
# The Panda's Pawprint: The environmental impact of the China-led re-primarization in Latin America and the Caribbean

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China's meteoric rise as an economic partner for LAC economies is well documented: it is now the largest export market for South American goods and the second-largest market for LAC overall. But China's demand for LAC exports and Chinese investments in LAC are concentrated in primary commodities, driving LAC away from industrial production and spurring "re-primarization." This creates a conundrum for environmental economists, as the traditional "pollution haven" literature cannot adequately describe a situation of south-south investment relationships. In contrast "environmental Kuznets curve" literature anticipates that for middle-income countries such as those in Latin America, primary production is environmentally less sensitive than manufacturing; these hypotheses suggest that re-primarization would be environmentally beneficial for LAC. This paper tests these hypotheses against the evidence from the last ten years of LAC exports. It finds that primary production is more environmentally intensive than manufacturing in LAC, measured through net greenhouse gas emissions and water footprints.

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## 1. Introduction

In the last 10 years, China has grown into a major trade and investment partner for Latin America and the Caribbean (LAC). It is now South America's top export destination and the second-largest source of FDI inflows for the LAC region. However, it has also come to symbolize the trend of "re-primarization" in LAC: the shift away from state-led industrialization back toward LAC's traditionally competitive production of raw commodities. While much has been written about how this new relationship fits into the history of industrial policy in LAC, less has been written about its environmental impacts in LAC, one of the world's most biodiverse regions and home to most of the world's annual tropical deforestation. Several prominent scholars have hypothesized that primary production should be less environmentally intensive than manufacturing in middle-income countries like those in LAC. This paper sets out to test that hypothesis against evidence from the last decade in LAC. It finds that primary production is *more* environmentally intensive than manufacturing in LAC (measured through net greenhouse gas emissions and water use), and LAC exports to China are significantly more environmentally intense than other LAC exports.

## 2. Background: LAC's China-Led Re-primarization and its Environmental Impacts

Many scholars have discussed re-primarization in LAC and the importance of China in driving it. Other scholars have posited that LAC has a comparative advantage in inexpensive production of environmentally-intensive goods and serves as a "pollution haven," attracting investment in these sectors from countries with stronger environmental safeguards. Finally, the work of a third group of scholars, grounded in the environmental Kuzents curve, predicts that primary production should be environmentally less intensive than industrial production in middle-income countries such as those in LAC. This paper aims to complement the existing literature by testing the differences in the environmental impact of production in LAC by the level of technology involved, and whether the China-driven trend of re-primarization in Latin America has, in fact, driven production into environmentally "cleaner" or "dirtier" sectors.

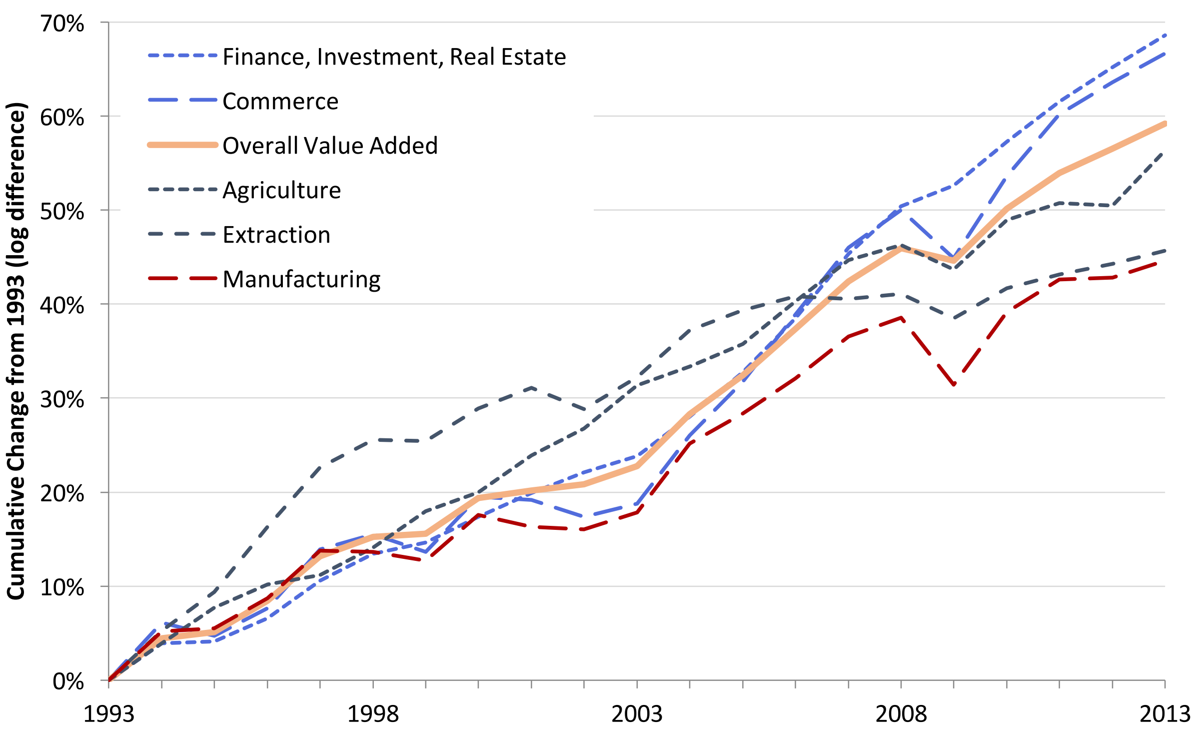
### *2.1 Re-primarization in LAC*

Scholars and policy makers alike have noted the tendency of LAC production to shift back toward primary commodity production over the last few business cycles, dubbed "re-primarization." The seminal works by Amsden (2001) and Bértolo and Ocampo (2012) both draw a direct link between this trend and the broader switch in Latin American development strategy from one based on state-led industrialization through import substitution (ISI) toward one based on neoliberal macroeconomic policy and export orientation. Bértolo and Ocampo point out that the late ISI period was characterized by trade deficits, counter to its stated goals. Amsden resolves this seeming paradox by explaining that LAC continued to rely foreign capital goods in order to support domestic manufacturing. Bértolo and Ocampo show that only in the last decade, since 2004, has Latin America regained positive trade balances. However, these trade surpluses came at the cost of an erosion of the gross fixed capital formation, and a shift back toward the primary production that characterized the period before ISI.

It is important to resist overstating the extent of re-primarization. As Bértolo and Ocampo (226) note, much of this apparent shift is an artifact of rising commodity prices. Thus, to more accurately assess the timeline of re-primarization, it is important to measure it in real terms. Figure 1 shows real growth by sector over the last 20 years.

As Figure 1 shows, goods production of all types has slowed relative to overall GDP growth in the last decade, but this is especially true for manufacturing. In fact, of the three merchandise-producing sectors (agriculture, extraction, and manufacturing), only agriculture has largely kept up with overall value added in the LAC economy. The manufacturing slowdown relative to overall real GDP growth began about 10 years ago, so the remainder of this paper will look more closely at the last decade.

**Figure 1: Real GDP Growth for the LAC Region, Selected Sectors, 1993-2013**



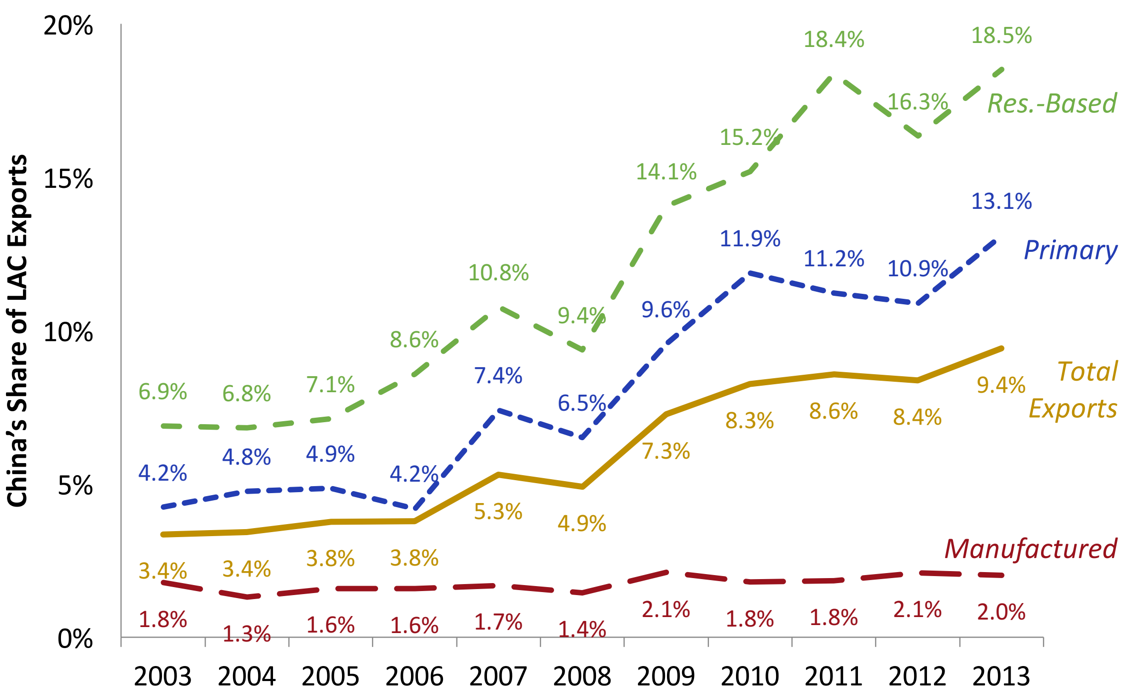

Source: ECLAC CEPALStat database.

*2.2 China's role in LAC's re-primarization*

Scholars attribute LAC's re-primarization over the last decade to the rise of China as the world's largest economy and as a major trading partner for the LAC region. China has contributed to LAC's re-primarization in two ways: by raising global demand (and prices) for raw commodities and by intensifying competition in the production of inexpensive manufactured goods. The UN Economic Commission for Latin America and the Caribbean (ECLAC, 2015) and Myers and Jie (2015) expand on the former point, showing that Chinese investment and import demand have spurred LAC primary production. Gallagher and Porzecanski (2010) and Mesquita Moreira (2007) expand on the latter point, showing that China has out-competed LAC for market share in world manufacturing exports.

All of the authors listed above agree on one important point: China's demand for LAC exports has been overwhelmingly concentrated in low-technology goods. Figure 2 shows China's rising share of LAC merchandise exports, according to the Lall (2000) technology scale. Overall, China's share of LAC exports more than doubled, from 3.4 to 9.4 percent of the total. China is now the largest market for South American goods, and the second-largest market for goods exports from LAC overall. The fastest growth was seen among primary goods, in which China more than tripled its market share, growing from just 4.2 to 13.1 percent of the region's exports in a decade. However, this growth has left manufacturing behind at just two percent of the total.

**Figure 2: China's Share of LAC Exports, by Technology Level**




Source: Author's calculations using CEPAL Stat, FAO World Food Price Index, Lall (2000), UN Comtrade, and World Bank GEM Commodity Database. Detailed information can be found in Appendices A and B.

China's importance as an LAC export market jumped in 2009 because of the global downturn, which China survived relatively unscathed. Instead of falling back to its pre-recession levels, however, China's importance continued to grow. By 2013 its market share was about twice its level from a decade before for total exports and for resource-based goods, and over four times as large for primary exports.

As Table 1 shows, China drove the growth in non-manufactured exports from Latin America. China accounted for about 40 percent of the growth in the LAC region's primary and resource-based exports, compared to about 20 percent of total export growth and just four percent of the growth in manufactured exports.

**Table 1: China's Contribution to the Re-Primarization of LAC Exports**

| | Sectors | | | Total |
|---|---|---|---|---|
| | Primary | Res.-based | Manuf. | |
| ***LAC Exports to China (billions of real USD)*** | | | | |
| 2003 | 3.6 | 7.9 | 3.3 | 14.8 |
| 2013 | 20.4 | 19.2 | 7.0 | 46.6 |
| *Growth* | *466.7%* | *143.0%* | *112.1%* | *214.9%* |
| ***Total LAC Exports (billions of real USD)*** | | | | |
| 2003 | 111.8 | 104.0 | 217.4 | 437.7 |
| 2013 | 154.0 | 132.0 | 305.1 | 600.2 |
| *Growth* | *37.7%* | *26.9%* | *40.4%* | *37.1%* |
| **China's share of LAC exports** | | | | |
| 2003 | 3.2% | 7.6% | 1.5% | 3.4% |
| 2013 | 13.3% | 14.5% | 2.3% | 7.8% |
| *Growth* | *314.9%* | *91.3%* | *51.2%* | *129.4%* |
| **China's contribution to LAC export growth** | **40.0%** | **40.3%** | **4.2%** | **19.6%** |

Source: Author's caluclations using CEPALStat, FAO World Food Price Index, Lall(2000), UN Comtrade, and the World Bank GEM Commodity Database. Detailed information can be found in Appendices A and B.

Interestingly, Table 1 also shows that LAC exports overall did not tilt dramatically away from manufactured goods: primary and manufactured goods both grew by about the same amount, and significantly more than resource-based goods. This implies that the re-primarization shown in Figure 1 may be due to switching from consuming domestically-produced to imported manufactured goods. Nonetheless, it remains clear from Table 1 that the effect of China's demand has been one of spurring primary production much more than it would be otherwise. Based on the information presented above, it is safe to conclude that China has pushed LAC exports toward primary and resource-based products. The sections below estimate the environmental impact of this re-primarizing pressure.

### *2.3 LAC as a "pollution haven:" an imperfect fit for the China boom*

Given LAC's new surge in investment and exports, the "pollution haven" framework is an intuitive fit for predicting the expected effect on of the China boom on the environmental intensity of LAC exports. This approach posits that developing countries attract pollution-intensive investment and specialize in those sectors under conditions of free trade. Stern (1998) expresses this as an intuitive extension of the Hecksher–Ohlin trade theory, in which developing countries have a comparative advantage in pollution-intensive production because of a dearth of costly regulation. In this line, Levinson and Taylor (2004) find a significant, positive impact of US environmental regulations on imports within that industry, implying that environmental protections discourage investment at home but encourage investment abroad instead. In contrast, Birdsall and Wheeler (1993) find that openness to trade among Latin American countries (with relatively weak environmental protection) was associated with *less* pollution-intensive growth in the 1960s through 1980s, and hypothesize that market forces such as the introduction of newer technology and shareholder pressure can account for the seeming paradox, in line with the "pollution halo" hypothesis. However, none of these approaches can adequately address LAC's "China boom," because each of them assumes a North-South trade and investment relationship, where the importing country has higher environmental standards than the exporting country. So LAC's "China boom" is fertile territory for new explorations of the environmental impact of South-South relationships.

### *2.4 Environmental effects of re-primarization in middle-income countries*

A more apt framework must incorporate the relative environmental intensities of different sectors within developing countries. Grossman and Krueger (1995) provide this by describing a mechanism behind the observed "environmental Kuznets curve," in which in which middle-income countries have more environmentally-damaging production than either poor or rich countries. In their framework, developing countries' pollution intensity rises as those countries industrialize, and then falls again, in part due to an "induced policy response" demanded by the citizenry to curtail the environmental damages caused by industry. Antweiler et al. (2001) develop a model to measure the impact of trade liberalization on emissions in poorer and richer countries. Their model anticipates that under free trade, poor and middle-income countries will switch from industrial to primary production, which is treated as intrinsically environmentally cleaner than manufacturing. Here, Antweiler et al. incorporate Grossman and Krueger's "induced policy response" by modeling an environmentally beneficial scenario of free trade in which rich countries (with more stringent environmental safeguards) specialize in capital-intensive industry, satisfying both their comparative advantage in capital-intensive industry and their ability to mitigate its pollution.

