welfare impact of the FTAA on the three NAFTA countries, which contain over half the region's population, is minimal. The gains that do accrue to FTAA member countries come at the expense of the rest of the world, particularly some of the world's poorest countries. Worldwide liberalization, on the other hand, does have a meaningful positive impact on world welfare, and the gains are universally positive for individual countries. China and the countries of South Asia are particularly big beneficiaries of global liberalization. Although NAFTA members are again some of the least affected by worldwide liberalization, our simulations show them all to be better off than they would be under the FTAA. Non-NAFTA FTAA members are also better off under worldwide liberalization.

The current study could be extended in a number of different directions. One possibility is to look at other proposed bilateral and regional trade agreements. Examples include APEC, an expanded EU, and an East Asian trading bloc which excludes the U.S. Further work could also examine the effects of trade liberalization on a range of pollutants beyond CO_2. Although the effects of CO_2 emissions on global climate change are an important long-run concern, many countries, especially in the developing world, are more concerned with the short-run effects of localized pollution on human health. The current model could also be used to investigate the concurrent use of targeted pollution policies – such as Pigouvian taxes or tradable permits – to mitigate any harmful environmental effects which might follow trade liberalization. In particular, if augmented with additional taxation data, the model could be used to explore the issues of revenue replacement and the "double dividend" hypothesis, currently subjects of much debate in the literature.

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Table 1

Regions in the Model

	Abbreviation	Region
FTAA	USA	United States
FTAA	CAN	Canada
FTAA	MEX	Mexico
FTAA	CAM	Central America and Caribbean
FTAA	BRA	Brazil
FTAA	ARG	Argentina
FTAA	COL	Colombia
FTAA	VEN	Venezuela
FTAA	CHL	Chile
FTAA	RSM	Rest of South America
	EU	European Union
	FSU	Former Soviet Union and Central Europe
	JPN	Japan
	CHN	China
	NIC	Newly Industrialized Countries (*Hong Kong, Korea, Singapore, Taiwan*)
	SAS	South Asia (*Bangladesh, India, Pakistan, etc.*)
	ASN	ASEAN-5 (*Indonesia, Malaysia, Philippines, Thailand, Vietnam*)
	AME	Africa and Middle East
	ROW	Rest of World

Table 2

Sectors in the Model

Abbreviation	Sector
AGR	Agriculture
FRS	Forestry
FSH	Fishing
COA	Coal
OIL	Oil
GAS	Natural Gas
OMN	Other Minerals
FBT	Food, Beverages, and Tobacco
TEX	Textiles
WAP	Wearing Apparel and Leather Goods
LUM	Wood and Paper Products
PCP	Petroleum and Coal Products
CRP	Chemicals, Rubber, and Plastics
NMM	Other Non-Metallic Mineral Products
MET	Ferrous and Non-Ferrous Metals
FMP	Metal Products
TRS	Motor Vehicles and Other Transport Equipment
ELE	Electronic Goods
OME	Other Machinery, Equipment, and Manufactures
HHS	Household Services (*Construction, Electricity, Gas, and Water*)
TSV	Trade, Transport, and Other Services

Table 3

Population, GDP, and Trade Shares of FTAA Regions

Region	% of FTAA Population	% of Total FTAA GDP	% of Intra-FTAA Trade
United States	34.6	76.2	44.8
Canada	3.8	6.1	25.8
Mexico	11.8	3.0	11.5
Central America and Caribbean	8.2	0.9	3.7
Brazil	20.7	7.6	4.6
Argentina	4.5	2.7	2.3
Colombia	5.0	0.8	1.6
Venezuela	2.8	0.8	2.2
Chile	1.8	0.7	1.4
Rest of South America	6.7	1.1	2.2
Totals	**100.0**	**100.0**	**100.0**

Notes: Column three is calculated as intra-FTAA trade (imports plus exports) by country divided by total intra-FTAA trade.

Sources: World Bank and GTAP 4 database.

