Climate Change in Latin America: Impacts and Mitigation Policy Options

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Abstract

Despite the extensive literature on the economics of climate change, there have been few studies with extensive coverage of Latin America and even fewer linking macro impacts to income distribution. This paper addresses the above issues in the context of a global general equilibrium model with an integrated climate module. Relative to their share of global emissions, LAC countries are disproportionately affected by climate change damages. Although welfare declines for all households, agricultural households benefit somewhat from rising food prices. Due to its low carbon intensity, the region stands to gain substantially from efficient mitigation or a cap-and-trade system.

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Introduction

Climate change is likely to become a major social and economic challenge over the next century. Estimates of damages from climate change, though varying widely across studies, range up to 20 percent of global GDP, with the mode at around 1-2 percent of GDP. There is also the possibility of tipping points—leading to uncontrollable climate change—such as a sudden release of greenhouse gases (GHG) stored in permafrost, for example, or the collapse of Antarctic ice sheet. Beyond the aggregate effects, the impacts of climate change and policies to mitigate GHG emissions will vary widely across and within countries. Yet, most studies have not included much regional detail, and virtually all have focused on the cross-country distributional impacts. This paper aims to fill the existing knowledge gap by building a global general equilibrium model with a high level of country disaggregation for the Latin America and the Caribbean region, and linking the macro model results with a comprehensive compilation of household surveys for the analysis of within-country distributional effects. The remainder of the paper is organized as follows: the next section provides a brief summary of the methodological approach, while section 3 discusses the macro implications of four key scenarios: model baseline starting in 2004 and going to 2050 with explicit accounting of climate-related damages to agricultural productivity, a scenario without climate change damages, an emissions mitigation scenario where an atmospheric concentration of carbon is limited to 490 parts per million (ppm) via a global uniform carbon tax, and a mitigation scenario where the same carbon concentration is targeted via country-specific carbon taxes. Section 4 presents the poverty and distributional effects of these scenarios, while section 5 offers concluding remarks and draws policy messages.

Methodology

ENVISAGE: a global computable general equilibrium (CGE) model

The simulations in the paper are produced with the World Bank's Environmental Impacts and Sustainability Applied General Equilibrium model (ENVISAGE). The detailed description is available in van der Mensbrugghe (2008), while the following paragraphs summarize its most relevant features. The ENVISAGE model is a global, (recursive) dynamic computable general equilibrium (CGE) model, with a 2004 base year. Its standard time frame moves the global economy forward to 2050. While ENVISAGE is a relatively standard CGE model, with a specific focus on the energy side of the global economy, it also contains a simple climate module that makes it suitable for integrated assessment analysis.

Production in ENVISAGE is modeled with a series of nested CES functions that allow for different degrees of substitutability across inputs, which include intermediate inputs, energy, skilled and unskilled labor, different capital vintages, land, and natural resources (figure 1). The latter are sector-specific, while land has limited transformation across agricultural uses. New capital vintages and skilled labor are freely mobile across sectors, while the mobility of old vintages is limited. Unskilled workers are freely mobile within farm and non-farm activities, but the movement from farm to non-farm employment is limited with a Harris-Todaro migration function. The energy bundle is disaggregated into different energy sources using a CES nest, with the top-level bundle composed of electric and non-electric bundles. The latter is decomposed into coal and an oil and gas bundle, with this final bundle decomposed into gas and oil demand (figure 2). Consumer demand is modeled with a nesting of Cobb-Douglas and constant-differences-in-elasticity (CDE) utility functions (figure 3). International trade is specified with nested CES and CET functions which allow for limited substitution between domestically produced goods and imports or exports—frequently referred to as the Armington assumption (figure 4).

As mentioned above, the model contains an integrated climate module which links energy-related CO_2 emissions to changes in global temperature with feedbacks to agricultural productivity (following the approach of Nordhaus and Boyer 2000, and Nordhaus 2007, and calibrated with estimates in Cline 2007). Carbon (or CO_2) emissions emanate from the consumption of fossil fuels in both production and final demand activities.[1] These are emitted into the atmosphere. A transition matrix approach is used to allocate the stock and flows of carbon across three sinks—the atmosphere and the upper and deep oceans. The initial flow, i.e. the human generated carbon emissions are 100 percent absorbed by the atmosphere, but over time, part of the stock of carbon in the atmosphere is absorbed by the shallow ocean and eventually by the deep ocean. Over (a long period of) time, in the absence of new emissions, a new carbon equilibrium would be obtained across the three sinks. The key to climate change is the increase of atmospheric concentration of carbon (and other greenhouse gases). This leads to an increase in so-called radiative forcing whereby more of the sun's energy is absorbed in the atmosphere and leads to rising temperatures. The model includes a further dynamic whereby atmospheric and ocean temperatures also interact.

The model includes an explicit feedback between the change in atmospheric temperature and economic activity, using damage functions. These latter represent sector- and region-specific productivity shocks that are calibrated to estimates available in a limited but growing literature. Hence a rise in atmospheric temperature of 2.5°C (relative to 1900), might lead to a decline in agricultural productivity of anywhere between 0 and 50 percent depending on the crop and region.[2] Some regions may benefit, at least initially, from global warming, such as those lying in the upper latitudes (e.g. Canada and Russia).[3]

The current version of the model is based on the GTAP database with a 2004 base year, which has been aggregated to 26 country/regions and 22 sectors (Table 1) with particular attention to Latin America. The model is solved forward, in recursive fashion, until 2050, with labor force and population growth rates lined up to the UN's medium variant population forecast. TFP growth in agriculture is set at 2.5 percent per annum with no differentiation across sectors or regions, based on estimates in Martin and Mitra (1999). Labor-augmenting productivity growth in the other sectors is endogenized to achieve the World Bank's long-term forecasted growth of real GDP through 2015 and is held fixed at the 2015 level afterwards. The macro closure has government expenditures as a share of GDP fixed at 2004 levels, while a demographically-driven savings function determines the allocation of private expenditures between consumer demand and domestic investment. The manufactured export price index of the high-income countries is the numéraire. Finally, it is assumed that energy efficiency, otherwise known as the autonomous energy efficiency

1 The emissions module adjusts for the transformation of fossil fuels in certain key sectors, for example petroleum refining.
2 Cline 2007 has a comprehensive set of estimates for climate change impacts on agriculture.
3 There are additional issues related to agricultural productivity and its link to climate change including water availability and the role of carbon fertilization.

improvement (AEEI) parameter, improves at an exogenous rate—currently set at 1 percent per annum in all regions and for all activities.

GIDD: a global micro-simulation model

The distributional analysis is carried out with the World Bank's GIDD model, which generalizes the existing CGE-microsimulation methodologies—e.g., Bourguignon, Bussolo, and Pereira da Silva (2008), Chen and Ravallion (2003), and Bussolo, Lay, and van der Mensbrugghe (2006)—at the global level and is described in detail in Bussolo, De Hoyos, and Medvedev (2008). The GIDD dataset consists of 73 detailed household surveys for low and middle income countries. These are complemented with more aggregate data on income groups (usually vintiles) for 25 high income and 22 developing countries. The final sample covers more than 90 percent of the world's population (see Table 6 in the Annex for country coverage). The majority of the surveys (54) use per capita consumption as the welfare indicator, while the remaining surveys-all but one for countries in Latin America-include only per capita income as a measure of household welfare. The data are standardized to around the year 2005 and are expressed in 2005 PPP prices for consistency with the 1.25 and 2.50 dollars a day poverty lines, which are calculated at 2005 PPP exchange rates.[4]

The counterfactual income distribution is obtained by capturing four major changes in the structure of the population and the economy of the aforementioned countries: (a) change in the age and skill composition of the population, (b) change in the allocation of workers across sectors in the economy, (c) change in returns to labor by skill and occupation, and (d) change in the relative prices of food and non-food items in each household's consumption basket. Although in reality these changes take place simultaneously, in the GIDD framework they are accommodated in a sequential fashion.

The conceptual framework of the GIDD is depicted in Figure 5. The expected changes in population structure by age (upper left part of Figure 5) are taken as exogenous from the population projections provided by the World Bank's Development Data Group. Therefore, we assume that fertility decisions and mortality rates are determined outside the model. The change in shares of the population by education groups incorporates the expected demographic changes (linking arrow from top left box to top right box in Figure 5). Next, new sets of population shares by age and education subgroups are computed and household sampling weights are re-scaled according to the demographic and educational changes above (larger box in the middle of Figure 5). The impact of changes in the demographic structure on labor supply (by skill level) is incorporated into the CGE model, which then provides a set of link variables for the microsimulation: overall economic growth, growth in relative incomes by skill and sector, relative price changes, and the movement of labor between agricultural and non-agricultural activities. The final distribution is obtained by applying the changes in these link variables to the re-weighted household survey (bottom link in Figure 5).[5]

The sequential changes described above reshape the income distribution under a set of strong assumptions. In particular, income inequality within population subgroups formed by

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4 See Chen and Ravallion (2008) for a discussion of the new poverty lines adopted by the World Bank.

5 See Annex B for a detailed description of the GIDD, including the mathematical statement.

skills and sector of employment does not change as a result of economic shocks. Moreover, data limitations affect estimates of the initial inequality and its evolution. Although consumption expenditure is a more reliable welfare measure than income, and its distribution is normally more equal than the distribution of income, consumption data are not available for all countries' surveys. To get a global picture, this paper had to include, both, countries for which only income data were available with countries with consumption information. Finally, measurement errors implicit in purchasing power parity exchange rates, which have been used to convert local currency units, also affect comparability across countries. The resulting hypothetical income distribution should thus not be seen as a *forecast* of what the future distribution might look like; instead it should be interpreted as the result of an exercise that captures the *ceteris paribus* distributional consequences of climate change.