Both of these papers assume that technology level and emissions are directly related, absent policy interventions controlling industrial emissions. The Antweiler, Copeland, and Taylor model assumes two kinds of production: one with low technology inputs and no emissions, and one with high technology inputs and high emissions. Grossman and Krueger envision three levels of production: clean primary production, dirty industrial production in middle-income, recently industrialized countries, and clean industrial production in wealthy countries with intensive environmental regulations. It is now possible to test this assumption of correlated technology and emissions by examining the environmental impact of global production by technology level, thanks to environmental intensity, technology, and trade data that has been published since those studies.

## 3. Testing the Models: Should Middle-Income Countries Specialize in Primary Production?

Thanks to recently published, detailed estimates of the environmental impacts of specific commodities for most countries in the world, it is now possible to test the expectation that specializing in primary production is environmentally beneficial for developing countries, and for Latin America in particular.[1] Specifically, this is possible for two forms of environmental impacts, one global (greenhouse gas emissions, GHG) and one local (water use). Each of these analyses is conducted separately in the sections below, drawing on the various methodologies to measure the embodied carbon and water in exports used by Peters (2011), Biewald et al (2014), and Sato (2014). They focus on exports rather than overall production, because export data is available disaggregated into highly specific categories through the UN Comtrade database.

For both GHG emissions and water use, environmental science literature has estimated the environmental footprints of most exports, disaggregated by the traded items and countries of origin. These disaggregated trade line items can be further classified into technology levels using the method developed by Sanjaya Lall (2000).[2] Lall's classification system has five main categories: primary products (unrefined agricultural and extractive products), resource-based products (processed agricultural and extractive products such as soybean oil and refined petroleum), low-technology manufactured goods (such as apparel and basic metal products), medium-technology manufactured goods (such as vehicles and chemical products), and high-technology manufactured goods (such as electronic and medicinal products). The resulting technology-based environmental footprints are explained in detail below.

### *3.1 Greenhouse Gas Emissions*

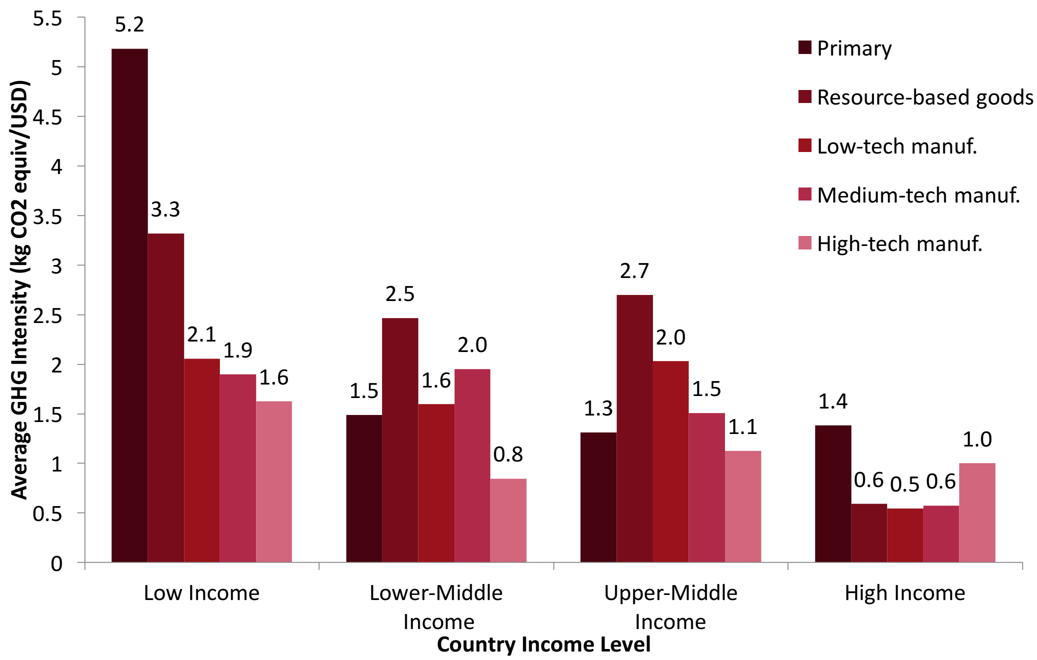
Contrary to the expectation suggested by the environmental economics literature cited

1 It should be noted that this paper does not directly test the theories presented by Grossman and Krueger (1995) or Antweiler, Copeland, and Taylor (2001), because both of those papers focus on emissions of SO2. This paper focuses on greenhouse gas emissions and water use, because these two factors are now more socially and politically relevant for policy makers. The former is now the subject of global negotiations, with active debates surrounding the proper role for developing countries in limiting global carbon emissions. The latter is the most frequent cause of environmentally-based social conflict in LAC, according to the case studies of Ray et al (2015).

2 Details for these calculations can be found in Appendix A.

above, the most GHG-intensive products in poor and middle-income countries are not high-technology manufactured goods but primary goods, resource-based goods (such as soybean oil and refined petroleum), and lower-technology manufactured goods. Figure 3 shows the average carbon intensity (kilograms of $CO_2$ equivalent per dollar) for exports in each of Lall's technology categories and each income level of countries.

**Figure 3: Net GHG emissions of exports by technology level and country income level, 2007**




Source: Author's calculation based on Lall (2000), Peters (2013), and UN Comtrade. Country income levels are defined using World Bank categories. Detailed information can be found in Appendix A.

These GHG emissions calculations use GHG intensity data from a model developed by Peters (2011), which establishes the net GHG embedded in each dollar of exports, by country of origin and GTAP category.[3] By applying these intensities to UN Comtrade export data for each country in the world, and classifying that data into Lall's (2000) technology categories, it is possible to calculate average net GHG intensities of globally traded merchandise by technology level. Figure 3 shows the result for the year 2007, the most recent year of Peters' data.[4]

According to Figure 3, for middle-income countries, net GHG emissions peak in resource-based goods before falling again as technology levels continue to rise. These falling emissions associated with higher-technology goods indicate that as technology levels increase, the value of these exports is rising more quickly than the emissions. For goods whose emissions are associated

3 The Global Trade Analysis Project (GTAP) classifies trade into 57 categories of goods and services, with heavy disaggregation among agricultural products. Because they are much broader categories than the SITC categories used by the UN Comtrade database, it is simple to establish a corresponding GTAP category for each SITC category. More information on GTAP is available at https://www.gtap.agecon.purdue.edu/.

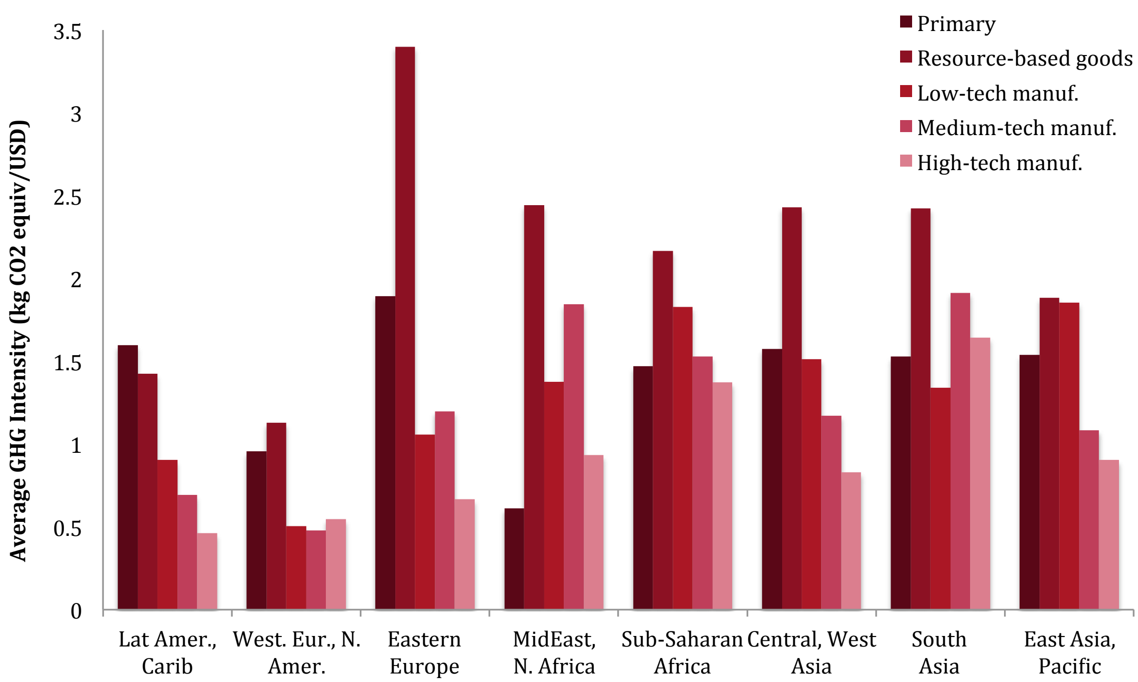
4 For a detailed explanation of the calculations behind Figure 3, see Appendix A.

with the upstream inputs (for example, leather goods whose emissions are associated with cattle ranching), this means that the value of the primary inputs is falling as a share of the final value of the exports.

Figure 3 shows GHG intensity on a net basis, including the destruction of natural carbon sinks through deforestation and the clearing of grasslands. It also includes non-$CO_2$ sources of carbon emission, such as methane from agricultural production. Finally, it includes emissions from upstream inputs. For example, for electronic goods, these intensity estimates include the impacts of mining the metals involved as well as emissions associated with the manufacturing process itself.

A *prima facie* analysis would support the hypothesis, associated with the environmental Kuzents curve, that if middle-income countries have more environmentally-intensive production, it is because they traditionally specialize in natural resource processing and lower-technology manufacturing. However, this inverted-U relationship between technology level of merchandise exports and net GHG emissions does not appear to hold for Latin America and the Caribbean, as Figure 4 shows. While in most regions, emissions are higher for natural resource refining and low-technology manufacturing, LAC show the highest net GHG emissions from primary productions, and falling emissions with each increase in technology.

**Figure 4: Net GHG emissions of export baskets by region and technology level, 2007**




Source: Author's calculation based on Lall (2000), Peters (2013), and UN Comtrade). Detailed information can be found in Appendix A.

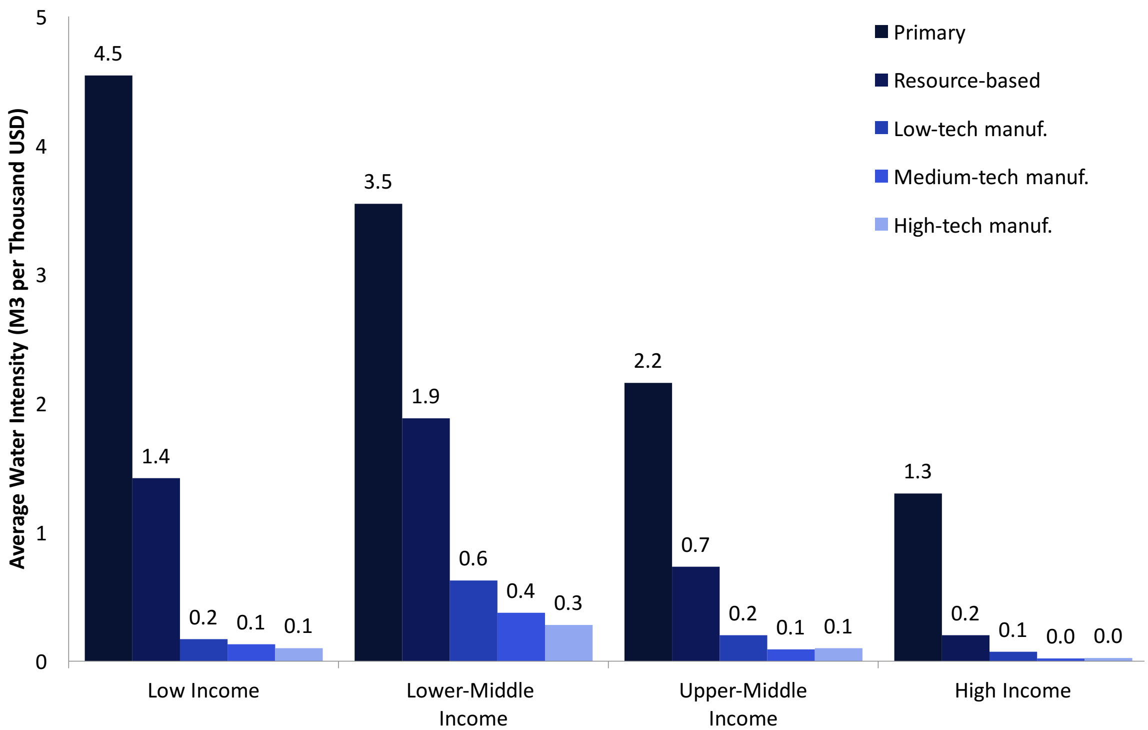
LAC is unique among world regions in the fact that the GHG emission intensity of exports falls with every increase in technology. Every other region shown in Figure 4 exhibits an inverted-U relationship between technology level of merchandise exports and their net GHG emissions. This outsized GHG intensity for primary products in LAC is likely because of the importance of land-use change in Latin America and the Caribbean. According to Global Forest Watch (2015), Brazil accounted for roughly two-thirds of global tropical deforestation from 2001 to 2012. Across the Amazon basin as a whole, ecologists have shown that agriculture, extraction, and most importantly, the access roads necessary to get those products to cities and ports, have been the major drivers of deforestation (see for example Cattaneo 2001, Fearnside 2006, and Swing 2011).

In sum, from a GHG perspective, it is unambiguously better for the LAC region to produce high-technology goods. This is especially true in an era of export-oriented growth, in which planners depend on export revenue for boosting GDP.

*3.2 Water Footprints*

Regarding water footprints (which incorporate both water use and water contamination), the trend is clearer: primary products are overwhelmingly more water intense. Figure 6 shows that this relationship holds globally, regardless of country income level.