Table 4

Country Shares of World CO_2 Emissions, CO_2 Emissions Per Capita, and Per Capita GDP, 1995

Region	CO_2 Emissions (% of world total)	CO_2 Emissions Per Capita (metric tons)	Per Capita GDP (PPP $)
United States	23.3	5.4	27,400
Canada	2.2	4.6	23,100
Mexico	1.5	1.0	7,100
Central America and Caribbean	0.6	0.5	3,500
Brazil	1.2	0.5	6,600
Argentina	0.6	1.0	10,700
Colombia	0.3	0.4	6,200
Venezuela	0.6	1.6	6,000
Chile	0.2	0.8	7,500
Rest of South America	0.3	0.3	4,000
European Union	14.5	2.4	19,700
Former Soviet Union	14.3	2.3	5,800
Japan	4.9	2.4	23,200
China	13.8	0.7	2,600
NICs	3.2	2.6	15,000
South Asia	4.3	0.2	1,800
ASEAN-5	2.6	0.4	3,500
Africa and Middle East	8.6	0.6	2,700
Rest of World	3.1	1.1	12,500
FTAA	**30.6**	**2.5**	**14,300**
World	**100.0**	**1.1**	**6,300**

Sources: Energy Information Administration, Oak Ridge National Laboratory, World Bank, U.S. Census Bureau, and GTAP 4 database.

Table 5

Trade and Barriers to Trade within the FTAA, 1995

Region	Share of Total Imports from FTAA Regions (%)	Average Tariff Imposed on: FTAA Regions (%)	Average Tariff Imposed on: Non-FTAA Regions (%)	Share of Total Exports to FTAA Regions (%)	Average Tariff Imposed by: FTAA Regions (%)	Average Tariff Imposed by: Non-FTAA Regions (%)
United States	31	1	3	31	2	9
Canada	72	0	5	77	0	8
Mexico	76	0	10	86	1	5
Central America and Caribbean	52	10	8	50	8	8
Brazil	44	11	13	40	7	9
Argentina	50	9	9	52	10	18
Colombia	61	6	8	61	7	3
Venezuela	56	11	7	81	3	2
Chile	51	8	8	31	5	4
Rest of South America	55	11	10	47	5	8
FTAA	**42**	**2**	**4**	**45**	**2**	**9**

Notes: Tariffs are trade-weighted averages.

Sources: GTAP 4 database.

Table 6

Average Bilateral Tariffs, 1995

	Importer:																		
Exporter:	USA	CAN	MEX	CAM	ARG	BRA	CHL	COL	VEN	RSM	EU	FSU	JPN	CHN	NIC	SAS	ASN	AME	ROW
USA	----	0	0	11	7	12	8	7	11	10	3	6	22	14	9	36	13	9	8
CAN	0	----	-3	9	5	6	4	3	11	6	3	6	16	5	4	36	10	8	7
MEX	0	0	----	7	8	17	10	9	9	10	4	2	4	13	4	36	4	3	14
CAM	8	3	6	----	8	11	8	9	9	11	8	7	10	14	2	8	4	5	9
ARG	5	2	1	9	----	13	9	9	13	7	19	7	22	14	10	46	29	10	32
BRA	4	3	10	9	10	----	10	9	12	11	7	7	5	15	6	52	9	12	23
CHL	1	2	5	13	9	4	----	11	3	12	4	3	2	2	3	47	4	7	20
COL	3	2	2	9	6	7	0	----	14	19	3	1	2	11	4	6	0	5	8
VEN	1	5	4	7	10	18	0	0	----	11	1	1	1	8	2	14	0	2	2
RSM	3	3	4	8	11	8	2	1	10	----	12	2	3	8	2	3	1	4	12
EU	3	5	8	6	9	14	8	7	8	10	----	8	6	25	5	37	8	10	8
FSU	2	4	5	2	5	4	6	8	1	7	4	----	5	11	2	45	7	9	20
JPN	3	4	11	9	7	13	9	12	15	15	4	7	----	30	4	57	15	13	10
CHN	6	7	16	17	15	14	10	11	7	12	6	11	5	----	3	60	14	16	21
NIC	3	5	12	8	8	17	9	14	13	11	4	10	4	30	----	51	12	11	16
SAS	6	14	14	11	12	11	10	12	2	8	6	8	3	17	3	----	11	13	14
ASN	3	5	11	11	8	6	7	4	2	4	4	7	4	16	3	50	----	14	21
AME	2	6	7	5	11	13	8	4	1	5	3	9	2	10	3	35	5	----	10
ROW	4	6	7	8	5	6	9	5	7	7	3	6	14	13	5	32	15	8	----
Average	**2**	**2**	**2**	**9**	**9**	**12**	**8**	**7**	**9**	**10**	**4**	**8**	**9**	**24**	**5**	**42**	**12**	**11**	**10**

Notes: All average tariffs are trade-weighted and given in percent. Tariffs within the FTAA are shaded gray.