Macro results

Baseline: Business-as-usual (BaU) with climate change damages

The main drivers of emissions in the baseline scenario are the carbon intensities of existing technologies, population, and economic growth, all of which vary by region and country. The behavior of these variables is summarized in Table 2, which shows that in 2005, the per capita emissions in Latin America were significantly below not only the per capita emissions of high income countries, but also the per capita emissions of other regions at approximately the same level of development (e.g., East Asia, Middle East, and Eastern Europe). Although population growth in Latin America and the Caribbean is expected to be on par with population growth in all developing countries, the low initial carbon intensity of the region combined with the less rapid income growth relative to other developing countries means that Latin America is likely to become even less carbon-intensive vis-à-vis the world average in 2050, even though the carbon intensity will increase in absolute terms. This aggregate development conceals a wide amount of variation within the region: while relatively more carbon-intensive countries like Argentina, Mexico, and the Caribbean are likely to see their per capita emissions more than double by 2050, other countries like Brazil, Paraguay, and Uruguay could experience a less marked increase in their per capita emissions due to their heavy use of cleaner technologies (e.g., biofuels and hydro power).

Another reason for the relatively low carbon intensity of growth in Latin America is the shifting composition of energy demand (Figure 6). While total energy demand grows by approximately 2 percent per year—roughly one percentage point slower than growth in real GDP reflecting the autonomous improvement in energy efficiency—the composition of energy demand shifts away from more polluting coal and oil and into cleaner natural gas. The growth rates of coal and gas consumption for the region are approximately 2.1 percent per year—markedly below the real GDP growth rate of 3.6 percent per annum—while the growth rate of gas consumption is one-third faster at 2.8 percent per year. These trends are quite different from the global average, where demand for coal grows nearly twice as fast as demand for other fossil fuel energy carriers due to increasing scarcity and therefore rising price of oil and gas.

Latin America currently contributes just 5.4 percent of the total amount of fossil fuel generated carbon annually released into the atmosphere. In the baseline scenario, this ratio would fall to 4.5 percent by 2050, as global emissions more than triple from 7.2 to 26.0

gigatons of carbon. The rapid rise in emissions leads to an increase in atmospheric concentration of carbon from 382 ppm to 582 ppm in 2050, clearly well above any stabilization scenario of 450 ppm promoted by some as an upper limit to avoid severe damages, or the more modest target of 550 ppm that many others perceive as a threshold not to surpass. As worrisome as the overall concentration level in 2050, the path is far from a stabilization scenario with concentrations likely to continue increasing well beyond 2050. Of course the true objective is the overall rise in temperature which in our baseline and given climate sensitivity rises to 1.77 ºC (relative to 1900 levels) and by overall more than a full ºC relative to 2005—driven by an increase in radiative forcing. This is in the range of estimates produced by IPCC 2007, though perhaps somewhat on the low end.

Baseline with no damages from climate change

In order to quantify the impact of the increasing temperature on output, income, prices, and trade, the second scenario in this paper sets the damage coefficient in agriculture to zero, which allows us to attribute the differences across scenarios exclusively to climate change. The results are summarized in Table 3, and show that the impacts in Latin America are likely to be substantial with a 0.9 percentage point reduction in real income by 2050. Although, as shown earlier, the contribution of Latin America to global emissions is very small, the impact on Latin American countries is on par with the world average. Comparing the climate change-related damages in Latin America to other regions paints an even more grim picture: real income losses in Latin America (as a share of baseline income) are more than twice as high as in Eastern Europe, while the contribution of LAC to global emissions in 2050 is less than half of that by Eastern European countries. High income countries, despite being responsible for one-fifth of the total amount of carbon released into the atmosphere in 2050, may actually gain slightly from the warmer temperatures. While the specific damage figures are estimated with some uncertainty and therefore should not be taken as *the* impacts of climate change, the orders and ranking of magnitude suggest that the climate change vulnerability of Latin America is high, especially relative to its contribution to global emissions.[6] This highlights the need for a global solution to tackle climate change, since the increasing amount of carbon in the atmosphere hurts everyone, not just the emitters.

Although the main reason for the disproportionate impact of climate change on Latin America rests outside the model—the climate change sensitivity parameters from Cline (2007)—another contributing factor is the substantial share of agriculture in total output, which makes the marginal impact of productivity losses larger in aggregate terms. By 2050, Latin America accounts for more than 22 percent of agricultural output in developing countries, but less than 11 percent of population. While this magnifies the LAC sensitivity to a decline in agricultural productivity, it also makes Latin America less dependent on food imports in an environment of slower growth in global agricultural output. As agricultural production declines due to climate change damages to agricultural TFP and demand for agriculture and food remains relatively stable, agricultural prices are pushed by an average of 12 percent worldwide. All countries experience an increase in their agriculture import bill (

[6] At the same time, it should be acknowledged that Latin America is not the most vulnerable region, as the real income loss in the region is just half of the average impact on developing countries. Even when contributions to global emissions are taken into account, Sub-Saharan Africa remains much more vulnerable than LAC.

Table 4), with approximately 57 percent of the increase coming from higher prices and the rest from higher volumes of agricultural trade (Figure 7). Although Latin America maintains a comparative advantage in agriculture, remains the largest net food exporter among developing countries, and therefore experiences terms of trade gains from higher agricultural prices, the value of its net exports still declines by 17 percent due to falling production volumes. Due to still sizeable domestic production, the agricultural CPI in Latin America rises less than the CPI for the developing world at large, meaning that most of the increase in the import bill (84 percent) is accounted for by higher volume of imports.

At the country level, the impact of climate change damages on real income and trade flows varies substantially. On the welfare side, the damages range from almost no change in Argentina to more than 3 percent of baseline income in Paraguay and Uruguay, largely due to the differences in impact estimated by Cline (2007). The extent of the impact on imports varies according to the extent of damages, but also the importance of domestically produced agricultural goods in the food consumption basket and competitiveness of the domestic agricultural sector. This explains why Bolivia and Ecuador experience the largest increase in imports despite their middle-of-the-pack damages, while Brazil experiences a smaller increase in imports relative to its ranking on the damage scale.

Mitigation policies: country-specific and global uniform carbon taxes

In order to mitigate the negative impacts of climate change, the prototype of a global public good, a number of proposals have suggested putting a price on carbon, the source of the externality. The scenarios in this section assess the potential impacts of two different mitigation strategies: imposing a country-specific carbon tax, where each country reduces its emissions by the same percentage to achieve a given global reduction, and a global uniform tax, where emissions are reduced more in countries where the cost of reducing emissions is the lowest. In both cases, we target the atmospheric concentration of carbon just under 490 ppm, therefore staying below the 500 ppm threshold proposed by a number of climate advocates. In order to achieve this target, global emissions decline by 55 percent in 2050 (relative to the baseline), with progressively lower reductions in the preceding years. Compared with the baseline scenario, where global emissions more than triple between 2004 and 2050, in the mitigation scenarios they increase by 47 percent, and emissions in high income countries actually decline by nearly 8 percent relative to the base year.

The low carbon intensity of Latin America means that if mitigation is done at the country level, the carbon taxes paid by Latin American consumers would be significantly above the global average. In a very simple partial equilibrium framework, the carbon tax can be summarized by the following formula[7]:

$$\tau^c = \frac{PNRG}{\rho}\left[(1-R)^{-1/\sigma} - 1\right] \tag{1}$$

In formula (1), τ^c is the carbon tax, *PNRG* is the price of energy (for example \$ per ton of oil equivalent (TOE)), ρ is the average carbon content of energy (for example ton of carbon per ton of oil equivalent), σ is the overall elasticity of substitution across factors of production,

[7] See Burniaux et al 1992.

including energy and *R* is the level of emissions reduction. Obviously for *R* equal to 0, the tax is zero, and the tax approaches infinity as the level of reduction approaches 100 percent, i.e. equal to 1. Let's start with an example, where the price is $50 (per TOE), the average carbon content is 50%, the substitution elasticity is 0.8 and the level of effort is a 50% reduction. The implied price of carbon is then around $140 per ton. The formula is highly sensitive with these values. The price of carbon is $90 for a 40% reduction in emissions and is $215 for a 60% reduction.

The formula summarizes the impacts across regions with three key variables. First, the higher is the price of energy, the higher is the price of carbon for the same level of reduction. For example, if energy costs on average of $100/TOE in the OECD, but $50 in the non-OECD, the carbon tax will have to be higher in the former to achieve the same level of reduction. (A tax of $25/tC has a smaller percentage impact on $100 than on $50 assuming the carbon content is the same per unit of energy). At the moment, the lowest prices are in places like China and India, and many of the oil exporters. The second key factor is the carbon content of energy, ie. ρ. The greater the carbon content of energy, the lower the cost. This makes countries like China and India relatively low cost countries as they have a relatively high carbon content of energy. Finally, the third factor is the degree of substitutability in the economy, σ. The greater the degree of flexibility, the lower the carbon tax. Again, using the same basic parameters as above, a reduction of the substitution elasticity from 0.8 to 0.6 raises the carbon tax to $218. A value of 1 would lower the tax to $100. Here, substitutability is summarized with a single parameter, in practice, it will reflect a more complex production structure that embodies not only energy's degree of substitution with labor and capital, but also the inter-fuel substitutability. Since the model has vintage capital, the degree of substitution also changes over time. In practice, countries with the overall higher level of savings and investment will tend to have a higher share of 'flexible' capital and this will tend to lower the carbon tax. China again stands out given its currently very high level of investment.