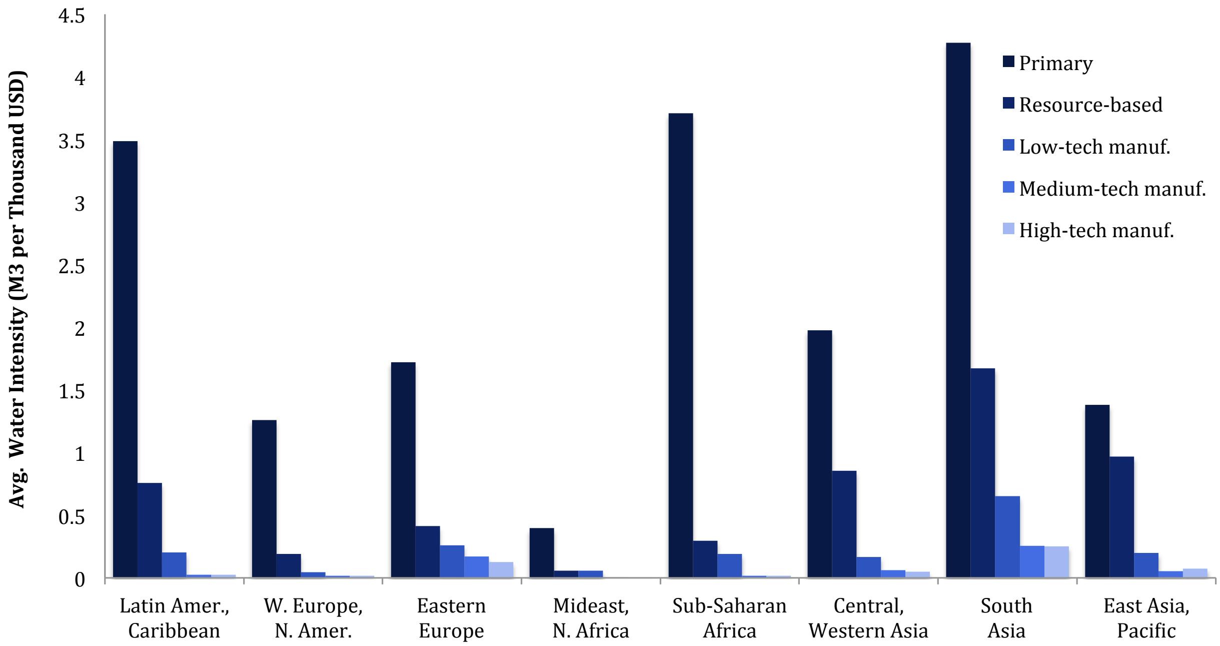
**Figure 5: Water Intensity of Exports by Technology Level in 2005, by Country Income Level**




Source: Author's calculation based on Lall (2000), UN Comtrade, and WaterStat). Country income levels are defined using World Bank categories. Detailed information can be found in Appendix A.

All regions share this same basic profile, as Figure 6 shows. There is a stark difference between the primary and manufactured goods worldwide, and the LAC region is no different.

**Figure 6: Water Intensity of Exports by Region and Technology Level in 2005**




Source: Author's calculation based on Lall (2000), UN Comtrade, and WaterStat. Detailed information can be found in Appendix A.

The water footprint calculations included here rely on the Water Footprint Network's WaterStat database, developed by Mekonnen and Hoekstra (2011 a, b; 2012). Mekonnen and Hoekstra identify the water footprints (expressed as cubic meters of water per thousand USD) for each six-digit Harmonized System (HS) code of exports, averaged across the period 1996-2005. Figure 6 applies those average intensities to UN Comtrade export data for every country in the sample for the year 2005, the most recent year of Mekonnen and Hoekstra's calculations. (See Appendix A for a full explanation of the calculations used here.)

In sum, it seems that from an environmental standpoint LAC would be wise to concentrate on manufacturing. In fact, the greater the technology used in production, the better the environmental impact of each dollar of exports will be.

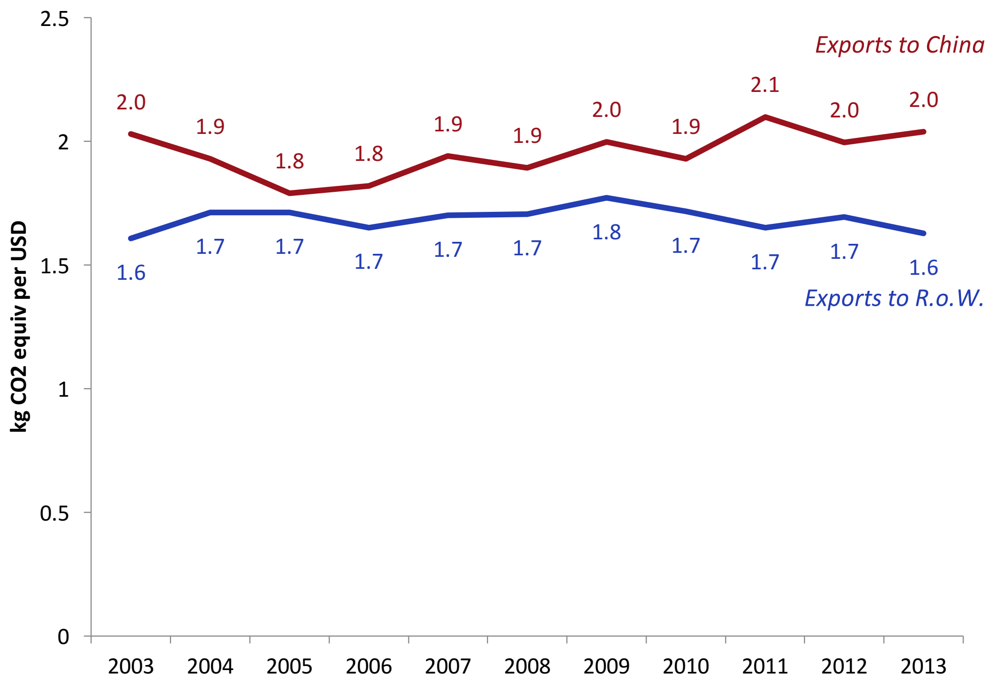
## 4. The China Effect on GHG and Water intensities of LAC Exports

The previous sections have established two key points. First, LAC market deregulation coincided with Chinese demand for raw materials to drive re-primarization of LAC exports. Second, primary commodity production is much more environmentally intensive than manufacturing in Latin America. From these two points, it is reasonable to expect that LAC exports to China have been more environmentally intensive than other LAC exports. It is possible to test that expectation by repeating the analysis behind figures 3 through 6, dividing the LAC export basket by destination market. The sections below do so, and find that LAC exports to China have indeed produced more net GHG emissions and used more water than other LAC exports. [5]

*4.1 Greenhouse Gas intensity of LAC exports to China and elsewhere*

The same method used to calculate relative GHG intensities of exports based on technology levels in Figures 3 through 6, above, can be used to compare the GHG intensities of LAC exports to China and other LAC exports. The results appear in Figure 7.

**Figure 7: Average GHG Intensity, LAC Exports by Destination**



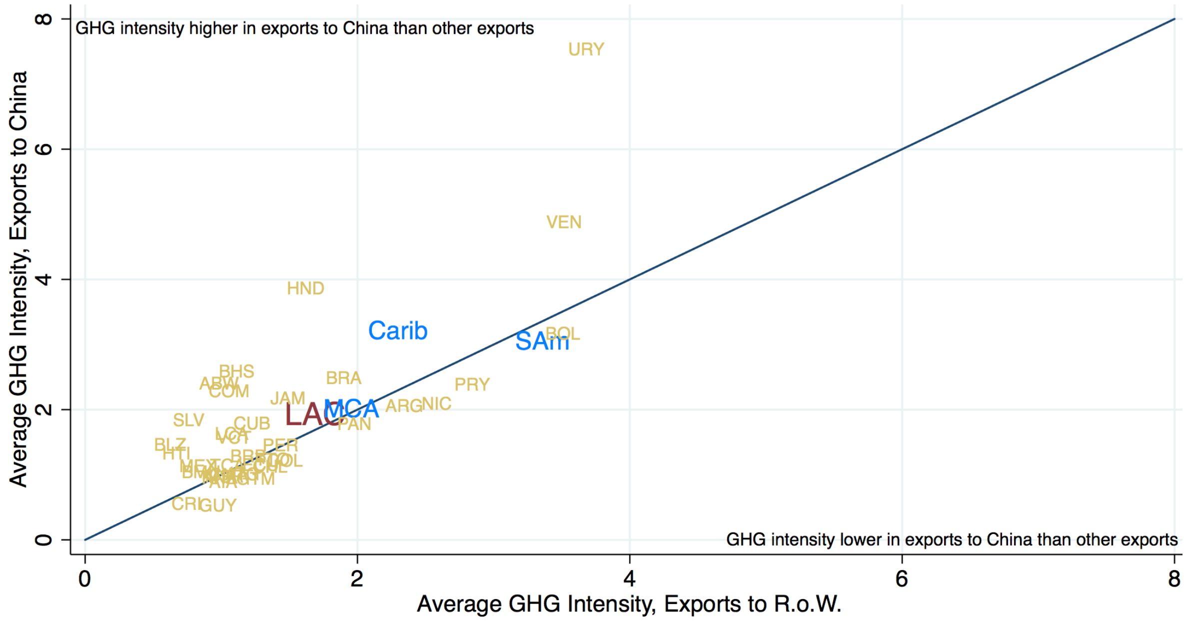

Source: Author's calculations using CEPALStat, FAO World Food Price Index, Peters (2013), UN Comtrade, and the World Bank GEM Commodity database. Information for the GHG intensity of overall economic activity is from World Resources Institute 2013. Detailed information can be found in Appendices A and B.

From 2004 through 2013, LAC exports to China were about 16 percent higher in net greenhouse gas emissions per dollar than other exports. Regression analysis shows that this difference was highly statistically significant (t=6.1), as shown in Appendix C.

However, it should be noted that among individual countries, the "China effect" ranges widely. In Guatemala, exports to China are only 81% as GHG-intensive as other exports, whereas in neighboring Honduras and El Salvador, exports to China are over twice as GHG-intensive as other exports (201% and 254%, respectively). Figure 8 compares the average GHG intensity of exports to China and other exports for each LAC country and sub-region in this study, as well as for the LAC region as a whole, from 2004-2013.

5 In order to trace the relative GHG intensities of exports over time, this section uses the same deflation technique as Table 1, above, described in Appendix B.

**Figure 8: Average GHG Intensity, exports to China and the R.o.W., by country and region**



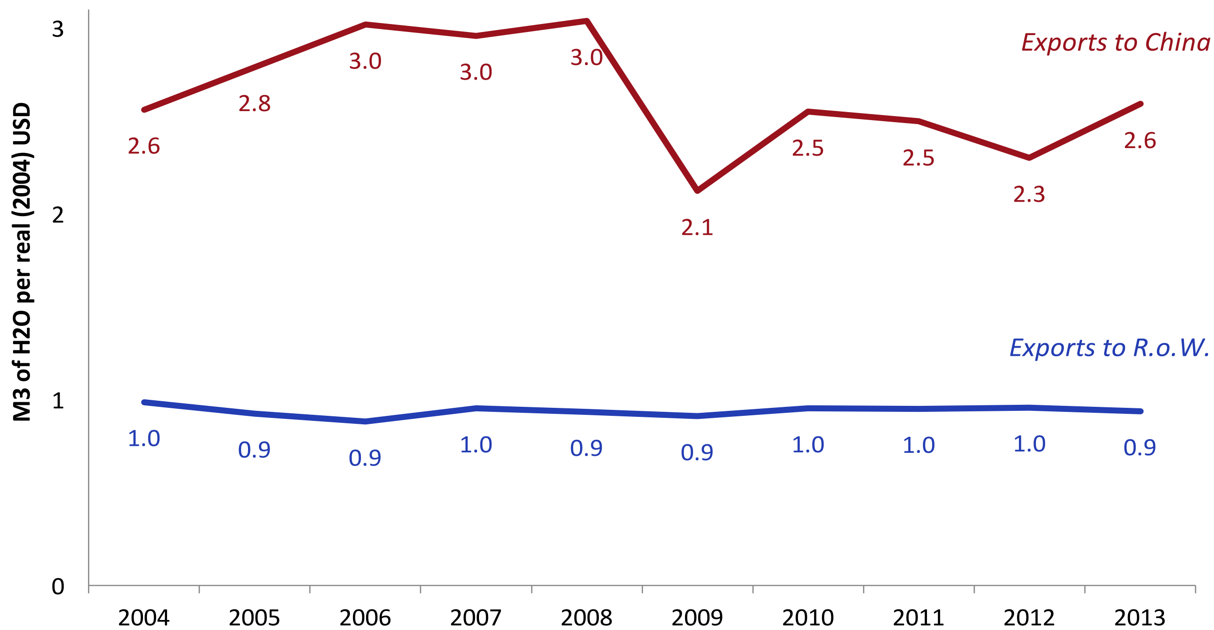

Note: GHG intensity is measured as kg of $CO_2$ equivalent in net emissions per real (2004) US dollar. Regions shown here include the Caribbean, Mexico and Central America, and South America.

Source: Author's calculations using CEPALStat, FAO World Food Price Index, Peters (2013), UN Comtrade, and the World Bank GEM Commodity database.

### *4.2 Water intensity of LAC exports to China and elsewhere*

By focusing the water analysis in Figures 5 and 6 on LAC exports and comparing the results by export basket, it is possible to determine how much LAC exports to China differ from other exports in their water footprint. As Figure 9 shows, LAC exports to China have used or contaminated two to three times as much water as other exports, per real dollar over the last decade.

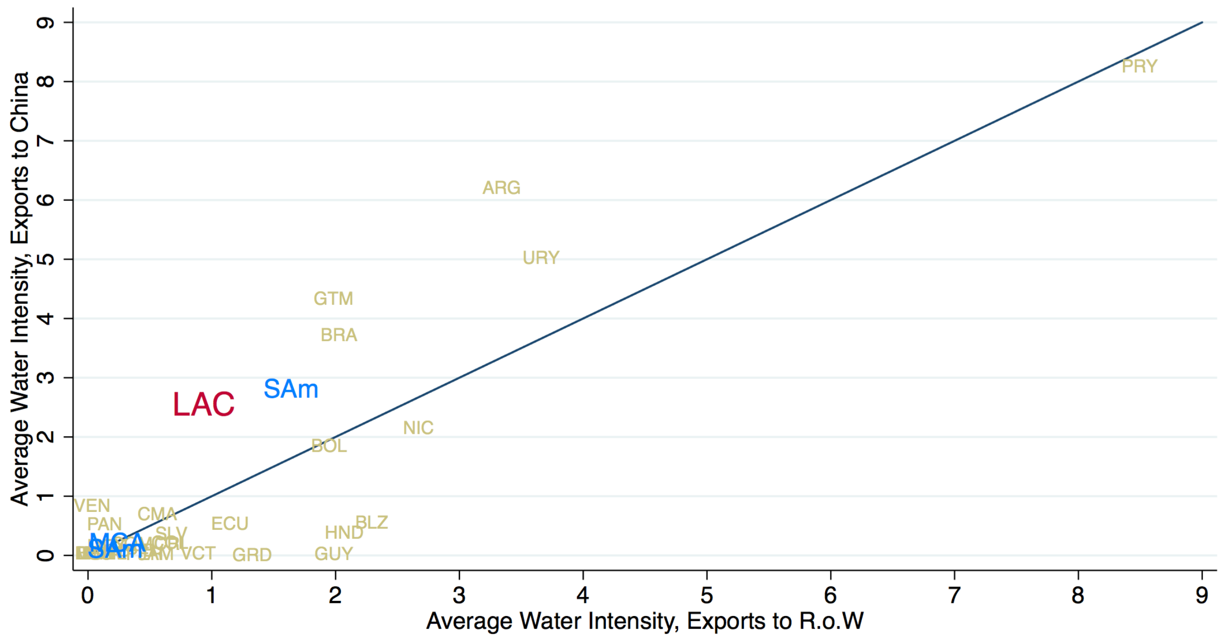
**Figure 9: Average Water Intensity, LAC Exports by Destination**




Source: Author's calculation using CEPALStat, FAO World Food Price Index, UN Comtrade, WaterStat, and the World Bank GEM Commodity database. Detailed information can be found in Appendices A and B.