Source: GTAP 4 database.

Table 7

Average Regional Tariffs by Industry, 1995

	Importer:																			Intra-FTAA	World
Commodity:	USA	CAN	MEX	CAM	BRA	ARG	COL	VEN	CHL	RSM	EU	FSU	JPN	CHN	NIC	SAS	ASN	AME	ROW	**Average**	**Average**
AGR	5	1	-1	-1	7	6	-1	0	-2	-4	10	5	117	7	40	30	28	13	51	**3**	**27**
FRS	0	0	1	13	15	2	5	5	11	9	0	3	0	3	1	19	2	8	1	**0**	**1**
FSH	0	0	11	15	10	10	4	10	10	5	5	8	4	26	4	53	45	10	5	**1**	**6**
COA	0	0	2	9	0	14	5	5	11	6	0	1	0	12	1	15	2	5	16	**1**	**1**
OIL	0	9	0	6	20	34	10	10	9	20	0	2	1	1	3	10	1	5	5	**2**	**2**
GAS	0	0	0	9	11	10	5	5	5	4	0	3	0	12	3	58	4	2	5	**1**	**1**
OMN	0	0	3	8	0	3	5	5	8	8	0	7	0	3	1	5	3	11	1	**1**	**2**
FBT	10	6	-2	12	1	12	7	17	9	15	26	14	31	17	19	56	41	19	65	**7**	**24**
TEX	7	6	3	15	12	18	14	14	10	15	5	9	4	58	3	70	21	16	35	**5**	**19**
WAP	10	16	3	25	16	19	18	19	11	17	9	13	8	43	3	71	16	21	16	**10**	**11**
LUM	1	0	1	10	4	10	9	11	10	12	2	8	1	22	3	51	11	13	7	**1**	**5**
PCP	4	1	1	8	18	2	4	10	10	7	1	7	3	8	8	45	8	14	9	**5**	**7**
CRP	3	2	3	7	9	10	7	11	10	10	3	9	2	20	5	64	13	10	6	**3**	**8**
NMM	5	1	5	13	10	13	10	14	10	14	5	11	2	33	4	62	14	15	12	**3**	**9**
MET	2	2	3	7	8	11	6	11	10	9	2	6	1	12	4	60	9	10	4	**2**	**6**
FMP	3	2	3	9	15	16	12	14	10	14	3	10	1	37	4	68	18	17	10	**2**	**8**
TRS	1	1	3	10	26	18	15	17	10	15	5	14	2	72	7	59	27	15	10	**2**	**9**
ELE	1	0	5	7	23	6	6	12	11	10	5	10	1	22	2	64	9	11	5	**3**	**5**
OME	2	1	3	8	18	9	9	12	10	10	3	7	0	24	4	54	10	11	8	**2**	**6**
HHS	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	**0**	**0**
TSV	0	0	0	0	0	0	0	0	0	6	0	1	3	1	0	0	0	0	0	**0**	**1**

Notes: All tariffs are trade-weighted and given in percent. Tariffs within the FTAA are shaded gray.

Source: GTAP 4 database.

Table 8

Percentage Changes in GDP and CO_2 Emissions Following Liberalization

Region	FTAA Liberalization		Global Liberalization	
	% Change in GDP	% Change in CO_2	% Change in GDP	% Change in CO_2
FTAA	0.0	0.2	0.1	0.3
Non-FTAA	- 0.0	- 0.0	0.5	1.0
World	**0.0**	**0.0**	**0.4**	**0.8**

Source: Model results.

Table 9

Trade Impacts on FTAA Members Following FTAA Liberalization

	% Change in Imports from:			% Change in Exports to:		
Region	**Total**	**FTAA Regions**	**Non-FTAA Regions**	**Total**	**FTAA Regions**	**Non-FTAA Regions**
United States	1	5	-1	1	7	-1
Canada	0	1	-1	1	1	0
Mexico	0	0	1	0	0	-2
Central America and Caribbean	18	34	1	15	46	-17
Brazil	9	34	-11	11	28	-2
Argentina	11	28	-6	9	25	-8
Colombia	8	17	-6	7	16	-8
Venezuela	6	18	-10	6	8	1
Chile	4	17	-9	5	15	0
Rest of South America	6	20	-11	10	21	1
FTAA	**2**	**8**	**-2**	**2**	**7**	**-2**

Source: Model results.