Latin America falls in the middle of pack in terms of average energy price and degree of substitutability, but has a low carbon content relative to most other regions. This results in a relatively high carbon tax in the go-it-alone scenario. Compared with the efficient, globally uniform price of carbon of $297 per ton in 2050, carbon prices in Latin America would range from $420 in Argentina to $2,225 in Paraguay and Uruguay (Table 5). The carbon tax in Latin America would be three-and-a-half times the efficient price of carbon, and more than double the world average price of carbon in the inefficient (country-specific) mitigation scenario.

Given the high cost of the carbon tax, Latin America is likely to experience substantial income losses if mitigation is done at the country level. By 2050, real incomes are likely to fall by more than 5 percent relative to the baseline, despite the fact that mitigation limits global warming damages to agricultural productivity (Table 6). At the country level, the impacts vary significantly, from virtually no effect on real income in Paraguay and Uruguay to losses close to 11 percent of baseline income in Venezuela, Bolivia, and Ecuador. It is important to note that the magnitude of losses is not proportional to the size of the carbon tax: in some countries with small shares of "dirty" industries in output and low consumption of energy-intensive goods, such as Paraguay and Uruguay, the high carbon tax, redistributed in a lump-sum fashion, can somewhat offset the higher production costs and higher energy prices. Still, the losses are quite substantial at the regional level, especially when compared with an efficient mitigation strategy with a uniform global tax. In this case, welfare losses for the region are likely to be much more modest at 1.4 percent, with no country experiencing a more than 5 percent reduction in real income (Table 7). This suggests that, given its vulnerability to climate change damages and the very large inefficiencies of pursuing mitigation policies alone, Latin America should be an advocate of a global solution to climate change.

Due to the relatively high carbon taxes in Latin America, an inefficient mitigation scenario is likely to give rise to a substantial amount of carbon leakage, i.e., the movement of energy-intensive manufacturing out of "cleaner" and more expensive Latin American countries and into "dirtier" and cheaper countries like China and India. For example, the value of energy intensive exports of Latin America is likely to fall by more than 11 percent in the inefficient mitigation scenario relative to the scenario with a global uniform tax.[8] Although the exit of "dirty" industries may be associated with various social benefits, this also presents a potential danger of an erosion in the domestic manufacturing base and potentially slower long-term growth due to a decline of high productivity growth industries.

Micro results

The evolution of poverty--at the global and regional levels--under the four scenarios discussed earlier is shown in Table 8.[9] The first message conveyed by this table is that by 2050, the extreme poverty line of $1.25 per day (PPP) loses much of its relevance as less than 0.5 percent of the developing world's population lives below that threshold.[10] Even the moderate poverty line of $2.50 per day (PPP) captures a very small share of the population of the developing world, although, as shown in Table 8, there is a large amount of regional variation around the global average. Given the conceptual difficulties in defining a new poverty line, as well as to remain consistent with other literature on poverty, the following analysis sticks with these conventional definitions of global poverty despite their obvious limitations in the long term.

At the global level, a temperature increase of approximately 1 degree C above today's levels could raise the 2050 global moderate poverty headcount ($2.50 per day) from 3.0 percent in a scenario with no damages to 3.1 percent when damages are taken into account. This represents slightly more than 7.5 million people slipping into moderate poverty due to global warming. The limited global impact conceals a wider variation across regions, with increases in poverty ranging from practically no change in Eastern Europe and Central Asia to 1.6 million in South Asia and 3.9 million in Sub-Saharan Africa. The differences across regions

8 The decline is even more pronounced in volume terms (13) percent due to the rising prices of energy-intensive manufacturing as a result of the carbon tax.

9 This paper uses the new World Bank poverty line of $1.25 (2005 PPP) per day, and, in accordance with earlier practice, defines the moderate poverty line as twice the extreme poverty line ($2.50 per day, 2005 PPP). The poverty estimates presented in this paper do not line up to the official World Bank poverty estimates published in World Development Indicators or in Chen and Ravallion (2008) due to differences in country coverage. The extreme poverty statistics in this paper are fully consistent with Chen and Ravallion (2008) at the country level, and are reasonably close at the global and regional level.

10 Furthermore, measurement of poverty becomes very difficult at the very tail end of the distribution.

are determined to a large extent by the impacts on average incomes shown in the previous section, but are also influenced by the density of the population around the poverty line.

Latin America's contribution to the total increase in poverty is the smallest among all regions after Eastern Europe: it is just 4 percent, or 300 thousand people. This increase in poverty is even less than the rise in the headcount or the number of poor in the Middle East and North Africa, despite the fact that per capita damages in that region are higher. The same does not hold true for higher-order measures of poverty, however. Although the increase in the poverty gap in Latin America (from 0.0220 to 0.0222) is less than the increase in poverty gap for the developing countries as a whole, it is above the increase in poverty gap in East and South Asia. The small change in poverty for the region as whole hides quite a bit of variation across countries, with moderate poverty rising in 8 out of 21 countries in the region. This is shown in Figure 8, which plots the increase in poverty for households with primary income source in agriculture and non-agriculture as a contribution to the total change in poverty (such that the overall length of each bar represents the total change in the poverty headcount).

As Figure 8 makes clear, the adverse effects of global warming vary by the main source of household earnings. Although climate change damages are concentrated in agriculture, the agricultural households are not necessarily the most affected (Table 9). Due to a reduction in global output of agriculture of approximately 1 percent (and more than 8 percent in developing countries), prices for agricultural products rise and help close the wage gap between earnings in the farm and non-farm sectors. At the same time, however, the cost of the food basket rises for all consumers, including agricultural households. As a result, households in the farm sector are still likely to experience a reduction in their welfare due to higher consumption costs and the slower rate of growth in global GDP, but this reduction is likely to be less pronounced than the welfare losses for non-farm households. At the global level, these trends translate into a 0.14 percentage point increase in the non-farm poverty headcount while the headcount in agriculture rises by just 0.06 percentage points. In Latin America, these impacts are even more pronounced, with agricultural poverty headcount actually falling when damages from climate change are taken into account. This occurs because farmers in Latin America experience a significant increase in the price of their output, which more than offsets the fall in economy-wide living standards as well as the increase in the price of their consumption basket. The latter is an important point because farmers in LAC tend to be better off than farmers in other developing regions, which means that they spend a smaller share of their income on food than, for example, farmers in South Asia or Sub-Saharan Africa. On the other hand, the poverty headcount in non-agriculture rises in Latin America which drives the overall increase in the headcount.[11]

The final two columns of Table 8 again highlight the inefficiencies of cutting emissions via a country-specific carbon tax. Relative to the baseline, an efficient global solution would raise moderate poverty in Latin America by just 0.2 percentage points or 1.6 million people (without any targeted social protection measures). The inefficient solution would double these numbers, bringing the increase in the total number of poor to 3.3 million.

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[11] By 2050, most of the poverty in region is urban poverty.

Because the adverse impacts of global warming are more pronounced in the poor countries located closer to the equator, including climate change damages in the analysis results in an increase in the global Gini coefficient from 56.2 to 56.7 in 2050. For Latin America, the increase is less pronounced, with the regional Gini coefficient rising by 0.2 points from 56.6 to 56.8 when climate change damages are included. The widening of inequality between countries is to a large extent offset by the falling within component due to faster growth in the earnings of agricultural households, which tend to be concentrated in the left tail of the national distributions. These dynamics give rise to the regional growth incidence curve in Figure 9, which ranks all the households in Latin America according to their income (from lowest to highest) and plots the income gains or losses realized by these households in the "no damages" and efficient mitigation scenarios relative to the baseline. The figure shows that the poorer households (those located in the bottom 50 percent of the income distribution) are likely to lose less as a result of climate change damages than the wealthier households, consistent with the discussion above. At the same time, the growth incidence curve is regressive in the uniform tax scenario, suggesting that the poorer households bear a larger share of adjustment than those in the upper tranches of the income distribution. Although the inefficient mitigation scenario is somewhat less regressive than the inefficient strategy, this result still points towards the need to carefully consider the distributional consequences of policy changes.

Conclusions

As the global community undertakes the current round of the complex negotiations on a new architecture to limit the damages from man-made global warming, it is abundantly clear that developing countries will play a central role. It is important that each individual country understands the stakes for itself—both in terms of the damages that it could absorb in the absence of mitigation, as well as in the potential 'costs' it could incur from its own mitigation policies—either independently or as part of a broader agreement. Latin America, given its current energy configuration would gain significantly from a global efficient price of carbon. There are still many critical issues that need to be explored—1) what role will be played by substitute energy technologies (for example biofuels, nuclear, solar, wind, geo-thermal, or carbon capture and storage) and how these interact with existing fossil fuel-based technologies; 2) what role is there for using land and forests to assist in the sequestration of carbon; and 3) what shape will the international architecture take including importantly for many developing countries resource transfers (perhaps in the form of cap and trade), that would place the burden of mitigation on the high-income countries.