Regression analysis (detailed in Appendix D) shows that on average over the last decade, LAC exports to China used or contaminated 2.75 times as much water per dollar than other exports, and that this relationship is highly statistically significant (t=22.0). As with GHG emissions, LAC countries have had a wide variety of experiences, but in this case the largest exporters (Mexico, Brazil, and Argentina) all have much higher water footprints in their exports to China than in other exports. Figure 10 shows the average water intensities of LAC exports to China and to the rest of the world, for each country, sub-region, and for LAC overall, from 2004-2013.

**Figure 10: Average Water Intensity, exports to China and the R.o.W., by country and region**




Note: Water intensity is measured as cubic meters of water per real (2004) US dollar. Source: Author's calculation using CEPALStat, FAO World Food Price Index, UN Comtrade, WaterStat, and the World Bank GEM Commodity database.

*4.3. Considering GHG and water together: scale and composition effects*

From 2003 to 2013, the real value of LAC exports rose by 37 percent, while the net GHG emissions from exports rose by 40 percent and the water used in exports rose by 59 percent. From this information alone it is clear that the composition of LAC exports is shifting toward more environmentally intensive production.

How much of the rise in export-based GHG emissions and water use is due to the simple growth of exports, and how much is due to the shift in basket composition toward more environmentally-sensitive sectors? Following the example of Grossman and Krueger, it is possible to disaggregate the effect by scale and by composition. (It is not possible to distinguish an effect for technology changes, Grossman and Krueger's third category, because this analysis applies Peters' GHG intensity estimates for 2007 and WaterStat's estimates for 1996-2005 to the entire decade of trade data.)

From 2003 to 2013, net GHG emissions from LAC exports rose by 40%, from 709 to 996 megatons. If the carbon intensity of those exports had remained stable and only their volume changed, the emissions would have risen 37%, or 92% of the actual rise. So between scale and composition effects, scale accounted for 92% of the increase in export-based GHG emissions and composition accounts for the remainder. Thus, if the total amount of LAC exports had remained at its 2003 level, but had still shifted toward China, net GHG emissions from exports would have risen by about eight percent.

Regarding water use, the total water footprint of LAC exports rose by 59%, from 383 to 608 billion cubic meters from 2003 to 2013. If the water intensity of exports had remained at its 2003 levels, the water used by those exports would have risen by just 37%, or about 62% of the actual rise in export-related water use. So the basket composition of exports accounted for the other 38% of the rise in the water use associated with exports.

Of course, in reality, scale and composition interact. The growth in exports to China represents not only a shift in the trade basket toward China, but also an overall growth in exports, concentrated in primary sectors. Table 2 explores the share of growth in emissions and water use resulting from the rise of China's importance and the rise of exports in each technology level. It shows that China had an outsized influence on this increase. China accounted for 7.8% of the real volume of LAC exports in 2013 (using 2004 USD), but accounted for 19.6% of LAC's export growth over the previous decade, 22.7% of the increase in export-based GHG emissions, and 33.4% of the increase in export-based water usage.

The majority of LAC's growth in both export-based net GHG emissions and water use was due to a rise in primary goods. As Table 1 shows, above, China was responsible for about 40% of the growth in both primary and resource-based goods.

**Table 2: China's Role in the Growth of LAC's Export-Based GHG Emissions and Water Use**

| | Share of real exports | | Share of total growth, 2003-2013 | | |
|---|---|---|---|---|---|
| | 2003 | 2013 | Volume of exports (real 2004 USD) | Export-based net GHG emissions | Export-based water use |
| ***By destination*** | | | | | |
| China | 3.4% | 7.8% | 19.8% | 22.7% | 33.4% |
| Rest of World | 96.6% | 92.2% | 80.2% | 77.3% | 66.6% |
| *Total* | *100.0%* | *100.0%* | *100.0%* | *100.0%* | *100.0%* |
| ***By technology level*** | | | | | |
| Primary | 25.5% | 25.7% | 30.3% | 51.0% | 96.6% |
| Resource-based | 23.8% | 22.0% | 21.7% | 26.3% | 4.4% |
| Low-tech manuf. | 9.9% | 7.4% | -1.1% | 0.4% | -1.6% |
| Med.-tech manuf. | 28.7% | 33.4% | 39.2% | 19.9% | 0.4% |
| High-tech manuf. | 11.0% | 10.0% | 7.7% | 1.4% | 0.1% |
| Other | 1.0% | 1.5% | 2.2% | 1.0% | 0.0% |
| *Total* | *100.0%* | *100.0%* | *100.0%* | *100.0%* | *100.0%* |

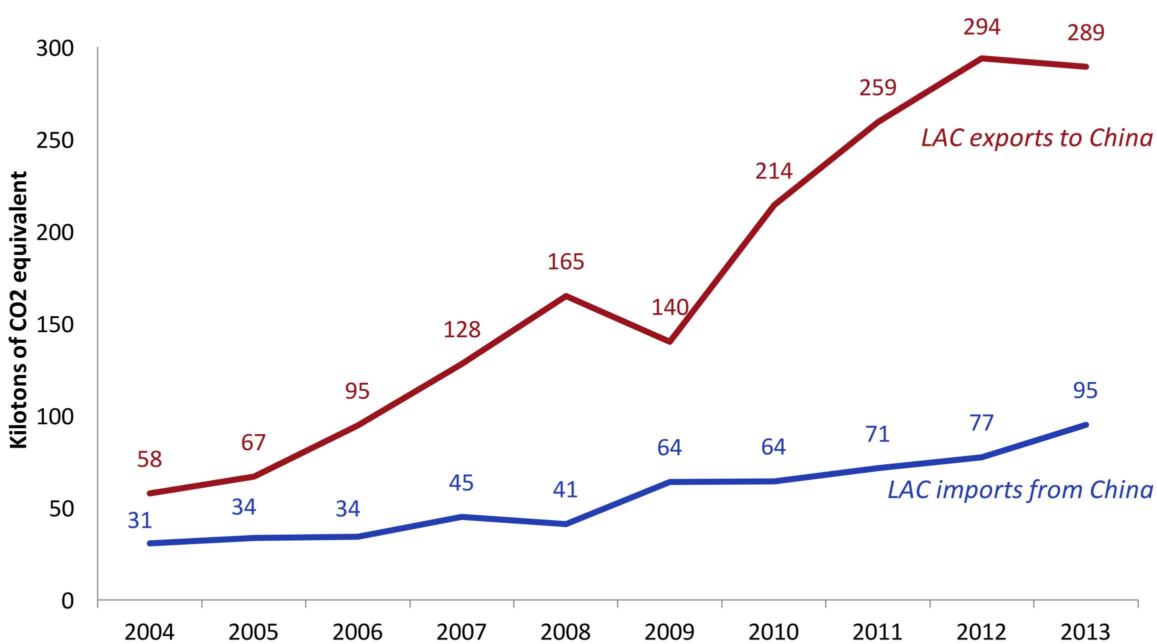
Source: Author's calculation using CEPALStat, FAO World Food Price Index, Peters (2013), UN Comtrade, WaterStat, and the World Bank GEM Commodity database. For detailed information, see Appendices A and B.

*4.4 LAC-China environmental balance of payments: importing carbon, exporting water*

The analysis above accounts only for one side of the LAC-China relationship: exports from Latin America to China. But LAC imports from China are not without their own environmental impact. For example, Peters (2011) shows that measuring the carbon emissions associated with a country's consumption – rather than production – changes the global emissions profile dramatically. Including trade with China (including the carbon in imports from China and excluding the carbon in exports to China) results in much higher carbon emissions than simply calculating the amount of emissions produced in most countries. This effect is due to the high concentration of Chinese exports in light manufacturing, and the relatively weaker environmental standards in the country.

While Peters does not specifically address Latin America, the trend he notes appears to hold for the LAC region as a whole. Even though the region's exports to China are more GHG intensive than other exports, the region's imports from China are even more GHG intensive, in part due to differences in the energy matrix and differences in the composition of the trade basket. The GHG intensity of LAC imports from China ranged from 2.5 to 2.7 kg CO2 equivalent per USD between 2004 and 2013 – much higher than the intensities of 1.8 to 2.0 for LAC exports to China. As a result, LAC is a net importer of greenhouse gas emissions from China, of about 300 kilotons in 2013. For reference, the World Resources Institute estimates that the LAC region produced a total of 4.6 gigatons of CO2 equivalent in net GHG emissions in 2012.

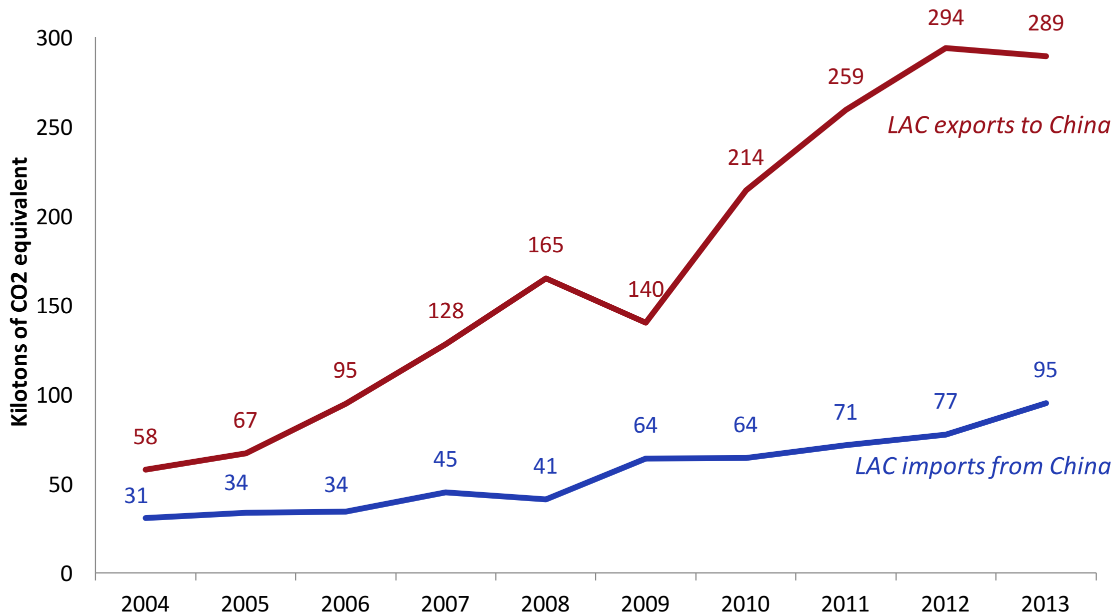
**Figure 11: LAC-China "Balance of Payments" in net greenhouse gas emissions**




Source: Author's calculations based on UN Comtrade (n.d.), Peters (2013), CEPALStat, FAO World Food Price Index, and the World Bank GEM Commodity Database. For detailed information, see Appendices A and B.

This relationship is reversed when it comes to water use, as Figure 12 shows. In 2013, LAC exported nearly 120 billion cubic meters of embedded water to China, or nearly eight times as much water as the amount embedded in its imports from China. For reference, Lake Nicaragua holds 108 billion cubic meters.

**Figure 12: LAC-China "Balance of Payments" in water**




Source: Author's calculations based on UN Comtrade (n.d.), CEPALStat, FAO World Food Price Index, WaterStat, and the World Bank GEM Commodity Database. For detailed information, see Appendices A and B.

Figures 11 and 12 show that LAC is, in effect, exporting water and importing carbon. Overall, LAC's boom in exports to China has driven the region's production into carbon- and water-intensive sectors. At the same time, LAC's boom in imports from China has further increased the region's environmental footprint on both fronts.

## 5. Conclusions

China's importance to the LAC economies is well established, as the largest export market for South American goods and the second-largest export market for LAC overall. But it is also well established that Chinese demand for raw materials and the competition from cheap Chinese manufactured goods have driven LAC away from manufacturing and back toward primary commodity production. Contrary to the hypothesis of the environmental Kuznets curve, primary production is more environmentally sensitive than manufacturing in LAC: it creates more net greenhouse gas emissions and uses or contaminates more water per million dollars. So it is not surprising that LAC exports to China are more environmentally sensitive than other LAC exports. Given these risks associated with this important new economic relationship, LAC governments would be wise to approach it with reinforced emphasis on setting environmental safeguards that meet the needs of their development strategies.

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## APPENDIX A: COMBINING DATA FROM LALL WITH DATA FROM PETERS AND WATERSTAT

The trade data used in this paper is from the UN Comtrade database. For a few country/year combinations, UN Comtrade has no data, and so imputations were taken instead, substituting imports reported by the rest of the world in place of exports reported by the missing country. These include:

- Anguilla: 2005, 2009-2013
- Antigua and Barbuda: 2003, ‘04, ‘06, ‘08
- Bermuda: 2003-2011
- Cuba: 2007-2013
- Dominica: 2011, 2013
- Haiti (all years)
- Honduras: 2008, 2013
- Macao: 2013
- Montserrat: 2011
- Netherlands Antilles: 2004, 2009-2013
- Saint Kitts and Nevis: 2012, 2013
- Saint Lucia: 2009-2013
- Saint Vincent and the Grenadines: 2013
- Trinidad and Tobago: 2011-2013
- Turks and Caicos: 2010, 2013
- Venezuela: 2007

Sanjaya Lall’s technology classification system assigns a category for almost all 3-digit SITC codes. The remaining codes, such as 999 (miscellaneous, not otherwise classified), are listed separately as “other,” but these make up a miniscule share of exports and are largely excluded from this analysis.

Glen Peters’ GHG intensity calculations estimate an emissions level per dollar for each GTAP category. Unfortunately, UN Comtrade data is nota available in GTAP categories, but a translation between the two systems is relatively simple, as GTAP categories tend to be umbrella categories covering several SITC categories each.

WaterStat water footprint data is available for 6-digit HS codes (for agricultural products) and for industrial products on average for each country. No translation was necessary, as Comtrade offers HS disaggretation. Unfortunately, WaterStat has several gaps, which were imputed following the method below.

- Where WaterStat has an intensity value listed for an umbrella category but not the sub-categories, the category average intensity is applied to the subcategories.
- Similarly, where WaterStat has an intensity value for all subcategories but not the aggregated category, a simple average is used.
- Where WaterStat is missing a value for last in a series of sub-categories, usually a miscellaneous sub-category, a simple average of other sub-categories is used.
- Processed foodstuffs not included in WaterStat are considered industrial.

- WaterStat excludes seafood (category 03, 1504, 1603, 1604, and 1605) because it considers it to be a "low or non-water consumptive product." (For more, see Hoekstra 2003). Those categories are excluded here.
- Category 50 (silk) is not included in WaterStat but it is an important element of Chinese exports (China exported 417 million USD of silk in 2013). To avoid omitting it altogether, this study uses the estimate of 54,000 $m^3$/metric ton established in Indian production, by Astudillo et al. (2014). Astudillo et al. estimate that this water footprint could be reduced to 26,700 with production process reforms. The authors state that Chinese silk has a lower water footprint because the production methods are more efficient. Thus, this study uses the low estimate of 26,700 $m^3$/MT for Chinese silk, the higher value for Indian silk, and omits it for LAC countries, which do not export significant levels of silk.
- Several uncommon items are omitted altogether from this analysis, such as human hair, live primates, pet food, and miscellaneous animal products not for human consumption.
- Other calculations, which vary by line item, are available upon request.