Figure 1: CO_2 Emissions by Country, 1995 (million tons)

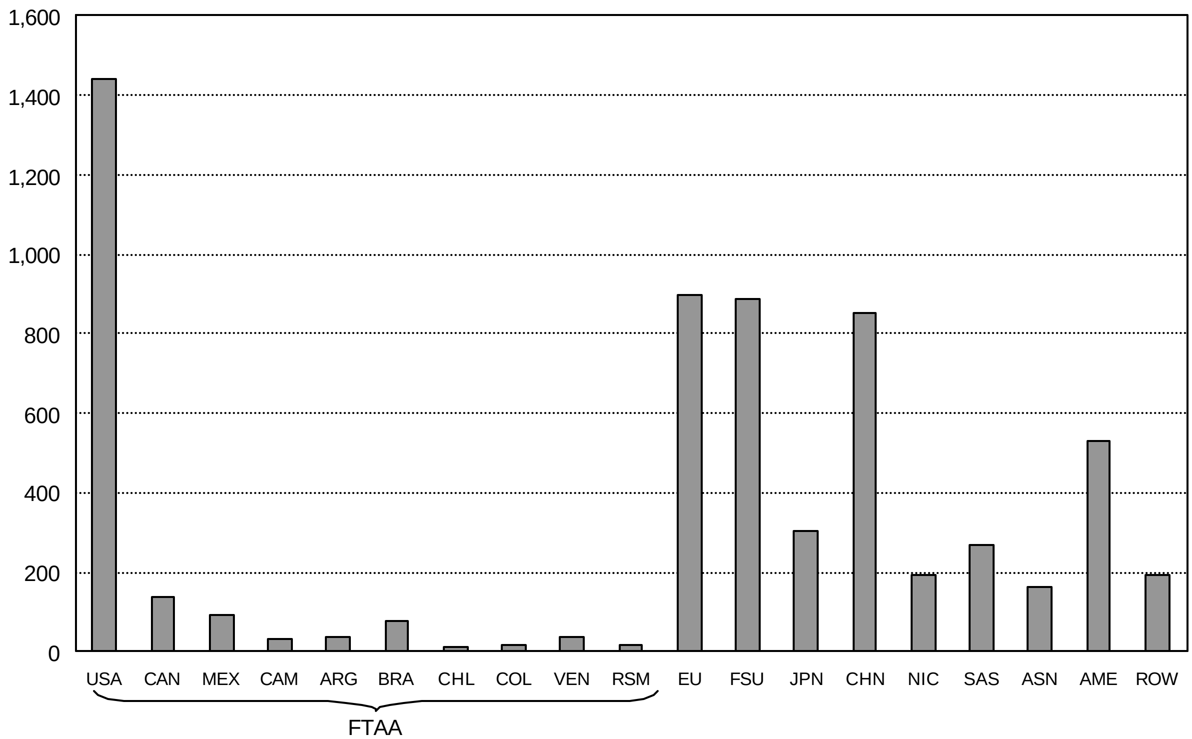

Figure 2: Composition of CO_2 Emissions by Fuel, 1995

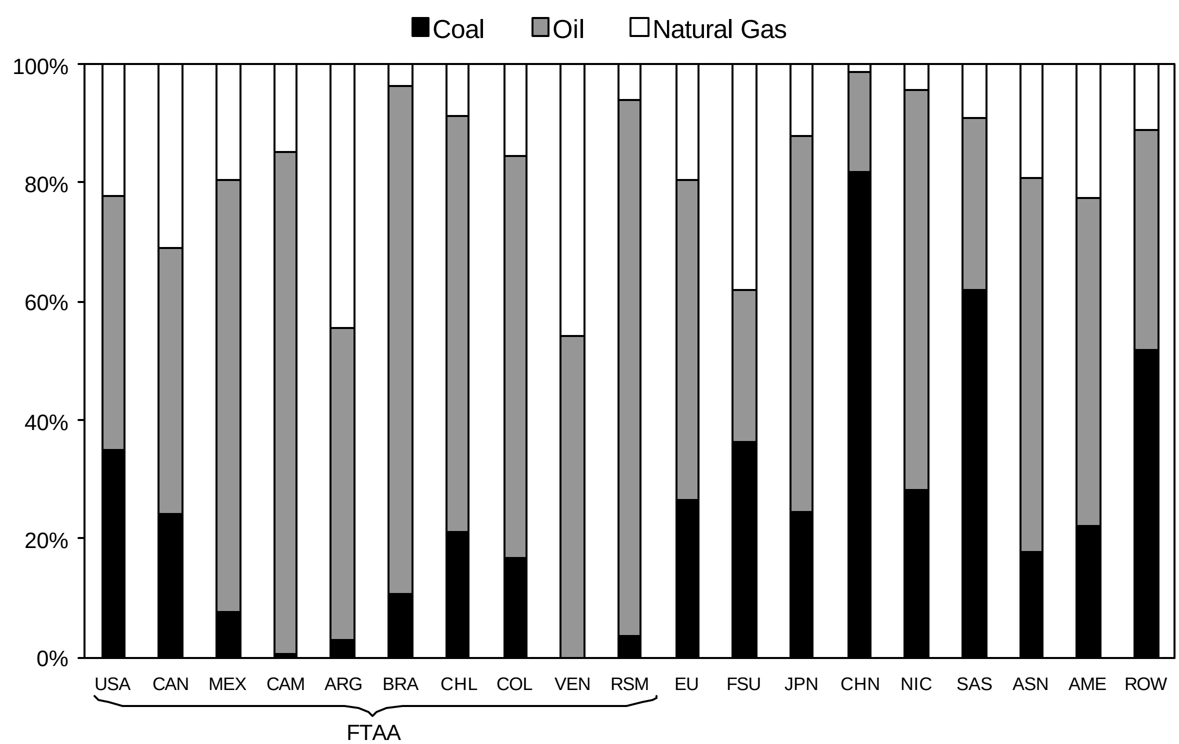