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Tables

Table 1 ENVISAGE dimensions

Regions		Sectors	
United States	MENA Energy exporters	Paddy rice	Other mining
Canada	Rest of MENA	Wheat	Processed food
Japan	Brazil	Other cereal grains	Refined oil
Rest of high income	Mexico	Oil seeds	Chemicals, rubber, plastics
Western Europe	Colombia	Sugar cane and beet	Energy int. manufacturing
China	Peru	Other crops	Other manufacturing
Indonesia	Venezuela, R.B.	Livestock	Electricity
Rest of Dev. East Asia	Argentina	Forestry	Gas distribution
India	Chile	Coal	Construction
Rest of South Asia	Bolivia and Ecuador	Crude oil	Transport services
Russia	Paraguay & Uruguay	Natural gas	Other services
Rest of ECA	Central America		
Sub Saharan Africa	Caribbean		

Table 2 Population, GDP, and emissions in the baseline

	Population (mn.)		Real GDP p.c. (US$)		Emissions p.c. (tC)	
	2005	2050	2005	2050	2005	2050
United States	295	354	40,796	65,584	5.6	6.6
EU 27 and EFTA	515	465	26,863	52,442	2.2	3.0
China	1,308	1,492	1,414	16,810	1.0	6.5
Rest of developing East Asia	352	500	1,346	6,061	0.5	1.4
India	1,095	1,585	640	5,772	0.3	1.5
Rest of South Asia	376	665	525	2,037	0.1	0.5
Russia	142	114	4,260	26,040	3.0	9.6
Rest of Europe and Central Asia	216	258	2,520	22,501	1.2	6.1
MENA Energy exporters	225	395	4,510	7,296	2.0	1.9
Rest of MENA	111	171	1,450	4,704	0.5	0.8
Sub Saharan Africa	732	1,410	757	4,810	0.2	0.6
Brazil	181	248	3,512	11,541	0.4	0.7
Mexico	105	163	6,668	21,463	1.1	2.3
Colombia	46	67	2,236	4,782	0.3	0.5
Peru	28	42	2,620	11,613	0.3	0.7
Venezuela, R.B.	26	40	4,510	13,710	1.4	2.5
Argentina	39	53	4,185	16,820	1.1	3.0
Chile	16	22	5,890	12,212	1.0	1.2
Bolivia and Ecuador	23	36	1,779	3,559	0.4	0.5
Paraguay and Uruguay	9	15	2,497	4,987	0.3	0.3
Central America	40	71	2,287	5,428	0.3	0.3
Caribbean	40	54	5,265	28,858	1.2	3.6
Annex I countries	1,443	1,452	24,160	49,413	3.0	5.3
Non Annex I countries	4,973	7,341	1,503	8,359	0.6	2.2
High income countries	1,084	1,080	31,088	58,313	3.3	4.6
East Asia and Pacific	1,881	2,304	1,378	12,754	0.9	4.6
South Asia	1,470	2,251	610	4,668	0.3	1.2
Europe and Central Asia	358	372	3,211	23,587	2.0	7.2
Middle East and North Africa	336	566	3,499	6,512	1.5	1.5
Sub Saharan Africa	732	1,410	757	4,810	0.2	0.6
Latin America and the Caribbean	554	811	4,076	13,576	0.7	1.4
Developing countries	5,331	7,713	1,618	9,093	0.7	2.5
World total	6,415	8,793	6,598	15,136	1.1	2.7

Table 3 Change in real income due to climate change damages

	$2004 billion				Percent of baseline income			
	2020	2030	2040	2050	2020	2030	2040	2050
EU 27 and EFTA	-4	-6	-7	-5	0.0	0.0	0.0	0.0
United States	1	6	16	36	0.0	0.0	0.1	0.2
Canada	0	2	5	10	0.0	0.1	0.3	0.7
Japan	-1	-1	0	0	0.0	0.0	0.0	0.0
Rest of high income	-2	-3	-4	-5	0.0	-0.1	-0.1	-0.1
China	-25	-88	-227	-472	-0.4	-0.9	-1.5	-2.0
Indonesia	-2	-4	-6	-9	-0.3	-0.5	-0.6	-0.7
Rest of developing East Asia	-2	-7	-14	-27	-0.3	-0.5	-0.7	-0.9
India	-28	-87	-216	-469	-1.4	-2.5	-3.7	-5.1
Rest of South Asia	-4	-8	-12	-15	-0.9	-1.1	-1.2	-1.1
Russia	-2	-3	-5	-7	-0.1	-0.2	-0.2	-0.2
Rest of Europe and Central Asia	-2	-5	-11	-23	-0.1	-0.2	-0.3	-0.4
MENA Energy exporters	-5	-10	-18	-26	-0.3	-0.4	-0.6	-0.7
Rest of MENA	-1	-2	-3	-4	-0.3	-0.4	-0.4	-0.5
Argentina	0	0	0	0	0.0	0.0	0.0	0.0
Brazil	-1	-3	-5	-7	-0.1	-0.2	-0.2	-0.3
Chile	0	0	0	-1	-0.1	-0.2	-0.2	-0.2
Colombia	0	0	-1	-1	-0.2	-0.2	-0.2	-0.2
Mexico	-5	-12	-27	-55	-0.4	-0.7	-1.1	-1.6
Peru	-1	-1	-3	-5	-0.4	-0.6	-0.8	-1.0
Venezuela, R.B.	-1	-2	-3	-4	-0.3	-0.4	-0.6	-0.7
Bolivia and Ecuador	0	-1	-1	-1	-0.4	-0.6	-0.8	-1.0
Paraguay and Uruguay	0	-1	-2	-2	-0.9	-1.6	-2.5	-3.5
Central America	0	-1	-1	-1	-0.2	-0.3	-0.3	-0.2
Caribbean	-1	-3	-7	-14	-0.3	-0.5	-0.7	-0.9
Sub Saharan Africa	-7	-20	-49	-116	-0.5	-0.9	-1.2	-1.7
Annex I countries	-9	-10	-6	7	0.0	0.0	0.0	0.0
Non Annex I countries	-84	-248	-593	-1,229	-0.5	-0.9	-1.4	-2.0
High income countries	-5	-2	9	36	0.0	0.0	0.0	0.1
East Asia and Pacific	-29	-98	-247	-508	-0.4	-0.8	-1.3	-1.8
South Asia	-32	-94	-227	-484	-1.3	-2.3	-3.4	-4.6
Europe and Central Asia	-4	-8	-16	-30	-0.1	-0.2	-0.3	-0.3
Middle East and North Africa	-6	-12	-20	-29	-0.3	-0.4	-0.6	-0.7
Sub Saharan Africa	-7	-20	-49	-116	-0.5	-0.9	-1.2	-1.7
Latin America and the Caribbean	-10	-24	-49	-91	-0.2	-0.4	-0.6	-0.9
Developing countries	-87	-256	-609	-1,259	-0.4	-0.8	-1.3	-1.8
World total	-92	-259	-600	-1,222	-0.1	-0.3	-0.6	-0.9

Table 4 Change in the value of agricultural imports due to climate change

	$2004 billion				Percent change			
	2020	2030	2040	2050	2020	2030	2040	2050
EU 27 and EFTA	1.0	1.7	2.6	3.5	1	3	5	8
United States	-0.2	-0.2	-0.1	0.2	-1	-1	-1	1
Canada	0.1	0.2	0.3	0.5	1	3	7	11
Japan	0.0	0.1	0.1	0.1	0	1	1	1
Rest of high income	0.6	1.1	1.8	2.7	3	5	8	12
China	5.7	20.3	50.6	102.7	2	3	4	6
Rest of developing East Asia	0.7	1.9	4.4	8.8	5	9	14	20
India	2.9	10.3	29.4	71.8	35	66	107	160
Rest of South Asia	0.9	2.1	4.1	6.8	15	32	58	101
Russia	0.1	0.3	0.7	1.5	1	2	4	7
Rest of Europe and Central Asia	0.4	1.0	2.3	4.9	5	9	13	19
MENA Energy exporters	1.2	1.4	1.6	1.8	12	20	31	48
Rest of MENA	0.4	0.7	1.0	1.5	9	15	24	36
Argentina	0.0	0.0	0.1	0.1	3	6	12	21
Brazil	0.1	0.1	0.2	0.2	5	9	15	23
Chile	0.0	0.1	0.1	0.1	8	15	26	42
Colombia	0.1	0.1	0.2	0.2	10	22	44	80
Mexico	0.9	2.2	5.2	11.1	13	27	50	81
Peru	0.2	0.5	1.0	1.7	21	36	49	60
Venezuela, R.B.	0.2	0.4	0.6	0.9	14	27	46	71
Bolivia and Ecuador	0.0	0.1	0.1	0.1	11	25	52	99
Paraguay and Uruguay	0.0	0.0	0.1	0.1	7	12	20	31
Central America	0.1	0.1	0.2	0.3	7	15	28	48
Caribbean	0.4	1.0	2.1	4.3	12	22	35	50
Sub Saharan Africa	0.9	2.7	7.8	22.3	9	17	32	52
East Asia and Pacific	7.0	23.5	57.4	115.6	2	3	5	7
South Asia	3.8	12.4	33.5	78.6	27	55	97	152
Europe and Central Asia	0.5	1.3	3.0	6.4	3	5	9	14
Middle East and North Africa	1.6	2.1	2.6	3.3	11	18	28	42
Sub Saharan Africa	0.9	2.7	7.8	22.3	9	17	32	52
Latin America and the Caribbean	2.0	4.6	9.8	19.2	12	24	42	65
High income countries	1.4	2.8	4.7	6.9	1	3	5	8
Developing countries	15.7	46.7	114.1	245.4	4	6	9	13
World total	17.2	49.5	118.8	252.3	4	6	8	12
Annex I countries	1.9	4.2	7.7	13.3	1	3	6	10
Non Annex I countries	15.2	45.3	111.1	239.0	4	6	9	13