WaterStat has data for more countries for agricultural products than for industrial products. A few assumptions for industrial water intensity levels were necessary:

- Hong Kong and Macao are assumed to have the same intensities as China (as many exports from those territories originate in the mainland).
- WaterStat contains industrial water intensity levels for only two Caribbean nations: Barbados and the Dominican Republic. A simple average of these two intensities is applied to other Caribbean nations included in WaterStat for agricultural but not industrial purposes: the Bahamas, Dominica, Montserrat, and Saint Vincent and the Grenadines.

## APPENDIX B: DEFLATION

For most specific raw commodities, including most agricultural, extractive, and chemical goods, this study uses the deflators found in the World Bank GEM Commodities database:

- Aluminum
- Ammonia
- Bananas
- Barley
- Beef
- Beverages
- Chicken
- Coal
- Cocoa
- Coconut oil
- Coffee
- Copper
- Cotton
- Crude petroleum oil
- Fertilizers
- Fishmeal
- Gold
- Groundnut oil
- Iron
- Lead
- Liquid natural gas
- Maize
- Misc. energy products
- Misc. metals, minerals
- Misc. raw agric. prods.
- Natural gas
- Nickel
- Oranges
- Palm kernel oil
- Palm oil
- Phosphate
- Phosphate
- Platinum
- Potassium
- Rice
- Rubber
- Sheep
- Shrimp
- Silver
- Sorghum
- Soybean meal
- Soybean oil
- Soybeans
- Sugar
- Superphosphate
- Tea
- Timber
- Tin
- Tobacco
- Urea
- Wheat
- Woodpulp
- Zinc

Simple averages of existing commodities were used for miscellaneous seafood, oilseeds, precious metals, and hydrocarbons.

For food commodities not found in the GEM Commodities database, this exercise uses the broader categories of deflators found in the FAO Food Price Index (FPI) database: meat, dairy, cereals, vegetable oils, sugars, and miscellaneous food products. For example, pork is not included in the GEM database, so it is deflated using the FPI deflator for meat. For manufactured and miscellaneous goods, this exercise uses the country of origin's export price deflator, calculated by UN ECLAC (CEPALStat).

## APPENDIX C: STATISTICAL ANALYSIS OF GHG INTENSITY LEVELS OF EXPORTS

By definition, an export basket contains a range of products, each with their own environmental intensity. This section examines the distribution of those products across GHG intensity levels and compares the distribution of LAC exports to China with LAC exports to the rest of the world.

Figure C1 shows the cumulative distribution of exports from LAC to China and to the rest of the world, measured against the GHG intensity of each commodity and weighted by the real (2004) dollars of exports of each commodity. The red line (representing exports to China) is mostly to the right of the gold line (representing other LAC exports). This position indicates that overall, LAC exports to China have a higher GHG intensity than other LAC exports.

**Figure C1: Cumulative distribution of exports across GHG intensity levels, by destination**

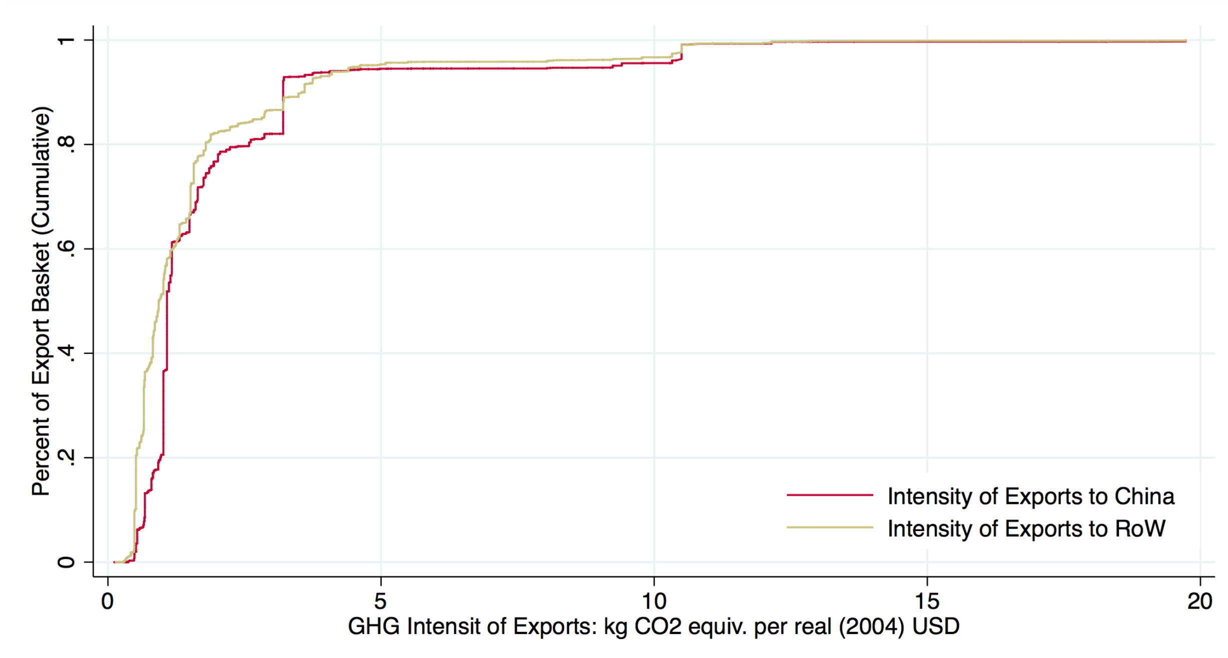



Figure C2 shows that exports to China appear more GHG-intensive in the Caribbean and in Mexico and Central America, but less intense in South America. Mexico alone accounts for roughly 40 percent of all LAC exports, which explains the region-wide difference in Figure C1.

**Figure C2: Cumulative distribution functions of export basket GHG intensity, by sub-region**

Caribbean | Mexico, Cent. Am. | South America

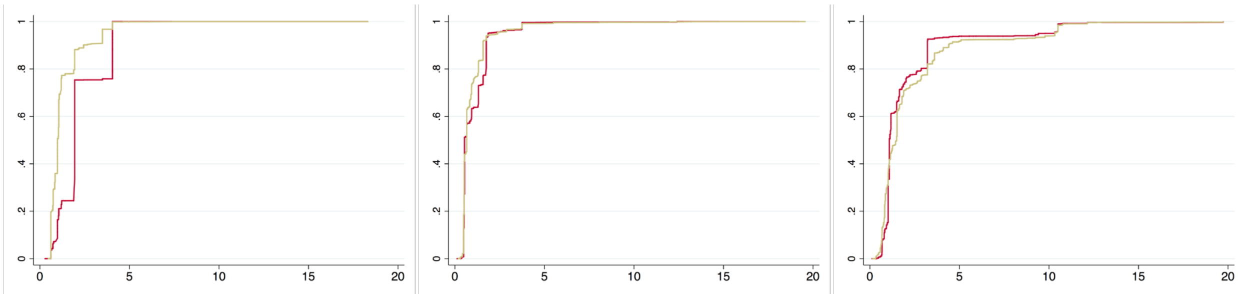
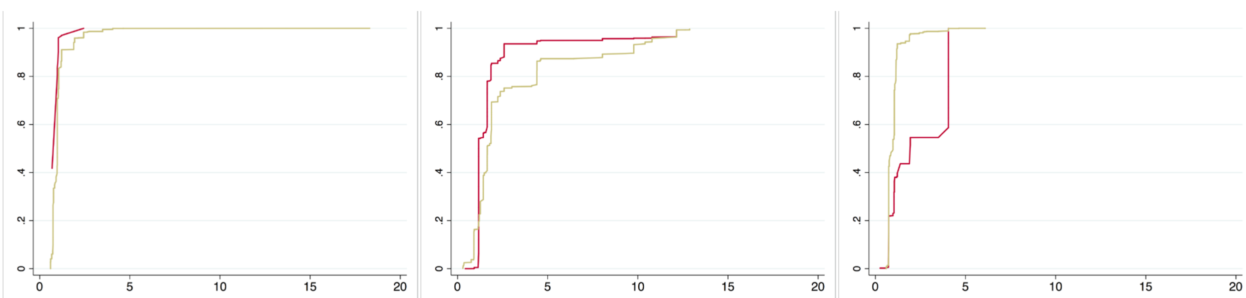



Figure C3 shows the cumulative distribution functions of exports across GHG intensity levels for each LAC country. Exports to China appear significantly more GHG intense than other exports in most Caribbean countries, Mexico, Ecuador, Honduras, Uruguay, and Venezuela. In contrast, exports to China appear significantly less GHG intense in most other South American countries.

**Figure C3: Cumulative distribution functions of export basket GHG intensity, by country**

Anguilla | Argentina | Aruba




Bahamas | Barbados | Belize

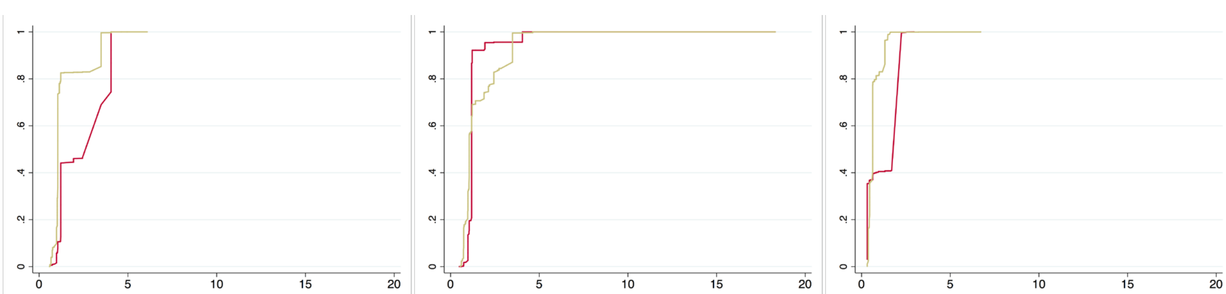


**Figure C3, cont'd: Cml. distribution functions of export basket GHG intensity, by country**

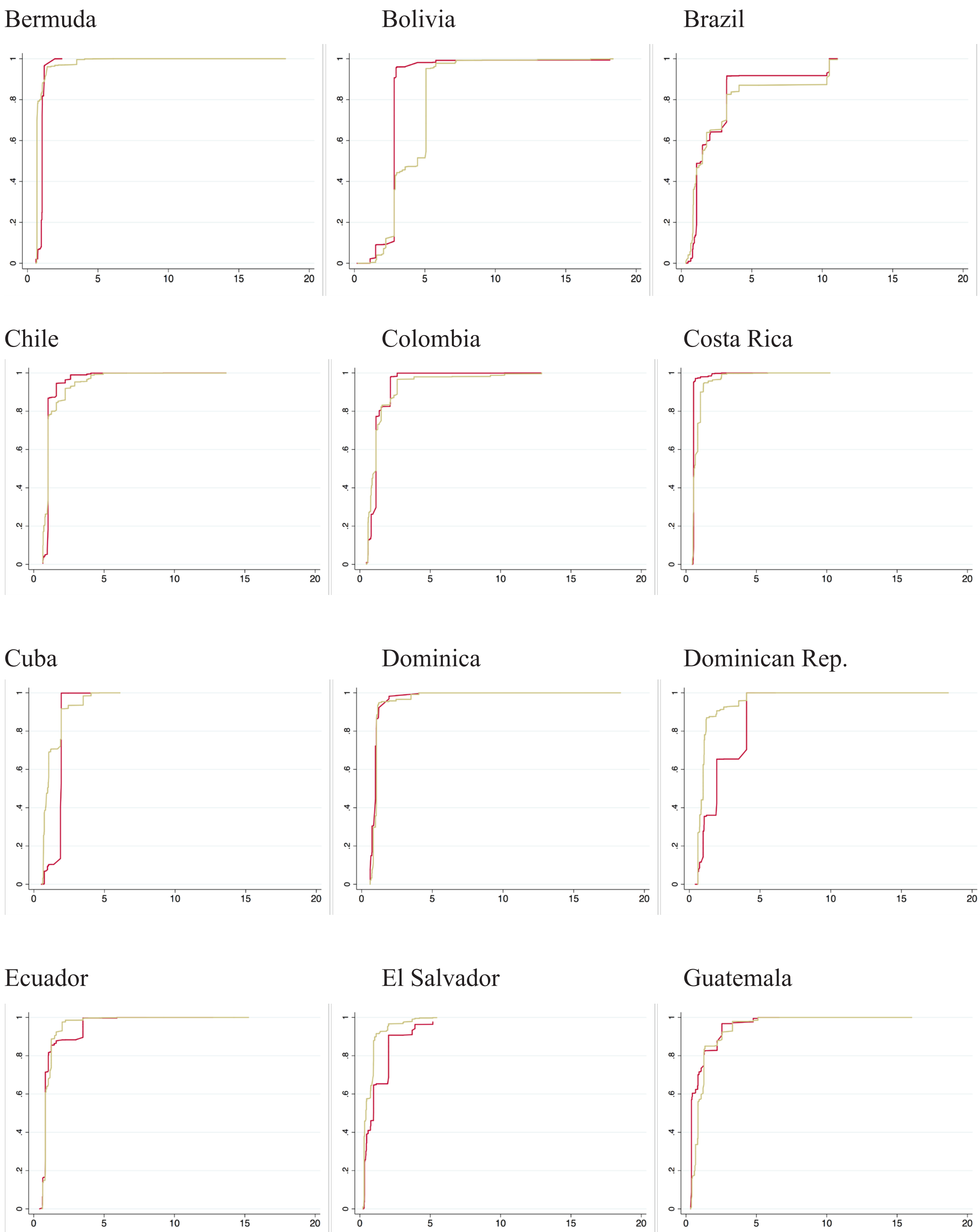
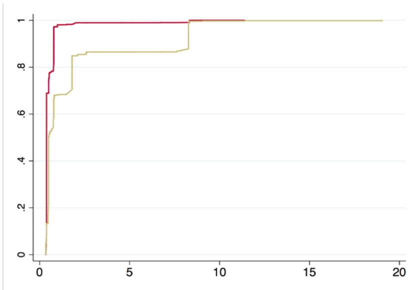
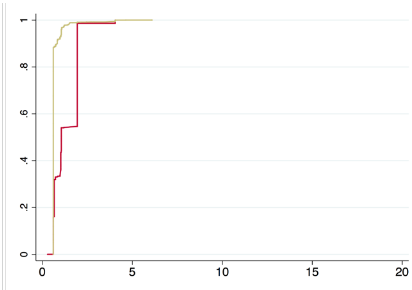