Figure 3: Percentage Changes in GDP and CO_2 Emissions Following FTAA Trade Liberalization

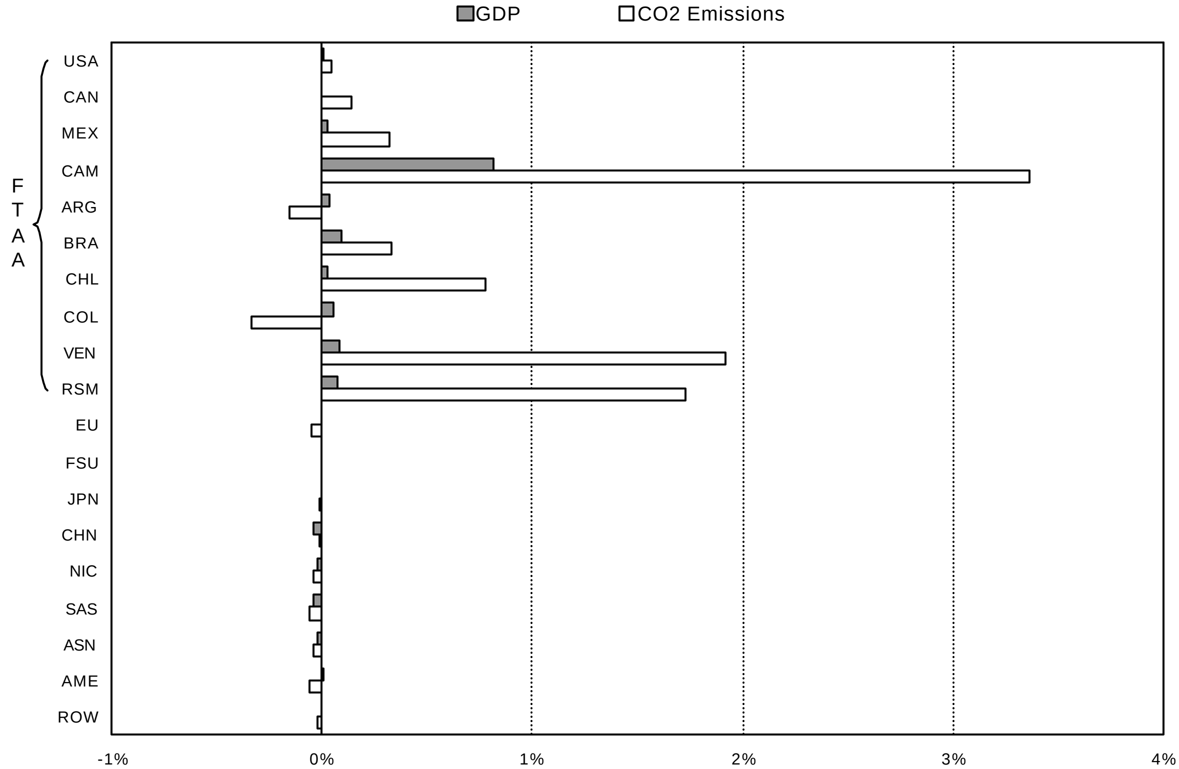

Figure 4: Percentage Changes in GDP and CO_2 Emissions Following Worldwide Trade Liberalization