Table 5 Carbon taxes and carbon tax revenues in mitigation scenarios

	Carbon tax (US$)				Carbon tax revenue (% of GDP)			
	Uniform		Country-specific		Uniform		Country-specific	
	2020	2050	2020	2050	2020	2050	2020	2050
EU 27 and EFTA	28	297	121	1,878	0.2	1.0	0.7	4.1
United States	28	297	72	876	0.3	1.5	0.7	3.2
Canada	28	297	83	1,073	0.3	1.6	0.8	3.9
Japan	28	297	139	1,616	0.1	0.7	0.5	2.3
Rest of high income	28	297	48	1,127	0.3	1.6	0.5	4.5
China	28	297	15	109	1.4	4.4	0.8	2.6
Rest of developing East Asia	28	297	62	764	0.8	4.4	1.5	8.5
India	28	297	12	120	1.0	2.9	0.5	1.7
Rest of South Asia	28	297	58	381	0.8	4.3	1.5	5.1
Russia	28	297	48	806	1.4	6.5	2.3	14.1
Rest of Europe and Central Asia	28	297	31	384	1.1	4.9	1.2	6.1
MENA Energy exporters	28	297	75	888	0.8	4.1	2.0	9.3
Rest of MENA	28	297	131	1,051	0.7	3.9	2.8	8.8
Argentina	28	297	32	420	0.5	2.6	0.6	3.6
Brazil	28	297	161	1,523	0.2	1.3	1.2	4.1
Chile	28	297	115	1,546	0.3	1.6	1.2	5.2
Colombia	28	297	45	998	0.3	1.7	0.5	4.4
Mexico	28	297	150	1,197	0.4	2.4	1.7	6.4
Peru	28	297	151	1,658	0.2	1.4	1.0	4.6
Venezuela, R.B.	28	297	39	621	0.5	3.0	0.7	5.5
Bolivia and Ecuador	28	297	167	1,092	0.5	3.0	2.4	7.5
Paraguay and Uruguay	28	297	317	2,225	0.2	1.5	2.0	5.6
Central America	28	297	228	1,619	0.2	1.6	1.7	5.1
Caribbean	28	297	60	840	0.5	2.5	0.9	5.5
Sub Saharan Africa	28	297	22	566	0.5	2.4	0.4	4.3
East Asia and Pacific	28	297	19	166	1.3	4.4	1.0	3.5
South Asia	28	297	18	152	0.9	3.1	0.7	2.1
Europe and Central Asia	28	297	41	557	1.2	5.5	1.8	9.2
Middle East and North Africa	28	297	81	914	0.8	4.1	2.1	9.2
Sub Saharan Africa	28	297	22	566	0.5	2.4	0.4	4.3
Latin America and the Caribbean	28	297	109	1,055	0.3	2.0	1.2	5.1
High income countries	28	297	88	1,245	0.2	1.3	0.7	3.6
Developing countries	28	297	34	327	0.9	3.7	1.2	4.8
World total	28	297	53	517	0.4	2.3	0.8	4.1
Annex I countries	28	297	77	1,004	0.3	1.6	0.7	4.1
Non Annex I countries	28	297	33	289	0.9	3.4	1.1	4.2

Table 6 Change in real income due to inefficient mitigation (country-specific carbon tax)

	$2004 billion				Percent of baseline income			
	2020	2030	2040	2050	2020	2030	2040	2050
EU 27 and EFTA	-15	-25	-183	-296	-0.1	-0.1	-0.8	-1.2
United States	-11	-16	-103	-175	-0.1	-0.1	-0.5	-0.8
Canada	-4	-9	-36	-54	-0.3	-0.6	-2.5	-3.6
Japan	-3	-4	-28	-44	0.0	-0.1	-0.4	-0.6
Rest of high income	-4	-8	-35	-66	-0.1	-0.2	-0.6	-1.0
China	-25	-75	-256	-530	-0.4	-0.8	-1.7	-2.3
Indonesia	-3	-6	-26	-45	-0.5	-0.8	-2.5	-3.5
Rest of developing East Asia	-4	-11	-71	-143	-0.5	-0.8	-3.4	-4.7
India	0	5	56	152	0.0	0.2	1.0	1.7
Rest of South Asia	-2	-4	-18	-32	-0.4	-0.6	-1.8	-2.4
Russia	-24	-62	-296	-520	-1.8	-3.3	-11.4	-15.3
Rest of Europe and Central Asia	-4	-9	-34	-77	-0.3	-0.4	-1.0	-1.4
MENA Energy exporters	-36	-93	-430	-681	-1.8	-3.7	-14.0	-19.7
Rest of MENA	-2	-4	-26	-40	-0.7	-0.9	-4.3	-5.0
Argentina	-2	-4	-13	-25	-0.5	-0.8	-2.1	-2.9
Brazil	-3	-6	-30	-52	-0.3	-0.4	-1.5	-2.0
Chile	0	0	-1	-1	0.1	0.2	-0.4	-0.2
Colombia	-1	-3	-10	-16	-0.8	-1.3	-3.6	-5.3
Mexico	-16	-40	-173	-328	-1.3	-2.3	-6.9	-9.6
Peru	0	-1	-6	-9	-0.2	-0.3	-1.6	-1.9
Venezuela, R.B.	-3	-8	-37	-65	-1.2	-2.3	-7.9	-11.3
Bolivia and Ecuador	-1	-2	-9	-15	-1.1	-1.9	-8.1	-10.9
Paraguay and Uruguay	0	0	0	0	0.0	0.1	-0.1	0.3
Central America	-1	-1	-7	-10	-0.3	-0.4	-2.2	-2.6
Caribbean	-2	-4	-26	-55	-0.4	-0.6	-2.5	-3.6
Sub Saharan Africa	-7	-20	-103	-245	-0.6	-0.9	-2.6	-3.6
Annex I countries	-64	-133	-715	-1,232	-0.1	-0.2	-1.1	-1.7
Non Annex I countries	-108	-277	-1,184	-2,139	-0.6	-1.0	-2.9	-3.6
High income countries	-37	-62	-385	-635	-0.1	-0.1	-0.7	-1.0
East Asia and Pacific	-33	-93	-353	-717	-0.5	-0.8	-1.9	-2.6
South Asia	-2	1	38	120	-0.1	0.0	0.6	1.2
Europe and Central Asia	-28	-71	-330	-597	-1.1	-1.8	-5.4	-6.7
Middle East and North Africa	-38	-97	-456	-721	-1.7	-3.3	-12.4	-16.9
Sub Saharan Africa	-7	-20	-103	-245	-0.6	-0.9	-2.6	-3.6
Latin America and the Caribbean	-28	-68	-311	-576	-0.7	-1.2	-3.9	-5.4
Developing countries	-135	-348	-1,514	-2,736	-0.7	-1.1	-3.2	-4.0
World total	-172	-410	-1,900	-3,372	-0.3	-0.5	-1.8	-2.6

Table 7 Change in real income due to efficient mitigation (global uniform carbon tax)

	$2004 billion				Percent of baseline income			
	2020	2030	2040	2050	2020	2030	2040	2050
EU 27 and EFTA	0	3	5	5	0.0	0.0	0.0	0.0
United States	-6	-10	-23	-42	0.0	-0.1	-0.1	-0.2
Canada	-1	-4	-11	-24	-0.1	-0.3	-0.8	-1.6
Japan	0	1	3	7	0.0	0.0	0.0	0.1
Rest of high income	-5	-11	-21	-29	-0.1	-0.2	-0.4	-0.4
China	-51	-194	-510	-952	-0.9	-1.9	-3.3	-4.2
Indonesia	-2	-6	-13	-22	-0.4	-0.7	-1.2	-1.7
Rest of developing East Asia	-2	-8	-23	-48	-0.3	-0.6	-1.1	-1.6
India	-10	-32	-56	-27	-0.5	-0.9	-1.0	-0.3
Rest of South Asia	-1	-3	-9	-20	-0.2	-0.5	-1.0	-1.5
Russia	-9	-32	-95	-204	-0.7	-1.7	-3.7	-6.0
Rest of Europe and Central Asia	-4	-15	-43	-85	-0.3	-0.7	-1.2	-1.5
MENA Energy exporters	-7	-32	-116	-266	-0.3	-1.3	-3.8	-7.7
Rest of MENA	0	-1	-3	-6	-0.1	-0.2	-0.4	-0.8
Argentina	-1	-3	-9	-18	-0.3	-0.7	-1.4	-2.1
Brazil	0	-1	-3	-6	0.0	-0.1	-0.1	-0.2
Chile	0	1	1	2	0.1	0.4	0.6	1.0
Colombia	-1	-2	-4	-8	-0.4	-0.8	-1.6	-2.6
Mexico	-3	-10	-31	-73	-0.2	-0.5	-1.2	-2.1
Peru	0	0	0	1	0.0	0.0	0.1	0.3
Venezuela, R.B.	-1	-3	-12	-29	-0.3	-0.9	-2.5	-5.0
Bolivia and Ecuador	0	-1	-2	-6	-0.2	-0.8	-2.1	-4.3
Paraguay and Uruguay	0	0	0	1	0.0	0.1	0.3	0.9
Central America	0	0	0	0	0.0	-0.1	-0.1	-0.1
Caribbean	-1	-3	-7	-14	-0.2	-0.4	-0.7	-0.9
Sub Saharan Africa	-4	-16	-53	-120	-0.3	-0.7	-1.3	-1.8
Annex I countries	-25	-68	-184	-373	-0.1	-0.1	-0.3	-0.5
Non Annex I countries	-84	-313	-849	-1,610	-0.5	-1.2	-2.1	-2.7
High income countries	-12	-21	-47	-84	0.0	0.0	-0.1	-0.1
East Asia and Pacific	-55	-208	-545	-1,022	-0.8	-1.7	-3.0	-3.8
South Asia	-11	-35	-65	-47	-0.5	-0.9	-1.0	-0.5
Europe and Central Asia	-13	-47	-138	-289	-0.5	-1.2	-2.3	-3.2
Middle East and North Africa	-7	-33	-118	-272	-0.3	-1.1	-3.2	-6.4
Sub Saharan Africa	-4	-16	-53	-120	-0.3	-0.7	-1.3	-1.8
Latin America and the Caribbean	-7	-22	-67	-149	-0.2	-0.4	-0.8	-1.4
Developing countries	-97	-360	-987	-1,900	-0.5	-1.2	-2.1	-2.8
World total	-109	-381	-1,033	-1,983	-0.2	-0.5	-1.0	-1.5