**Figure C3, cont'd: Cml. distribution functions of export basket GHG intensity, by country**

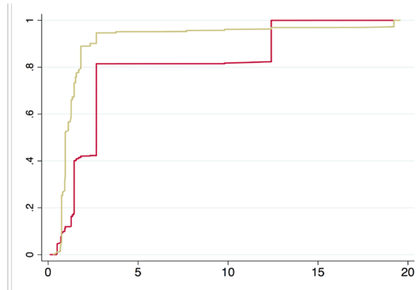
Guyana



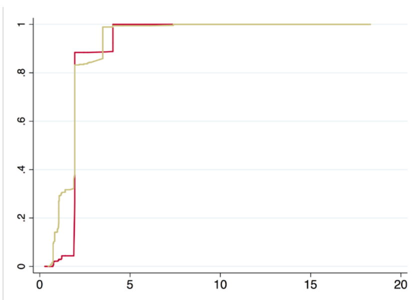

Haiti



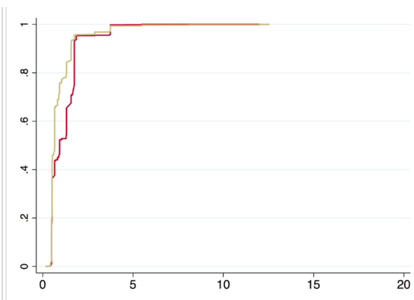

Honduras



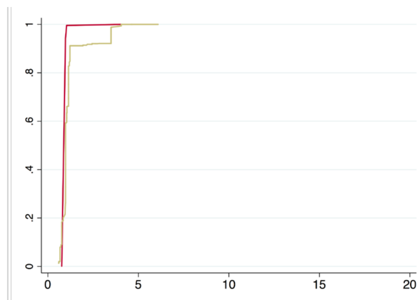

Jamaica



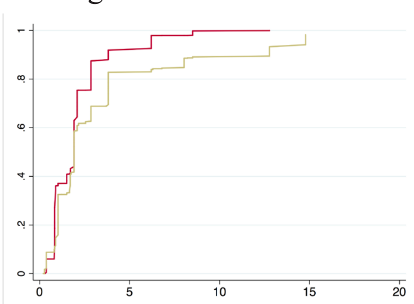

Mexico



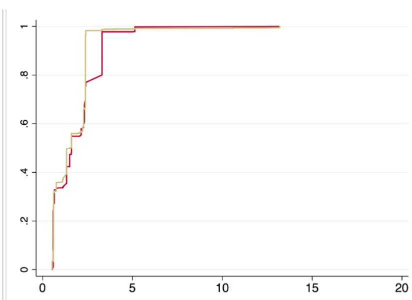

Montserrat



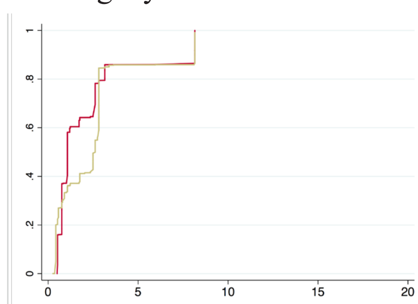

Nicaragua



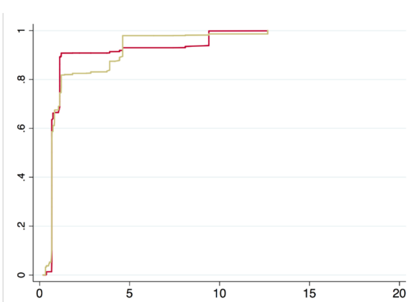

Panama



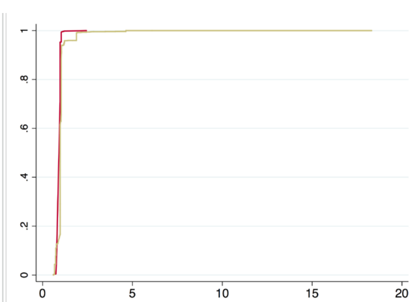

Paraguay




Peru




St. Kitts & Nevis




St. Lucia

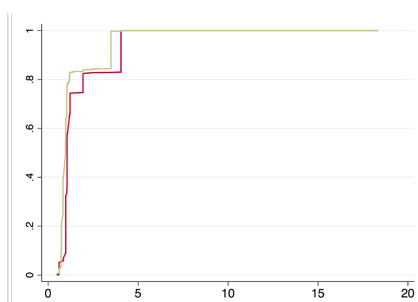
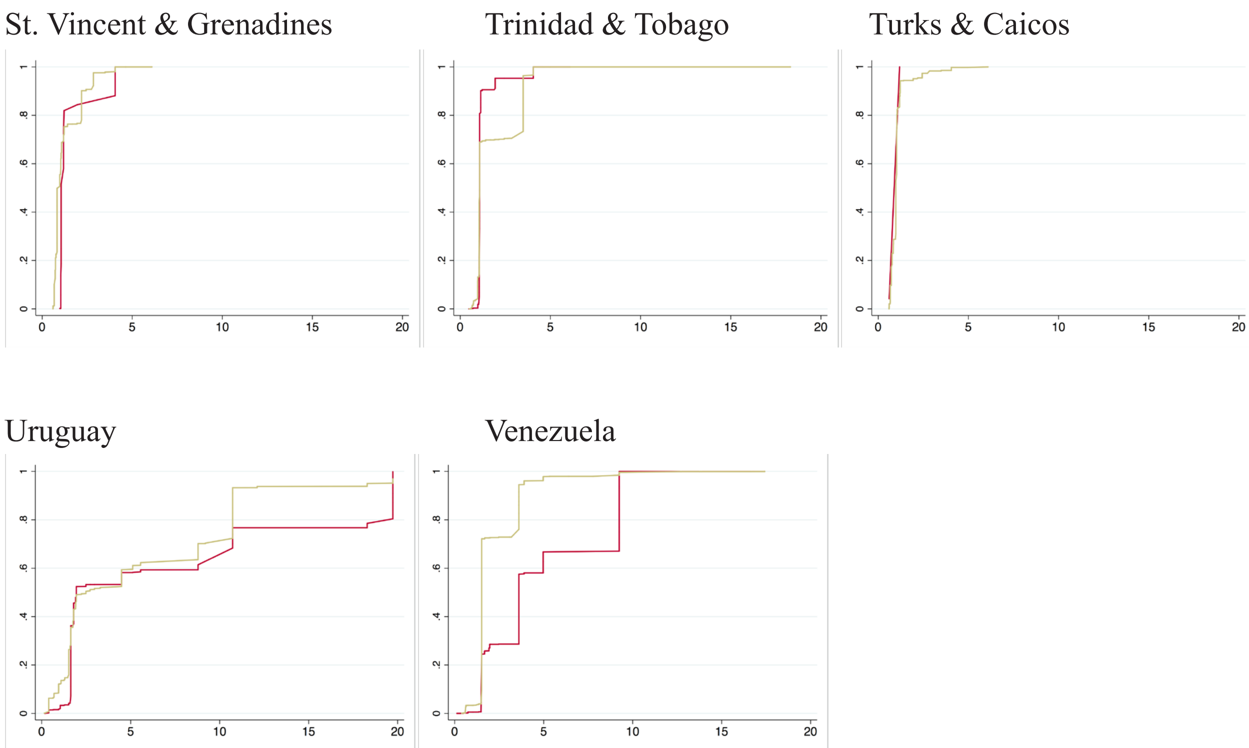


**Figure C3, cont'd: Cml. distribution functions of export basket GHG intensity, by country**




Tables C1 and C2 show two different statistical tests for the impact of China on the water intensity of LAC exports. First, a two-sample t-test is conducted to establish whether the means of the distributions shown in Figures C1 through C3 above are statistically significant. Second, regression analysis is conducted to distinguish the impact of China and the impact of time (in other words, the progression of the commodity boom in general) on the changing average GHG intensity of these exports over the decade studied here.

The regression analysis is repeated separately for each sub-region and country rather than incorporating them all into one analysis with interaction variables. This choice prevents the unnecessary introduction of additional heteroskedasticity. It takes the form

$$\left(\frac{GHG}{USD}\right)_i = \alpha + \delta_1 China_i + \beta_1 Year_i$$

Where:

- $\left(\frac{GHG}{USD}\right)$ represents the mean GHG intensity of a given export basket.
- i corresponds to each of 20 export baskets: to China and the rest of the world over a 10-year period from 2004 to 2013, weighted by their value in millions of real (2004) US dollars, so that years with higher exports are weighted more heavily.
- Year is the calendar year less 2008 (the midpoint of the sample)

- China is a binary variable (1= exports to China, 0 = exports to elsewhere).

Eleven countries and territories had insufficient exports to China during the study period to calculate country-level coefficients: Anguilla, Antigua and Barbuda, Aruba, Dominica, Montserrat, the Netherlands Antilles, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and the Turks and Caicos Islands. However, their exports are included in overall LAC and Caribbean exports in Table C2.

Venezuela is an outlier, because not all of Venezuela's exports to China are registered as such in the UN Comtrade database. Venezuela's oil exports (which account for the overwhelming majority of the country's total exports) go to refineries in countries that are often not the final destination. Many of Venezuela's trading partners use their own refineries, but China's imports of Venezuelan oil go through intermediary countries. So UN Comtrade reports only non-oil exports from Venezuelan to China, which is hardly an accurate representation of the whole. With this in mind, it is worth repeating the regressions for South America and for LAC overall without Venezuela. The relationship holds, because Venezuela accounts for only 6.8% of the region's total exports during the decade studied.

Finally, Tables C1 and C2 list the ratio of average emission intensities of exports to China compared to other exports. For example, the region-wide value of 1.16 indicates that overall, LAC exports to China cause 16 percent more net GHG emissions per dollar than other LAC exports.

**TABLE C1: Mean GHG intensities and regressions results for LAC region and sub-regions**

| | Average GHG Intensity of Exports | | | | | Two-sample t-test | | Regression Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | To China | | To R.o.W. | | China/ R.o.W.[1] | T-statistic | N | China | | Year | | Intercept | | $R^2$ |
| | Mean | SE | Mean | SE | | | | Coeff. | SE | Coeff. | SE | Coeff. | SE | |
| ***LAC Overall*** | | | | | | | | | | | | | | |
| W/ Venezuela | 1.96 | 0.00 | 1.69 | 0.00 | 1.16 | 58.2*** | 5,273,434 | 0.28*** | 0.05 | 0.00 | 0.00 | 1.69*** | 0.01 | 0.6893 |
| W/O Venezuela | 1.93 | 0.00 | 1.65 | 0.00 | 1.17 | 60.5*** | 4,912,485 | 0.28*** | 0.04 | 0.00 | 0.00 | 1.65*** | 0.01 | 0.7691 |
| ***Sub-Regions*** | | | | | | | | | | | | | | |
| Caribbean | 2.26 | 0.03 | 1.30 | 0.00 | 1.74 | 29.8*** | 69,006 | 0.94*** | 0.18 | -0.01 | 0.01 | 1.31*** | 0.03 | 0.6344 |
| Mex., Cent. Amer. | 1.03 | 0.00 | 0.96 | 0.00 | 1.08 | 15.4*** | 2,354,278 | 0.08 | 0.05 | 0.00* | 0.00 | 0.96*** | 0.01 | 0.3597 |
| South America | 2.08 | 0.01 | 2.36 | 0.00 | 0.88 | -51.8*** | 2,850,150 | -0.29*** | 0.05 | 0.01 | 0.01 | 2.36*** | 0.02 | 0.6388 |
| S. Amer. W/O Venez. | 2.05 | 0.01 | 2.38 | 0.00 | 0.86 | -61.2*** | 2,489,201 | -0.35*** | 0.04 | 0.02*** | 0.00 | 2.37*** | 0.01 | 0.8605 |

[1] This column shows the ratio of average intensity of LAC-China exports to the average intensity of other LAC exports. A value greater than 1.0 indicates that exports to China are more GHG intensive than other exports, and a value less than 1.0 represents the opposite.

**TABLE C2: Mean GHG intensities and regressions results for LAC countries**

| | Average GHG Intensity of Exports | | | | | Two-sample t-test | | Regression Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | To China | | To R.o.W. | | China/ R.o.W.[1] | T-statistic | N | China | | Year | | Intercept | | $R^2$ |
| | Mean | SE | Mean | SE | | | | Coeff. | SE | Coeff. | SE | Coeff. | SE | |
| Argentina | 2.08 | 0.02 | 2.99 | 0.01 | 0.69 | -55.5*** | 403,735 | -0.93*** | 0.11 | -0.07*** | 0.01 | 3.04*** | 0.03 | 0.8720 |
| Bahamas | 2.78 | 0.26 | 1.46 | 0.01 | 1.90 | 5.0*** | 4,911 | 1.13* | 0.42 | 0.03** | 0.01 | 1.43*** | 0.03 | 0.5226 |
| Barbados | 1.29 | 0.10 | 1.52 | 0.02 | 0.84 | -2.4* | 3,064 | -0.19 | 0.52 | -0.01 | 0.02 | 1.53*** | 0.06 | 0.0253 |
| Belize | 1.57 | 0.23 | 0.69 | 0.01 | 2.29 | 3.8*** | 1,784 | 0.84* | 0.30 | 0 | 0.01 | 0.69*** | 0.03 | 0.4285 |
| Bermuda | 1.05 | 0.03 | 0.85 | 0.01 | 1.24 | 5.7** | 4,103 | 0.19 | 1.25 | 0 | 0.02 | 0.86*** | 0.05 | 0.0069 |
| Bolivia | 3.03 | 0.16 | 4.07 | 0.01 | 0.74 | -6.6*** | 35,122 | -0.91*** | 0.19 | 0.02* | 0.01 | 4.04*** | 0.03 | 0.6183 |
| Brazil | 2.50 | 0.01 | 2.83 | 0.00 | 0.89 | -39.5*** | 1,022,431 | -0.41*** | 0.08 | 0.07*** | 0.01 | 2.8*** | 0.03 | 0.7969 |
| Chile | 1.14 | 0.00 | 1.26 | 0.00 | 0.90 | -45.5*** | 342,229 | -0.13*** | 0.01 | 0.01*** | 0.00 | 1.26*** | 0.00 | 0.9496 |
| Colombia | 1.23 | 0.01 | 1.38 | 0.00 | 0.90 | -18.4*** | 225,467 | -0.1 | 0.11 | -0.03** | 0.01 | 1.4*** | 0.02 | 0.4904 |
| Costa Rica | 0.57 | 0.00 | 0.80 | 0.00 | 0.71 | -81.3*** | 75,141 | -0.23*** | 0.04 | 0 | 0.00 | 0.8*** | 0.01 | 0.6746 |
| Cuba | 1.81 | 0.01 | 1.23 | 0.01 | 1.47 | 64.6*** | 21,034 | 0.59** | 0.14 | -0.02 | 0.02 | 1.24*** | 0.05 | 0.5114 |
| Dominican Rep. | 2.31 | 0.05 | 1.14 | 0.00 | 2.02 | 24.5*** | 49,671 | 1.18*** | 0.20 | -0.02 | 0.01 | 1.15*** | 0.03 | 0.6831 |
| Ecuador | 1.17 | 0.03 | 1.04 | 0.00 | 1.13 | 5.0*** | 90,499 | 0.13* | 0.06 | 0 | 0.00 | 1.04*** | 0.01 | 0.2480 |
| El Salvador | 1.11 | 0.14 | 0.73 | 0.01 | 1.52 | 2.7** | 34,806 | 1.12 | 0.54 | -0.01 | 0.01 | 0.74*** | 0.02 | 0.2820 |
| Guatemala | 0.92 | 0.06 | 1.19 | 0.00 | 0.78 | -4.6*** | 47,570 | -0.22 | 0.20 | 0 | 0.01 | 1.18*** | 0.02 | 0.0789 |
| Guyana | 0.47 | 0.02 | 1.88 | 0.40 | 0.25 | -32.8*** | 4,782 | -1.34*** | 0.19 | 0.05*** | 0.01 | 1.84*** | 0.03 | 0.8229 |
| Haiti | 1.34 | 0.10 | 0.68 | 0.00 | 1.98 | 6.8*** | 6,649 | 0.64*** | 0.08 | 0 | 0.00 | 0.69*** | 0.01 | 0.8061 |
| Honduras | 3.91 | 0.23 | 1.92 | 0.02 | 2.03 | 8.5*** | 23,946 | 1.96 | 1.43 | 0 | 0.06 | 1.93*** | 0.19 | 0.0989 |
| Jamaica | 2.20 | 0.04 | 1.91 | 0.01 | 1.15 | 7.9*** | 10,663 | 0.33* | 0.15 | 0.02 | 0.01 | 1.91*** | 0.03 | 0.2790 |
| Mexico | 1.15 | 0.00 | 0.91 | 0.00 | 1.26 | 47.0*** | 2,100,911 | 0.25*** | 0.03 | -0.01*** | 0.00 | 0.92*** | 0.00 | 0.8740 |
| Nicaragua | 2.00 | 0.17 | 3.60 | 0.04 | 0.56 | -9.1*** | 13,462 | -1.54 | 1.84 | -0.17** | 0.05 | 3.96*** | 0.16 | 0.4557 |
| Panama | 1.80 | 0.06 | 1.64 | 0.01 | 1.10 | 2.5* | 56,658 | 0.17 | 0.22 | 0.07*** | 0.01 | 1.59*** | 0.02 | 0.7818 |
| Paraguay | 2.38 | 0.11 | 3.20 | 0.07 | 0.74 | -6.1*** | 31,544 | -0.81 | 0.84 | -0.01 | 0.04 | 3.22*** | 0.13 | 0.0521 |
| Peru | 1.47 | 0.02 | 1.55 | 0.01 | 0.95 | -5.0*** | 159,906 | -0.13 | 0.10 | 0.08*** | 0.01 | 1.49*** | 0.04 | 0.7489 |
| Trinidad, Tobago | 1.25 | 0.03 | 1.75 | 0.00 | 0.71 | -15.4*** | 91,941 | -0.43 | 0.45 | -0.04** | 0.01 | 1.79*** | 0.03 | 0.4425 |
| Uruguay | 7.50 | 0.14 | 6.96 | 0.06 | 1.08 | 3.6*** | 39,867 | 0.69 | 0.45 | -0.08 | 0.04 | 7.03*** | 0.12 | 0.2394 |
| Venezuela | 4.90 | 0.06 | 2.21 | 0.00 | 2.21 | 45.1*** | 360,949 | 2.61* | 1.05 | -0.07* | 0.03 | 2.24*** | 0.09 | 0.4010 |