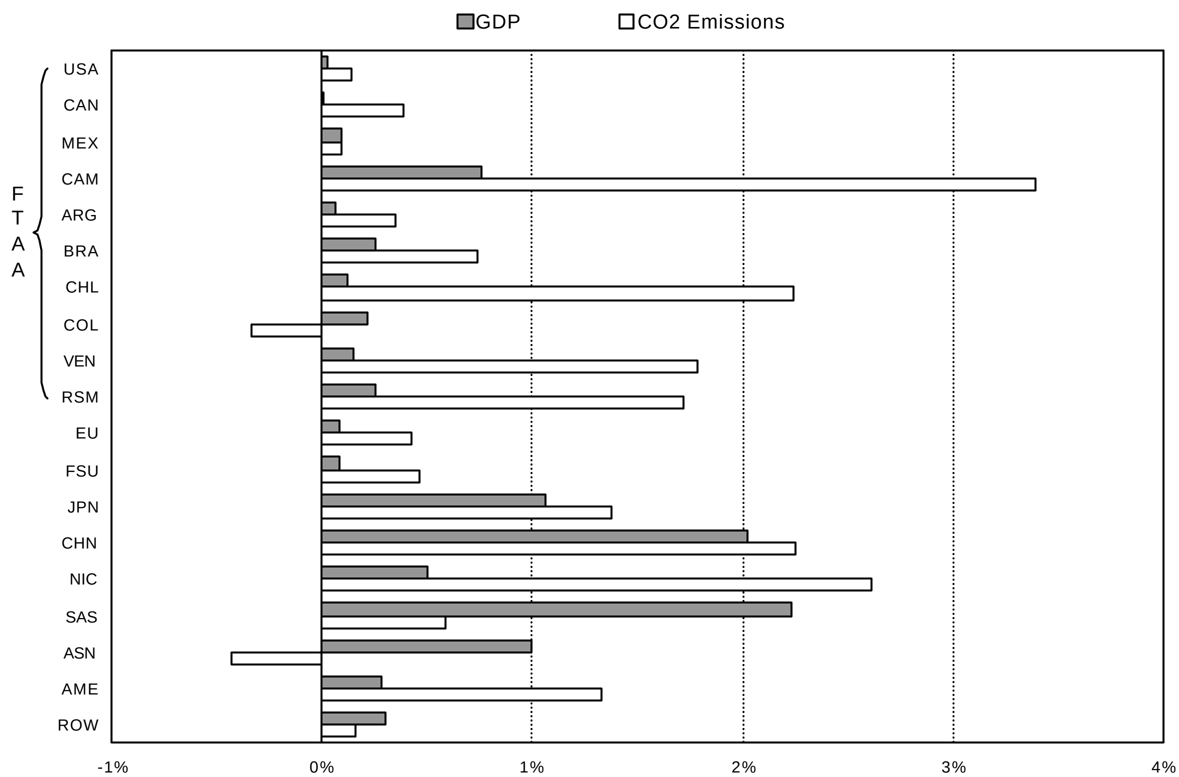

Figure 5: Decomposition of Percentage Change in CO_2 Emissions Following FTAA Trade Liberalization