Table 8 Poverty headcount, percent of population

	Observed, 2000	Baseline, 2050	No climate change damages, 2050	Efficient mitigation, 2050	Inefficient mitigation, 2050
US$1.25 (PPP) per day poverty line					
Developing countries	24.80	0.46	0.45	0.51	0.70
East Asia and Pacific	16.96	0.01	0.01	0.01	0.02
Eastern Europe and Central Asia	5.38	0.00	0.00	0.00	0.00
Latin America and Caribbean	8.13	2.22	2.21	2.29	2.46
Middle East and North Africa	2.88	1.17	1.11	1.62	4.78
South Asia	39.32	0.02	0.01	0.02	0.02
Sub-Saharan Africa	49.70	1.08	1.04	1.18	1.27
US$2.50 (PPP) per day poverty line					
Developing countries	58.84	3.13	3.02	3.37	3.87
East Asia and Pacific	51.72	1.03	0.96	1.13	1.28
Eastern Europe and Central Asia	24.23	0.03	0.03	0.03	0.03
Latin America and Caribbean	21.45	6.02	5.98	6.27	6.76
Middle East and North Africa	29.72	8.96	8.85	10.23	16.13
South Asia	85.81	1.78	1.72	1.88	1.94
Sub-Saharan Africa	80.46	7.97	7.55	8.62	9.14

Source: Authors' simulations with the GIDD and ENVISAGE models

Table 9 Changes in poverty indicators by main source of household income

	Agriculture	Non-agriculture	Total
Difference in poverty headcount (FGT(0)) at the US$2.50 (PPP) per day poverty line, (BaU-BaUND)			
Developing countries	0.06	0.14	0.11
East Asia and Pacific	0.05	0.09	0.07
Eastern Europe and Central Asia	0.00	0.00	0.00
Latin America and Caribbean	-0.29	0.08	0.03
Middle East and North Africa	0.86	0.03	0.11
South Asia	-0.10	0.18	0.06
Sub-Saharan Africa	0.44	0.36	0.42
Difference in poverty gap (FGT(1)) at the US$2.50 (PPP) per day poverty line, (BaU-BaUND)			
Developing countries	0.02	0.02	0.03
East Asia and Pacific	0.01	0.01	0.01
Eastern Europe and Central Asia	0.00	0.00	0.00
Latin America and Caribbean	-0.11	0.03	0.02
Middle East and North Africa	0.46	0.03	0.08
South Asia	-0.01	0.02	0.01
Sub-Saharan Africa	0.14	0.06	0.12

Note: FGT0 and FGT1 are expressed in percentage points prior to taking differences