[1] This column shows the ratio of average intensity of LAC-China exports to the average intensity of other LAC exports. A value greater than 1.0 indicates that exports to China are more GHG intensive than other exports, and a value less than 1.0 represents the opposite.

*Note on representation:* Anguilla, Antigua and Barbuda, Aruba, Dominica, Montserrat, Netherlands Antilles, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Turks and Caicos are omitted due to small sample sizes, but their exports are included in overall and Caribbean exports in Table X, above.

## APPENDIX D: STATISTICAL ANALYSIS OF WATER INTENSITY LEVELS OF EXPORTS

Figure D1 shows the cumulative distribution of exports from LAC to China and to the rest of the world, measured against the water intensity of each good and weighted by the real (2004) dollars of exports of each good. The results show that LAC exports to China fall roughly into two categories: about 60 percent have extremely low water intensity, and an additional share (over 20 percent) have intensity levels between 6 and 8 cubic meters per dollar. In contrast, over 80 percent of exports to the rest of the world have very low intensity.

**Figure D1: Cumulative distribution of exports across water intensity levels, by destination**

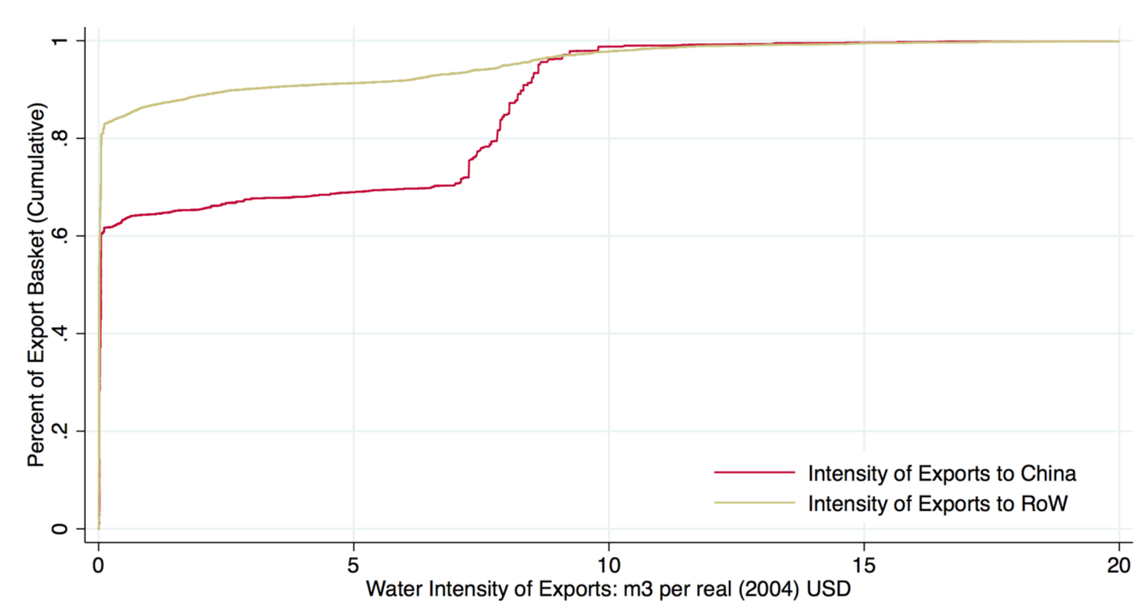
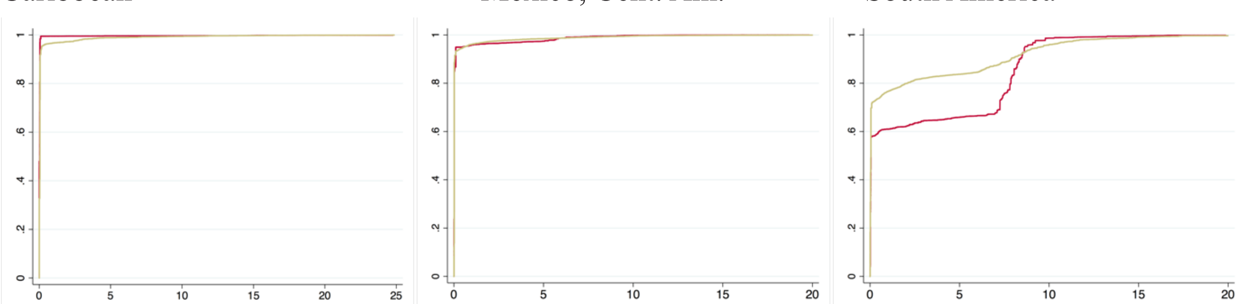



Figure D3, disaggregated by sub-region, shows that the results for LAC overall are due primarily the experiences of South America.

**Figure D2: Cumulative distribution functions of export basket water intensity, by sub-region**

Caribbean Mexico, Cent. Am. South America



Among countries (below) it is clear that exports to China are more water intense in Argentina, Brazil, Guatemala, and Uruguay, and less intense in several smaller countries.

**Figure D3: Cumulative distribution functions of export basket water intensity, by country**

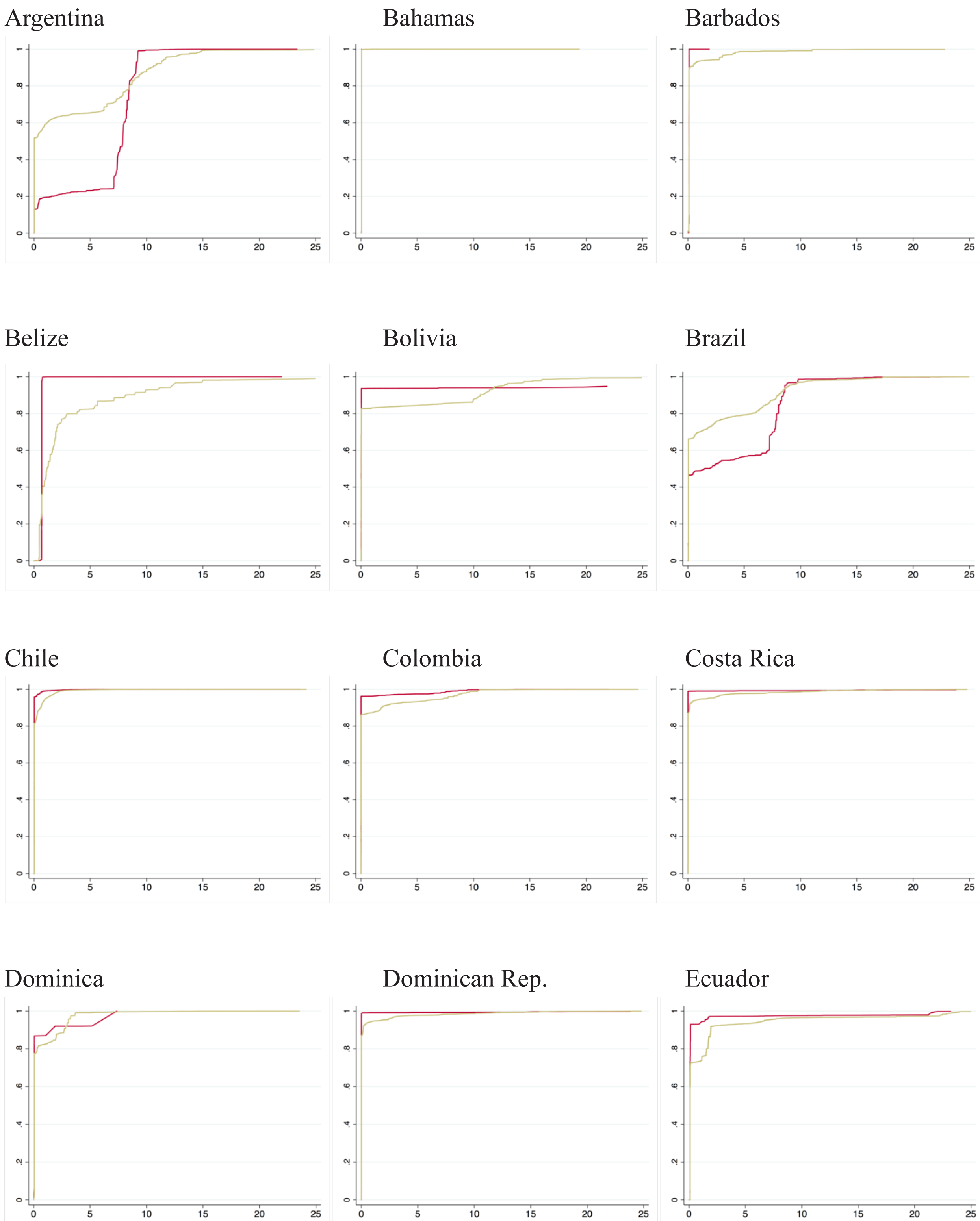
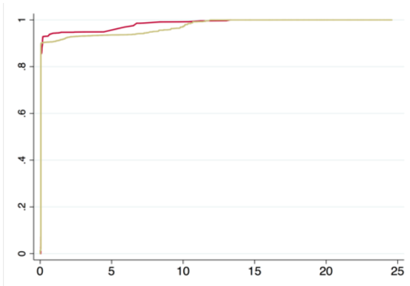
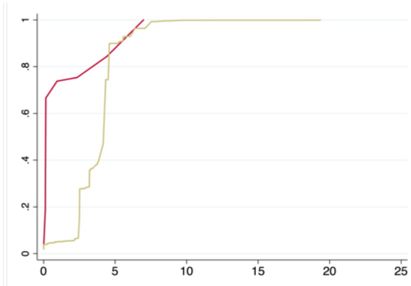