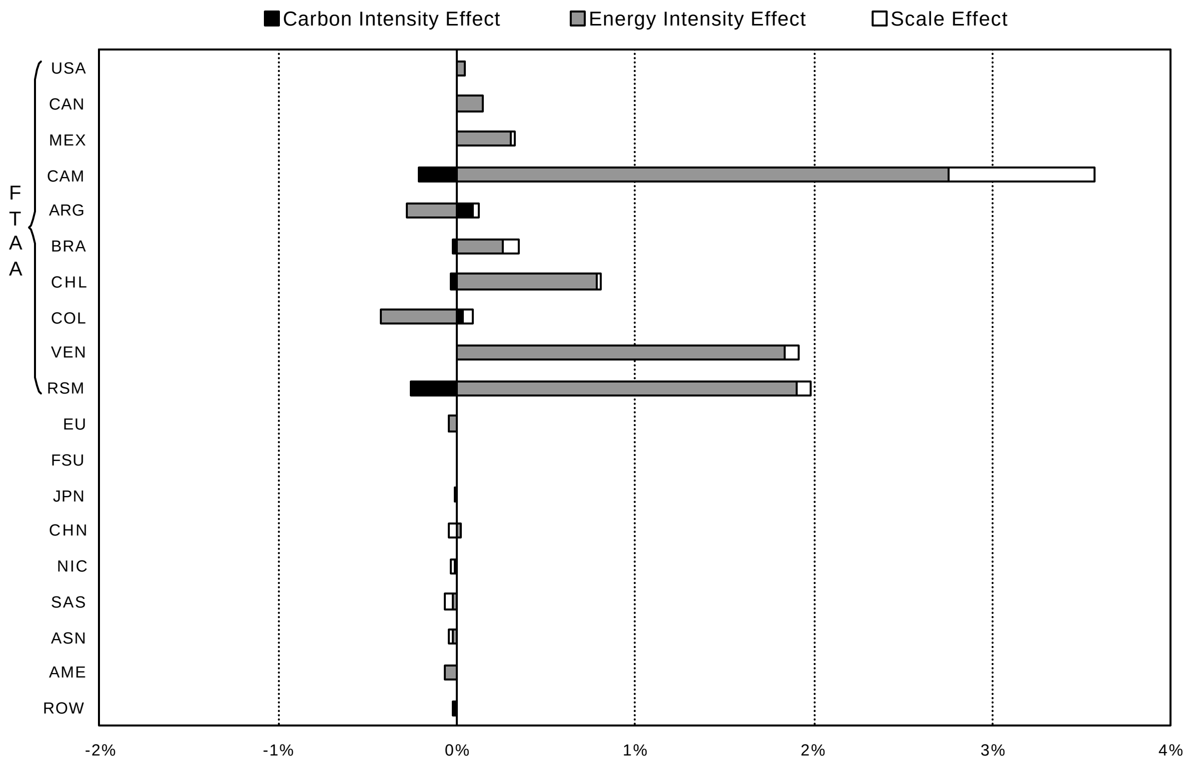

Figure 6: Decomposition of Absolute Change in CO_2 Emissions Following FTAA Trade Liberalization