Source: Authors' simulations with the GIDD and ENVISAGE models

Figures

Figure 1: Production structure nesting

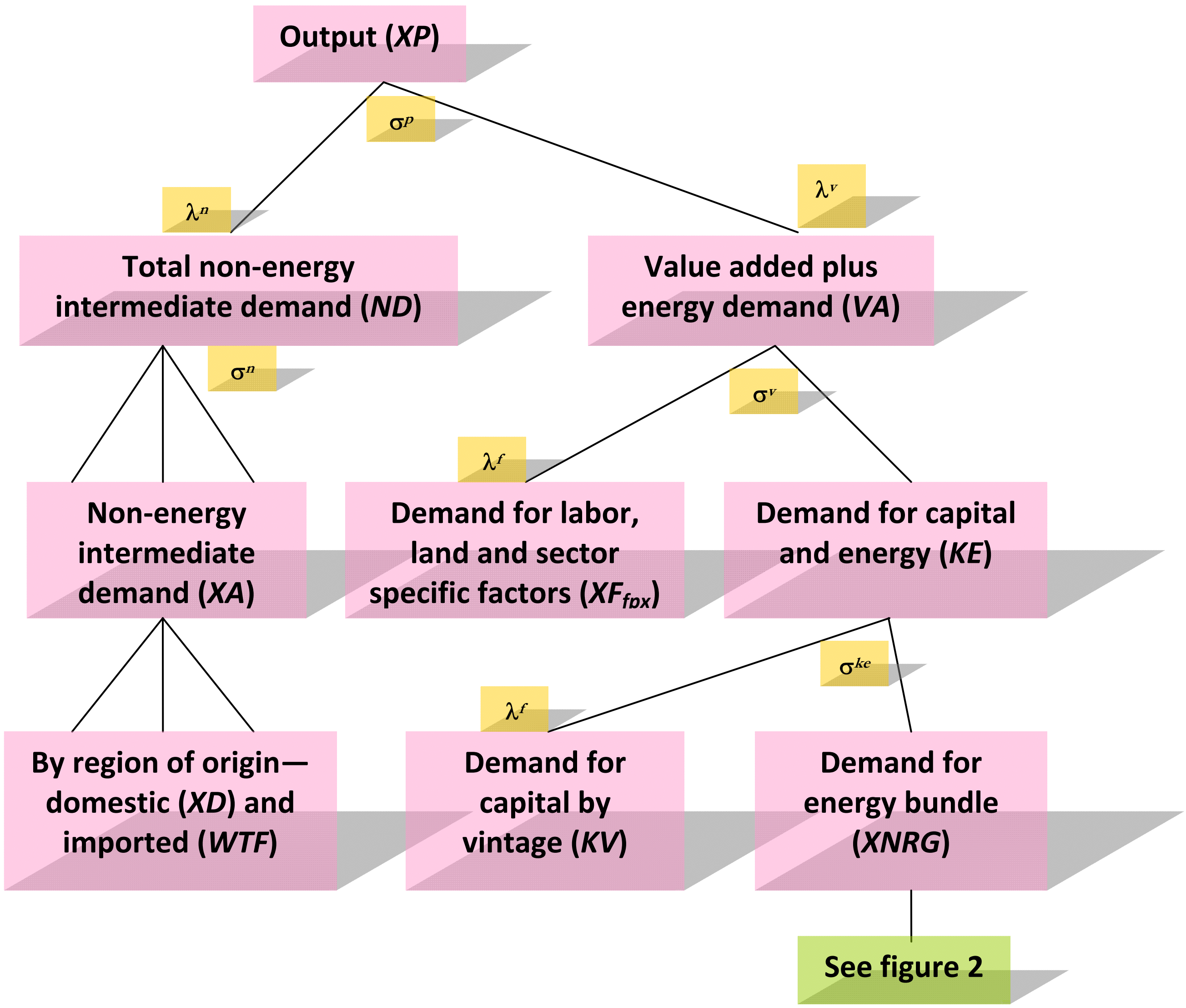

Figure 2: Energy nesting

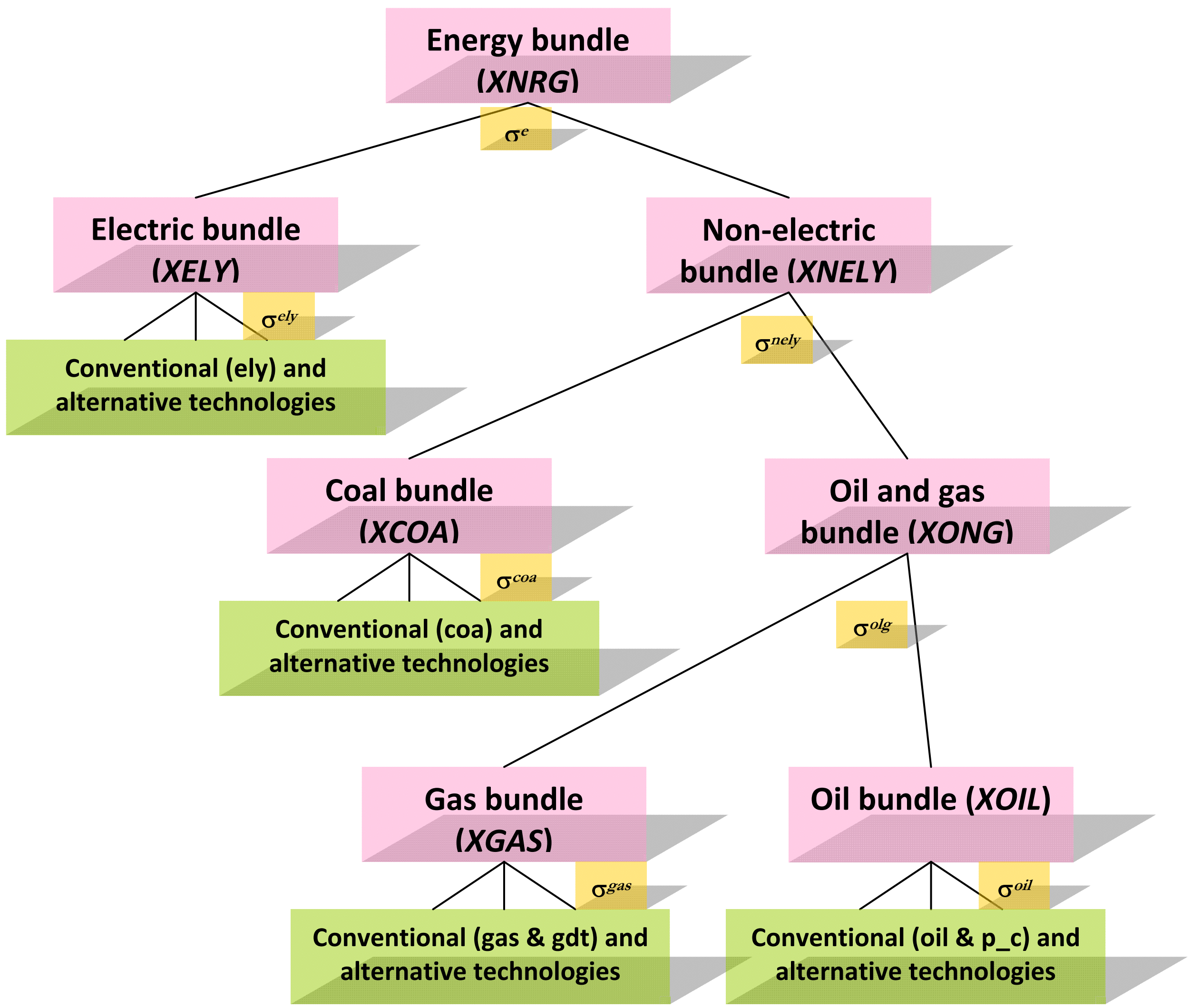

Figure 3: Domestic demand nesting

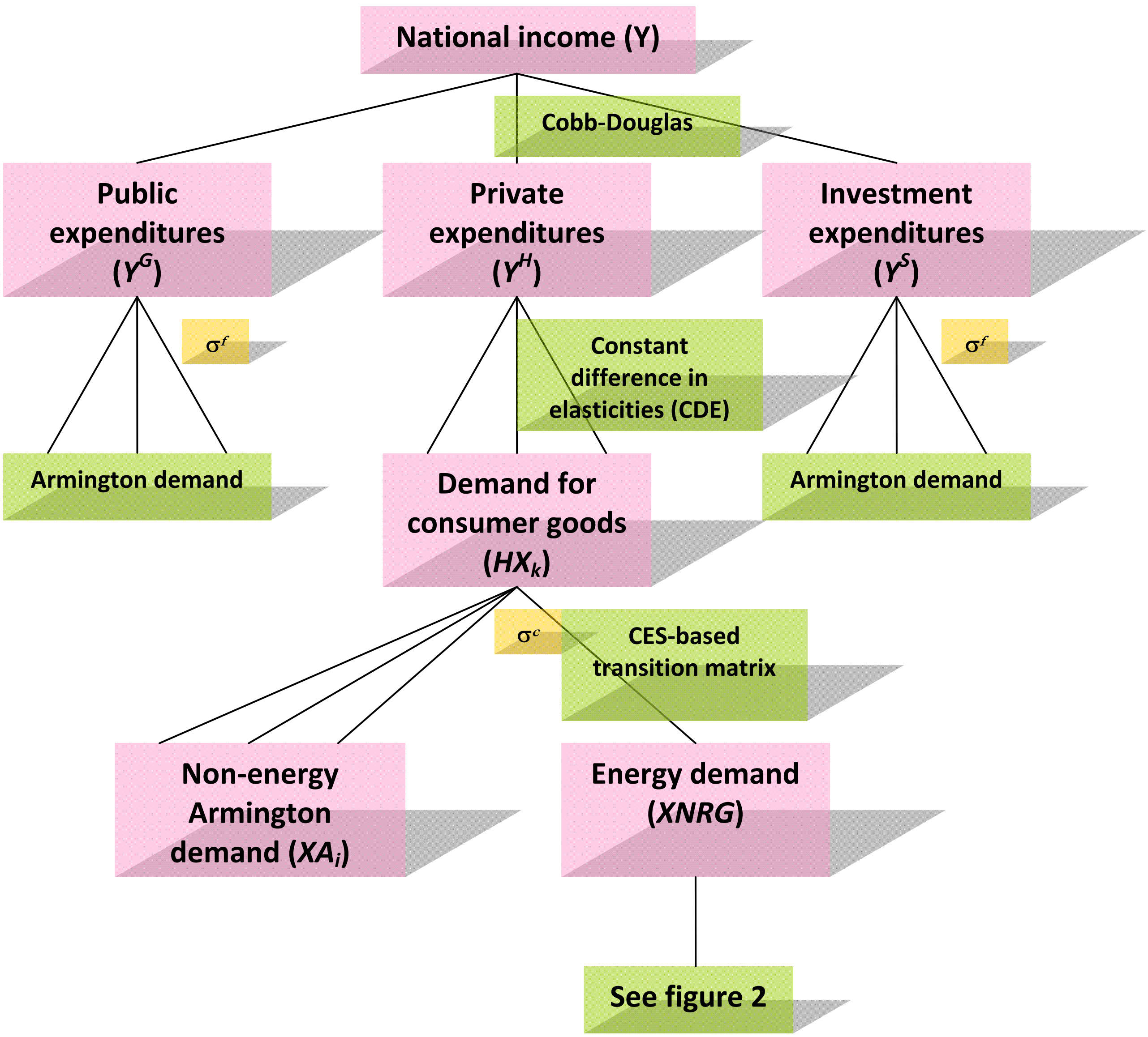

Figure 4: Output, supply and trade

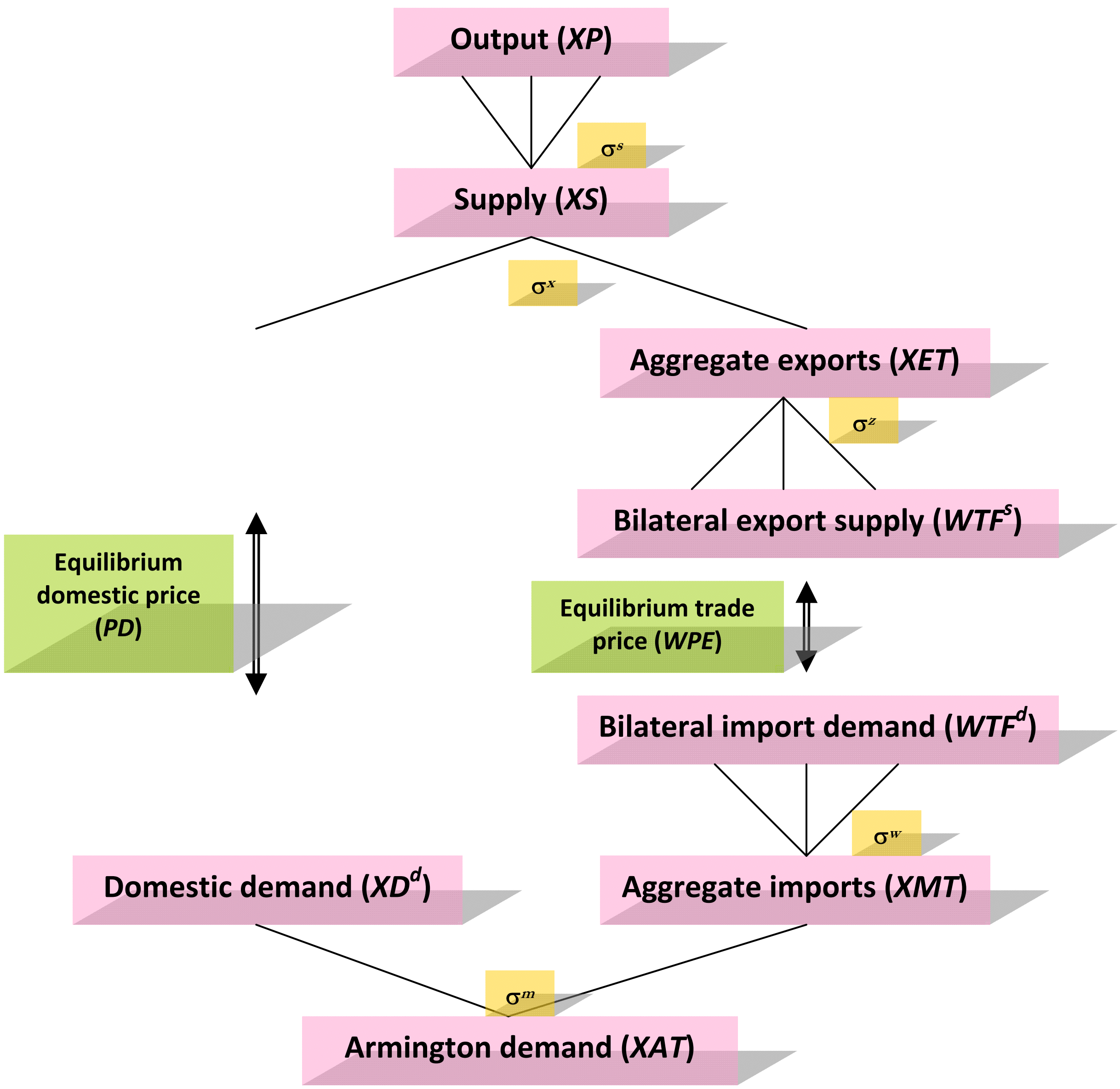

Figure 5: GIDD methodological framework

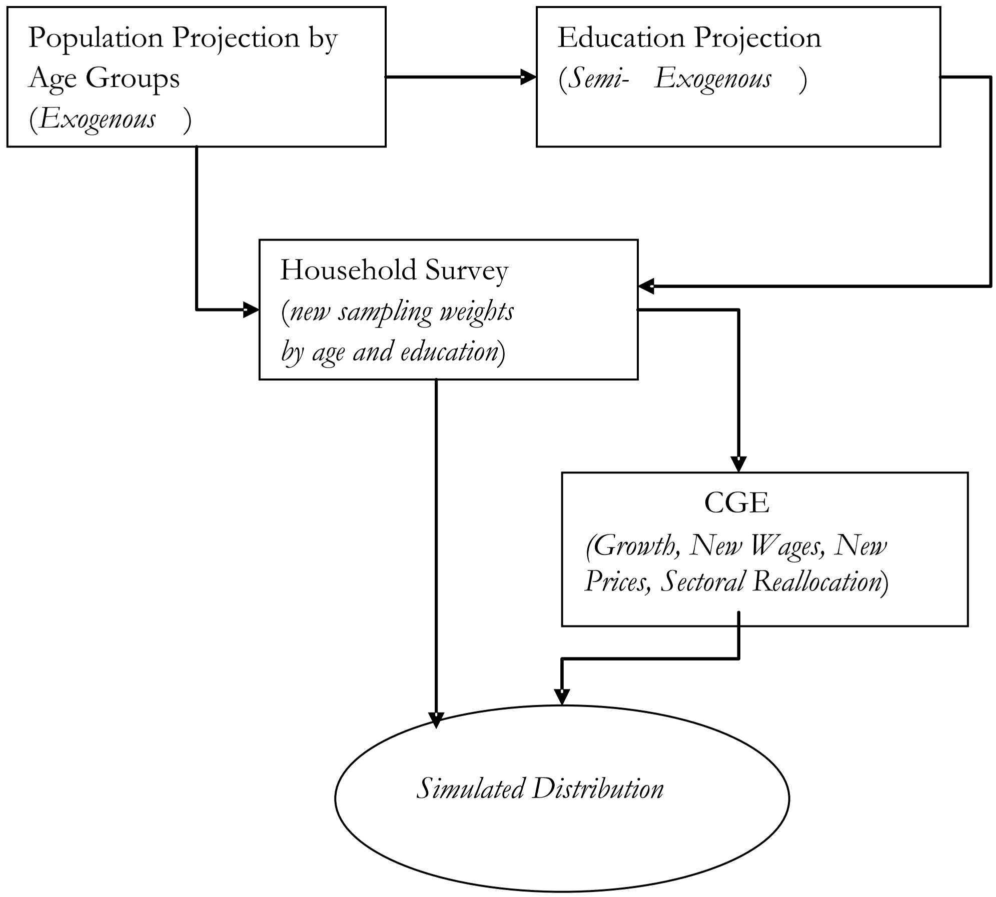