**Figure D3, cont'd: Cml. distribution functions of export basket water intensity, by country**

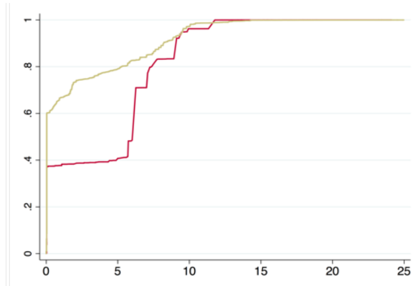
El Salvador



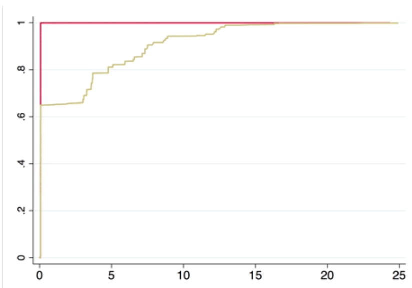

Grenada



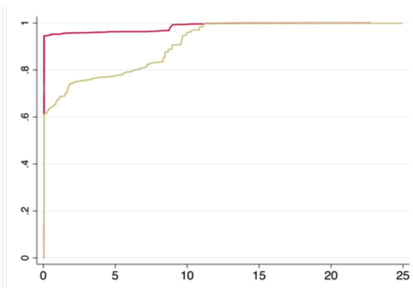

Guatemala



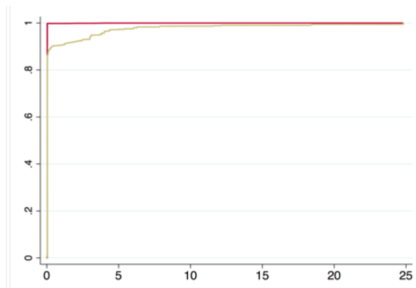

Guyana



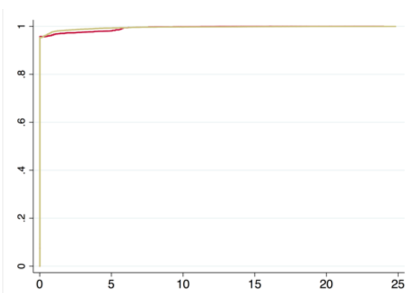

Honduras



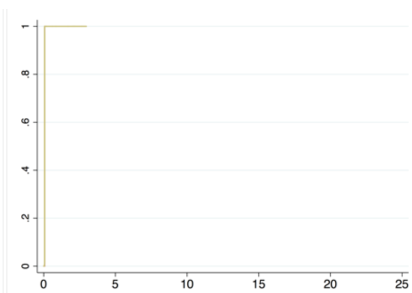

Jamaica



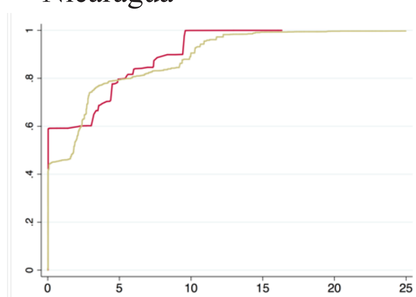

Mexico



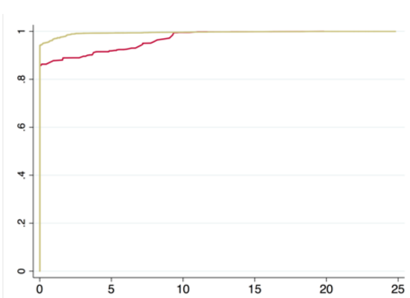

Montserrat



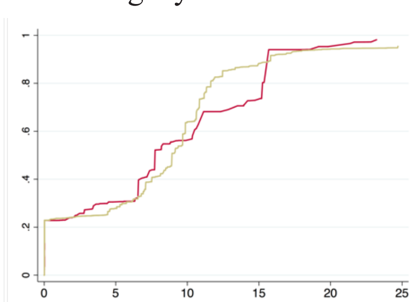

Nicaragua




Panama




Paraguay




Peru

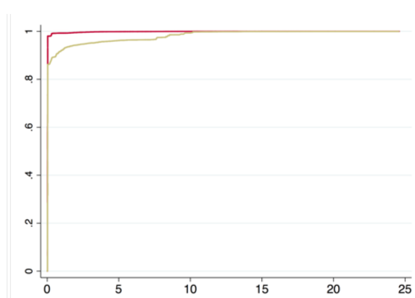
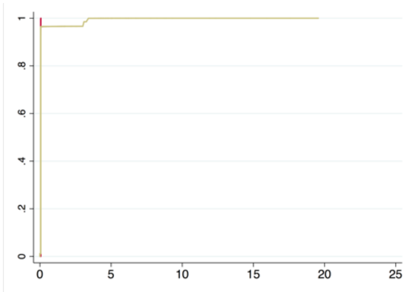
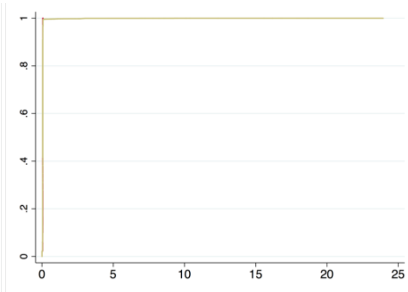


**Figure D3, cont'd: Cml. distribution functions of export basket water intensity, by country**

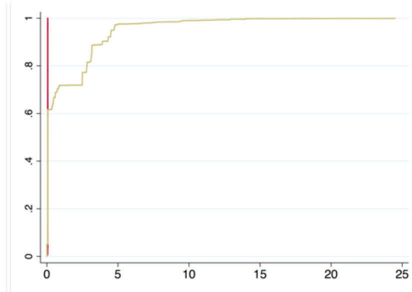
St. Kitts and Nevis



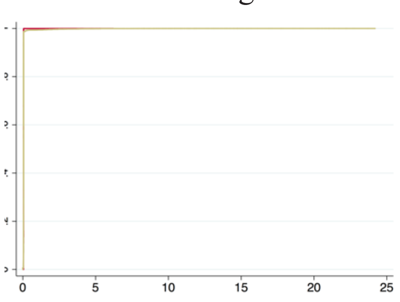
St. Lucia



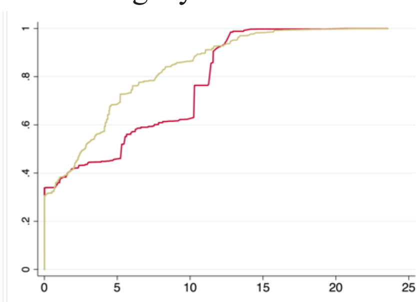
St. Vincent, Grenadines



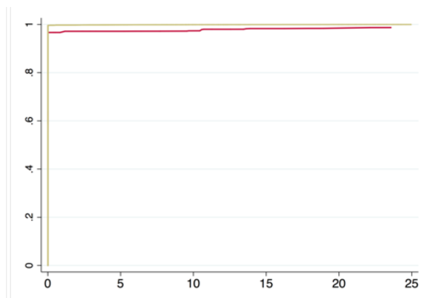
Trinidad and Tobago



Uruguay



Venezuela



Tables D1 and D2 show two different statistical tests for the impact of China on the water intensity of LAC exports. First, a two-sample t-test is conduction to establish whether the means of the distributions shown in Figures D1 through D3 above are statistically significant. Second, regression analysis is conducted to distinguish the impact of China and the impact of time (in other words, the progression of the commodity boom in general) on the changing average water intensity of these exports over the decade studied here.

The regression analysis is repeated separately for each sub-region and country rather than incorporating them all into one analysis with interaction variables. This choice prevents the unnecessary introduction of additional heteroskedasticity. It takes the form

$$\left(\frac{H_2O}{USD}\right)_i = \alpha + \delta_1 China_i + \beta_1 Year_i$$

Where:

- $\left(\frac{H_2O}{USD}\right)$ represents the mean water intensity of a given export basket.
- i corresponds to each of 20 export baskets: to China and the rest of the world over a 10-year period from 2004 to 2013, weighted by their value in millions of real (2004) US dollars, so that years with higher exports are weighted more heavily.
- Year is the calendar year less 2008 (the midpoint of the sample)

- China is a binary variable (1= exports to China, 0 = exports to elsewhere).

Five countries and territories had insufficient exports to China during the study period to calculate country-level coefficients: Dominica, Montserrat, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines. However, their exports are included in overall LAC and Caribbean exports in Table D2. In addition, Anguilla, Antigua and Barbuda, Bermuda, Cuba, Grenada, Haiti, and the Netherlands Antilles are omitted from the analysis entirely because water intensity estimates for their national production are unavailable.

As with Appendix C, the tables here show the LAC region and South America both with and without Venezuela in order to address this country's outlier status. Finally, Tables D1 and D2 list the ratio of average emission intensities of exports to China compared to other exports. For example, the region-wide value of 2.80 indicates that overall, LAC exports to China can be expected to use or contaminate 180 percent more net GHG emissions per dollar than other LAC exports.

**TABLE D1: Mean water intensities and regressions results for LAC region and sub-regions**

| | Average Water Intensity of Exports | | | | | Two-sample t-test | | Regression Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | To China | | To R.o.W. | | China/ | | | China | | Year | | Intercept | | |
| | Mean | SE | Mean | SE | R.o.W. | T-statistic | N | Coeff. | SE | Coeff. | SE | Coeff. | SE | $R^2$ |
| ***LAC Overall*** | | | | | | | | | | | | | | |
| W/ Venezuela | 2.70 | 0.01 | | 0.97 | 2.80 | 225.1*** | 4,792,095 | 1.64*** | 0.07 | 0.00 | 0.01 | 0.94*** | 0.02 | 0.9622 |
| W/O Venezuela | 2.72 | 0.01 | | 1.03 | 2.60 | 218.7*** | 4,513,788 | 1.60*** | 0.08 | 0.00 | 0.01 | 1.00*** | 0.02 | 0.0620 |
| | | | | | | | | | | | | | | |
| ***Sub-Regions*** | | | | | | | | | | | | | | |
| Caribbean | 0.05 | 0.02 | | 0.23 | 0.20 | -7.7*** | 117,296 | -0.09 | 0.05 | -0.01* | 0.00 | 0.23*** | 0.01 | 0.3975 |
| Mex., Cent. Amer. | 0.25 | 0.01 | | 0.24 | 1.03 | 0.9 | 2,234,613 | 0.01 | 0.14 | -0.01 | 0.01 | 0.25*** | 0.02 | 0.0861 |
| South America | 2.96 | 0.01 | | 1.74 | 1.71 | 143.7*** | 2,440,186 | 1.16*** | 0.09 | 0.01 | 0.01 | 1.65*** | 0.03 | 0.9036 |
| S. Amer. W/O Venez. | 2.98 | 0.01 | | 1.98 | 1.50 | 115.8*** | 2,161,879 | 0.96*** | 0.10 | 0.01 | 0.01 | 1.87*** | 0.03 | 0.8562 |

*Note on sample sizes and weights:* For the two-sample t-test, the unit of analysis is millions of real (2004) dollars of exports during the decade studied here. The sample sizes are the corresponding number of millions of dollars of exports during that time. Since the two-sample test statistic eliminates any possibility that the differing means could be the result of chance, it is possible to conduct regression analysis on just the mean intensity level of the whole basket of exports from each reporter to China or to the rest of the world. For these regression functions, the sample size is 20 (two exports markets and 10 years). The regression analysis uses analytic weights of the dollar value of each year's exports (in millions), which allows years with more exports (in real terms) to be counted more heavily.

*Note on country representation:* Antigua and Barbuda, Bermuda, Cuba, Haiti, and the Netherlands Antilles are omitted from the analysis because water intensity estimates for their national production are unavailable.

**TABLE D2: Mean water intensities and regressions results, by countries**

| | Avg. Intensity of Exports | | | | | Two-sample t-test | | Regression Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | To China | | To R.o.W. | | China/ R.o.W. | T-statistic | N | China | | Year | | Intercept | | $R^2$ |
| | Mean | SE | Mean | SE | | | | Coeff. | SE | Coeff. | SE | Coeff. | SE | |
| Argentina | 6.36 | 0.02 | 3.50 | 0.01 | 1.8 | 143.0*** | 379,925 | 2.88*** | 0.28 | -0.06* | 0.03 | 3.39*** | 0.09 | 0.8671 |
| Bahamas | 0.06 | 0.00 | 0.06 | 0.00 | 1.0 | -0.9 | 3,442 | 0.01 | 0.01 | 0.00*** | 0.00 | 0.05*** | 0.00 | 0.7979 |
| Barbados | 0.11 | 0.00 | 0.50 | 0.06 | 0.2 | -6.5*** | 2,079 | -0.27 | 0.58 | -0.02 | 0.02 | 0.41*** | 0.06 | 0.0804 |
| Belize | 0.68 | 0.00 | 2.71 | 0.11 | 0.3 | -18.2*** | 1,594 | -1.89 | 1.78 | 0.05 | 0.06 | 2.27*** | 0.17 | 0.0872 |
| Bolivia | 1.85 | 0.29 | 1.98 | 0.03 | 0.9 | -0.6 | 36,542 | 0.01 | 0.39 | -0.16*** | 0.02 | 2.18*** | 0.06 | 0.7942 |
| Brazil | 3.81 | 0.01 | 2.07 | 0.00 | 1.8 | 142.4*** | 1,003,350 | 1.66*** | 0.10 | 0.04** | 0.01 | 2.01*** | 0.03 | 0.9522 |
| Chile | 0.05 | 0.00 | 0.18 | 0.00 | 0.3 | -77.1*** | 292,376 | -0.12*** | 0.01 | 0.01*** | 0.00 | 0.16*** | 0.00 | 0.9676 |
| Colombia | 0.23 | 0.02 | 0.69 | 0.01 | 0.3 | -29.0*** | 196,367 | -0.32** | 0.10 | -0.06*** | 0.01 | 0.72*** | 0.02 | 0.8670 |
| Costa Rica | 0.21 | 0.02 | 0.70 | 0.01 | 0.3 | -25.0*** | 56,119 | -0.44** | 0.11 | 0.00 | 0.01 | 0.66*** | 0.02 | 0.4910 |
| Dominican Republic | 0.06 | 0.05 | 0.39 | 0.01 | 0.1 | -7.2*** | 43,108 | -0.15 | 0.13 | 0.01 | 0.01 | 0.35*** | 0.02 | 0.2231 |
| Ecuador | 0.63 | 0.10 | 1.42 | 0.02 | 0.4 | -7.7*** | 69,790 | -0.62** | 0.19 | 0.02* | 0.01 | 1.13*** | 0.02 | 0.5003 |
| El Salvador | 0.47 | 0.29 | 0.72 | 0.01 | 0.7 | -1.7 | 30,874 | -0.29 | 0.31 | -0.01 | 0.00 | 0.68*** | 0.01 | 0.1832 |
| Guatemala | 5.07 | 0.24 | 2.12 | 0.02 | 2.4 | 10.7*** | 42,715 | 2.39* | 1.02 | -0.02 | 0.03 | 2.01*** | 0.09 | 0.2603 |
| Guyana | 0.07 | 0.00 | 2.38 | 0.06 | 0.0 | -37.6*** | 4,126 | -1.94* | 0.73 | -0.04 | 0.03 | 2.01*** | 0.10 | 0.3283 |
| Honduras | 0.30 | 0.09 | 2.26 | 0.03 | 0.1 | -23.1*** | 20,969 | -1.57 | 1.60 | -0.10 | 0.07 | 2.22*** | 0.21 | 0.1710 |
| Jamaica | 0.03 | 0.00 | 0.63 | 0.03 | 0.0 | -19.6*** | 9,216 | -0.67*** | 0.14 | -0.07*** | 0.01 | 0.56*** | 0.03 | 0.7652 |
| Mexico | 0.18 | 0.01 | 0.15 | 0.00 | 1.2 | 4.2*** | 2,024,608 | 0.04 | 0.15 | -0.01 | 0.01 | 0.16*** | 0.02 | 0.1338 |
| Nicaragua | 2.55 | 0.46 | 3.03 | 0.05 | 0.8 | -1.8 | 11,440 | -0.39 | 2.58 | -0.21** | 0.07 | 3.03*** | 0.23 | 0.3621 |
| Panama | 0.84 | 0.18 | 0.14 | 0.01 | 5.9 | 3.8*** | 52,152 | 0.41 | 0.71 | -0.02 | 0.03 | 0.15* | 0.06 | 0.0360 |
| Paraguay | 9.08 | 0.34 | 8.71 | 0.09 | 1.0 | 0.7 | 28,485 | -0.69 | 1.94 | -0.61*** | 0.09 | 9.43*** | 0.29 | 0.7241 |
| Peru | 0.05 | 0.00 | 0.50 | 0.01 | 0.1 | -63.2*** | 123,484 | -0.43*** | 0.03 | 0.02*** | 0.00 | 0.44*** | 0.01 | 0.9401 |
| Trinidad & Tobago | 0.05 | 0.00 | 0.07 | 0.00 | 0.7 | -15.0*** | 59,946 | -0.01 | 0.01 | 0.00*** | 0.00 | 0.07*** | 0.00 | 0.8007 |
| Uruguay | 5.75 | 0.10 | 4.07 | 0.02 | 1.4 | 16.3*** | 35,713 | 1.24** | 0.42 | 0.12** | 0.04 | 3.55*** | 0.12 | 0.5387 |
| Venezuela | 0.83 | 0.13 | 0.03 | 0.00 | 25.6 | 6.1*** | 278,829 | 0.83** | 0.25 | 0.00 | 0.01 | 0.03 | 0.02 | 0.3996 |

See the note on sample sizes and weights on Table X, above.

Note on country representation: Dominica, Montserrat, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines are omitted from this step due to small sample sizes, but their exports are included in the “Caribbean” category in Table X, above.

Anguilla, Antigua and Barbuda, Bermuda, Cuba, Grenada, Haiti, and the Netherlands Antilles are omitted from the analysis entirely because water intensity estimates for their national production are unavailable

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