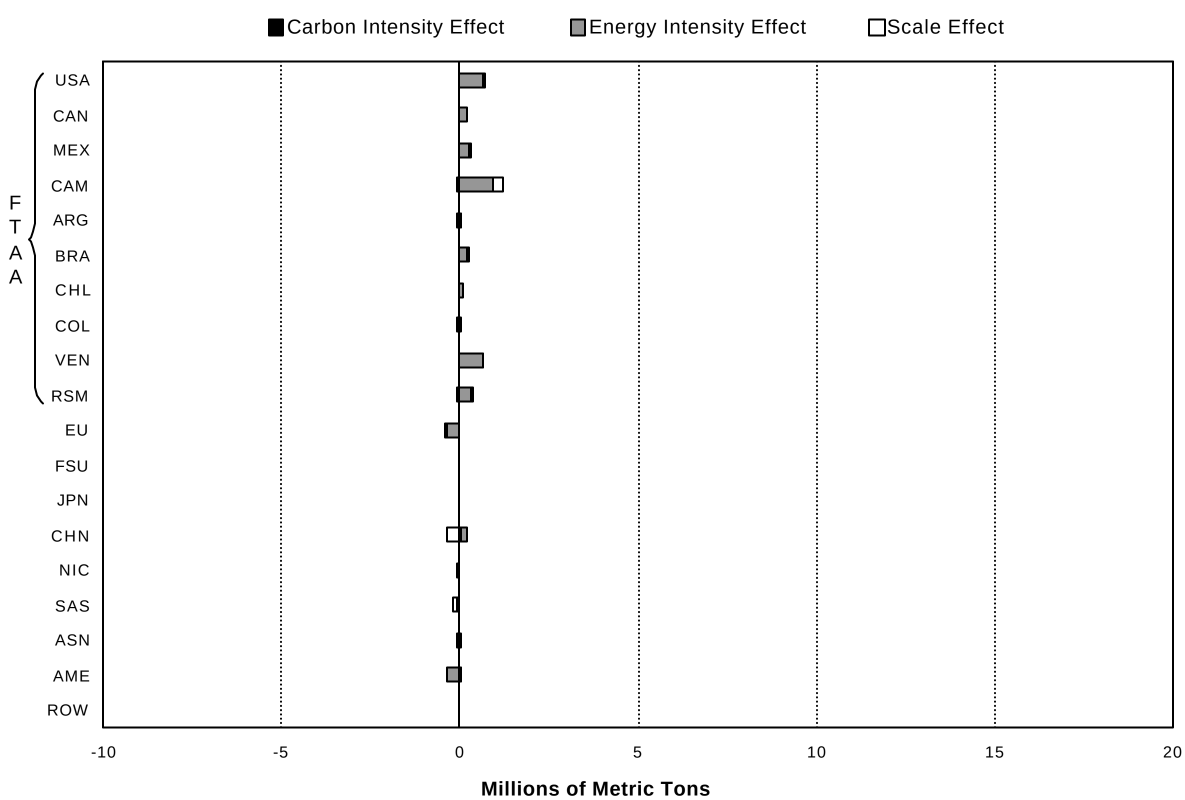

Figure 7: Decomposition of Percentage Change in CO_2 Emissions Following Worldwide Trade Liberalization

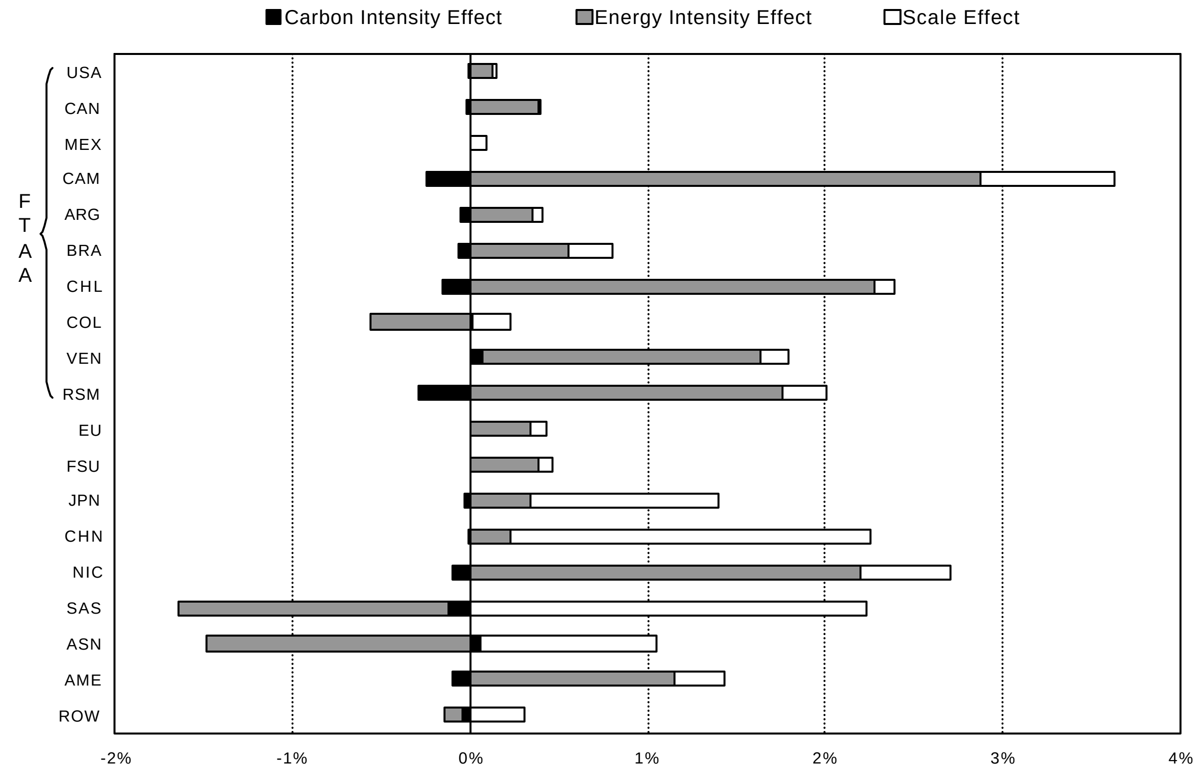

Figure 8: Decomposition of Absolute Change in CO_2 Emissions Following Worldwide Trade Liberalization