Figure 6: Composition of energy demand in Latin America (mtoe)

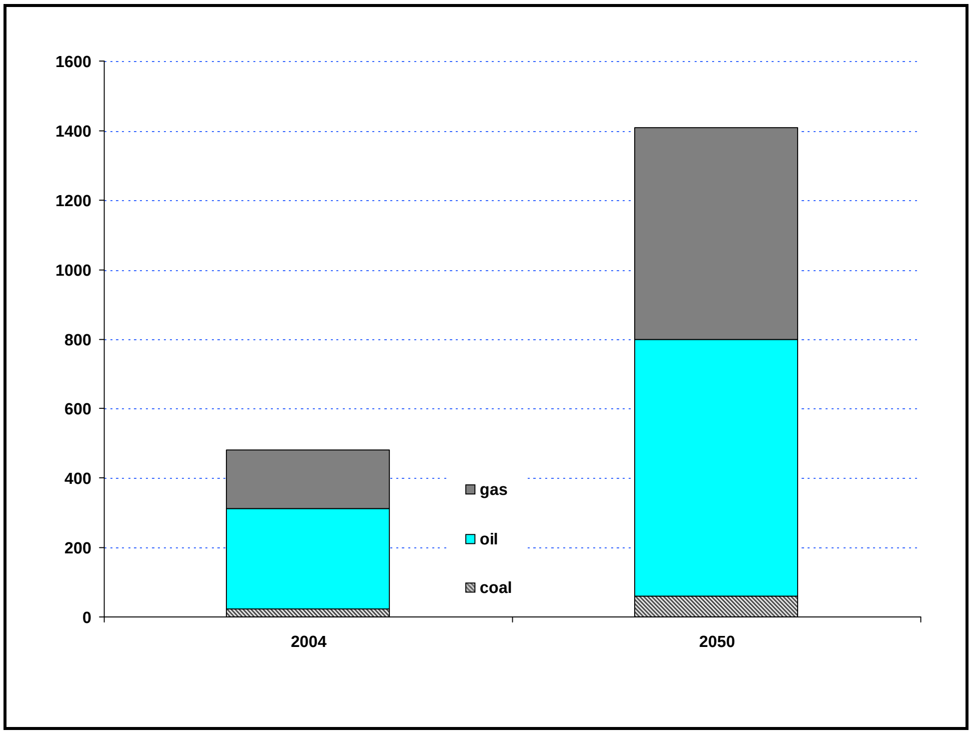

Figure 7: Percent increase in agricultural imports due to climate change damages

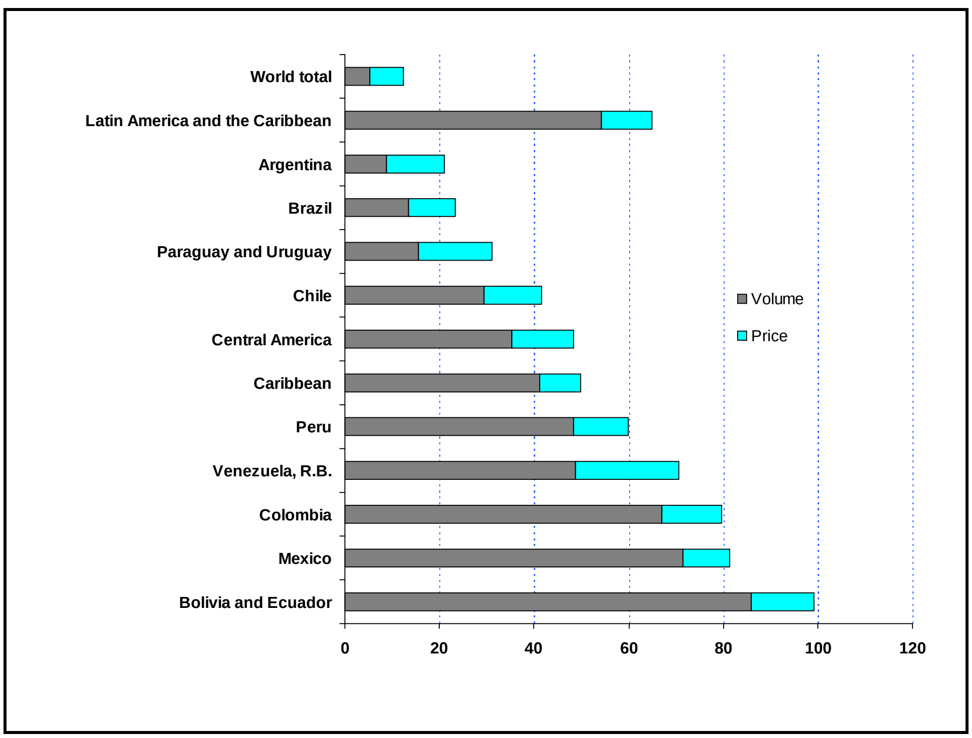

Figure 8 Impact of climate change damages on the moderate poverty headcount

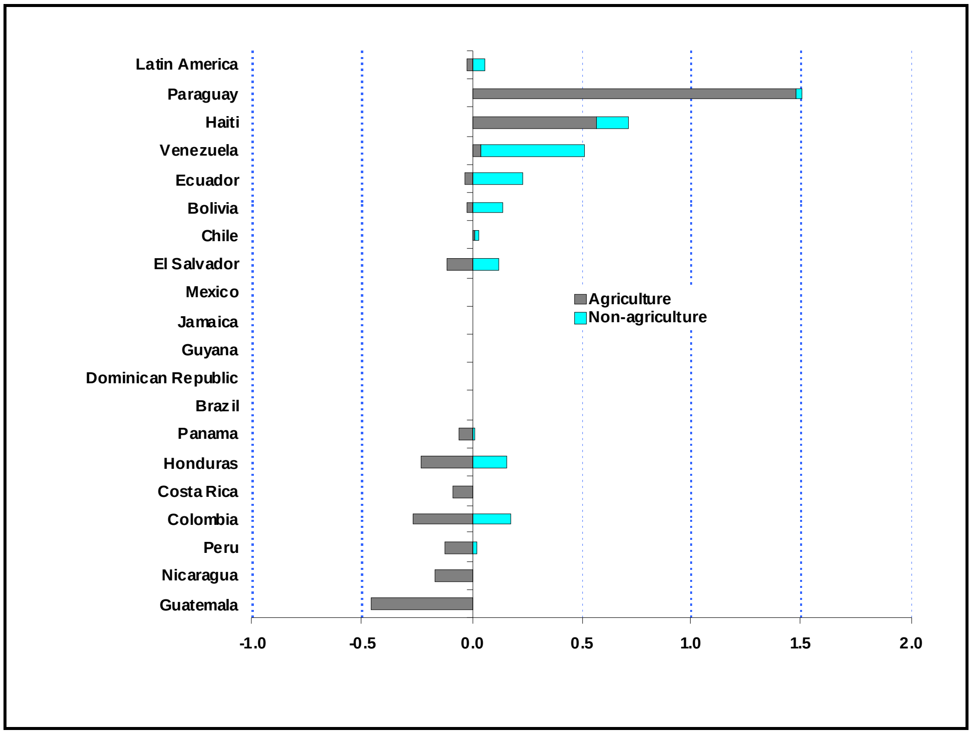

Figure 9 Growth incidence of climate change damages and mitigation policies in Latin America